NANOTECHNOLOGY IN SPAIN: TECHNOLOGY WATCH BY PATENTS

VIGILANCIA TECNOLÓGICA DE LA NANOTECNOLOGÍA ESPAÑOLA A TRAVÉS DE SUS PATENTES

TESIS DOCTORAL

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Granada, Noviembre 2015

UNIVERSIDAD DE GRANADA

FACULTAD DE COMUNICACIÓN Y DOCUMENTACIÓN

DEPARTAMENTO DE INFORMACIÓN Y COMUNICACIÓN

Editor: Universidad de Granada. Tesis Doctorales
Autor: Björn Jürgens
ISBN: 978-84-9125-722-6
URI: http://hdl.handle.net/10481/43486

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Memoria que presenta

Björn Jürgens

para optar al Grado de Doctor en Documentación

Dirigida por: Dr. Víctor Herrero Solana

Granada, Noviembre 2015

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Resumen

La nanotecnología constituye una de los campos de investigación y desarrollo científico más fascinante, complejo e innovador de nuestros días. En la presente tesis se realiza un estudio de las patentes españolas en nanotecnología de los años 2004 al 2014. Para ello se ha trabajado con la base de datos Espacenet de la que se obtuvo más de 3400 registros. Con ellos se realizó un análisis detallado, empleando el conocido programa MatheoPatent que fue de mucha utilidad. Con los resultados obtenidos se pudo ver que en el contexto global estamos ante dos tipos de países. Por un lado tenemos un grupo compuesto por Estados Unidos, Japón y Corea del Sur donde la producción de patentes es relativamente mayor que la producción científica. Por otra parte tenemos un grupo con el comportamiento contrario, donde destacan especialmente China y en menor medida España y el Reino Unido.

España interviene, de una o de otra, en el 1% de la patentes sobre nanotecnología en el mundo, pero al mismo tiempo tiene más del doble de la representación por papers científicos. No cabe duda que el país ha hecho un gran esfuerzo por fortalecer el ámbito científico, pero lo ha hecho poniendo énfasis en el sector público y académico. La iniciativa de la empresa privada no ha tenido la misma suerte en los últimos años.

El perfil temático español también es multidisciplinar, pero con un sesgo diferente, ya que predominan (en términos porcentuales relativos) los códigos de clasificación relacionados con la nano-medicina y nano-biotecnología. Al contrario, se puede apreciar un déficit en las patentes relacionadas con la nano-óptica, el nano-magnetismo y la tecnologías “nano” de la información y comunicación (TIC). En el campo de las ciencias de materiales, la producción es en términos relativos equivalente a la del resto del mundo.

La evolución temporal de España es sostenida desde hace varios años y la provincias que más destacan son: Madrid, Barcelona, Valencia, Sevilla y La Coruña. Si analizamos la producción de patentes por sectores encontramos que entre los solicitantes predominan las universidades (37%), seguidas por la empresa privada (24%), el CSIC (20%) y otros centros de investigación (16%). Del mundo universitario destacan la Universidad de Sevilla y la Universidade de Santiago de Compostela, a las que se le puede sumar un poco más atrás la Universitat Politécnica de Valencia. En el CSIC destaca, tanto por su producción en patentes y papers, el

Instituto de Ciencia de Materiales de Madrid. Finalmente, cierran el listado de solicitantes destacados las empresas Advancell y Nanobiomatters.

En esta tesis proponemos un sencillo indicador, la tasa de internacionalización, que es un cociente entre la cantidad de registros de patentes y las familias. Cuando analizamos la tasa de internacionalización en España, nos encontramos que los valores más altos los presentan las empresas. Se trata, por tanto, de empresas cuyo modelo de negocio se basa en la protección de esas innovaciones y por tanto que están dispuestas a tal esfuerzo.

Ciertas universidades parecen tener mayor capacidad de internacionalización que los centros de CSIC, aunque en principio podría pensarse lo contrario. Las que realmente destacan son la Universidad de Sevilla y la Universidade de Santiago de Compostela. Ambas presentan un comportamiento tal que amerita por si mismo un posterior estudio de sus respectivas OTRI. La tesis finaliza mostrando la potencia de los indicadores tecnológicos de red para definir temáticamente las relaciones que tienen los distintos solicitantes de patentes.

Abstract

Nanotechnology is one of the most fascinating, innovative and complex fields of scientific research and development of today. In this thesis, a study of the Spanish nanotechnology patents is done for the years 2004 to 2014. The database Espacenet has been used as a data source and more than 3400 records were retrieved. Subsequently a detailed analysis was performed using the software tool *Matheo Patent*. With the results obtained we could identify two types of countries in the global context. On the one hand we have a group comprising the United States, Japan and South Korea where the production of patents is relatively higher than the scientific production. On the other hand we identified a group with the opposite behaviour, which includes especially China and to a lesser extent the UK Spain.

Spain intervenes, one or the other, at 1% of the patents on nanotechnology in the world, but also has more than double the representation for scientific papers. There is no doubt that the country has made great efforts to strengthen the scientific field, but it has an emphasis on public and academic sector. The initiative of private enterprise has not had the same luck in recent years. Spain forms part in 1% of the patents on nanotechnology in the world, but has more than double the representation for scientific papers. There is no doubt that the country has made great efforts to strengthen the scientific field, but it has an emphasis on public and academic sectors. The private enterprise initiatives have not had the same luck in recent years.

The Spanish thematic profile has a multidisciplinary character, but with a different bias since classification codes related to nano-medicine and nano-biotechnology prevail (relative in percentage terms). On the contrary we found a deficit in patents related to nano-optics, nano-magnetism and "nano" technologies of information and communication technologies (ICT). In the field of materials science related to nanocomposites, production is equivalent in relative terms to the rest of the world.

The temporal evolution of Spain has found to be steady for several years and the most productives provinces were Barcelona, Madrid, Valencia, Seville and La Coruna. If we analyze the patent output according to its applicant’s sector affiliation the universities are prevalent (37%), followed by private enterprises (24%), the CSIC (20%) and other research centres (16%).

From the academic world we can point out the Universidad de Sevilla and the Universidade de Santiago de Compostela, followed by the Universitat Polytechnic of Valencia. Among the CSIC

stands out in both, its production of patents and papers, the Instituto de Ciencia de Materiales de Madrid. The only two companies which appear in the ranking are Advancell and Nanobiomatters.

In this thesis we propose a simple indicator, the rate of internationalization, which is a ratio between the number of patent registrations (in different offices) and patent families (the invention or innovation itself). When we analyze the rate of internationalization in Spain, we find that the highest values are presented by the companies, whose business model is based on the protection of such innovations and therefore are willing to such an effort.

Some universities appear to have higher capacity of internationalization than the CSIC centres. The institutions which really stand out are the Universidad de Sevilla and the Universidade de Santiago de Compostela. Both have such a positive productive behaviour that a further study of their technology transfer offices (TTO) would be of interest.

The thesis concludes by showing the power of the network for technology indicators thematically define relationships that different patent applicants.

Acknowledgements

The authors acknowledge the support of Spanish Ministry of Science and Economy for funding the framework project "Vigilancia tecnológica de la nanotecnología española a través de sus patentes (Technology watch of Spanish Nanotechnology via its patents)", grant by "Plan Nacional de I+D+i 2008-2011", project code: CSO2012-38801, for which this study was used.

Agradecimientos

El presente trabajo se desarrolló en el marco del proyecto "Vigilancia tecnológica de la Nanotecnología española a través de sus patentes" (CSO2012-38801) proyecto de investigación financiado por el Programa Nacional de Proyectos de Investigación Fundamental en el marco del VI Programa Nacional de Investigación Científica, Desarrollo e Innovación Tecnológica 2008-2011, Subprograma de Proyectos de Investigación Fundamental no Orientada (BOE de 31 diciembre de 2011)

1 Preface

1.1 Motivation

"It is of the highest importance in the art of detection to be able to recognize, out of a number of facts, which are incidental and which vital"

Sherlock Holmes

Nanotechnology is known to be one of the most promising and radical new technological frontiers involving engineering, design, production and application of materials at the scale 40,000 times smaller than the width of a human hair.

In the last decade Nanotechnology has captured the popular imagination with movies, video games, utopian fantasies and even horror scenarios involving nanotechnology. The hyperbole surrounding this new technology came not only from the media but even from scientists who exaggerated the anticipated benefits of nanotechnology to justify research funding (Berube 2006).

But what is nanotechnology exactly? Is it a specific technology or a collection of different concepts? Is it a well defined science field? Who are the important actors and how is the nanotechnology evolving? All these questions fascinated and inspired me to find out more about this so called “emerging” technology.

Having an educational background in Information and Knowledge Management from Germany and Library Science in Spain and a work experience of over 10 years in a European wide networked patent information centre of the regional government of Andalusia (Agencia de Innovacion y Desarollo de Andalucia) I was especially interested in analyzing Nanotechnology since, as a highly innovative field, it is predestinated to be rich in patents.

Patent documents are a well known source of technological information and can be analyzed with a technology watch approach using patentometric methods, that is, bibliometric analysis applied to patents documents.

Thanks to the experience gained as an author of previous technology watch studies (Jürgens et al 2007, 2008 2009 and Jürgens & Herrero-Solana 2011), patent information databases (Jürgens & Herrero-Solana 2015) and as speaker about the subject in several international patent conferences (PATLIB 2008,2012, PATINFO 2013, EPOPIC 2014) I decided to analyze this complex and ambiguous science and technology field. Due to my country of residence and to the fact that very comparable studies were found, I chose to focus my research on the technological domain of Spain.

1.2 Objectives of the thesis

The aim of the present work is an approach to develop a technology watch of Spanish nanotechnology via its patents.

1.3 Delimitation of the thesis

This thesis is based on an analysis about patents related to nanotechnology in Spain over a specific time period. Therefore it does not include earlier and posterior data and subsequently, any findings related to it. Furthermore, as in every thematic document search, a completeness of the data cannot be guaranteed since the search depends on subjective criteria. A search strategy was developed using specific keywords and patent classifications that were in our judgment the best in order to identify the most relevant nanotechnology documents used for the following analysis.

1.4 Structure of the thesis

The present work is organized with the common structure of scientific publications. First we describe the basics of what is nanotechnology, its history, its multidisciplinary character, and how it is defined in academic literature. Then we tackle how worldwide nanotechnology growth has been driven by R&D initiatives and give an overview of the situation in Spain. In the second part of the introduction we explain the patent system, the characteristics of patent documents and its classifications and give a summary of the most important patent information sources. Then we describe what the technology watch is and how patent analysis can be used for it in order to analyze a technology domain like Nanotechnology. In this context we illustrate the different patent indicators which can be used for a technology watch activity and how the data can be visualized and with which tools this can be performed. In the last part of the introduction we discuss the most relevant scientific publications which deal with nanotechnology patent analysis, on a global scale and then specifically for the country of Spain.

After the introductory part we explain the methodology used for the present paper. First we describe the scope of the study and explain the search strategy we used in order to identify Nanotechnology patents. Then we outline how we identified the most suitable patent data sources for the patent search and which analysis and visualization tool we used for this study. After that we explain the process of data retrieval, the generation of the patent data set and its consecutive data harmonization procedure in order to clean data for the analysis. As last point of this part in the study we give details about the indicators we used for the patent analysis study.

The third part of the paper is the most important since it exposes the results of the patent analysis. It is divided in different sections according to the type of indicators used. Furthermore it will highlight the results of the most active Spanish research entity in Nanotechnology.

The last part concludes the present paper with a discussion of the patent analysis obtained and will sum up the most important findings.

2 Introduction

2.1 What is nanotechnology?

"The principles of physics, as far as I can see, do not speak against the possibility of manoeuvring things atom by atom. It is not an attempt to violate any laws; it is something, in principle, that can be done; but in practice, it has not been done because we are too big."

Richard Feynman, 1959

2.1.1 History ofnanotechnology

Nanotechnology involves design, engineering and application of materials at the nano scale, which is approximately 40000 times smaller than the width of a human hair.

Long before the start of the modern era of nanotechnology, mankind came across different nanosized objects and related processes and used them in practice in an intuitive way without proper understanding of the nature of these objects and processes.

The first documented example is the roman Lycurgus Cup dated from the 4th century AD (Fig. 1) which was made from glass impregnated with gold nanosized particles giving it the effect that the colours of the cup can change from green when looked at in reflected light to red when light is shone into the cup and transmitted through the glass (Liz-Marzán, 2004).

Fig. 1: Lycurgus Cup[1]

In the Middle Ages craftsman in Europe began to use a similar technique by adding gold and silver salts to molten glass in order to give it a red and yellow tint which led to manufacturing of coloured church stained glass windows, especially during the 16th through 18th century

[1] From: http://commons.wikimedia.org/wiki/File:Lycurgus_Cup_red_BM_MME1958.12-2.1.jpg andhttp://www.britishmuseum.org/explore/highlights/highlight_objects/pe_mla/t/the_lycurgus_cup.aspx

(Fig. 2). It was later found that the size of the metal nanoparticles define the variations in colour (Mulvaney, 2001; Tuovinen, 2002).

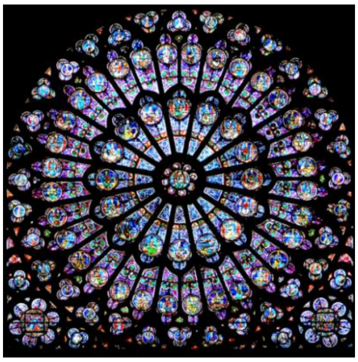

Fig. 2: Stained glass window of Notre-Dame Church of Paris[2]

Another example is the 'Damascus steel' which was used in blades forged from the 12th to 18th century by Middle Eastern metal smiths (Fig. 3), and which gained a good reputation due to their higher durability than other blades at the time. Studies found out that traces of carbon nanoparticles were present in these steel blades, which is thought to be one reason for their increased strength (Reibold, 2006).

Fig. 3: Close-up of an 18th-century Iranian forged Damascus steel sword[3]

In the late 19th and early 20th centuries it was discovered that carbon black added to natural rubber improved its strength and hardness and extended its life span. Today, virtually all automotive tires are reinforced with carbon black, but only recent studies have found out that the reinforcement properties can be attributed to the interaction between the rubber and the nanosized carbon particles (Donnet, 2003; Samarzija-Jovanovic, 2013).

The birth of modern nanotechnology is often connected with a lecture called 'There's Plenty of Room at the Bottom' delivered by the American physicist Richard Feynman at an American Physical Society session in 1959, which was later published (Feynman 1960). In this lecture,

[2] From: http://commons.wikimedia.org/wiki/File:Rozeta_Pary%C5%BC_notre-dame_chalger.jpg
[3] From: http://en.wikipedia.org/wiki/Damascus_steel#/media/File:Watered_pattern_on_sword_blade1.Iran.JPG

Richard Feynman mentioned for the first time the possibility to create nanosized products with the use of atoms as building particles.

However, the term ’nanotechnology’ in itself only emerged decades later when the Japanese scientist Norio Taniguchi of the Tokyo University of Science used it during a conference in 1974 to describe the processing of materials with nanometre accuracy and the creation of nano-sized mechanisms (Taniguchi, 1974).

After this the term was not used again until the mid-eighties when Eric Drexler, an American scientist of the Massachusetts Institute of Technology who did not know about Taniguchi's work, published the book ’Engines of Creation: The Coming Era of Nanotechnology’ (Drexler, 1986). In it, he described what became known as molecular nanotechnology, and which is considered to be one of the books that triggered the nanotech boom of the eighties (Shew, 2008).

This boom was also made possible thanks to certain technological developments that enabled scientists to work at nanoscopic scale (or ‘nanoscale’) which usually refers to structures with a length scale of 1 to 100 nanometers (Hornyak et al 2008, see also chapter 2.1.2).

The first to mention is the invention of the scanning tunnelling microscope (STM) which was developed at IBM by the German and Swiss physicists Gerd Binnig and Heinrich Rohrer (Binnig and Rohrer, 1983). This new microscope enabled imaging surfaces at the atomic level and led to the discovery of the fullerene, a molecule of carbon in the form of a hollow sphere. In 1985, the researchers Harold Kroto, Sean O Brien, Robert Curl and Richard Smalley from Rice University, USA, discovered the buckminsterfullerene, which is a spherical molecule consisting of 60 carbon atoms and became more known as “bucky-ball” because of its football-like shape (Fig. 4).

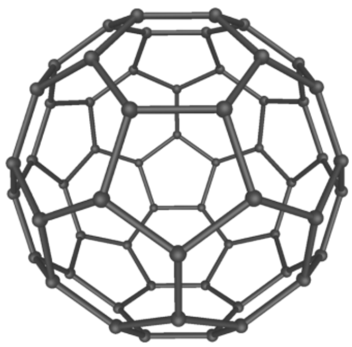

Fig. 4: Buckminsterfullerene atomic structure model[4]

[4] From: http://en.wikipedia.org/wiki/Fullerene#/media/File:C60a.png

Some years later the Japanese physicist SumioIijima from the Japanese company NEC described the Carbon Nanotubes which are also carbon molecules with the difference that they showed to have a cylindrical 'tube-like' nanostructure (Fig. 5) and therefore are also called 'buckytubes' (Iijima, 1991)[5].

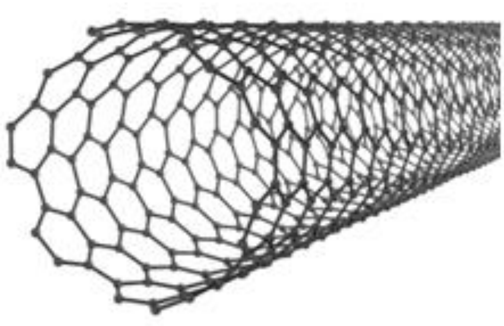

Fig. 5: Carbon nanotube atomic structure model[6]

In 1986 the inventor of the scanning tunnelling microscope (STM) Gerd Binnig and two colleagues developed another technological milestone: the atomic force microscope (AFM), an improved microscope which had the capability to view, measure and manipulate materials down to fractions of a nanometer in size, including the measurement of various forces intrinsic to nanomaterials (Binning, 1986).

A further important nanotechnology-related discovery of the eighties was quantum dots, first described by the Russian scientist Alexei Ekimov. Ekimov discovered nanocrystalline – semiconducting quantum dots in a glass matrix (Ekimov, 1982) – and his discovery was shortly followed by Louis Brus who discovered the synthesis of colloidal nanocrystalline quantum dots at the American AT&T Bell Laboratories. These quantum dots were made of semiconductor materials that were small enough to reveal quantum mechanical properties (Brus, 1984).

In the nineties the developments accelerated at huge steps, but it took until the early years of 2000 that nanotechnology invaded everyday life with the first consumer products appearing which applied nanomaterials, although did not involve any atomic control of matter. Some examples include nanoparticle-based transparent sunscreens, carbon nanotubes for stain-resistant textiles, car bumpers that resisted scratching or golf balls that flied straighter (Palmberg, 2009).

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[5] Although the question who discovered nanotubes remains a contentious issue, the scientific community agrees that the publication SumioIijimain 1991 is of particular importance because it brought carbon nanotubes into the awareness of the scientific community as a wholegenerating a unprecedented interest in these types of nanostructures (Monthioux 2006) .

[6] From: https://www.flickr.com/photos/ajc1/13560499845/

In this decade nanotechnology is still an emerging scientific field with developments being produced at exponential rates for a wide and diverse range of applications, as shown in Table 1 (Dang, 2009).

Year	Milestones in Nanotechnology
Early 2000	Consumer products making use of nanotechnology begin appearing.
2003	Gold nanoshells developed, which serve as a platform for the integrated discovery, diagnosis, and treatment of breast cancer.
2004	Researchers from the University of Manchester, UK, discover graphene, an atomic-scale honeycomb lattice made of carbon atoms.
2005	Researchers at IBM develop vertical nanowire transistors that can be used to produce more powerful microprocessors.
2006	Researchers at Rice University, USA, develop a low-cost method of using nanoparticles to remove arsenic in drinking water.
2007	Researchers at MIT, USA, built a lithium-ion battery with a common type of virus that is non-harmful to humans, using a low-cost and environmentally benign process.
2009	New York University, USA, creates several DNA-like robotic nanoscale assembly devices.
2010	Researchers at New York University and China's Nanjing University demonstrate an assembly-line method using nanorobots built from DNA strands.
2012	IBM creates 9 nm carbon nanotube transistors which outperforms silicon.
2013	Researchers from Stanford University, USA, said that they had successfully built a carbon nanotube computer.
2013	Researchers at Rice University trap bismuth in a nanotube cage to tag stem cells for X-ray tracking.

Table 1: Recent Milestones in Nanotechnology innovations and discoveries[7]

The latest most popular milestone in nanotechnology is graphene, a material which was discovered in 2004 by two researchers from the University of Manchester. Graphene is an atomic-scale honeycomb lattice made of carbon atoms (Fig. 6), and similar to the fullerenes, also consists of carbon atoms and can be considered as its basic structural element[8]. What makes it so unique are its many extraordinary properties which give it a high potential for future applications: it is about 200 times stronger than steel by weight, it conducts heat and electricity with high efficiency and is nearly transparent (Geim, 2007).

[7] Source: own research and http://www.nano.gov/timeline

[8] A Nanotube for example can be considered to be made of rolled graphene

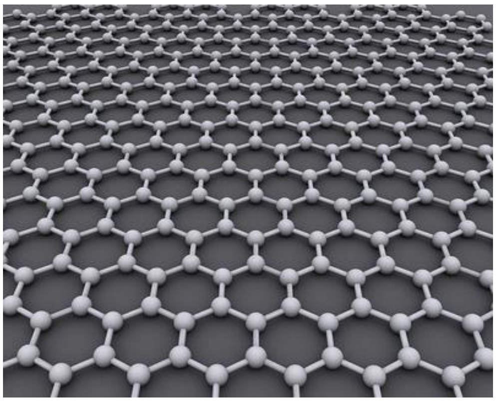


Fig. 6: Graphene Layer[9]

2.1.2 What makes nanotechnology so special?

Nanotechnology, which is also sometimes called the 'science of the very small', is expected to introduce remarkable changes to modern civilization and be a key economic driver for the 21st century (Tegart, 2004). It is believed that it is likely to have a major economic and social impact in the years ahead since it might be able to create numerous new materials and devices with a huge range of applications, such as in electronics, medicine, energy production, biomaterials and consumer products (OECD, 2009).

Although their meaning is mainly unknown outside the scientific community words like nanoparticles, nanodevices, nanocoatings or nanobots have entered our vocabulary and are associated with benefits like enhancements in medical treatments, lighter, stronger and cheaper materials or faster and more powerful electronic products.

Considered to be one of the latest key technologies which will be able to change our lives in many ways, it is becoming increasingly linked with advances in other emerging fields like biotechnology or information technology (Martín-Palma, 2010). Compared to latter nanotechnology it is still in its infancy though – meaning it requires high fundamental research efforts – although an increasing number of products which are either enabled or improved by nanotechnology have been on the market for a few years now (see Barker et al, 2005).

Nanotechnology is not a single process, and neither does it involve a specific type of material. Although its definition is still subject to numerous debates among the scientific community (see chapter 2.1.3), nanotechnology can be described as the technology of devices and

[9] From:"Graphen" by AlexanderAlUS - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Graphen.jpg#/media/File:Graphen.jpg

materials that involve manipulation of matter at a very small scale, enabling new materials with better optical, electronic or mechanical characteristics.

The word ‘nano’ originates from the Greek word *νᾶνος* (pronounced ‘nanos’) meaning ‘dwarf’ and is used in the metric system which defines ‘nano’ as a prefix to describe very small units. The International System of Units (ISU)[10], as the modern form of the metric system and the world's most widely used method of measurement (Goldmann, 1986), defines ‘nano’ as a fraction of one-billionth (10^{-9})for its seven base units[11].

Whereas the macroscopic world deals with everything that can be observed without any technical means and the microscopic world can be explored thanks to the invention of the microscope, the nanoscopic world is even smaller, since it deals with objects which are measured in nanometres – objects one-billionth of a meter (or 0,000000001 meter) in size, as demonstrated in Fig. 7 .

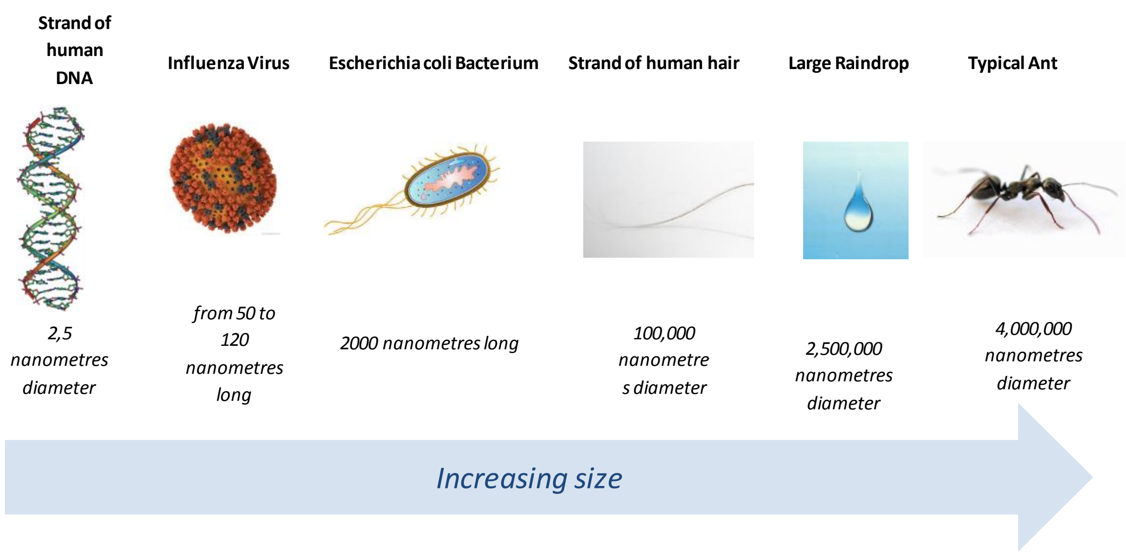


Fig. 7: Nanoscale proportions[12]

But it is not only the fact that nanotechnology studies and manipulates matter at this extremely small scale that makes it so special. Another reason is, that at this small scale, the physical and chemical properties of materials can change substantially to those familiar at larger scales. This happens mainly because of two effects – quantum effects and surface area effects.

[10] http://physics.nist.gov/cuu/Units/prefixes.html
[11] Length (meter), time (second), mass (kilogram), electric current (ampere), thermodynamic temperature (kelvin), amount of substance (mole) and luminous intensity (candela)
[12] Own research, Images from Wikipedia Commons

2.1.2.1 *Quantum effects*

Nanomaterials with dimensions of less than 100nm in at least one dimension (length, width or height) can have characteristics that differ considerably from those observed in larger objects with the same composition. This is due to the so-called quantum effects, which at that scale prevail over the classical mechanics that govern matter at the macro- and micro-scale, and can change the following fundamental properties of materials, often bringing significant improvements in performance:

- electrical conductivity
- magnetism
- optical characteristics
- hardness or fluid qualities
- chemical reactivity
- melting point

Quantum effects are effects that cannot be explained by traditional physics like classical mechanics or electrodynamics. They form part of a relatively new branch of physics, the quantum mechanics, which explains the behaviour of matter and its interactions with energy on the scale of atoms and subatomic particles.

2.1.2.2 *Surface area effects*

Another fundamental characteristic of nanomaterials is its relatively larger surface area when compared to the same mass of material in larger forms. As surface area per mass of a material increases, a greater amount of the material can come into contact with surrounding materials, thus affecting reactivity and making them ideal for use as absorbers, sensors and catalysts. The following diagram[13] (Fig. 8) shows an example which demonstrates why smaller particles have more surface area than larger particles since the cube on the left has the same volume as the smaller cubes added together on the right, although the total surface area is considerably larger for the smaller cubes.

[13] Source: http://www.bbc.co.uk/schools/gcsebitesize/science/21c/materials_choices/nanotechnologyrev1.shtml

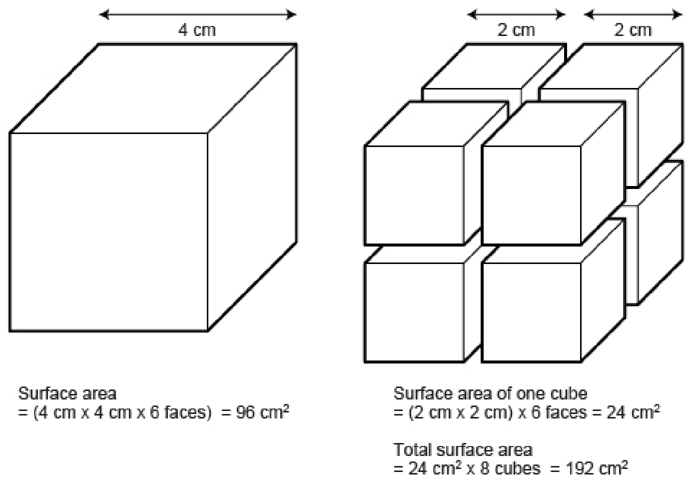


Fig. 8 : Surface area example

Taking this cube example further to the nanoscale dimension, one can imagine why nanomaterials can have phenomenally high surface areas, since a single cubic centimetre of cubic nanoparticles would have a total surface area one-third larger than a football field (Nanogov, 2011).

2.1.2.3 Top-down vs. bottom-up

When it comes to the technique used for fabricating nanostructures, the nanotechnology is often classified in 'top-down' and 'bottom-up' methods, which are two approaches that originate at opposite ends of the continuum of research and development (R&D) trajectories in the field of physics (OECD, 2014).

Top-down nanotechnology is based on reducing the size of structures, generally by the use of a physical technique called lithography. This technique is also used in the semiconductor industry to create the various elements of computer chips by applying a light or electron beam to selectively remove structures from a precursor material. The top-down approach is currently the more common one, primarily because of its application in the fields of electronics – one of the major industries that utilises nanotechnology (OECD, 2014).

Bottom-up nanotechnology works in the opposite direction by employing techniques that use atomic or molecular precursors and gradually assemble them until the desired nanostructures are formed. Bottom-up nanotechnology is fabricated through a controlled fabrication route that starts from the single atoms or molecules and increasingly techniques such as molecular self-assembly are used for this purpose (Filipponi, 2010). Self-assembly is a phenomenon where the components of a system assemble themselves spontaneously via an interaction to form a larger functional unit (Fig. 9) and is found in various systems in nature where it is used to create molecules and structures. Copying these strategies and synthesising new molecules with the ability to self-assemble into supramolecular structures has become an important technique in nanotechnology (Jasty, 2006).

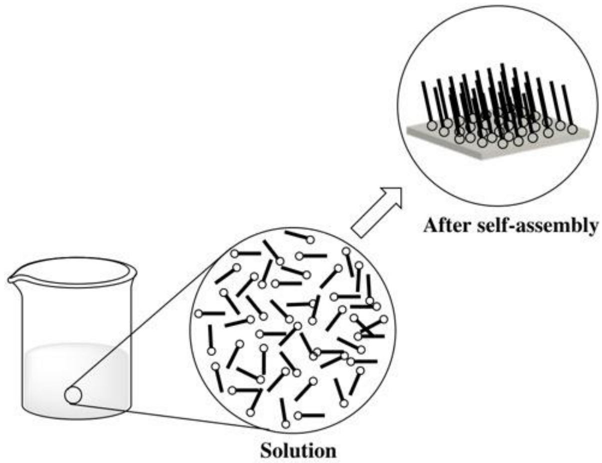


Fig. 9:Example of self-assembly of nanoparticles[14]

2.1.2.4 *Interdisciplinary of nanotechnology*

As we have seen before, nanotechnology and nanoscience comprises of a wide variety of disciplines: chemistry, physics, mechanical engineering, materials science, molecular biology and computer science (Peterson, 2000).

In order to get an overview of the main sectors where nanotechnology is enabling significant progress, the following table shows some of the top research priorities in nanotechnology according to a recent study of the European Union (Tokamanis, 2013). It illustrates that nanotechnology is not a single scientific discipline, but penetrates several research fields from very distinct sectors.

Research Field	Description
Nanoelectronics	The constant shrinking of integrated circuits according to 'Moore's law'[15]will approach a physical barrier when at nanoscale the quantum mechanics prevail, making it impossible to shrink the dimensions of common metal-oxide-semiconductor (CMOS) technology. Existing electronics combined with molecular materials, nanoparticles, nanotubes and nanowires, quantum

[14] Source: https://commons.wikimedia.org/wiki/File:Self-Assembly_of_Nanoparticles.jpg#/media/File:Self-Assembly_of_Nanoparticles.jpg
[15] Intel co-founder Gordon E. Moore predicted in 1965 that improved computing power would go hand in hand with decreasing size of the transistors in integrated circuits.

	dots and graphene may take over in some applications and ultimately, pure molecular electronics or quantum devices.
Nanophotonics	Nanomaterials can be used to manipulate single photons of light which will lead to an improved generation of lasers, light sources and optical fibres and detectors.
Nanobiotechnology	Nanobiotechnology is providing a wealth of new tools for biological research at the single molecule and cellular level. For example, nanoscale porous materials are being explored for DNA sequencing, with the potential for simpler and more accurate detection.
Nanomedicine	Nanotechnology could transform future cancer treatment, as well as that for a whole host of other chronic and debilitating conditions. For example the use of highly-sensitive detectors based on gold nanoparticles to identify the biomarkers of cancer in breath.
Catalysts	The large surface area of nanoporous materials and nanoparticles makes them ideal putative catalysts. But not only can nanoscale catalysts reduce the amount of raw materials used in the process, they can also reduce the amount of catalytic material needed too.
Energy and environment	Novel fuel cells or lightweight nanostructured solids that have the potential for better hydrogen storage or efficient low-cost photovoltaic solar cells. Energy savings thanks to nanotechnological developments will lead to better insulation and efficient lighting. In terms of environment, nanotechnologies could aid in the production of drinking water in more efficient and economical ways and in the decontamination of polluted water streams.

Table 2: Main sectors where nanotechnology is enabling significant progress

2.1.3 Defining nanotechnology

"*Nanomaterials, nanostructures, nanostructured materials, nanoimprint, nanobiotechnology, nanophysics, nanochemistry, radical nanotechnology, nanosciences, nanooptics, nanoelectronics, nanorobotics, nanosoldiers, nanomedecine, nanoeconomy, nanobusiness, nanolawyer, nanoethics to name a few of the nanos. We need a clear definition of all these burgeoning fields for the sake of the grant attribution, for the sake of research program definition, and to avoid everyone being lost in so many nanos.*"

(Joachim, 2005)

The incorporation of nanotechnologies in legal regulations has raised the question of a definition of nanomaterials beyond a purely technical or scientific approach. As mentioned earlier, the first definition comes from the Japanese scientist Taniguchi who, in 1974, noted that nanotechnology"mainly consists of the processing of separation, consolidation, and deformation of materials by one atom or one molecule" (Taniguchi, 1974). Years later in his ground-breaking publication, Drexler formulated the earliest popular definition of nanotechnology, where he referred to the technological goal of accurately manipulating matter at atomic or molecular level for fabrication of macroscale products – a concept which today is only a small fraction of the discipline[16].

Since then, nanotechnology extended into far more fields and combines many classical basis technologies covering a wide range of activities that form part of several different industrial sectors and varied scientific fields such as organic chemistry, molecular biology, semiconductor physics or surface science. This is what makes it so difficult to find a clear and common definition, and why the search for one has been the subject of controversy amongst the scientific community over the past decades and although various institutions have proposed definitions of nanotechnology, such an international harmonisation of definitions still remains a work in progress (Lövestam, 2010).

The first general definitions of nanotechnology appeared in the early nineties from the authorities in charge of the nanotechnology funding programmes in order to plan and implement policies and assist in the R&D funding allocation. The following table (Table 3) shows the definitions used by some of the mayor players in terms of public investments in nanotechnology R&D: the United States, Japan and the European Union (see also chapter 2.1.4).

Scope (country)	Publication year	Source	Definition
United States	**2001**	**National Nanotechnology Initiative[17]**	*Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometres, where unique phenomena enable novel applications. Encompassing nanoscale science, engineering and technology, nanotechnology involves imaging, measuring, modelling, and manipulating matter at this length scale.*
Japan	**2001**	**Second Science and Technology Basic Plan[18]**	*Nanotechnology is an interdisciplinary Science & Technology field that encompasses IT technology, the environmental sciences, life sciences, materials science, etc. It is for controlling and handling atoms and molecules in the order of nano (1/1 000 000000 meter), enabling discovery of new functions by taking advantage of its material characteristics unique to nano size, so that it can bring technological innovation in various fields*
European	**2001**	**Nanotechnology**	*Nanotechnology - the manipulation, precision*

[16]considered today as molecular nanotechnology (MNT)
[17]http://www.nano.gov/nanotech-101/what
[18]http://www8.cao.go.jp/cstp/english/basic/2nd-BasicPlan_01-05.html

Union		**Expert Group Working Definition**[19]	*placement, measurement, modelling or manufacture of sub-100 nanometer scale matter.*

Table 3: Definitions of Nanotechnology – Funding authorities[20]

Standardisation organisations like the International Organization for Standardization (ISO) followed some years later with their own definitions as shown in Table 4 .

Scope (country)	Publication year	Source	Definition
International	**2005**	**ISO TC229** **Working Definition**	*Understanding and control of matter and processes at the nanoscale, typically, but not exclusively, below 100 nanometres in one or more dimensions where the onset of size-dependent phenomena usually enables novel applications. Utilising the properties of nanoscale materials that differ from the properties of individual atoms, molecules, and bulk matter, to create improved materials, devices, and systems that exploit these new properties.*
International	**2010**	**ISO TCC 229** **ISO/TS 80004-1:2010**	*Nanotechnology: application of scientific knowledge to manipulate and control matter in the nanoscale (size range from approximately 1 nm to 100 nm) in order to make use of size- and structure-dependent properties and phenomena, as distinct from those associated with individual atoms or molecules or with bulk materials.*

Table 4 : Definitions of nanotechnology – standardisation organisations

Finally some mayor patent authorities defined nanotechnology in their patent classification schemes as shown in Table 5. This will be discussed in more in detail in chapter3.1.5, since it will be part of the definition used in this study.

Scope (country)	Publication year	Source	Definition
Patents (only US patents)	**2004**	**United States Patent Classification**	*The term 'nanostructure' is defined to mean an atomic, molecular, or macromolecular structure that:* *(a) Has at least one physical dimension of approximately 1-100 nanometers; and* *(b) Possesses a special property, provides a special*

[19]http://ec.europa.eu/research/era/pdf/nanoexpertgroupreport.pdf
[20] Own research and from OECD (2014)

			function, or produces a special effect that is uniquely attributable to the structures nanoscale physical size.
Patents (worldwide)	**2011**	**International Patent Classification (IPC)**	*'Nano-size' or 'nano-scale' relates to a controlled geometrical size below 100 nanometres (nm) in one or more dimensions;* *'Nano-structure' means an entity having at least one nano-sized functional component that makes physical, chemical or biological properties or effects available, which are uniquely attributable to the nano-scale.*

Table 5: Definitions of nanotechnology – patent authorities

2.1.3.1 Common aspects

Whilst the precise wording of each of the mentioned definitions differ, the following three fundamental aspects of nanotechnology are in common in all definitions and will be used in this study:

- Definitions normally emphasize the scale of measurement at which research and engineering moves into the nanotechnology domain – where a threshold of 100 nanometres is most often recommended since then the size dependent phenomena like the surface area effects and the quantum effects sets in (see also chapter 2.1.2)[21].
- Nanotechnology is stated to be the purposeful manipulation of matter at a very small scale. This is intended to eliminate from the definition nanotechnology that is naturally occurring or that has occurred without purposeful engineering.
- There is a commonly accepted hierarchical relationship between many of the different objects described in the context of nanotechnology (ISO, 2008). Some elements of this are shown in Fig. 10 to illustrate a number of the relationships that exist.

[21] Although some size-dependent phenomena can emerge above 100 nanometres, the threshold is meant to be indicative of a point at which the laws of classical physics start to give way to quantum mechanical effects (OECD 2014)

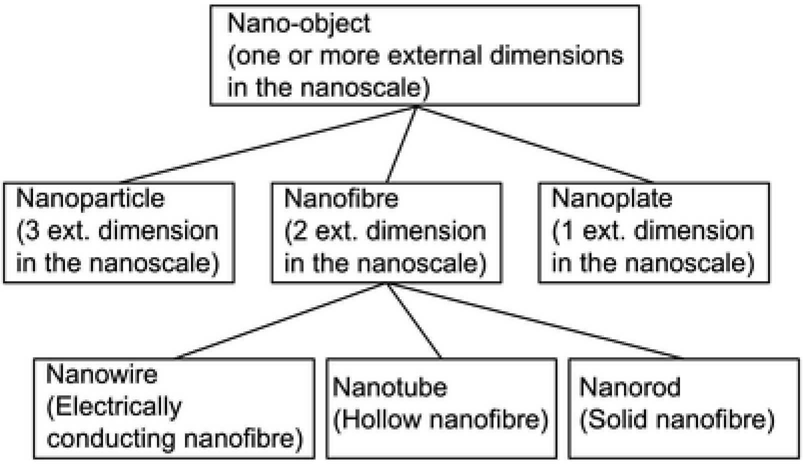


Fig. 10: Hierarchy of terms related to nano-objects[22]

2.1.3.2 Nanotechnology vs. nanoscience

Finally, nanoscience is often mentioned within the context of nanotechnology, which can also create confusion amongst the readers. Although it is common practice to speak of nanosciences and nanotechnologies without specifying the differences between their concepts (Meyer et al, 2001), there is a consensus among experts that nanosciences can be considered as the discipline where basic knowledge is generated about this specific phenomenon at the nanoscale from the point of view of either theoretical physics, chemistry or biology science fields (Table 6). On the other hand, nanotechnology refers more to the techniques which monitors, handles or manufactures nanostructures and devices on that scale (Barrere et al, 2008).

Nanoscience	Nanotechnology
- Study of objects at nanometer scale and deriving theoretical concepts for them.	- Engineering, manipulation and using nanoscale objects to produce useful applications. - Using the knowledge of nanoscience for applications.

Table 6: Nanotechnology vs. nanoscience

Following this distinction it is important to point out that in this present study we will tackle more the nanotechnology discipline since it is based on an analysis of patent documents. Patent documents, as we will see in chapter 3.1.1, have to describe technologies with the potential of an industrial application, and thus nano-related patents can be considered

[22]From: https://www.iso.org/obp/ui/#iso:std:iso:ts:27687:ed-1:v2:en

describing nanotechnologies, whereas most nanoscience-related outputs can be found in scientific publications like articles or conference papers.

2.1.4 Nanotechnology and its impact on R&D

2.1.4.1 Worldwide

The universal potential of nanotechnology led to support from policy makers of the world's most developed countries, since its versatile applications are believed to be an immense potential for the manufacture of new and better consumer goods and innovative technologies in general (Roco, 2005). Given this universal potential, there has been an explosion in worldwide research and development (R&D) funding in recent decades with an estimate that by 2015 governments around the world have invested over USD 118 billion in nanotechnology research since 2000, a growth of approximately 20% on a yearly basis, making it one of the fastest growing areas in R&D spending (Harper, 2011).

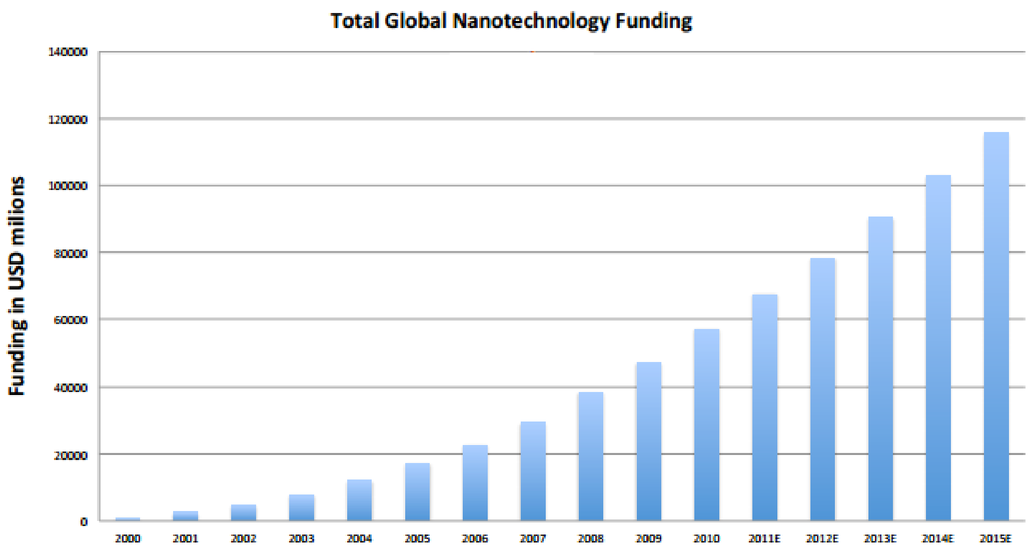


Fig. 11: Cumulative global funding of nanotechnologies. Source: Harper (2011)

Although the results of the R&D in nanotechnology will, in many cases, not be commercialised in the near future, the expected economic impact has generated a lot of interest among the relevant public and private stakeholders, and many countries have adopted national programmes over the last few decades to foster research in nanotechnology with the aim to remain competitive.

The first mayor funding programme started with the US American National Nanotechnology Initiative (NNI) which was established in 2000 and connected 25 federal US agencies related to nanotechnology research. The importance the US government is giving to this emerging field in order to accelerate its development can be seen by its budget allocation which increased from USD 464 million in 2001 to currently USD 1.5 billion for 2016 totalling a cumulative investment since the year 2001 of more than USD 22 billion[23]. Since this initiative was announced almost every developed economy has created own national nanotechnology programmes.

The European Union (EU) has explicitly included nanotechnology as a theme in its research funding programmes over the past decade and supported scientists through the European Research Council (ERC) and its framework programmes to foster cooperation in European research and development projects. In these programmes the research in nanotechnology was canalised through thematic areas, with a nano-related budget of EUR 1429 million in the 6th Framework Programme (2003-2006) and a substantial increase of EUR 3475 million in the Seventh Framework Programme (2007-2013).

The current EU research programme Horizon 2020, as the world's largest research programme of its kind with a budget of nearly EUR80 billion for the period 2014–2020[24], specifically covers the Nanotechnology area in its Leadership in Enabling and Industrial Technologies (LEIT) part with a budget of EUR 500 million alone for the years 2014 and 2015 [25].

Among the EU members, Germany, as one of the leading nanotechnology nations in Europe, has launched the Nanotechnology 2015 Action Plan that carries on from its Nano-Initiative Action Plan from the year 2010, and presents a concept that pools lines of action and fields of application in the context of nanotechnology[26].

Regarding industrialised countries from Asia that have promoted the development of nanotechnology from the industrial and governmental sectors, South Korea, Taiwan and Japan significantly increased their budget for research projects and their companies are leading the nanotechnology investments in their respective countries.

Especially to mention in this context is China, which experienced a remarkably strong growth in nanotechnology (Liu et al, 2009) becoming a key player in the area with competences in the development of nanoparticles and nanomaterials (Correia, 2011).

[23]http://nano.gov/about-nni/what/funding
[24]http://ec.europa.eu/programmes/horizon2020/en/what-horizon-2020
[25]http://www.forskningsradet.no/en/Funding/H2020NMPB/1253992329863
[26]http://www.research-in-germany.org/en/research-areas-a-z/nanotechnology.html

Other countries which are worth mentioning are Israel, Singapore, and the developing countries Iran, India, Malaysia and Indonesia, which have all launched specific programmes to promote the use of nanotechnologies within several industrial sectors with local or regional impact including manufacture, textiles, wood or agriculture (Phantoms, 2011).

Year	Milestones - nanotechnology in politics and society
2000	The Center for Nanotechnologies at the Chinese Academy of Sciences opens in Beijing.
2001	National Nanotechnology Initiative launched in the US.
2002	Nanotechnology Research Network Centre of Japan established.
2002	The European Commission designated nanotechnology a priority area in the 6th Framework Programme.
2004	The "21st Century Nanotechnology Research and Development Act" in the US provides further funding.
2004	Spanish National Plan for Scientific and Technical Research cites nanotech as one of its priorities.
2005	The Japanese Strategic Technology Roadmap is published.
2006	The 3rd Science and Technology Basic Plan is launched in Japan.
2006	The EU "Roadmaps on Nanotechnology Application" published
2007	Russia announces USD 8 billion investment in nanotechnology from 2007-2015
2008	The US "Technology Roadmap for Productive Nanosystems" published
2008	Korean "Nanotechnology Roadmap" published
2010	Germany launches its Nano-Initiative – Action Plan 2010
2014	Horizon 2020 European funding scheme launched with specific Nanotech Area[27] that focuses on new opportunities for industrial leadership

Fig. 12 : Milestones - Nanotechnology in politics and society[28]

2.1.4.2 Spain

Spain had no institutional framework nor initiative pointed towards the support and promotion of R&D in nanotechnology at the end of the nineties. This fact led the scientific community of Spain to promote initiatives to support research in nanotechnology and, at the same time, to increase the awareness of public administration and industry about the need to promote and support this emergent discipline (Correia, 2012).

Among the initiatives that emerged in Spain, the creation networks with multidisciplinary character have enabled communication between scientific communities improving the

[27]Area: "Nanotechnologies, Advanced Materials and Advanced Manufacturing and Processing (NMP)"
[28] Source: Palmberg 2009 and own research

interaction between Spanish groups working in the field of nanotechnology and the visibility of this community (Correia, 2012).

The most important is NanoSpain[29], the Spanish Nanotechnology Network, which was created in early 2000 with the aim to promote the exchange of knowledge between Spanish research groups working in different fields related to nanotechnology and nanoscience to increase collaboration among universities, research institutions and industries. It comprises of 364 research groups with more than 2000 researchers distributed throughout Spain (Nanospain, 2015).

Another important nano institution in Spain is the Phantoms Foundation[30]- a non-profit organisation and nowadays a key stakeholder in promoting national and European collaborations in nanoscience and nanotechnology for Spanish entities. The Foundation coordinates the NanoSpain network and provides reports in nanotechnology-related research areas in collaboration with Spanish and European governmental institutions such as the Spanish Foundation for Science & Technology (FECYT) and the Spanish Institute for Foreign Trade (ICEX). Furthermore it is playing an important role as a dissemination platform in national European funded projects to promote Spanish nanotechnology to a wider audience.

In respect to governmental funding programmes nanotechnology was incorporated in the governmental National R&D Plan for the first time, figuring as a 'Strategic Action in Nanoscience and Nanotechnology' in the 2004-2007 periods. This Strategic Action has had its continuity in the National Plan (2008-2011), and also includes topics related to new materials and production technologies. During the 2004-2007 period the Strategic Action focused on small-scale projects whereas during the 2008-2011 period the funding was mainly allocated to large-scale initiatives, such as the building of new R&D centres or public-private consortia and platforms (Barrere et al 2008, Etxabe 2012).

Both strategic actions maintained an increasing rate of investment in nanotechnology, for example, the effort made by the General State Administration in Nanoscience and Nanotechnology funding has been over EUR 82 million in 2008 (Correia,2012).

Other important nano initiatives are meetings and conferences which showcase Spanish nanoscience and nanotechnology in order to attract international researchers and improve the visibility of Spanish scientists. In this context, since 2004 the 'NanoSpain Conference'[31] has been organised by NanoSpain and has become one of the most important nano-related

[29]http://nanospain.org/
[30]http://www.phantomsnet.net/
[31]http://www.nanospainconf.org/

conferences in Europe (Correia,2012). Other initiatives which emerged from the scientific community tobecome international benchmarks are the 'Trends in Nanotechnology'[32]conference and 'ImagineNano'[33], an international event which, in its last edition in 2015, gathered nearly 1500 participants from all over the world, and combineda set of high impact conferences and an industry exhibition with more than 160 institutions and companies (Phantoms, 2014).

Another effort has been made in the creation of research centres dedicated to nanoscience and nanotechnology (Table 7). One of the first was the 'International Iberian Nanotechnology Laboratory' (INL)[34] a joint cooperation project between the governments of Portugal and Spain, created in 2005 and which was one of the first fully international research institutions in Europe in the field of nanoscience and nanotechnology (Correia, 2011).

The Spanish regional governments also began to see the impact and importance of nanotechnology and began promoting research centres in cooperation with universities and the central government, for example the 'Centro Andaluz de Biomedicina y Biotecnología = Andalusian Centre for Nanomedicine and Biotechnology(BIONAND)'[35]was inaugurated in 2011, or the 'Institut Català de Nanociència i Nanotecnologia = Catalan Institute of Nanoscience and Nanotechnology' created in 2014 based on the merger of the former 'InstitutCatalà de Nanotecnologia' and 'Centro de Investigación en Nanociencia y Nanotecnología'.

Year of inauguration	Centre	Location
2005	International Iberian Nanotechnology Laboratory (INL)	Braga (Portugal)
2006	IMDEA-Nanociencia	Madrid
2006	CIC nanoGUNE Nanoscience cooperative Research Center	San Sebastian (Basque Country)
2006	Biomedical Research Networking Centre in Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN)	Zaragoza (Aragon)
2007	Nanomaterials and Nanotechnology Research Center (CINN)	Oviedo (Asturias)
2011	Andalusian Centre for Nanomedicine and Biotechnology (BIONAND)	Malaga (Andalusia)
2014	Catalan Institute of Nanoscience and Nanotechnology (ICN2)	Barcelona (Catalonia)

Table 7 : Mayor nanotechnology centres created in the last decade

[32]http://www.tntconf.org/conf/index.php
[33]http://www.imaginenano.com/
[34]http://inl.int/
[35]http://www.bionand.es/

3 Patents and the patent system

"The stated purpose of the patent system is to encourage invention and technical progress by providing a temporary period of exclusivity over the invention in exchange for its disclosure"

OECD Patent Manual

The term 'patent'has its origin from the Latin word *patere*meaning "to lay open" or to make available for public inspection, and the term originally denoted royal decrees granting exclusive rights to individuals or companies (Edfjäll,2007). The first formal patent system in history was established in Venice in 1474 (Fig. 13) in order to protect inventions in the field of glass making where the Venetian Republic issued a law by which new and inventive devices had to be communicated in order to obtain legal protection against copying of the techniques (Granstrand, 2005).

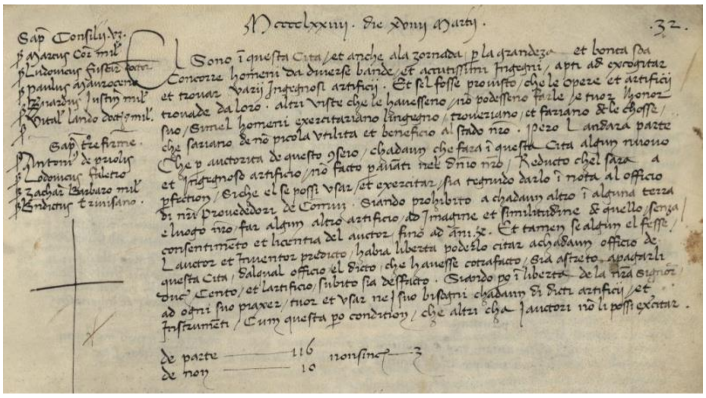


Fig. 13 : Venetian Patent Statute of 1474[36]

This basic principle has not changed since then, and found its way to modern practices where patents are filed to protect inventions or technical innovations from the imitation of others by giving the patent owner the exclusive right of economic utilisation for a certain period of time(Hullmann, 2003).

According to WIPO (2004) a patent is a "*document, issued, upon application, by a government office (or a regional office acting for several countries), which describes an invention and creates a legal situation in which the patented invention can normally only be exploited (manufactured, used, sold, imported) with the authorization of the owner of the patent*."

[36]Source: https://commons.wikimedia.org/wiki/File:Venetian_Patent_Statute_1474.png

Regarding the conditions that must be met in order to obtain a patent, in most industrialized countries like Spain we have the following patentability criteria:

- The invention must show an element of novelty which means that the characteristic to be protected has to be new on a worldwide scale and is not known in the existing knowledge in its technical field. This is also called the 'prior art'.
- The invention must not be obviously deducible by a person having ordinary skill in the relevant technical field. This is called 'inventive step' or 'non-obvious'.
- The invention must be able to be used for an industrial or business purpose beyond a more theoretical phenomenon. This is called the 'industrial application'.
- The invention must be disclosed in an application in a manner sufficiently clear and complete to enable it to be replicated by a person with an ordinary level of skill in the relevant technical field.
- Finally the characteristics of the invention to be protected (the so called 'subject matter') must be accepted as patentable under the law of each country. In most countries (including Spain) the following is not patentable (WIPO, 2015):
    - laws of nature
    - natural phenomena
    - abstract ideas
    - discoveries of natural substances
    - aesthetic creations
    - scientific theories
    - mathematical methods
    - plant or animal varieties
    - commercial methods
    - methods for medical treatment (as opposed to medical products)

  Patenting of computer programs (software) is in most countries (especially Europe) not allowed (or only in certain restricted circumstances) whereas it is patentable in the USA[37].

Patents are temporary rights where the protection conferred by the patent is limited in time and by paying annual fees. In most countries the maximum time span of a patent is 20 years after the date of application. Some exceptions are the utility models and the supplementary protection certificate:

[37]More informationaboutpatentsforsoftwareatthe European Patent Office: https://www.epo.org/news-issues/issues/software.html

- The utility model, also considered as a ‘patent light’ is a form of protecting inventions which is only available in some countries (e.g. Germany or Spain) and usually has a shorter term (often 6 to 15 years) and less stringent patentability requirements.
- A supplementary protection certificate is available for pharmaceuticalspatents and can extend the life of a patent 5 more years (25 years in total). The certificate is restricted to drug patents in order to compensate the pharmaceutical companies for the long clinical trial periods of human drugs which can consume a considerable amount of the patent lifespan.

Once the maximum patent lifetime has passed or the patent owner does not pay the annual fees, the patent is considered expired and the invention falls into the public domain.

Furthermore patents hold territorial or geographical rights which only apply to the country for which the patents has been granted. A patent which is only granted in Spain will not confer exclusivity in other countries, but, since worldwide novelty is required to obtain a patent, it will prevent the patenting of the same invention other countries.

The original purpose of the patent system is to foster innovation and progress in technology by providing a temporary period of exclusivity over the invention in exchange for laying open the invention to the public and thus encouraging inventors and companies to invest in R&D activities. According to Scotchmer (2004) patents support the innovation process for the following reasons:

- they reveal new knowledge through the disclosure of the invention.
- they diffuse information to the public that might otherwise be kept secret.
- they enable other inventors to develop new inventions based on improvements on disclosed inventions.
- they prevent needless duplication of R&D efforts since researchers can check if something already has been invented and therefore help researchers to focus on new areas.
- they can be traded, which allows users to implement inventions even if they did not invent them, or to exchange inventions needed for further innovations.

3.1.1 Patenting processes

To obtain a patent, the individual or institution which owns the invention has to file an application at a patent office. The institution can be an enterprise, or a public or private institution such as a university or a governmental body. The procedure for obtaining a patent can be summed up in several steps whichare similar in all countries (Zuninga, 2009):

1. At first the applicant seeking patent protection (which is usually a company,but can also be an individual, university or governmental body) must file a patent application at a patent office. In the application, the applicant must disclose the invention in sufficient detail for the average skilled person to be able to understand and make use of it. The most important part of the application is the section on claims, and the list of aspects of the invention for which the applicant is claiming exclusive rights (see also chapter 3.1.2). The applicant must pay certain administrative fees, which vary widely across patent offices.
2. Then the patent office appoints an examiner who is ideally an expert in the particular technical field. The examiner searches for documents that were published before the date of filing of the application and are related to the particular invention in the scientific and technical literature in order to measure the novelty of the invention. The search report is of special interest for patent analysis purposes since it contains references to documents that are technically related to the patent. Along with the documents mentioned by the inventor in the patent description these documents of the search report will be referenced in patent databases as documents which the patent cites (backward citation, see also chapter 4.1.5). Furthermore the examiner's task in this step is to classify the invention according to its technical field using a patent classification at the most detailed level which is applicable to its contents (see chapter 3.1.4)
3. The patent application is not usually divulged by the patent office until 18 months have passed. Then the patent office publishes the application via its patents office bulletins and patent databases. The patent application is in most cases published along with the search report from the examiner.
4. Then the examiner studies the patent application in order to decide whether the invention meets the patentability criteria's mentioned in chapter 3. If some criteria are not fulfilled, the examiner communicates it to the applicant who has the right to submit a written opinion to discuss the examiner's findings and to modify the scope of the claims defined in the application if necessary. This thorough substantive patent examination whichdetermines if a patent will be granted or not is only compulsory in some patent systems. In others it is optional, and in some countries or for some patent types like the utility model it is not done at all. The European patent is considered to

be a strong patent because this exam is compulsory at the European patent system, whereas in other patent systems like the Spanish one this exam is optional and most granted Spanish patents do not have it since it involves extra fees, which makes it less attractive (OEPM, 2011)[38].

5. If all the criteria are fulfilled a patent is granted. The time required for a patent to be granted will depend on the registration procedure and a number of other factors that can vary from country to country[39]. In countries where no examination as to the substance of the patent application is conducted, the procedure will generally be relatively fast and a patent can be granted within 18 months. However, in countries where the patent office conducts a substantial examination the entire procedure from application to grant will generally take over 30 months.
6. Once a patent is granted it can be maintained for a maximum duration of 20 years from the filing date (with some exceptions as we have seen in chapter 3). The patent holder is required to pay renewal fees to the patent office to maintain the patent (these are annual in most countries). The patent office will revoke patents that are not renewed.
7. A patent may then be challenged. Challenges are usually by competitors who consider the patent invalid and believe it should not have been granted – either because the patent office did not detect a significant weakness in the patent filing or did not correctly implement the statute.

The concept of priority

As mentioned before, patents filed at a national office provide protection only within the country of the office. For example, a patent granted by the Spanish Patent Office will only provide patent rights within Spain, and if the inventor wishes to protect the invention in another country, a separate patent application has to be filed in that country. In order to not to have to file the application in several countries at the same time the priority rule was established in 1883 at the Paris Convention for the Protection of Industrial Property.Nearly all countries form part of this treaty[40]. This rule is one of the first intellectual property treaties establishing a union for the protection of industrial property and is currently still in force.

[38]On July 2015 a new Spanish patent law has been approved and will come into force on April 2017. The law adapts the Spanish system more to the European one, with the main changes is that the substantive examination will be compulsory (Amat 2015).
[39]Forinstancetheratioofnumberof patent examinerstothenumberof patent applicationreceivedbytherespective patent office.
[40]withfewexceptionslikeAfganistan, Burma orEthiopia.

Since then, according to the Paris system, the'priority date' is the date of the first application, whereas the country of that applicationis referred to as the 'priority country'. Therefore, when protection in other countries is planned, the filing date of the first application is considered to have primacyduring those twelve months over other applications filed after that date (see also Fig. 14).

Although the decision to apply for a patent protection in a specific country depends in most cases on the applicant's business strategy, usually a patentapplication is filed first at the local (national) patent office of the applicant for the purpose of protecting the invention in the domestic market, and then followed by filings in foreign countries (Zuniga, 2009).

Regional and international patenting procedures

If extension of a patent to other countries is sought, apart from the before mentioned procedure, since the seventies the applicant has the choice of other procedures, of which the most important ones are the international PCT system and the regional European Patent system[41].

PCT patent application

The Patent Cooperation Treaty (PCT), signed on June 1970 and entered into force in the beginning of 1978is an international treaty with more than 148contracting states[42]. Managed by the World Intellectual Property Organization (WIPO)[43] the PCT patent application makes it possible to seek patent protection for an invention simultaneously on a nearly worldwide scale by filing a single 'international'PCT patent application instead of filing several separate local patent applications.

The PCT patent application process can be summed up to the following steps (Fig. 14):

1. Between the timeframe of priority (month 1 to 12) the applicant can file a PCT application with a national or regional patent office or WIPO.
2. In month 16 (4 month after the latest possibility to file a PCT) a search report is completed by an International Searching Authority (ISA), which can be the national office if it is assigned by WIPO (e.g. the Spanish office). The search report identifies the

[41]Thereis also a regional patent systemofafrican countries (ARIPO) andformersoviet countries (EAPO), but due to their country coverage they are not of mayor importance for most patent applicantsand also not for the scope of analysis of the present study.
[42]As of 2015. Source: http://www.wipo.int/pct/en/pct_contracting_states.html
[43]www.wipo.int

prior art and contains a written opinion from the patent examiner on the invention's potential patentability.

3. After the expiration of 18 months from the priority date, the PCT application is published.
4. After the end of the PCT procedure – usually30 months after the priority date –the PCT application enters in the 'national phase' where the applicant has to pursue the grant of the patent directly before the national patent offices of the countries where the applicant wants to extend the patent.

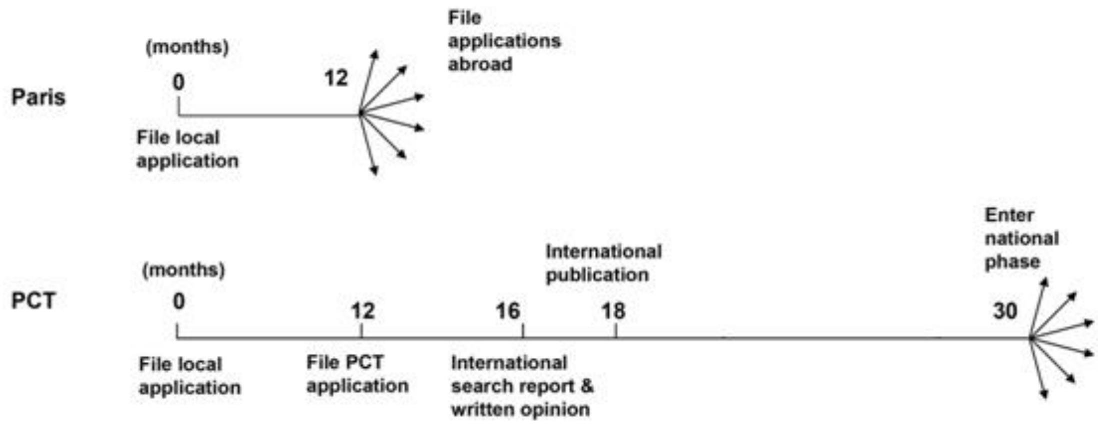


Fig. 14 : Timeline Paris vs. PCT patent extension procedure[44]

ThePCT patent system is one of the most used patent procedures, especially by multinational companies and research organisations (WIPO, 2014) since it offers the possibility to extend the patent to multiple countries worldwide with a single application. It is called PCT application and not a PCT patent since the granting of patents remains under the control of the national patent offices.

The main advantages of the PCT patent system is that the applicant 'buys' time, since the costs of a patent extension (country patent office fees and costs for translations and patent agents working in the designated country) are postponed until the month 30 (instead of month 12 with the Paris system). This way gives to the applicant more time to sell his invention, to find licensees, or to evaluate which country is an important market for the invention.

[44]Source: http://www.wipo.int/pct/en/

European Patent

The European Patent procedure is another important international patent system which was considered for this study. It is based on the European Patent Convention (EPC) which was signed in 1973 and entered into force in 1977and currently covers 38 member countries from all over Europe[45]. This convention led to the creation of the European Patent Office (EPO)[46] which manages the European patent (EP) system.

Contrary to the PCT system, the EP system also grants the patent, which means that by filing a single European patent application it is possible to obtain patent rights in all EPC countries with the same legal rights as patents granted by the national patent office (EPO-7, 2015). Another difference is that, while PCT patent applications can be filed in the official patenting language of the country of origin, the European patent has to be filed in English, German or French, the three official languages of the EPO.

Once granted, a European patent is a 'bundle' of national patents, which must be validated at the national patent office of the designated states in order to be effective in the EPC member countries. The validation consists of paying a designated fee and translating the patent to the language of the corresponding national patent office of the EPC member state, and leads to the generation of a national patent document. If validation in all 38 EPC member states is sought, all patent office's fees and translation costs have to be totalled – leading to considerable costs[47].

It is important to note that the European Patent Office is not an institution of the European Union and that an EP patent is not to be confused with an EU patent. This patent with EU-wide validity yet without the need to validate and convert to national patents has been discussed within the European Union since the 1970s and is currently in projection to be launched as so-called 'Unitary Patent' in the coming years (depending of the ratification process of each EU country). Unitary patent protection will make it possible for inventors to protect their invention in 25 EU countries by submitting a single patent application which will make the existing European system simpler and less expensive for inventors. Spain is one of the few EU countries which is currently not participating in the Unitary Patent [48] due to discrepancies about the official languages. By not participating Spain will likely have a competitive disadvantage since its companies will not have the possibility to benefit from it.

[45] https://www.epo.org/about-us/organisation/member-states.html
[46] www.epo.org
[47] Aprox. 30.000€ acording a study (Berger 2005)
[48] http://www.epo.org/law-practice/unitary.html

Euro-PCT patent

A European patent application can originate from a direct filing to the EPO or an extension of an earlier national patent application within 12 months of the first filing. Another possible course of action is when the applicant files a PCT application and after the 30 month period enters the national phase, but instead of designating a specific country it is possible to designate the European patent as the 'national phase' that is then called Euro-PCT.

This procedure has become one of the most used patent application procedures since the early 2000s, andpatent applications to the EPO from national offices have significantly decreased. Themajority of the EPO patent applications originate from a PCT application with a share of more than 50% over the last years of PCT applications (IP5, 2013).

3.1.2 Patent documents

Bibliographic data

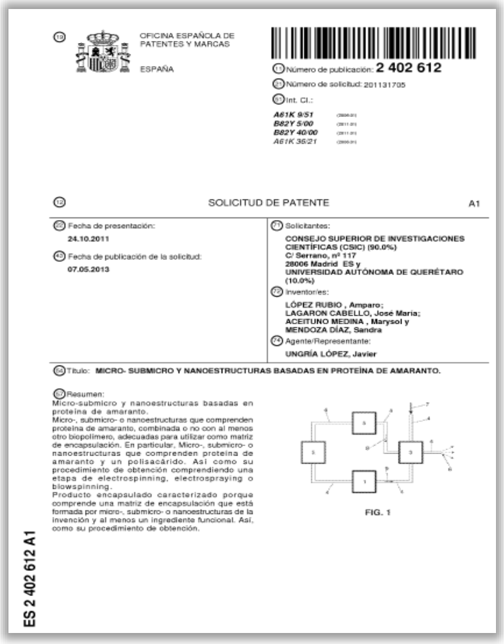
Patents are very structured documents that makes highly valuable for statistical analysis. They can be divided in three basic parts:

- Frontpage
- Description
- Claims

The front page is the most important part for statistical analysis since it contains on one single page the bibliographic data where the most important points to mention are:

- Title of the invention
- Abstract of the invention
- Inventor
- Applicant
- Application date
- Application number
- Publication date
- Publication number
- Patent classification

All these structured data fields can be seen in a front page of a Spanish patent application in nanotechnology (figure 14).



(19) OFICINA ESPAÑOLA DE PATENTES Y MARCAS

ESPAÑA

(11) Número de publicación: **2 402 612**

(21) Número de solicitud: 201131705

(51) Int. Cl.:

A61K 9/51
B82Y 5/00
B82Y 40/00
A61K 36/21

(12) SOLICITUD DE PATENTE A1

(22) Fecha de presentación:
24.10.2011

(43) Fecha de publicación de la solicitud:
07.05.2013

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UNGRÍA LÓPEZ, Javier

(54) Título: **MICRO- SUBMICRO Y NANOESTRUCTURAS BASADAS EN PROTEÍNA DE AMARANTO.**

(57) Resumen:
Micro-submicro y nanoestructuras basadas en proteína de amaranto.
Micro-, submicro- o nanoestructuras que comprenden proteína de amaranto, combinada o no con al menos otro biopolímero, adecuadas para utilizar como matriz de encapsulación. En particular, Micro-, submicro- o nanoestructuras que comprenden proteína de amaranto y un polisacárido. Así como su procedimiento de obtención comprendiendo una etapa de electrospinning, electrospraying o blowspinning.
Producto encapsulado caracterizado porque comprende una matriz de encapsulación que está formada por micro-, submicro- o nanoestructuras de la invención y al menos un ingrediente funcional. Así, como su procedimiento de obtención.

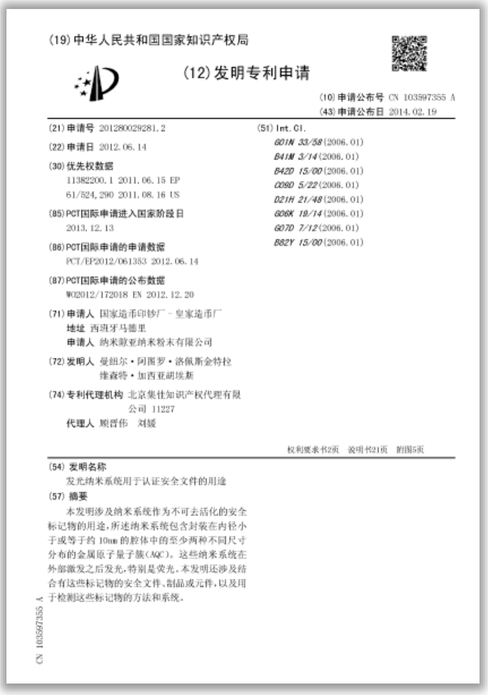
FIG. 1

ES 2 402 612 A1

Fig. 15 : Example of a frontpage of a Spanish Nanotechnology patent application

In order to standardise the patent front page and its bibliographic data and to overcome the language barriers (especially for non-English patent documents) the front pages of most patents worldwide use a codification system, the 'INID Codes' or' INID Numbers'[49](WIPO 2, 2013). Managed by the World Intellectual Property Organization, they assign specific numbers to the bibliographic elements on the front pages of patent documents which makes them language-independent. The standard covers all important bibliographic patent data items, e.g. the title is under item 54 on every patent document worldwide whatever its language. As shown in the following figure, that shows a Chinese and a Moroccan patent document of the same invention.

[49]"INID" is an acronym for "Internationally agreed Numbers for the Identification of (bibliographic) Data"



(19) 中华人民共和国国家知识产权局

(12) 发明专利申请

(10) 申请公布号 CN 103597355 A
(43) 申请公布日 2014.02.19

(21) 申请号 201280029281.2

(22) 申请日 2012.06.14

(30) 优先权数据
11382200.1 2011.06.15 EP
61/524,290 2011.08.16 US

(85) PCT国际申请进入国家阶段日
2013.12.13

(86) PCT国际申请的申请数据
PCT/EP2012/061353 2012.06.14

(87) PCT国际申请的公布数据
WO2012/172018 EN 2012.12.20

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代理人 顾晋伟 刘媛

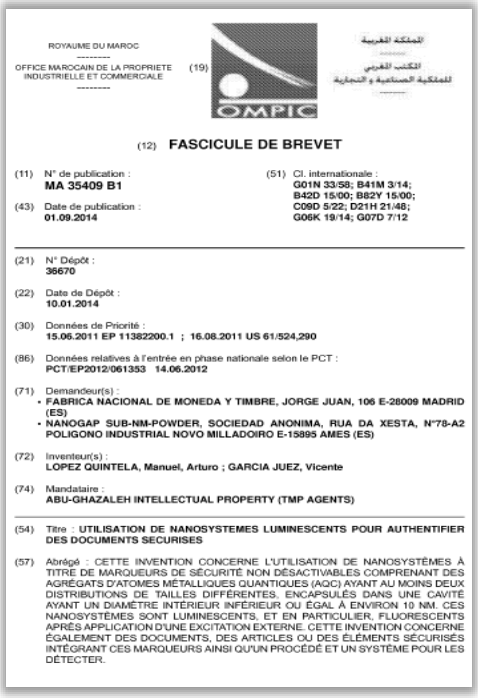
(51) Int. Cl.
G01N 33/58 (2006.01)
B41M 3/14 (2006.01)
B42D 15/00 (2006.01)
C09D 5/22 (2006.01)
D21H 21/48 (2006.01)
G06K 19/14 (2006.01)
G07D 7/12 (2006.01)
B82Y 15/00 (2006.01)

权利要求书2页 说明书21页 附图5页

(54) 发明名称
发光纳米系统用于认证安全文件的用途

(57) 摘要
本发明涉及纳米系统作为不可去活化的安全标记物的用途，所述纳米系统包含封装在内径小于或等于约 10nm 的腔体中的至少两种不同尺寸分布的金属原子量子簇(AQC)。这些纳米系统在外部激发之后发光，特别是荧光。本发明还涉及结合有这些标记物的安全文件、制品或元件，以及用于检测这些标记物的方法和系统。

CN 103597355 A



ROYAUME DU MAROC

OFFICE MAROCAIN DE LA PROPRIETE INDUSTRIELLE ET COMMERCIALE

(19) OMPIC

(12) FASCICULE DE BREVET

(11) N° de publication :
MA 35409 B1

(43) Date de publication :
01.09.2014

(51) Cl. internationale :
G01N 33/58; B41M 3/14; B42D 15/00; B82Y 15/00; C09D 5/22; D21H 21/48; G06K 19/14; G07D 7/12

(21) N° Dépôt :
36670

(22) Date de Dépôt :
10.01.2014

(30) Données de Priorité :
15.06.2011 EP 11382200.1 ; 16.08.2011 US 61/524,290

(86) Données relatives à l'entrée en phase nationale selon le PCT :
PCT/EP2012/061353 14.06.2012

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ABU-GHAZALEH INTELLECTUAL PROPERTY (TMP AGENTS)

(54) Titre : **UTILISATION DE NANOSYSTEMES LUMINESCENTS POUR AUTHENTIFIER DES DOCUMENTS SECURISES**

(57) Abrégé : CETTE INVENTION CONCERNE L'UTILISATION DE NANOSYSTÈMES À TITRE DE MARQUEURS DE SÉCURITÉ NON DÉSACTIVABLES COMPRENANT DES AGRÉGATS D'ATOMES MÉTALLIQUES QUANTIQUES (AQC) AYANT AU MOINS DEUX DISTRIBUTIONS DE TAILLES DIFFÉRENTES, ENCAPSULÉS DANS UNE CAVITÉ AYANT UN DIAMÈTRE INTÉRIEUR INFÉRIEUR OU ÉGAL À ENVIRON 10 NM. CES NANOSYSTÈMES SONT LUMINESCENTS, ET EN PARTICULIER, FLUORESCENTS APRÈS APPLICATION D'UNE EXCITATION EXTERNE. CETTE INVENTION CONCERNE ÉGALEMENT DES DOCUMENTS, DES ARTICLES OU DES ÉLÉMENTS SÉCURISÉS INTÉGRANT CES MARQUEURS AINSI QU'UN PROCÉDÉ ET UN SYSTÈME POUR LES DÉTECTER.

Fig. 16 : Chinese (left) and Moroccan (right) patent document of the same Spanish Nanotech invention

The description is the part of the patent which contains detailed information about the invention and starts off with general background information and progresses to more detailed information about the invention (including drawings). Most patents use the following structure (EPO-7, 2015):

1. Describing the technical field of the invention
2. Describing background information and prior art (e.g. similar patents the inventor is aware of)
3. description of how the invention addresses a technical problem
4. a list of drawings
5. a detailed description of the invention
6. an example of intended use

The part of the description where the inventor has to describe the existing technology related to the invention (prior art or state of the art) is of particular interest for statistical analysis, since it contains references to documents where the inventor considers similar in some way and in most databases forms part of the documents that the patent cites (together with the documents that the patent office has cited in the correspondent search report once the patent has been examined).

Finally the claims are the essence of the invention. They define in technical terms the extent (or the scope) of the protection given to a patent when granted and are the most important element both during prosecution and litigation, since in most jurisdictions the right that the patent confers to exclude others is restricted to the subject matter defined in the claims. In order to exclude someone from using a patented invention, the patent owner needs to demonstrate in a court proceeding that what the other person is using falls within the scope of a claim of the patent.

Document types

In the patent procedure from filing to grant several patent documents can be generated, a fact that has to be taken into account if a statistical analysis likes the present study is developed.

As described earlier the patent application is usually published by the patent office's 18th month after the filing, which generates published patent application document which in nearly all patent offices is described as an 'A' document. After examination, once the patent is granted, a second document of the same invention is generated, as shown in Fig. 17, which is the 'B' document and stands for a published granted patent.

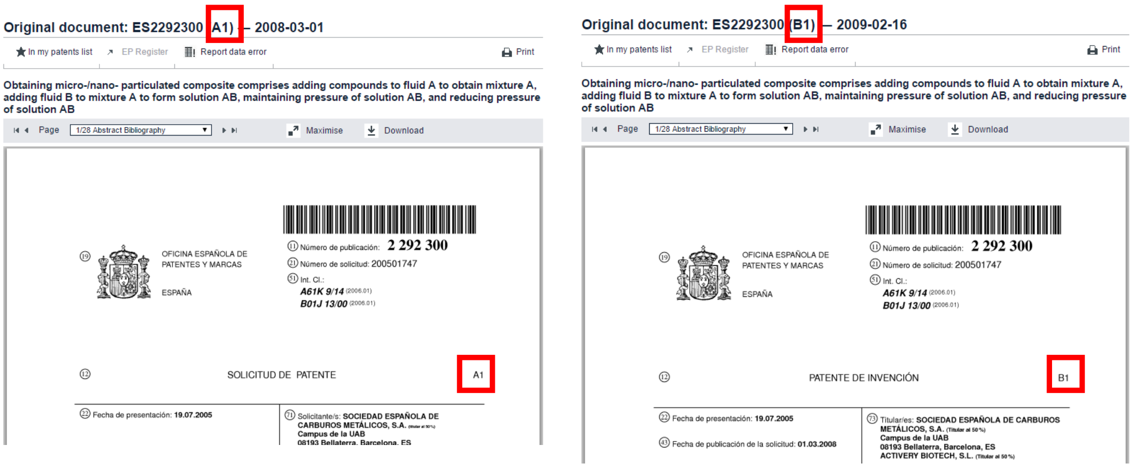

Fig. 17 : A and B patent document of the same invention. Source: Espacenet database.

Furthermore, when using regional (e.g. European Patent) or international procedures (e.g. PCT) or both (Euro-PCT), more document types can be generated from the same invention. Taking the case of an invention which was directly filed as a EP patent and validated in Spain and Germany as an example, the following patents documents are generated (Fig. 18):

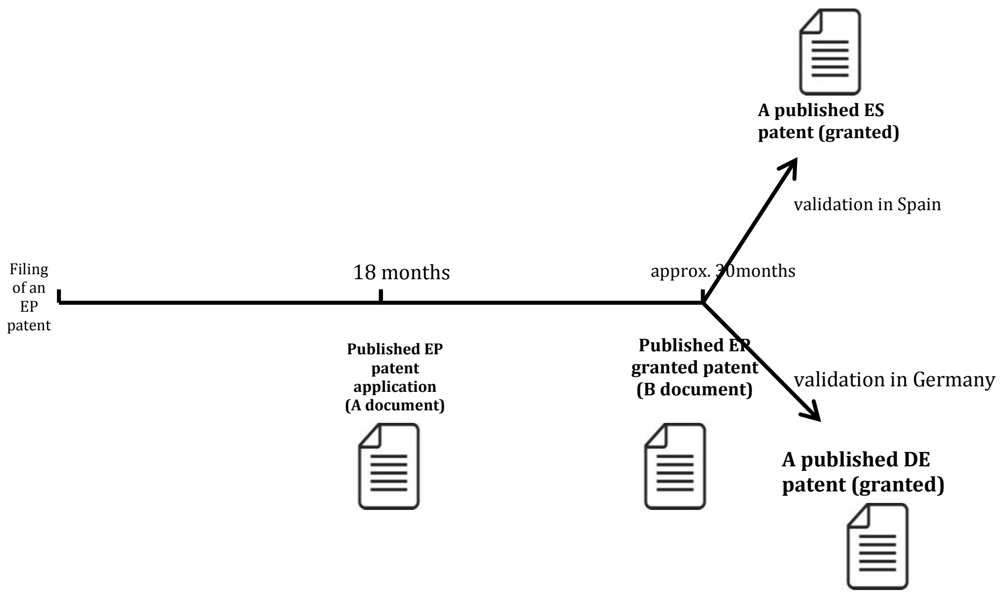

Fig. 18 : EP patent filing and generated documents. Source: own elaboration

Apart from the A and B codification which is common in most patent offices, the document codifications may vary according to each patent office[50], for example the published granted ES document which comes from a EP patent would be codified at the Spanish patent office as a 'T' document (Moreno, 2011).

3.1.3 Patent families

As we have seen in the previous chapter, a single patent application can generate several documents. When extending a patent to different countries either via the Paris, PCT or regional procedure it always generates a priority document (of first filing) and several patent documents of each patent office where protection was sought. All these patent documents which belong to the same invention are called a patent family.

A patent family is therefore a set of either patent applications or publications filed in multiple countries to protect a single invention by a common inventor and then patented in more than one country (EPO-4, 2011). As described in chapter 3.1.1a first application is made in one country – the priority – and is then extended to other offices. Therefore a patent can have 'family members' of the same invention in different countries, each one with an own patent document. Depending on the relationship between a patent document and its priority, the term patent family can be defined in a number of ways, the three most important patent family types are the following (EPO-4, 2011):

[50]the codification used at the EPO: https://www.epo.org/searching/essentials/definitions.html

- All documents have exactly the same priority or combination of priorities belong to one patent family. This is called the simple patent family and in many databases (e.g. Espacenet) patents from the simple family are referred as 'equivalents'.
- All the documents have at least one common priority belonging to the same patent family.
- All the documents directly or indirectly linked via a priority document belong to one patent family. This is called the Extended or INPADOC[51] patent family. Of the three family types it is the broadest definition since it takes the domestic application numbers as additional connecting elements. Even includes documents having the same scope but lacking a common priority which can be the case if the application was filed too late to claim the priority for instance (EPO-4, 2011). This kind of patent family have an special interest to patent attorneys and patent departments in industry.

It is important to note that patent families are defined by databases, not by national or international laws, and family members for a particular invention can vary from database to database (Simmons,2009) as they are generated according to the rules mentioned before.

For example, the INPADOC families are generated via an algorithm where as a first step all priority numbers are used to retrieve additional documents and for every document found in this step, the process is repeated until no more new documents can be found (EPO-5, 2011).

In most cases no human intervention is done, which can lead to incomplete patent families, or patents appearing in families where they do not belong, also called 'rogue members' or 'black sheep' caused by transcription errors, variations in national patent issuing procedures or inconsistent treatment by databases (Simmons,2009).

Family Representative Document

In order to develop a statistical analysis of patents with patent families a reference document is defined which is the representative document of the patent family to which the selected document belongs, and means that a search will first display the document 'representing' the family (EPO-6,2011). In most databases preference is given to documents in English and to EP or PCT patents followed by US patents which are also done for the analysis in the present study (see chapter 6.1.2)

[51] INPADOC stands for "International patent documentation centre" which is a company founded in 1974 by an agreement between the Austrian Patent Office and the World Patent Organization with the primarily purpose to collect and document patent families. The company was incorporated into the European Patent Office (EPO) in 1989 and the INPADOC database has been integrated into EPOs master database with bibliographic patent records "DOCDB" in 2007 (Intellogist 2013).

3.1.4 Classification systems

Most patent offices classify their patents according to their technology field using the International Patent Classification (IPC), to facilitate the search of prior art that patent examiners have to check when analysing the novelty of a patent application and in order to retrieve patent documents that reflect the state of the art in a particular field. Although still some patent offices, like the Japanese and the German office, use their own classification systems, they are both related to the IPC which became a de facto standard and is currently used in over 100 countries worldwide to classify the content of patents in a uniform manner. Furthermore they have specific importance for statistical reasons since, according to the INID standard (see also chapter3.1.2), the IPC has to be visualised on the patent document's frontpage as part of their bibliographic data and is available in every patent database.

3.1.4.1 International Patent Classification

The International Patent Classification was created in 1971 under the Strasbourg Agreement and is administered by the World Intellectual Property Organization (WIPO). The classification is a hierarchical system which divides technology into eight sections with currently approximately 70,000 subdivisions. Each subdivision has a symbol consisting of Arabic numerals and letters of the Latin alphabet. The highest hierarchical levels are the following eight 'sections' corresponding to very broad technical fields (Table 8):

Section	Description
A	HUMAN NECESSITIES
B	PERFORMING OPERATIONS, TRANSPORTING
C	CHEMISTRY, METALLURGY
D	TEXTILES, PAPER
E	FIXED CONSTRUCTIONS
F	MECHANICAL ENGINEERING, LIGHTING, HEATING, WEAPONS
G	PHYSICS
H	ELECTRICITY

Table 8 : IPC main sections

The IPC is a strictly hierarchical classification with increasing detail level the further down the hierarchy gets. The sections are subdivided into ‘classes’ (e.g. 120 in the latest edition of the IPC) and classes are further subdivided into more than 640 ‘subclasses’ which are divided into ‘main groups’ and ‘subgroups’ as shown in the example of the nanotechnology classification B82Y5/00 in the following table (Table 9):

Division	Classification	Description
Section	B	PERFORMING OPERATIONS; TRANSPORTING
Class	B82	NANO-TECHNOLOGY
Subclass	B82Y	SPECIFIC USES OR APPLICATIONS OF NANO-STRUCTURES; MEASUREMENT OR ANALYSIS OF NANO-STRUCTURES; MANUFACTURE OR TREATMENT OF NANO-STRUCTURES
Main group / Sub group	B82Y5/00	NANO-BIOTECHNOLOGY OR NANO-MEDICINE, E.G. PROTEIN ENGINEERING OR DRUG DELIVERY

Table 9 : IPC hierarchy example with nanotechnology classification

The IPC is updated or extended on a regular basis by a Committee of Experts of representatives of the Contracting States of that Agreement (WIPO, 2014). The latest edition was updated in January 2015 (IPC version 2015.01). Each IPC symbol assigned to a patent is usually followed by the version number of the first introduction of the symbol in the IPC e.g. “B82Y5/00 [2011.01]”, although this does not necessary mean that patents published before that date are not classified with this class since the WIPO constantly reclassifies older documents. Nanotechnology classes are relatively new classifications, and this issue will also be addressed in chapter 6.2.2.

The IPC class is assigned to an invention based on its function or field of application. Therefore the IPC is a combined function-application classification system in which the application takes precedence (WIPO, 2014). Furthermore as the invention may contain several technical objects, a patent can be assigned to more than one IPC class as shown in the following figure (Fig. 19).

Fig. 19 : Spanish Nanotechnology patent classified with four IPC symbols

3.1.4.2 Cooperative Patent Classification

The only competing classification system for the purpose of this study is the Cooperative Patent Classification (CPC). The CPC was created as a joint partnership between the US patent office (USPTO) and the European Patent Office (EPO) in October 2010 where the offices agreed to unify their own existing classification systems (ECLA and USPC, respectively). The CPC is based in large part on the former European Classification System (ECLA) which, contrary to the former US classification system, is an extension of the IPC. Therefore the CPC ensures compatibility with the International Patent Classification system (IPC), with a difference being that is has an additional main section (Y section[52]) and it has more classes at the main group/sub group level making it far more detailed than the IPC with over 250.000 classification symbols (vs. 70.000 of the IPC). The following figure shows an example of an electronics-related class where the different hierarchy depth of the CPC classes (marked in green) become evident (Fig. 20).

[52] This section evolved from a tagging system used in the predecessor classification ECLA from EPO and further includes some classes from the former US classification which had no concordance in the IPC.

Symbol	Classification and description
H	ELECTRICITY
H01	BASIC ELECTRIC ELEMENTS
H01B	CABLES; CONDUCTORS; INSULATORS; SELECTION OF MATERIALS FOR THEIR CONDUCTIVE, INSULATING OR DIELECTRIC PROPERTIES (selection for magnetic properties H01F 1/00; waveguides H01P; installations of cables or lines H02G; {printed circuits H05K})
H01B 1/00	Conductors or conductive bodies characterised by the conductive materials; Selection of materials as conductors (resistors H01C; selection of materials for superconductivity H01L 39/00)
H01B 1/06	• mainly consisting of other non-metallic substances
H01B 1/12	• • Organic substances {(organic macromolecular compounds or compositions C08)}
H01B 1/121	• • • {Charge-transfer complexes}
H01B 1/122	• • • {Ionic conductors}
H01B 1/124	• • • {Intrinsically conductive polymers}
H01B 1/125	• • • • {comprising aliphatic main chains, e.g. polyactylenes}
H01B 1/127	• • • • {comprising five-membered aromatic rings in the main chain, e.g. polypyrroles, polythiophenes}
H01B 1/128	• • • • {comprising six-membered aromatic rings in the main chain, e.g. polyanilines, polyphenylenes}

Fig. 20 : Hierarchy depth of IPC vs. CPC in green. Source: Espacenet Classification Search tool[53]

The CPC is a relatively new classification and is used to classify patents at the EPO since the beginning of 2013, at the USPTO since 2014, and recently also at some mayor Asian patent offices, with the Chinese Patent Office being the most prominent (EPO-3 2013).

Although the CPC is a relatively new classification, it is of interest to include it in the present statistical patent study (whose analysis timeframe lies before the CPC was introduced) since with the introduction of the CPC, the European and US office have undergone mayor efforts in reclassifying older patent documents, especially in emerging technology fields like nanotechnology. In this sense the CPC can also benefit from its predecessor since the European classification ECLA had incorporated specific nanotech classifications and a reclassifying project to identify nanotechnology-related patents (see also chapter 6.2.2).

3.1.5 Patent classifications for nanotechnology

Taking into account the increasing importance of nanotechnology in patents and its interdisciplinary nature, several mayor patent offices have made intense efforts over the last decade to improve their respective classification systems with the aim to better classify patents related to nanotechnology.

[53] http://worldwide.espacenet.com/classification?locale=en_EP

European Patent Office approach

The European Patent Office (EPO) created in 2003 a working group of internal and external experts with the aim to define and tag nanotechnology patents in order to better to be able to follow trends in nanotechnology patents (OECD 2009, Scheu et al 2006). This was the first emerging technology being tagged in the Y tagging system of the EPO which was used as an additional, internal classification to mark documents related to new technological developments but not as a classification replacement. The work resulted in the creation of a specific internal EPO classification tag (“Y01N”) describing Nanotechnology patents in six subclasses (Table 10) and was used to mark Nanotechnology related patents in the EPO databases like Espacenet.

EPO Y01N Tag	Description
Y01N2	NANOBIOTECHNOLOGY OR NANO-MEDICINE
Y01N4	NANOTECHNOLOGY FOR INFORMATION PROCESSING, STORAGE AND TRANSMISSION
Y01N8	NANOTECHNOLOGY FOR INTERACTING, SENSING AND ACTUATING
Y01N10	NANOTECHNOLOGY FOR OPTICS
Y01N12	NANOMAGNETISM
Y01N6	NANOTECHNOLOGY FOR MATERIALS AND SURFACE SCIENCE

Table 10 : EPOs Y01N Tagging system for Nanotechnologies

The U.S. patent office approach

The U.S. patent and trademark office (USPTO) on the other hand, decided in 2004 to introduce a new category for nanotechnology related patents into its own classification scheme in order to facilitate nanotechnology related prior art searches, the Class 977 Nanotechnology Cross-Reference Art Collection (USPTO 2011). This category has 5 mainlines or subclasses (Table 11 :) which each included five hierarchical levels adding up to a total of over 250 cross-reference subclasses, making it the most detailed nanotechnology patent classification available[54]. In addition to the class schedule it further includes a definition for each subclass and search notes to related classifications in other U.S. classes (USPTO 2012).

U.S. Class 977 Subclass	Description
700	NANOSTRUCTURE
839	MATHEMATICAL ALGORITHMS, E.G., COMPUTER SOFTWARE, ETC., SPECIFICALLY ADAPTED FOR MODELING CONFIGURATIONS OR PROPERTIES OF NANOSTRUCTURE
840	MANUFACTURE, TREATMENT, OR DETECTION OF NANOSTRUCTURE
902	SPECIFIED USE OF NANOSTRUCTURE
963	MISCELLANEOUS

Table 11 : US patent class 977 with main subclasses

Although both, the U.S. class 977 and the EPO tag Y01N1, were valuable initiatives to classify nanotechnologies they were discontinued some years ago. With the introduction of a dedicated nanotechnology classification symbol in the patent classification scheme used by patent offices worldwide, the International Patent Classification (IPC), in early 2011, all patent offices worldwide started to classify nanotechnology uniformly with the new classification symbol B82Y.

Till the introduction of B82Y in 2011, the international patent classification to describe Nanotechnology had only one subclass (B82B) and was used by the patent offices worldwide which did not had developed any specific internal classes like EPO or USPTO.

The problem was, that this class was far too restrictive in terms of the definition of Nanotechnology since it included only patents related to "*nano-structures formed by manipulation of individual atoms, molecules, or limited collections of atoms or molecules as discrete units*". This classification structured around the concept of nano-structures has been subject to critics as being too narrow and leaving essential technological developments outside of the scope which, would not enable any technology watch or interdisciplinary search and resulted in a dispersion of these inventions though several different classes and subclasses (Scheu et al. 2006).

[54]http://www.uspto.gov/web/patents/classification/uspc977/sched977.htm

Since its introduction B82Y is nowadays the most used patent classification symbol describing modern nanotechnology (EPO-2 2013) whereas the older B82B classification has become a subset of B82Y since patent examiners are advised to classify all B82B documents also in B82Y as explained in the official B82B classification note[55]:

"Subject matter classified in this subclass is further classified in subclass B82Y, in order to enable a comprehensive search of nano-structure technology using classification symbols of B82Y in combination with classification symbols of B82B."

The B82Y subclass was built on the Y01N system that the EPO working group had created to tag nanotechnology-related patent applications. It adopted all six Y01N subclasses and added two more subclasses as outlined in Table 12 (EPO 2013). As a consequence the EPO replaced all Y01N codes in its databases, making it no longer available for patent searches.

Former EPO Y01N Tags	New correspondent IPC symbol
Y01N2	B82Y5
Y01N4	B82Y10
Y01N8	B82Y15
Y01N10	B82Y20
Y01N12	B82Y25
Y01N6	B82Y30
-	B82Y35
-	B82Y40

Table 12 : IPC and Y01N Tag Concordances

The B82Y classification is divided into nine main groups (Table 12), eight of which relate to specific areas of nanotechnology (where six of them are adopted from the Y01N scheme as stated earlier).

IPC symbol	Description
B82Y5/00	Nano-biotechnology or nano-medicine, e.g. protein engineering or drug delivery
B82Y 10/00	Nano-technology for information processing, storage or transmission, e.g. quantum

[55] http://web2.wipo.int/ipcpub/#refresh=page&notion=scheme&version=20150101&symbol=B82B

	computing or single electron logic
B82Y 15/00	Nano-technology for interacting, sensing or actuating, e.g. quantum dots as markers in protein assays or molecular motors
B82Y 20/00	Nano-optics, e.g. quantum optics or photonic crystals
B82Y 25/00	Nano-magnetism, e.g. magnetoimpedance, anisotropic magnetoresistance, giant magnetoresistance or tunnelingmagnetoresistance
B82Y 30/00	Nano-technology for materials or surface science, e.g. nano-composites
B82Y 35/00	Methods or apparatus for measurement or analysis of nano-structures
B82Y 40/00	Manufacture or treatment of nano-structures
B82Y 99/00	Subject matter not provided for in other groups of this subclass

Table 13 : B82Y symbol subclasses

Nanotechnology definitions in patent classifications

When it comes how the U.S. class and the B82Y class define Nanotechnology many similarities become obvious as seen in the comparison in the following table (Table 14). Both classifications have also similar definitions to the ones used in the literature as described earlier in chapter 2.1.3especially when it comes to the size restriction of the nanostructures, although it is interesting to notice that the B82Y does not include a minimum size limit contrary to the approach chosen by the U.S. class that defines a bottom limit of 1nm.

Classification	U.S. Patent Classification	Cooperative Patent Classification (CPC) / International Patent Classification (IPC)
Symbol or Number	977	B82Y
Class name	US Classification Class Nanotechnology Cross-Reference Art Collection	Nanotechnology - Specific uses or applications of nano-structures; measurement or analysis of nano-structures; manufacture or treatment of nano-structures
Scope	- Nanostructure and chemical compositions of nanostructure; - Device that include at least one nanostructure; - Mathematical algorithms, e.g., computer software, etc., specifically adapted for	- Applications and aspects of nano-structures which are produced by any method, and is not restricted to those that are formed by manipulation of individual atoms or molecules.

	modeling configurations or properties of nanostructure; - Methods or apparatus for making, detecting, analyzing, or treating nanostructure; and - Specified particular uses of nanostructure.	
Terminology	The term "nanostructure" is defined to mean an atomic, molecular, or macromolecular structure that: (a) Has at least one physical dimension of approximately 1-100 nanometers; and (b) Possesses a special property, provides a special function, or produces a special effect that is uniquely attributable to the structures nanoscale physical size.	"Nano-size" or "nano-scale" relate to a controlled geometrical size below 100 nanometres (nm) in one or more dimensions; "Nano-structure" means an entity having at least one nano-sized functional component that makes physical, chemical or biological properties or effects available, which are uniquely attributable to the nano-scale.

Table 14 : B82Y and US Class 977 scope and terminology definition[56]

Nanotechnology in the Cooperative Patent Classification

Another aspect which makes this classification symbol so important for a nanotechnology patent search is that B82Y has been fully integrated into the relatively new Cooperative Patent Classification (CPC) scheme with identically descriptions and classification hierarchies[57].

As described in chapter 3.1.4.2 the CPC is a classification scheme which was jointly introduced by EPO and USPTO in 2013 and is becoming the new standard in patent classifications since more and more mayor patent office's not only classify with IPC but also with the more detailed CPC (EPO-3 2013), amongst them is the Spanish Patent and Trademark Office.

Although in the case for nanotechnology, both IPC and CPC use then same class symbols with the same hierarchy depth (usually CPC has more symbols and more hierarchies than IPC, see also chapter 3.1.4.2) there is a significant difference between both classification systems when it comes to the classification of relevant nanotechnology documents.

We will outline this more in detail in chapter 6.2.2where we describe the classifications used for the present study.

[56]Source: http://www.uspto.gov/web/patents/classification/uspc977/defs977.htmand http://worldwide.espacenet.com/classification?locale=en_EP#!/CPC=B82Y
[57]http://worldwide.espacenet.com/classification?locale=en_EP#!/CPC=B82Y

3.1.6 Patent information sources

The access to patent information has evolved considerably over the last decades, in particular due to the rise of computers and database technology which made information retrieval in general much easier and faster. Whereas previously paper patent documents had to be looked up manually in catalogues of dedicated patent office libraries, now information technology and the evolution of databases has made it possible to search for patents in a much more efficient way. First, in the late seventies via local, on site search systems, and then in the late eighties the first online patent search systems appeared which have evolved considerable ever since then (Sanderson, 2012). Nowadays patent information is searched online via internet-based search systems which can be distinguished as either free of charge or pay services systems, as outlined in Table 15:

	Free of charge services			Pay services
Providers	Patent Offices	Patent Offices	Private companies	Private companies & Patent Offices
Coverage	National	Multinational	Multinational	Multinational
Access type	Public access (Free of cost)	Public access (Free of cost)	Public access (Free of cost)	Pay per view or License based (pay database)
Cases	Most patent offices offer databases with access to their own (national) patent data collection	Some mayor patent offices offer multinational, free databases.	Some commercial providers offer multinational, free databases. Free access is financed by advertisement or cost based added value features.	Commercial providers and some patent offices offer multinational patent databases with added value functionality (e.g. statistics, better search functions, etc.)

Table 15 : Types of patent databases

3.1.6.1 Free of charge patent databases

National public patent databases

At present nearly all patent offices made their own patent collections searchable free of cost to the public via internet accessible databases (with more or less search functionalities). For example:

- *PatFT/AppFT*[58] database from the US patent office
- *SIPO*[59] database from the Chinese patent office
- *KIPRIS*[60]database from the Korean Office
- *Invenes*[61]database from the Spanish patent office

All of these databases usually provide bibliographic patent information and in some extent also full texts and other information such as the legal status of examination and the filing and publication of the application. The only downside is their limitation to a patent collection of a specific country. For the purpose of this study the US and the Spanish database were of special interest and will be discussed in more detail in chapter6.3.

Fig. 21 : Screenshot of the search interface of the Spanish INVENES database

Multinational public databases

Multinational public databases not only provide their own patent collections but also patents from other countries free of charge to the public. The most important databases of this kind are offered by some of the mayor patent authorities:

- *Patentscope*[62] from the World Intellectual Property Organisation
- *Espacenet*[63] from the European Patent Office
- *Depatisnet*[64] from the German Patent Office

[58]http://patft.uspto.gov/
[59]http://english.sipo.gov.cn
[60]http://eng.kipris.or.kr
[61]http://invenes.oepm.es
[62]https://patentscope.wipo.int/
[63]http://worldwide.espacenet.com/
[64]https://depatisnet.dpma.de

Also some private companies began offering free patent information search sites, remarkably Google with *Google Patents*[65], but also other webpages like *Freepatentsonline (FPO)* [66](Fig. 22). In order to finance their expenses they usually include advertisement or a paying version with more search functionalities.

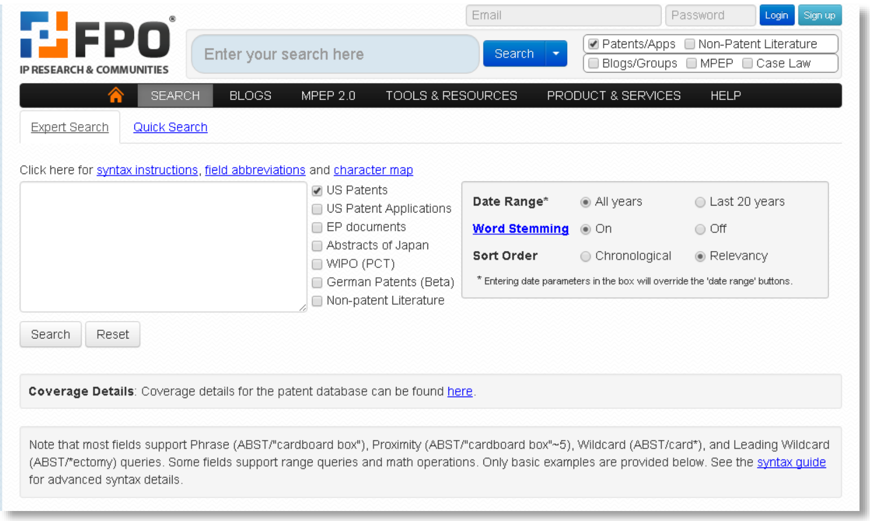

Fig. 22 : Screenshot from the search interface of the patent search system FPO

All multinational databases vary not only in their functionalities like the national ones, but also have differences in their country coverage which will be discussed more in detail in chapter 6.3.

3.1.6.2 Commercial Patent Databases

Although patent data are produced by the patent offices, but also fee based patent databases using this data are published by private companies (usually via license models) adding value by extended coverage, analysis and search features. The most important on the market are currently the following:

- *Patbase*[67] from the British company Minesoft
- *Thomson Innovation*[68]from the US American company Thomson Reuters
- *Orbit*[69] from the French company Questel

[65] https://patents.google.com
[66] http://www.freepatentsonline.com
[67] https://www.patbase.com
[68] http://info.thomsoninnovation.com/
[69] https://www.orbit.com

4 Technology watch and patents

4.1.1 Technology watch - concepts and methodologies

"It is pardonable to be defeated but never to be surprised"

Frederick the Great

Concepts of Technology Watch

Technology watch (in Spanish "Vigilancia Tecnologica"), also known in the Anglo-Saxon world as "technology intelligence", "technology monitoring" or "patent competitive intelligence", is a methodology for organisations (especially companies, but also research organizations) to systematically analyze technical information in a continuous way in order to gain insight and competitive advantage in a specific technical domain.

Technology watch is a part of the broader concept of "Competitive Intelligence" (CI) which can be defined as a methodology for gathering, analyzing, and managing external information that can affect the company's plans, decisions, and operations (Negash 2004, Miller 2001). Technology watch can be considered as competitive intelligence focused on technology changes and monitoring future technology developments which can reveal potential threats or opportunities.

Although companies have always gathered information about competitors, the increasingly globalized and fast-moving economy forces companies to react faster to changes in their competitive environment in order to stay competitive. This competition in the market requires from the companies the anticipation of technology trends and competitor's strategy (David 2013).Especially high tech corporations or research intensive companies need to be able to anticipate the technology trends, since a wrong choice can result in low profits and obsolete products and can have a major impact on the financial performance for many years (Hodgson 2008). In this context, Lichtenthaler (2004) pointed out the most important reasons that make technology watch so important for the companies:

- the globalisation of technology development requires a global approach to technology watch.
- the rising competition increases the pressure on R&D to improve effectiveness.

- the increased use of external sources of technology makes a systematic observation of external technology sources necessary.
- the growing complexity of technological development, which often leads to the fusion of formerly independent technology fields, requires a more systematic approach to technology intelligence.
- the reduction of long-term research has often diminished the ability to identify relevant trends in science.

Origin of Technology Watch

Porter (1980) laid the foundation of modern competitive intelligence and technology watch by identifying the need for a system to watch over the competitors. After that, competitive intelligence developed rapidly as a discipline, especially in the United States, where the ´"Society of Competitive Intelligence Professionals (SCIP)" was founded in 1986[70]and during the following years new analysis techniques and information sources were added to the practitioners toolbox with the works from Prescott (1995) or Kahaner (1997).

In Spain competitive intelligence and technology watch as a discipline was first brought to a wider audience by the work from Palop & Vicente(1999) and subsequently from Giménez-Toledo & Román(2001), Ortega (2003) and Muñoz Durán et al (2006). Nowadays, it is anestablished methodology for fostering the competitiveness of organisations and even counts with an own certification scheme of the Spanish certification entity AENOR[71] (García& Velasco 2006).

Although applied by many Spanish multinational companies from a diversity of sectors e.g. Telefónica[72], Repsol[73] or Ferroatlántica (Rey-Vázquez2006) there is still a knowledge gap amongst the small and medium enterprises which is why many regional development agencies have initiated to provide technology watch services to fill this gap (Jürgens & Herrero-Solana 2011).

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[70] www.scip.org in the year 2010 changed its name to: "Strategic and Competitive Intelligence Professionals"
[71] www.aenor.es
[72] www.ines.org.es/node/300
[73] In the context this paper it is of interest to mention the technology watch project "SONAR" of the company REPSOL in order to identify nanotechnologies which might affect its business http://blogs.repsol.com/innovacion/proyecto-sonar-como-aprovechar-la-nanotecnologia/

Methodology of technology watch

According to Lichtenthaler (2004), the goal of technology intelligence[74] is to exploit potential opportunities and to defend the company against potential threats, through timely relevant information about technological trends in the competitive environment of the company.

The intelligence is generated from the information which can be found through patent analytics as discussed in the last chapter (chapter 4.1.5), therefore the role of patent information for the technology watch process is essential (Davidson 2001). In fewer cases also other technological sources are included in the technology watch process, like R&D project abstracts from dedicated databases[75] or profiles from technology transfer platforms, although this data is less structured than patent data and has much lover coverage over countries and/or sectors[76].

Translating patent data into competitive intelligence allows the firm to gauge its current technical competitiveness, to forecast technological trends, and to plan for potential competition based on new technologies (Fleisher 2003). Although in the literature different technology watch methodologies are discussed (Escorsa 2001, Lichtenthaler 2004, Savioz 2003), they all have in common that it is a an iterative process which involves the following basic steps as shown in Fig. 23. :

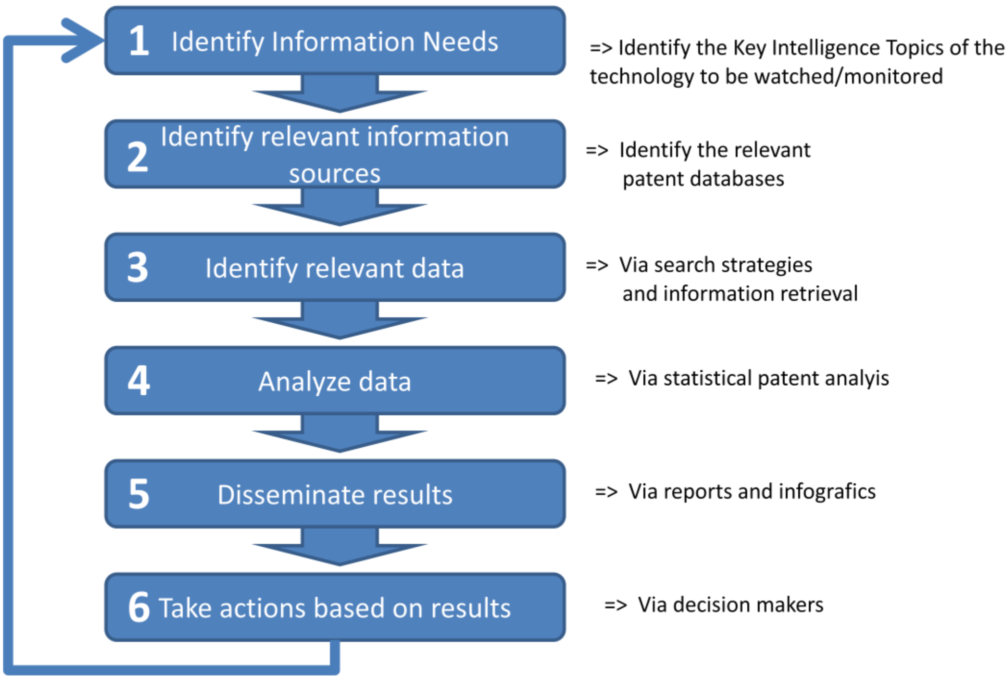

Fig. 23 : General Competitive Intelligence Cycle and its application to technology watch via patents

[74]Lichtentahler speaks in his paper of "Technology Intelligence", which can be considered as a synonym for technology watch
[75]For example the R&D project abstracts available from the CORDIS dtabase from the European Union http://cordis.europa.eu
[76]For example the technology profiles available from the enterprise europe network databaseathttp://een.ec.europa.eu/

The process begins with the determination of the information needs and the identification of the so called key intelligence topics (KIT). The key intelligence topics, first introduced by Herring (1999), identify and prioritize the key intelligence/information needs of the organization. In the case of the present study the KIT is its defined scope, as detailed in chapter 6.1.

Once the key intelligence topics are agreed, the second step involves the identification of the best information sources in order to gather the most meaningful data related to the KIT. In our case this would be the database comparison as described in chapter 6.3.

With the best information sources identified, the third step is the data collection which involves the compilation of a comprehensive search strategy which is able to collect the most relevant data (see chapter 6.2.1). The quality of the further analysis is related to the retrieved information it is crucial to give high attention to the reliability of the data sources and the gathering process.

Once the information is retrieved (in our case bibliographic patent records) it is decisive to analyze and process it, gaining indicators etc. and therefore to convert information into intelligence (chapter 6.8 in the present study).

In step 4 of the technology watch process the processed information or technical intelligence has to be adequately transmitted to the decision makers in the company so that they can take actions based on the indicators and conclusions (Step 5) in order to lead to a competitive advantage.

4.1.2 Patent statistics and its use for technology watch

"... patent statistics remain a unique resource for the analysis of the process of technical change. Nothing else even comes close in the quantity of available data, accessibility, and the potential industrial, organizational and technological detail."

(Griliches, 1990)

Patent statistics have been used to monitor and evaluate science and technology activities from 1960s with the work of Schmookler who was one of the first to use patent counts as indicators of technological change in particular industries (Schmookler 1966).

With currently more than 90 million open access patent documents[77], being standardised, structured and technologically detailed, patent information is a powerful source for statistical analysis in order to conduct technology watch of specific technological domains.

As we have seen in chapter 3.1.2 patent data does not only include information about the invention itself, but also relevant information of the applicant and inventor, prior art and corresponding technological areas in form of patent classifications. Taking advantage of its structured format, patent statistics are commonly based on its bibliographic data (see also chapter 3.1.2) and therefore generated with bibliometric techniques. This is why it is also known as patent bibliometrics, first introduced by Narin (1994) or as patentometrics in the Spanish speaking realm ("Patentometría") (Guzman Sanchez 1999).

Nowadays patent bibliometrics is the most commonly used method for measuring technology and innovative output of research and development activity provides an important source of information for the analysis of innovation and technological change (Grilliches 1990, Hullmann 2003, Dang 2009).Statistics generated by patent bibliometrics are now to be found in recurrent publications of the European Commission (Science and Technology Indicator Reports), the OECD or the US National Science Foundation and are also used by many companies and policy and government agencies to assess technological progress (Van Looy 2006).

The reasons for this recurrent use is that patent data is considered as a good predictor of economic performance, the number of patents filed by a company is considered to be a good reflection of its technological performance and that there is a high correlation between patent

[77]Present patent number coverage of Espacenet database (www.espacenet.org) See also chapter**Error! Reference source not found.**

numbers and the performance in research and development activities (Keller 1982, Narin 1994, Hagedorn 2003,Rassenfosse 2009).

As patents cover mainly technical inventions, they are a natural source of data regarding technical change and are in many cases the only reliable source at all which is notably the case for investigating new, emerging technical fields (Zuniga 2009).

Especially in emerging sectors like nanotechnology, patent data can reveal the intermediate stages of innovation activities and offers a basis for analysis where other data is only scarce (Palmberg 2009). This makes patent analysis particularly relevant for analysing the technological domain of nanotechnology.

In general, the analysis of patent data has several advantages according to Palmberg (2009):

- Patents are closely linked to inventions
- They cover a broad range of technologies on which there are sometimes few other data sources
- The content of patent documents is a rich source of information
- Patent data are available as long time series and across many (most) countries
- They are readily available from patent offices

Regarding the use of patent statistics, Zuniga (2009) distinguishes several topics of investigation that can be addressed, as described in the following table (Table 16):

Topic of Investigation	Description
Technological performance of entities or regions	Patents are used to monitor the technological performance of entities (companies, organisations, etc.), regions or countries, to track technological leadership in a given technology area and to identify weak and strong areas in national or regional innovation systems.
Analyzing emerging technologies	Patents are used to track the rise of emerging technologies (like nanotechnology) and to identify the companies or agencies active in these fields, the modes of invention (e.g. inter-institutional collaboration), the mapping of technology clusters, etc.
Geography of invention	As patents include the addresses of the inventor and applicant, patents can be used to study the geographical properties of inventive processes and their interactions (collaborations) in regions, countries or even cities.
Knowledge	As patents provide a detailed description of the invention and its prior art,

transfer	patents can be used for a measure of knowledge transfer. The inventor usually cites in the description older related patents which make it possible to identify the influence of particular inventions and map their connection (see chapter 4.1.5). They also sometimes include citation of non-patent literature (seminalscientific publications) which is useful in quantifying knowledge transfers across organisations (e.g. company to company or university to industry).
Social &Collaboration networks	Patent information can be used to follow the career and performance of individual inventors (e.g. their field of work, location, employer), or to analyse networks of inventors (who invents what and with whom, etc.).
Patent value	Patent data provide unique access to information about the value of inventions since correlations between the value of a patent and the number of its receiving citations has been demonstrated (see chapter 4.1.5).
Technological performance of researchers	As the inventors name is reported in patent documents, it is possible to investigate aspects of inventiveness at the individual level of the researchers.
Performance Evaluation of academic institutions	In an increasing number of countries patent data is used by funding agencies or ministries to evaluate the performance of academic institutions or individual researchers. In this context patent data can be used to measure the impact of universities by compiling counts of the patents and their receiving citations or by observing the citations of academic research in patents filed by industry.
Globalisation of R&D activities	Patents include information on the inventive performance and activities of multinational firms. Through the inventors addresses, it is possible to measure research collaboration between inventors located in different countries.

Table 16 : Use of patent statistics (typical topics of investigation)

In the present study we will focus our research on some (not all) of these topics of investigation as we will outline in chapter 6.8.

4.1.3 Bibliometrics vs. Patentometrics

Classic bibliometrics can be described as the statistical analysis of written publications such as scientific articles and was first mentioned in 1969 by Pritchard, who defined it as "*the application of mathematical and statistical methods to books and other media of communication*" (Pritchard, 1969).

The general properties of classical bibliometrics and patentmetrics are very similar (Narin 1994) but we have to be careful when comparing both types of analysis since the documents analyzed have some substantial differences which have to be taken in mind. Hence in the following table (Table 17)[78] we compare scientific publications and patent publications and enumerate their main differences.

	Scientific publications	**Patent publications**
Total number of publications	Approximately 57 million[79]	Approximately 93 million[80]
Annual number of publications (in 2014)	Approximately 3 million[81]	Approximately 4,4 million[82]
Content	Mainly basic research findings	Technical solutions to a problem
Access	Paid access or open access or depending on the journal	Open access via public patent databases
Quality filter	Peer review	Patent examination process
Indexing	Scientific papers can have inconsistent bibliographical details, meaning that they can be hard to index.	Patent publications have a (more or less) standardised numbering system, meaning that it is possible to fully index them.
Subject categorization	Core journals by subject field	Patent classifications by technology field
Reason to publish	Scientific recognition	Economic (gain commercial monopoly, licensing, etc.)
Who publishes	Research entities (mainly Universities)	Companies and to a lesser degree research entities and private persons (inventors)
Cost	Sometimes fee based and others for free (depending on journal prestige)	Fee based (depending on patent office and coverage)

[78] Source: Lloyd (2015) and own research
[79]In SCOPUS databasehttps://www.elsevier.com/solutions/scopus/content
[80]In GlobalPatentIndexdatabaseof EPO: https://data.epo.org/expert-services/start.html
[81]In SCOPUS database, fromwww.scimagojr.com
[82]In GlobalPatentIndexdatabaseof EPO: https://data.epo.org/expert-services/start.html

Content duplicity	No (the article can only be published in one single journal)	Yes (as patents are territorial, the same invention can generate several different patent documents for each country)
Timeliness	Article publishing depends on the efficiency of the peer review process of the journal	Patent is not published before 18 month after filing

Table 17 : Scientific literature vs. patent literature

4.1.4 Limitations of patent statistics

Statistics based on patent information are widely accepted as an indicator of innovation there are also some limitations to take in mind.

First of all, the timeliness: since patents are not made public before 18 months after the filing date (see chapter 3.1.1) patent indicators have a delay of 18 months.

Second, not all innovative activity is patented or even patentable and therefore cannot be captured in a patent analysis. This can be due to the following reasons:

- the costs a patent process incurs is too high for the inventor/researcher
- the necessary public disclosure of the invention is not wanted by the inventor/researcher and it is preferred to keep the invention it secret instead of patenting
- the invention itself is not patentable according to the patenting criterias (see also chapter 3).
- the invention is not patented due to strategic decisions

When comparing patent data between technological sectors it has to be taken in mind that patenting activity tends to vary significantly across different industries (Pavitt 1985).

Another factor is that due to the high cost that patenting in several countries can generate larger firms tend to patent more than smaller ones (Noteboom 2000).

Finally, most patent indicators are quantity based and do not measure quality of the patents. It has to be taken in mind that not every patent has the same value and the distribution of the value of patent is skewed as only a few patents turn out to be commercially successful (and therefore are of substantial value) whereas many patents do not reach the market. According to a EU wide survey based on the inventors of 9017 European patented inventions nearly 40%

of the patents are not used for industrial or commercial purposes with 18.8% only aimed to block competitors, and 17.5% not used at all (Giuri et. al. 2007).

Most of the limitations outlined above can be solved by using appropriate methodologies, for example, the issue of patent value will be addressed in this study by selecting only specific patent documents as described in chapter 6.1.3. Furthermore the differing patent activities across industries are not relevant in the present study since it analyzes only a specific sector (Nanotechnology) and although Nanotechnology is considered multidisciplinary (see chapter 2.1.2.4) all involved technology fields like Electronics, Chemistry or Biotechnology have a similar high patenting activity[83].

4.1.5 Patent indicators

As we have seen, patent statistics can be used in several different investigation topics which all require specific indicators. In this sense we can distinguish two main types of patentometric analysis: single field analysis and multiple field analysis (E-IPR 2013). The single field analysis, widely used in bibliometrics, is a one field analysis based on lists or rankings and is conducted on a set of bibliographic patent references. The resulting lists provide valuable information on the set of analyzed patents.

Multiple field analysis, also known as cross reference analysis, combines different types of bibliographic fields via matrices. This is the basis for data visualization via collaboration networks which can reveal valuable information for a technology watch activity as we will see later in this work. The following table (Table 18) sums up the most common multiple field analysis combinations and its information obtained for the technology watch activity.

	Applicants	Inventors	Priority or Publication Year	Priority Country	Classifications
Applicants	Collaboration between organisations	Who is working where	Evolution of filing activity	Home market or most important market	Technological focal points of the organisation

[83] For example they all form part in the top ten patenting technology fields of the latest annual report from the European Patent Office (EPO-9 2015)

Inventors	Who is working where	Research collaborations	Evolution of inventors patenting activity	Inventors country of origin	Research fields of the inventors
Priority or Publication Year	Evolution of filing activity	Evolution of inventors patenting activity	Evolution ofthe activityper country	Evolution of country patent output	Evolution of technology sector
Priority Country	Home market or most important market	Inventorscountry oforigin	Evolution of technologies	Collaboration between countries	Technological focal points of countries
Classifications	Technological focal points of the organisation	Research fields of the inventors	Evolution of technology sector	Technological focal points of countries	Relationships between technological domains

Table 18 : Cross Reference Patent Indicator Matrix

4.1.5.1 Types of indicators

With the before mentioned types of patentometric analysis we generate several patent indicators which we classified according to its scope of analysis:

- *Performance indicators*
- *Technology indicators*
- *Patent value indicators*
- *Collaboration indicators*
- *Text mining indicators*

Performance Indicators

For this study we consider performance indicators as patent indicators who deal with the patent output of the analysed entities (inventors or applicants) and who are used to monitor the technological performance of company/institutions and inventors/researchers and to track their technological leadership in a given technology over time (Zuniga 2009). In the following table we describe various typical patent indicators of this type (Table 19)

Indicator	Metrics	Description
Top country applicants (per patent family)	Patent family counts per applicant	Indicate the company/institutions which have most inventions in a field or topic.
Top country applicants (per patent publication)	Patent document counts (published) per applicant	Indicate the top company/institutions which have most patents in a field or topic.
Patent counts by the applicant over years	Patents filed (priority) / applicant / year	Measure the level of R&D efforts. A variation can be interpreted as a change in their R&D strategy.
Patent internationalisation rate of applicants	Patent document counts (published) per applicant / Patent family counts per applicant	Indicate the applicants with the highest ratio of generated patents of their invention portfolio.
Top country inventors (patent family)	Patent family counts per inventor	Indicate the inventors which have most inventions in a field or topic.
Top country inventors (patent publication)	Patent document counts (published) per inventor	Indicate the inventors which have most patents in a field or topic.
Patent internationalisation rate of inventors	Patent document counts (published) per inventor / Patent family counts per inventor	Indicate the inventors with the highest ratio of generated patents of their invention portfolio.

Table 19 : Performance indicators

Technology network indicators

Technology network indicators analyze patent classifications and are another very valuable indicator for technology watch activities since every patent is classified with one or more classes according to its technological field as we have described earlier (see 3.1.4). With single and multiple field analysis of the classification we can reveal the technological focal points of an organisation, the research fields of inventors, the evolution of a technology sector and the relationships between technological domains (Table 20).

In some cases we distinguish between Macro and Micro vision of the technology field by analyzing the patent classes in different levels of hierarchy. For a more general vision of technology landscape (macro vision) we aggregate to a 4-digit classification level (subclass) and for the more detailed technology perspective (macro vision) we use the 7-digit classification level (till sub group hierarchy) of both IPC and CPC (see also chapter 3.1.4)

Indicator	Metrics	Description
Technology evolution (per patent family)	Patent family counts in technology field / year	Forecasts the technological trend on the number of inventions.
Technology evolution (per patent publication)	Patent document counts (published) in technology field / year	Forecasts the technological trend on the number of patents.
Technological distribution	Patents filed (priority) / Classification Patents filed (priority) / Classification	Identifies the core technologies of the analyzed technology.
Technological Networks (Macro level)	CPC level 4 / CPC level 4 IPC level 4 / IPC level 4	Relationships between technological domains
Technological Networks (Micro level)	CPC level 7 / CPC level 7 IPC level 7 / IPC level 7	Relationships between specific technologies
Applicant technology network	CPC level 7 / applicant IPC level 7 / applicant	Relationships between company/Institution and technological domains (Macro and Micro level)
Inventor technology network	CPC level 7 / inventor IPC level 7 / inventor CPC level 4 / inventor IPC level 4 / inventor	Relationships between inventor/researcher and technological domains (Macro and Micro level)

Table 20: Technology indicators

Patent value indicators

Patent value indicators can give us an idea about the economical value of a patent by looking at several factors. First of all, the size of the patent family and the geographic coverage are important indicators. As described in chapter 3 patents provide protection on a country level and can be extended to other countries in the 12 months of priority since its first filing. In this sense, the more countries a patent is extended, the broader is their protection and the invention can be considered as economically more promising since the applicant is willing to assume the correspondent high costs of the patent extensions[84](Hullmann 2003). In this context another indicator is the ratio of the family size and total invention output compared which can be used to measure the grade of internationalization of an inventors or applicants patent portfolio.

Apart from the quantitative measure of patent families, specific patent types or countries are also used as patent indicators. Patenting in certain countries can be considered as more important than in others (Palmberg 2009). For example a European Patent (EP) or PCT patent application is considered of special relevance, and if a invention is filed as Japanese, US and European Patent by the same applicant or inventor the patent is given a special importance since it covers the three most important patenting authorities worldwide (the so called Triadic patent family). In chapter 6.1.2 we will discuss this matter more in detail and justify its use for the present study.

Patent citations are another important indicator related to patent value and to identify knowledge flows from company to company, or from other sectors, e.g. research institutes and academia to companies (Meyer 2002). Contrary to citation in scientific articles in patent citation we can distinguish citations from the inventor and citations from the patent examiner. Citations from the inventor are the references that the inventor provides in the patent to describe the state of the art and to give evidence for the novelty of the patent (see also chapter 3.1.1). Therefore in many patent documents the inventor references previous inventions or other relevant scientific information aimed at showing the differences from existing patents. Taking into account that patents are considered to build on the knowledge of the documents it cites (Azagra-Caro 2009), these citations in patents can be used to

- trace the information sources on which the invention is built
- illustrate the relations with other inventions
- reveal geographical and technological linkages.

Citations from the patent examiner on the other hand are the documents that the patent examiner references in the search report (as explained in chapter 3.1.1). They are also considered prior art (sometimes even destroying the novelty of the patent) and are often even more related to the patent than the documents the inventor has cited.

[84] National patent office fees of every country, translation costs, patent agent costs, etc. (see also chapter 2.2.1)

Another patent citation distinction is Forward and Backward citation. Backward citations are the references in a patent document to earlier documents (from the inventor or examiner as explained) whereas forward citations are more recent documents that cite the patent. In other words: For a given patent a forward citation is another patent document's citation back to that given earlier patent. Both, the applicant and the patent examiner, must find and cite documents that might be similar to the claimed invention and limit the scope of the patent protection, or which generally reveal the state of the art of the technology the number of forward citations a patent receives is often used as a measure of a patent's significance and considered as an indicator of the economic value of the invention (Trajtenberg 1990).

Citation indicators have to be handled with care since one must consider that new patents rarely earn many forward citations because it takes time for a patent to be cited by newer patent documents and therefore a strict forward citation analysis will favour older patents. Furthermore with the obligation to cite all possible prior art, patent applicants tend to cite much more references than needed, leading to patent references where the cited patent is not of particular relevance. This is the case especially in US patents since, contrary to the European patent system, in the US both, the applicant and every other involved party (e.g. the patent attorney), must include any possible prior art of an invention in order to minimize the risk of the application being rejected which leads to the fact that US patents on average include far more citations than European ones (Azagra-Caro 2009, Alcacer Gittelman 2006).

Indicator	Metrics	Description
Publications per patent office	Patent application published / patent authority	Indicate which are the most important markets for patents from the analyzed technological domain.
Family size	Patents application published / family members	Reflects the intention to produce or commercialize globally the products related to the invention.
Top applicants Geographic coverage	Ratio patent application published / family size	Indicates the grade of internationalization of applicants patent portfolio.
Top inventors Geographic coverage	Ratio patent application published / family size	Indicates the grade of internationalization of an inventors patent portfolio.

Family network	Patent authority / Patent authority	Indicates which markets are co-protected and identifies the essential markets where protection is sought together.
Top patents with backward citations	Number of cited patents / patent	Helps to identify technical complementarities or substitutes or prior art patents.
Top forward cited patents	Number of citing patents / patent	Reflects the technological impact of the patented invention and helps to identify key patents which influenced other patents.

Table 21: Patent value indicators

Collaboration indicators

These type of indicators are one of the most important patent indicators in our opinion since they gives us information about patterns of collaboration of the entities we are analyzing. Collaboration indicators are generated with multiple field analysis and can be visualized with network maps as shown in chapter 4.1.6. Similar to traditional bibliometrics, in patent bibliometrics the most important collaboration indicators are related to co-authorship (Glänzel et al 2003), although their interpretation slightly differs as outlined in the following table (Table 22):

Indicator	Metrics	Description
Applicant collaboration network	Applicant / Applicant	Collaboration between organisations: Connect entities that share the ownership of a patent and contrary to co-inventions can point to a shared interest in utilising a patented invention.
Inventor co-authorship collaboration network	Inventor / Inventor	Research collaborations: Identifies individuals (inventors or researchers) who generated the technology in a common undertaking and can be considerate as most closely related to the co-authorships in scientific publications.
Applicant collaboration by country	Applicant country / Applicant country	Identifies international collaboration on an institutional level.
Inventor co-	Inventor country	Identifies international collaboration on a research level.

authorship by country	/ Inventor country	

Table 22: Collaboration indicators

Text mining indicators

Finally, the descriptive part of the patent, which is the less structured data, can also be analyzed statistically via text mining techniques. Patent text mining is based on a statistical approach of words recurrence or occurrence in the textual corpus of the patent (e.g. title or abstract). It is often regarded as a process to find implicit, previously unknown, and potentially useful patterns from a large text repository (Tseng 2007). For example for the co-occurrence analysis in the present work the chosen patent analysis tool (see chapter 6.4) uses "Part-of-Speech tagging"[85] where the software adds tags on each word in a sentence and in order to extract word sequences (Mannina 2014).

The disadvantage of patent text mining in general lies in the fact that the textual corpus of the patent document is written by the inventor who has the opportunity to infer on the analysis outcome by the way the patent was drafted (Cattaneo, 2012).

4.1.6 Patent data visualization

Patent data visualization is a an essential part of the technology watch methodology since it is the way of how the generated indicators can be visualized in order to easily be understood by the decision makers of the organization (see also chapter 4.1.1). In the present study we use several types of patent data visualization:

- *Bar graphs & Pie charts*
- *Choropleth maps*
- *Scatter graphs*
- *Networks maps*
- *Citation nodes*

[85] https://en.wikipedia.org/wiki/Part-of-speech_tagging

Bar Graph & Pie charts

Bar Graph & Pie charts are well known and popular types of data visualization. Bar graphs are diagrammatical illustrations of data sets and are one of the most common ways to visualize tabular or listed data like evolutions (time lines) or rankings, whereas pie charts is a circular statistical graphic, which is divided into slices to illustrate numerical proportion. In the present study we use both of them for visualizing various patent indicators as we outline in Table 42 in chapter 6.8. The following figure shows an example of a horizontal bar graph as used for visualizing the nanotech patent output over years.

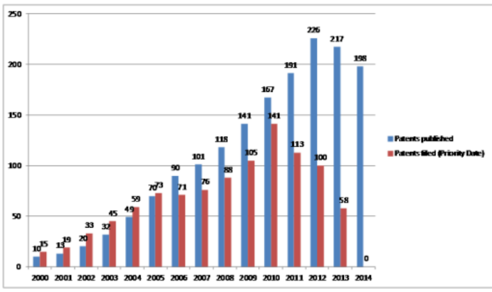

Fig. 24 : Example of bar graph visualization (Spanish Nanotech output)

Choropleth maps

Choropleth maps are thematic maps of geographic regions (countries, states, etc.) andshow data aggregated over predefined regions with colour ranges representing the data ranges. We use them in our study to visualize the patent output of countries and Spanish regions (Fig. 25).

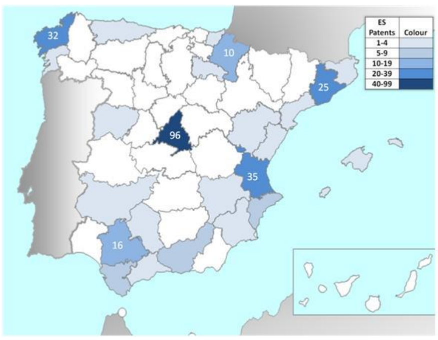

Fig. 25 : Choropleth map example (Nanotech output in Spanish provinces)

Scattergraphs

A Scattergraph is a diagram using coordinates to display values for typically two variables for a set of data. The data is displayed as a collection of points, each having the value of one variable determining the position on the horizontal axis and the value of the other variable determining the position on the vertical axis (Fig. 26).

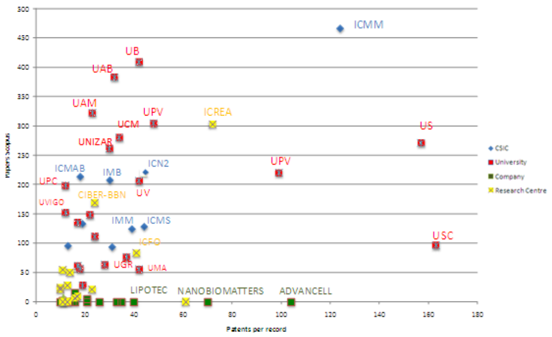

Fig. 26: Scattergraph example (Nanotech companies patenting/publishing)

Network maps

In network maps entities are connected to each other in the form of a node and link diagram. In the present study we use these types of maps to visualize collaborations and to detect similar technologies which are connected to each other. In the figure below, we show an example of a network map visualizing the collaboration in Nanotech patents of three Spanish applicants (Fig. 27).

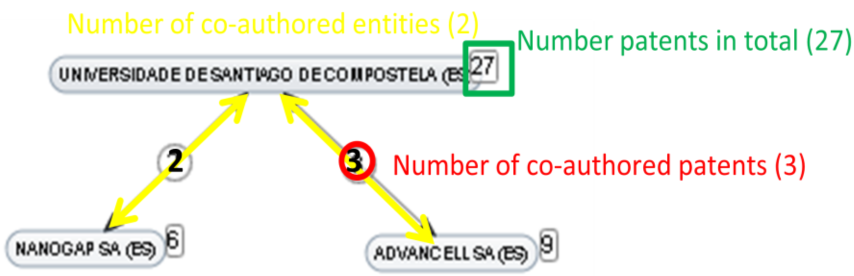

Fig. 27: Example of network map (Applicant collaboration)

Citation nodes

Citation indicators are presented in ranked lists (top cited patent & top citing patents), but in order to show forward and backward citations we use citation node maps which can visualize the relationship in citations where a receiving arrow means that a citation was received, whereas a outgoing arrow means that the pointed patent is cited, as showed in the following example (Fig. 28).

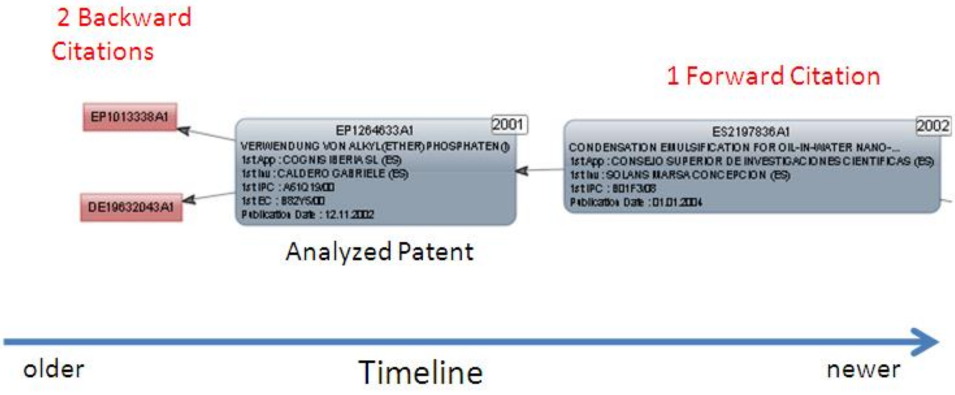

Fig. 28 : Citation nodes example

4.1.7 Patent analysis tools

As patent analysis is the most common information source of technology watch activities nowadays several software tools were developed over the last years in order to facilitate the analysis of large patent data sets. Based on their access method we can distinguish server based and client based analysis tools.

Server based analysis tools are mostly integrated in patent databases and are the most common tools for patent analysis nowadays. Since, being one of the most important added values comparing to free of charge patent sources, all of the commercial database providers described earlier (chapter 3.1.6.2), offer integrated online statistical patent analysis solutions where the user can directly analyse the retrieved patent set as seen in the example in Fig. 29.

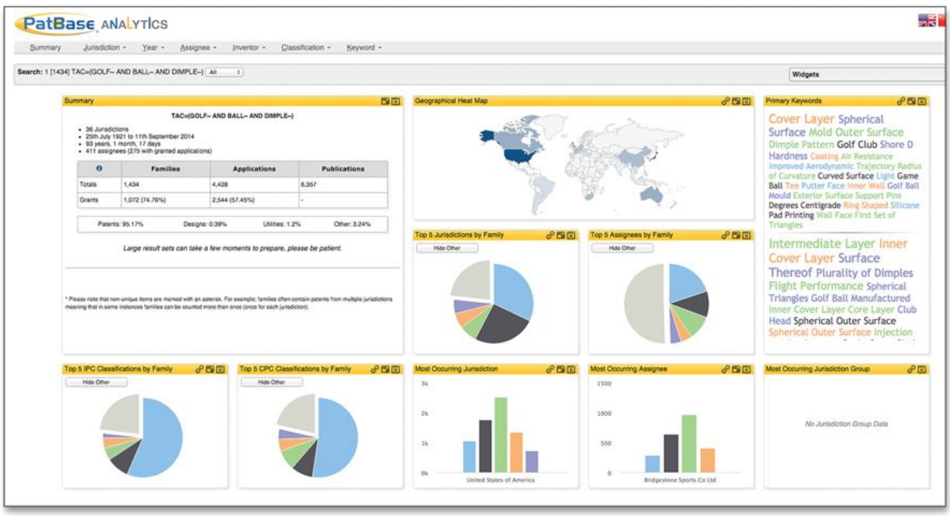

Fig. 29 : Patent Analysis with the commercial database Patbase

Desktop or client-side products for patent analysis are usually a software which has to be installed on one's own computer. The most important patent analysis software tools (Yang et al 2008) are:

- Thomson Analyzer[86]
- Vantage point[87]
- STN AnaVist[88]
- Matheo Patent[89]

Both types of patent analysis tools have advantages and disadvantages as outlined in the following table (Table 23):

	Server based (online)	Client based (desktop)
Advantages	• No need to install additional software • No need for data downloading	• In most cases more configuration options • No fees for data downloading (if free of charge data sources are used) • Allows analysis to be performed offline • Fully confidentiality (working offline)
Disadvantages	• Need always internet connection • Processing/Analyzing speed depends on quality of internet and server connection	• Need to install the software • Download of data may imply high costs depending on the database used

Table 23: Comparison of Server side and client side patent analysis tools[90]

Another tool for patent analysis which we would like to point out is PATSTAT, a database managed by the European Patent Office and specifically designed for statistical patent analysis. It can be purchased as a downloadable file to be integrated in a local database (e.g. MS SQL) or

[86] http://thomsonreuters.com/en/products-services/intellectual-property/patent-research-and-analysis/thomson-data-analyzer.html
[87] https://www.thevantagepoint.com/
[88] https://www.cas.org/products/stn/anavist
[89] http://www.matheo-software.com/matheo-patent/
[90] Source: E-IPR 2013

also used via a web interface called PATSTAT online [91] (Fig. 30). Although not very user friendly (no proper user interface, SQL command based interaction only), PATSTAT is the statistical data source of various international studies (e.g. OECD 2009, 2010).

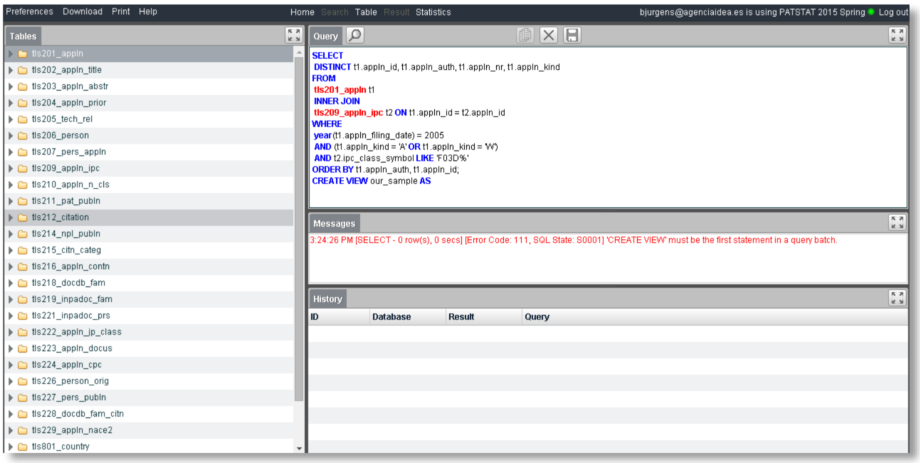

Fig. 30: Patstat online statistical patent database

All the described patent analysis tools will be compared more in detail in chapter 6.4where we will evaluate its potential use for the present study.

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[91]https://www.epo.org/searching/subscription/patstat-online.html

5 Nanotechnology based metrics studies

Since the late nineties of the last century there has been great interest in monitoring the emerging field of nanotechnology and an increasing number of bibliometric and patentometric studies were published that dealt with patterns of publication and patenting. This chapter wants to give an overview over the state of the art of these types of studies.

5.1.1 Global studies

One of the first bibliometric studies of the emerging field of nanotechnology was the research of Braun et al in 1997. Braun and his colleagues analyzed the word occurrences of the prefix *nano* in the titles of scientific articles and revealed an exponential growth rate in nanoscience and -technology publications since the early 1990s. Furthermore the authors delineated in their analysis the research topics *Nanostructure, Nanocrystals, Nanoparticles* and *Nanotubes* as well as their respective publication trends, giving the impression of a fast emerging and quite clearly defined research field.

Meyer & Persson (1998) attempted the following year to characterise nanotechnology by exploring the contributions that various fields of science and technology made to nanoscience. The authors were among the first to define the scope of nanoscience using research publications and confirmed the observations of Braun and his colleagues with respect to the significant increase of publication rates in the 1990s and furthermore characterised the field as more interdisciplinary than other areas of science.

Another interesting global study was developed nearly a decade later from Kostoff et al (2007) who analyzed the global nanotechnology related scientific paper output in the time period 1991-2005. By using institution and country auto-correlation maps the researchers could show co-publishing networks among institutions and among countries. Furthermore by using text mining data they presented institution networks and country networks based on use of common terminology and found that global nanotechnology research production has exhibited exponential growth for more than a decade.

5.1.2 Interdisciplinary of nanotechnology

The interdisciplinary of nanotechnology (see also chapter 2.1.2.4) was also a recurrent field of studies. Schummer (2004) stated that nanoscale research revealed no particular patterns and degrees of interdisciplinarity and that its apparent multidisciplinarity consists of different largely mono-disciplinary fields which are rather unrelated to each other and which hardly share more than the prefix *nano*.

Leydesdorff on the other hand, found in his study of 2007 that articles published in nanotechnology journals are frequently cited in general science, and stated in his study of 2008 a developing interdisciplinarily at the interfaces between applied physics, chemistry, and the life sciences.

In this context Basselcoulard et al. (2007) showed that the themes uncovered in nanotechnology are moderately multidisciplinary by mapping the citation flows of nanotechnology publications and classifying nanotechnology papers into thematic clusters.

In the same year, Braun (2007) found that nanotechnology papers are published in many journals in different specialties and concluded that the Nanotech discipline is not yet stabilized in a core set of journals and interdisciplinary character of nanoscale research is reflected in the appearance of new nano journals. This was confirmed by Huang (2011) who claimed that the core journal strategy does not provide a robust delineation of an emerging field such as nanotechnology due to the fact that nanotechnology related articles are published in a wide range of journals.

5.1.3 Patentometric analysis of nanotechnology

One of the first patent bibliometric studies about nanotechnology were to our knowledge the ones from Meyer (2000, 2001) where the interrelationships between science and technology were explored by patent citation relations with scientific articles. The researchers' findings were that by then only a small number of citations connected the patents and the author concluded that nanoscience and technology are still mostly separated spheres.

Huang et al (2003) did a basic analysis of worldwide nanotechnology patents between 1976 and 2002 including a content map analysis and citation network analysis with patent data obtained on individual countries, institutions and technology fields. He found that the fastest growth of nanotechnology patents has been in chemical and pharmaceutical fields, followed by semiconductor devices.

The studies from Noyons (2003) and Glänzel et al (2003) address both patent and paper output, using the same search strategy from, but whereas Noyons focuses on a Macroanalysis to identify excellent institutions, Glänzel describes a regional analysis and its collaborative patterns.

Hullmann (2003) study EP and PCT nanotechnology patents applied between 1991 and 1999 and calculated the shares of the 20 most active countries where he could show the predominance of the US. Huang et al (2004) only used US patent data for a country, institution, and technology field analysis but included US patents originated from all countries that contain nanotechnology-related keywords. Heinze (2004) show the patent and paper output of nanotechnology in Europe and makes comparisons with the United States. He furthermore provides in his article a methodology for measuring the contribution of the public research sector to the knowledge base in nanotechnology by linking patent and publication databases.

In 2007 several mayor global nanotechnology patent studies were published, namely the OECD study from Igami (2007) and the work from Li et al (2007) who did a comparative study of nanotechnology patents applied at the US, EPO, and Japanese patent office(JPO) over a long time period (1976–2004). Wong et al (2007) study the evolution of application areas of nanotechnology and found that the dominance of the industrialized countries has declined, not only in terms of quantity, but also in terms of quality as measured by citation indicators.

Liu et al (2009) compared the output of nanotechnology related patents and scientific articles of China, Russia and India in the period 1976-2007 and demonstrated their high publication and patenting growth rates especially for China.

Finally we would also like to point out two recent patent co-citation studies: Schultz & Joutz (2010) used US patent data to track the emergence of nanotechnologies since 1978. They identified the nanotechnologies that have undergone the most development using patent citation data and examined co-citation patterns of patents in order to define clusters of related nanotechnologies. Barirani et al (2013) developed a patent co-citation network in order to discover and assess fields of expertise in nanomedicine by comparing USPTO, EPO and JPO nanotech patent output.

5.1.4 Studies about nanotechnology in Spain

As we have seen in the previous chapter there are numerous studies dealing with the patentometric analysis of nanotechnology, both on a global scale and on specific patent domains (e.g. US or EP).

For the country Spain things look different, as relatively few studies which analyze this emerging domain for the Spanish geography exists, which is one of the main reason and motivation for the elaboration of this present research.

One of the first and most extensive studies we found is from the year 2006, published by the Madrid+D foundation (Andaluz & Sanchez 2006). This study it can be considered as the only technology watch study, since it follows the approach and methodology as outlined in chapter 4.1.1. Nevertheless the study is centred more in an information analysis of the R&D Output and the patent analysis plays a minor role in the study e.g. only few patent indicators were used and all of them were based on a single field analysis (see also chapter 4.1.5).

In this context, two years later Barrere et al (2008) published a supra-national bibliometric nanotech study of Iberoamerican countries including Spain. In this work the authors analyzed the publication output of the countries in Nanotechnology with a focus on the bibliometric examination of scientific papers, but also some patent indicators. As the geographical scope of the analysis is so broad, the study does not get into the sufficient detail on a country level as it is intended in the present study.

The same year a short report from the Nanospain network was published (Nanospain 2008, see also chapter 2.1.4.2) which talked about the evolution of the sector in Spain and describes proposals for a national funding action plan for the Nanotechnology sector. The study from the related Phantoms Foundation (Correira 2011) goes further and gives an extensive description of the Research Topics and Centres in Spain including some statistics about the funding evolution, the companies working in the sector and the publication output on a regional, yearly and journal level. No patents were used in this study.

The paper from Correia & Serena (2012) deals with the evolution of the sector in general and how the different funding programs and initiatives from the scientific community promoted the sector in Spain (as described in chapter 2.1.5.2). In this context the paper from Etxabe et al (2012) describes the initiatives from the main Spanish research institution, the Spanish National Research Council (CSIC), to foster the Nanotechnology sector and to transfer its knowledge from laboratory to industry.

One of the few bibliometric studies which are centred to the Spanish realm we can point out the recent Nanotech scientific production report from the research group SCIMAGO (Moya-Anegón et al 2012) which works extensively the scientific paper output of the sector. But also here no patents were found to be analyzed.

6 Materials and methods

6.1 Scope definition

As we show in the preface of this present work, the scope of the study is to analyse Spanish authored patents related to nanotechnology from 2004 to 2014.

6.1.1 Timespan and reference dates

Regarding the timeframe we have chosen to analyse the years 2004 to 2014 for a couple of reasons:

- 2014 was the most actual year for patent retrieval purposes in the preparation of the present study
- Similar time periods are used in many comparable bibliometric studies (Braun 1997, Glänzel et al 2003, Clarke et al 2007, Souza Antunes et al 2012), and enables to give us a comprehensive overview of the evolution of the sector.

Regarding the reference dates we took into account, whenever possible, the priority date since it is the first date of filing of a patent application and mostly used for statistical purposes since it is the closest date to the date of invention (Zuniga 2009).

Additionally we also use the publication date, usually 18 months after the filing of the patent (see chapter 3.1.1). This was done mainly for the indicators related to patent families as described in chapter 3.1.3 and chapter 4.1.5.1.

6.1.2 Geographical domain

For our understanding a Spanish authorship is a patent with at least one inventor or applicant with Spanish residence. This means that we could not only focus our analysis on Spanish patents only[92] for the following reasons:

- we want to retrieve patents which have a Spanish patent as origin, but were extended to other countries since this is an important indicator of the patent value (see also chapter 4.1.5.1)
- we want to identify patents which are filed by foreign entities in a foreign country but have a Spanish inventor authorship (as defined earlier)

[92]Spanishpatentsare in thiscontext all patents registered attheSpanish Patent and Trademark Office (SPTO) whichgenerate a Spanish patent document (e.g. patent number ES...).

- we want to detect patents which might be filed by Spanish entities only in foreign countries (with no correspondent Spanish patent)

This is why we broaden our search scope to a worldwide patent search and identified the Spanish authorship by the address data of either the inventors or applicants (Table 24). The address forms part of the bibliographic inventor and applicant data on the front-pages of patents as defined by the INID standard which we mentioned in chapter 3.1.2.

Geographical patent coverage (patent authorities)	WORLDWIDE
Geographical address restriction	Country: SPAIN
Fields analyzed	Inventor Applicant

Table 24: Geographical domain delineation

Regarding the address fields it had to be taken in mind:

- The address data is also affected by different forms of spelling (together with the inventor and applicant names). Data harmonization was an essential step before being able to do the analysis. This will be described more in detail in chapter 6.6.
- As we will see in chapter 6.3not all patent databases have the address data searchable. Therefore it was an essential criteria for the selection of the right database for this study

Interpreting the geographical patent data

Regarding the interpretation of the geographical data it is important to point out that, notably in terms of activities by companies, as their research activity is spread geographically and the address of invention is not necessarily where the research actually took place (Zuniga 2009).

Another aspect to consider is that when taking into consideration the inventor’s address there may be a risk of distorting the analysis, especially for smaller countries, because the inventor may not live in the country where the invention occurs and on the other hand, by using the applicant’s address the analysis may be biased by patent applications from multinationals for which the country of residence of the applicant possibly differs from the country where the invention occurred (Soltmann 2013).

6.1.3 Patent document delineation

Patent applications or grants

As we have discussed in chapter 3.1.2 an invention that has been patented can generate different document types in its ongoing patenting process, where the patent application and the patent grant document are the most important ones for statistical purposes.

In the present study we decided to focus our analysis on patent applications rather than patent grants. The decision is based on the following reasons:

- PCT data is only available as applications (there is no granted PCT patent, see also chapter 3.1.1).
- patent applications are made public on average some 18 months earlier than grants and thus represent more timely data, indicating ongoing innovation activities, while grants only include those patents that have not subsequently been withdrawn or rejected (Palmberg 2009).

Therefore when speaking of patents from now on we refer to patent applications and not granted patents unless otherwise stated.

Patent family & family representatives

Patent family data is often used in economic and statistical studies (Martinez 2011). In this study we use it since it allows us the generation of unique, specific family based indicators as outlined in chapter 4.1.5.1.

Regarding the type of patent family (as explained in chapter 3.1.3) we chose for the present study the INPADOC patent family since it is the most common family type used in patent databases (Intellogist 2010) and was also supported by the analysis tool we used for this paper (Matheo Patent, see chapter 6.4).

Although working with patent families can reveal new interesting insights one has to be aware that it can complicate the patent analysis. As we have mentioned in chapter 3.1.3 a patent family is a set of patents from multiple countries to protect a single invention when the patent was applied in one country (the priority country) and then extended to other offices. Thus, while each patent of the family usually targets different geographical markets they may be considered to be duplicate observations for the same underlying invention and can thereby inflate patent counts (Palmberg 2009).

In order to count the inventions and not the patents of a patent family (of the same invention) a patent family has to get assigned a reference document for statistical purposes, the so-called patent family representative document.

The patent family representative document is the patent that is used in statistical patent analysis as the identifier that represents the other family members when analysing patent data on a family level instead of a record level. For example when generating the indicators for patent counts of applicants in the Spanish nanotechnology realm we used patent counts based on family representatives in order to identify the number of inventions and not the number of patent documents related to that invention (e.g. when a invention is patented in 10 countries the patent count would be 10 when counting patents per document and not per family representative).

Regarding the type of patent we used the following criteria for our study when choosing a patent family reference document:

1. PCT documents
2. If unavailable, the first EP document published in English
3. If unavailable, the first US document published
4. If unavailable, then the first ES document published

This preference model is aligned to the model the European Patent Office is using, with the difference that due to the geographical delineation for our study we favour a Spanish patent document as third selection (ES document), whereas the EPO uses a British patent (UK) if available(EPO-4 2011).

Triadic patent families

The triadic patent family is a set of patent applications filed at the European, the Japanese and the US patent office and is a common indicator in international patent studies (e.g. OECD 2009, OECD 2010). Its use was not considered for the present study since too few triadic patents were identified in the Spanish nanotechnology data set in order to be used as indicator.

6.1.4 Patent authority delineation

As we have described in the geographical domain delineation regarding the analysed patent authorities we wanted to identify patents on a worldwide scale which are related to Nanotechnology and have Spanish authorship. Therefore we did not restrict the search to patents registered at specific patent offices.

Nevertheless we analysed the nanotechnology patenting activity especially at these authorities for the reasons outlined as follows.

- Spanish patent documents (ES)
- PCT patent documents (PCT)
- European patent documents (EP)
- US patent documents (US)

We considered Spanish patents of importance since we analyse in this study patents with Spanish authorship and Spain is usually the first country to protect for a Spanish inventor or applicant. We did not take into account Spanish utility models for the reasons that it is a weak patent with very low economical value (see also chapter 3.1.1).

We also analysed PCT patent documents, important for several reasons:

- They are considered to offer the most comprehensive coverage of international patent applications while avoiding some of the country biases when using country offices such as the US Patent Office (USPTO) or the Japanese Patent Office (JPO).
- by giving PCT applicants the possibility to file a patent in countries all over the world (see chapter3.1.1) it can be assumed that a global market is targeted and the invention represents more significant technologies than those applications in national patent systems alone (Palmberg 2009).
- fees for a PCT patent application are generally higher than for patent applications filed with national patent authorities. Therefore it is assumed that the invention has enough commercial potential to compensate for the higher fees (Soltmann 2013, Barrere 2008).

European patent documents (EP) were also considered of importance for the present study. Similar to PCT applications the costs for an application are also high and furthermore the examination procedure is considered to be one of the most rigorous comparing to other patent systems and thus represents inventions of high technological and commercial value (Heinze 2004). The major bias with European patents can be seen in its different strategic relevance of the European market for European countries like Spain and for overseas countries like USA or Japan (Noyons 2003).

Finally, US patent documents were taken into account because the United States still is considered as one of the most important markets and therefore a US patent filing (when coming from a foreign applicant) is considered to be a sign of a strategic or economical importance of the invention.

6.2 Search strategy

Intelligence is not the ability to store information, but to know where to find it

Albert Einstein

For a statistical patent analysis, the construction of an appropriate search strategy depends critically on how the area is defined that is to be analysed. The lack of a universal definition of the nanotechnology domain, as described in chapter 2.1.3, has some implications for a statistical study since the ambiguity of the concept does not allow a straightforward search strategy (Meyer & Persson 2001).

In the literature the search for nanotechnology patents in patent databases is carried out essentially through two methods (Huang 2011):

- searching the patents using a combined set of keywords
- searching the patents using nanotechnology patent classes

For this study we will use both search methods in a combined way, as we will describe subsequently.

6.2.1 Keyword selection

The keyword search, as the common search methodology to retrieve scientific publications in bibliometric studies, can also be used effectively for a patent search. It requires building up a search string, also called lexical query (LQ), which is a set of relevant terms (keywords) organized with suitable Boolean operators (e.g. AND, OR, NOT). The way lexical queries are formulated, what keywords are used and how they are combined is one of the most important parts in establishing an effective search strategy which has the goal to retrieve the most relevant documents and the less possible non relevant documents.

When it comes to build a lexical query for this study we first looked up the queries and search strategies used in comparable studies that dealt with nanotechnology searches.

Meyer et al. (2001) and Dunn and Whatmore(2002) used only the truncated *nano* as their elementary search string, whereas Glänzel et al. (2003) and Noyons et al. (2003) used several nanotechnology related keywords to build their search strategies. Porter et al. (2008) implemented a modular search in which the authors combined *nano** and nanotechnology related keywords and furthermore excluded irrelevant records that used keywords that are similar, but not related to nanotechnology (e.g.*NaNO3, nanoliter* or *nanoplankton*). Huang et al. (2004) used a similar methodology but added several specific nanotechnology relevant keywords (e.g. *self assemble* and *quantum dot*).

For the present study we used the keyword search query developed by Maghrebi et al (2010). This query, named by the author “collective and abridged lexical query” (CALQ),was selected for the following reasons:

Based on the queries for nanotechnology used in the previously cited studies and the queries used by Warris (2004), Maghrebi conducted a set of case studies to remove keywords which are not exclusive to nanotechnology. The authors showed through bibliometric quantification of already-proposed as well as novel nanotechnology keywords, that all keywords included in the proposed new query (Table 25) had considerable exclusive retrieval and precision, while the removed keywords did not influence the results negatively.

Muñoz-Ecija et al (2013) describe another interesting query based on the combination of queries from the above mentioned studies and several other bibliometric nanotechnology papers. The proposed query has far more search terms comparing to CALQ, but no evidence was shown how it affects its precision regarding the results obtained and therefore we opted for CALQ in this study. This kind of query trend to discover Journals instead documents, in order to construct a new subject category in SCImago Journal & Country Rank[93].

[93]http://www.scimagojr.com

CALQ original version from Maghrebi (2011)
(nano not nano2 not nano3 not nanog not nanosecond* not nanomol* not nanogram* not nanoplankton* or "atom* scale" or "atomic layer deposition*" or "giant magnetoresist*" or graphen* or dendrimer* or fulleren* or "c-60" or "langmuirblodgett*" or mesopor* or "molecul* assembl*" or "molecul* wire*" or "porous silicon*" or "quantum dot*" or "quantum well*" or "quantum comput*" or "quantum wire*" or qubit* or "self assembl*" or supramolecul* or supermolecul* or "ultrathin film*" or "ultra thin film*")*

Table 25: CALQ original version from Maghrebi (2011)

Language issues

Keyword search is language dependent. This is not a crucial issue when performing scientific publications searches (since English is the common language for scientific publications), but it has to be taken in mind when dealing with patent documents since they are territorial documents written in the official language of the correspondent patenting authority (see chapter 3.1.2). For example a search with English keywords in the title will not retrieve a relevant Spanish based title in the database.

Hence for the search strategy of the present study we had to consider the translation of English keywords to their Spanish equivalents. We merged them with the English keywords from the original query and generated the following Spanish translated version of CALQ (Table 26).

CALQ with added Spanish translated keywords
(nano not nano2 not nano3 not nanog not nanosecond* not nanosegund* not nanomol* not nanogram* not nanoplankton* not nanoplancton* or "atom* scale" or "escala* atomic*" or "atomic layer deposition*" or "deposicion* de capa* atomic*" or "giant magnetoresist*" or "magnetorresistencia* gigante*" or graphen* or grafen* or dendrimer* or fulleren* or "c-60" or "langmuirblodgett*" or mesopor* or "molecul* assembl*" or "ensambla* molecul*" or "molecul* wire*" or "alambr*+ molecul*" or "hilo* molecul*" or "porous silicon*" or "silicon* porosa" or "quantum dot*" or "puntocuantic*" or "quantum well*" or "pozocuantic*" or "quantum comput*" or "computa* cuantic*" or "ordenador* cuantic*" or "quantum wire*" or "alambre* cuantic*" or "hilo* cuantic*" or qubit* or "self assembl*" or “autoensambla* or molecul*” or supramolecul* or supermolecul* or "ultrathin film*" or "ultra thin film*" or "lamina ultra-delgada*" or "lamina ultra delgada*")*

Table 26: CALQ with added Spanish translated keywords

Not all keywords were needed to be translated since they turned out to be scientific terms valid in both languages (e.g. *fulleren* or *qubit*). Some others were not translated or had to be combined with other keywords. This was the case with the Spanish translation *autoensambla** for the keyword *"self assembl*"*which retrieved too many results not related to nanotechnology. It was modified to *"autoensambla* OR molecul*"*specifying it to its application in the field of nanotechnology.

6.2.2 Patent classification delineation

The studies from Scheu et al (2006) and Huang et al (2011) revealed that especially in the nanotechnology domain a keyword only patent search is not satisfying because numerous non relevant results were retrieved.

One reason might be, along with the popularity of nanotechnology in society, the term "nano" has significantly invaded common language and is used increasingly as a scientific marketing term or magic prefix to get funds and visibility (Loeve 2010).

As described in chapter 3.1.4 patent classifications represent the technical domain of a patent document defined by the patent examiner that is an expert in the subject matter. When searching for patents this, compared to keyword-based searches, can lead to more precise results especially in a difficult domain to define as nanotechnology (Scheu et al 2006).

Regarding patent classifications for nanotechnology, as we have outlined in chapter 3.1.5, several mayor patent offices worldwide improved their respective classification systems with the aim to better classify patents related to this field. Especially the classification scheme B82Y turned out to be of interest for our study since it is based on the results of an extensive nanotechnology tagging project of the European Patent Office (Scheu et al 2006).

Since its introduction B82Y is nowadays the most used patent classification symbol describing modern nanotechnology (EPO-2 2013), which is why it is used as one of the main search aspects in this study.

B82Y is available in both important classification schemes, the International Patent Classification (IPC) and the Cooperative Patent Classification (CPC) but note every database considered for this patent study showed to have CPC support. This is why we wanted to find out if there are any significant differences in the number of nanotechnology patents classified with the symbol B82Y in either CPC or IPC.

A case study with a database wide search revealed that far more nanotechnology documents were retrieved when using B82Y in the CPC than in the IPC scheme (Fig. 31). We estimate several reasons for this discrepancy:

- First of all we think that the patent documents which were classified with the internal EPO tag Y01N have only been mitigated to the correspondent CPC class and not the IPC, since EPO controls the CPC classification of its worldwide patent databases and therefore has the authority to reclassify documents in this scheme.
- Furthermore for the patent office's that only classify with IPC, the B82Y class is a relatively new class, so not all patent examiners throughout the world might use it yet correctly.
- And lastly, as mentioned before, especially EPO and USPTO have invested considerable efforts in classifying and reclassifying documents in its databases in order to better identify nanotech related documents which might be another reason that far more documents are classified with their "own" CPC scheme instead of IPC in this technological domain.

For these reasons, one important criterion for choosing the patent database for this study (see chapter 6.3) was that it should support the CPC classification.

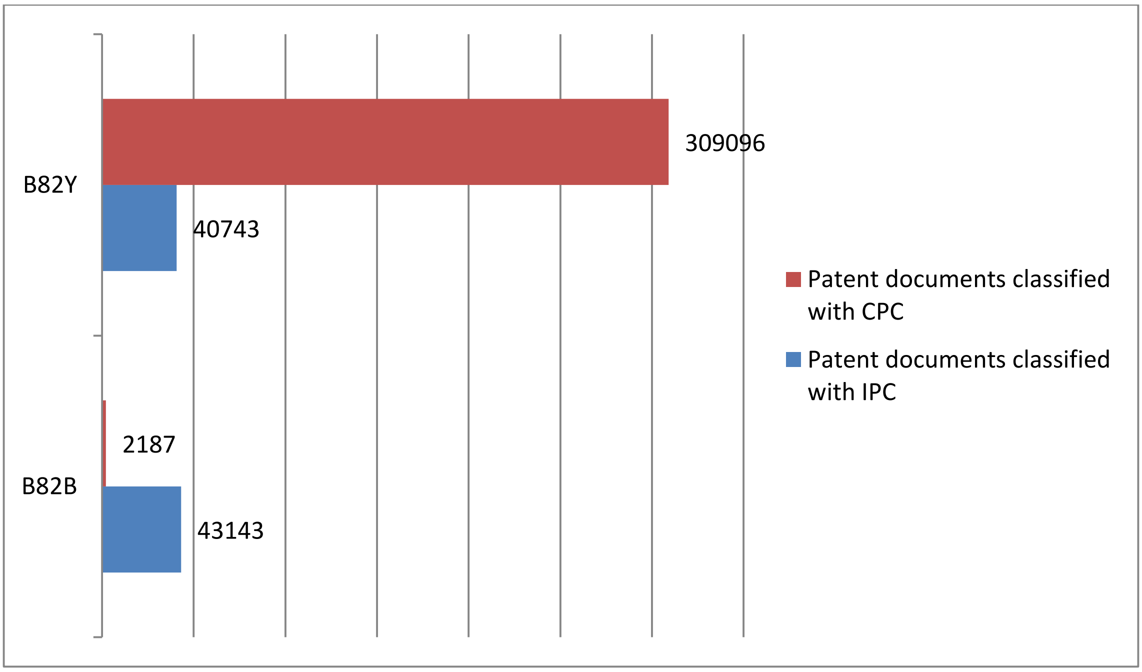

Fig. 31 : Patent classification distribution in B82B and B82Y classes of IPC and CPC

Regarding the before mentioned class 977, as a direct consequence of the introduction of the CPC scheme at the U.S. office, the whole U.S. patent classification is no longer updated since 2014 and is currently being replaced by the CPC and not used anymore by the patent examiners to classify newly issued U.S. patents (USPTO 2014). Therefore it was not considered for the search strategy of the present study.

A part from the before mentioned patent classes we added several other classes to our patent search which are classes that existed before the introduction of the B82Y class and described some specific Nanotechnology related subjects (Table 27) which due to the multidisciplinary nature of the discipline (see also chapter2.1.2.4) are subclasses of several different main classes e.g. medical sciences (A61), measuring/testing instruments (G01) or basic electric elements (H01).

Although, according to the class notes of B82Y, an patent examiner who classified a patent in one of these classes has the obligation to always supplementary classify with B82Y ("*obligatory supplementary classification of subject matter already classified as such in other classification places*[94]") we do not know to what extent this is done at the patent offices and preferred to include them in our search query for the sake of completeness, keeping in mind that these classifications are all very specific and will result in a search output with high precise.

The following table (Table 27) sums up all classifications used in the patent search of the present study, and the following figure (Fig. 32) shows the distribution of patents classified with the symbols, which demonstrates the clear dominance of the B82Y class when it come to describe nanotechnology related patents.

Classification	Symbol	Description
IPC / CPC	B82Y	Specific uses or applications of nano-structures; measurement or analysis of nano-structures; manufacture or treatment of nano-structures
IPC / CPC	B82B	Nanostructures formed by individual manipulation of atoms, molecules, or limited collections of atoms or molecules as discrete units; manufacture or treatment thereof
IPC / CPC	G01Q	Scanning probe techniques
IPC / CPC	A61K9/51	Nano-capsules for medicinal preparations

[94] http://web2.wipo.int/ipcpub/#refresh=page&notion=scheme&version=20150101&symbol=B82Y

IPC / CPC	H01F10/32	Nano-structured thin magnetic films
IPC / CPC	G02F1/017	Optical quantum wells or boxes
IPC / CPC	B05D1/20	Langmuir-Blodgett films
IPC / CPC	H01F41/30	Molecular beam epitaxy [MBE]
CPC only	C01B31/0206	Preparation of carbon nano-structures, e.g. bucky-balls, nanotubes, nanocoils, nano-doughnuts or nano-onions
IPC / CPC	H01L29/775	Quantum wire FETs

Table 27: Classifications used for the master patent query

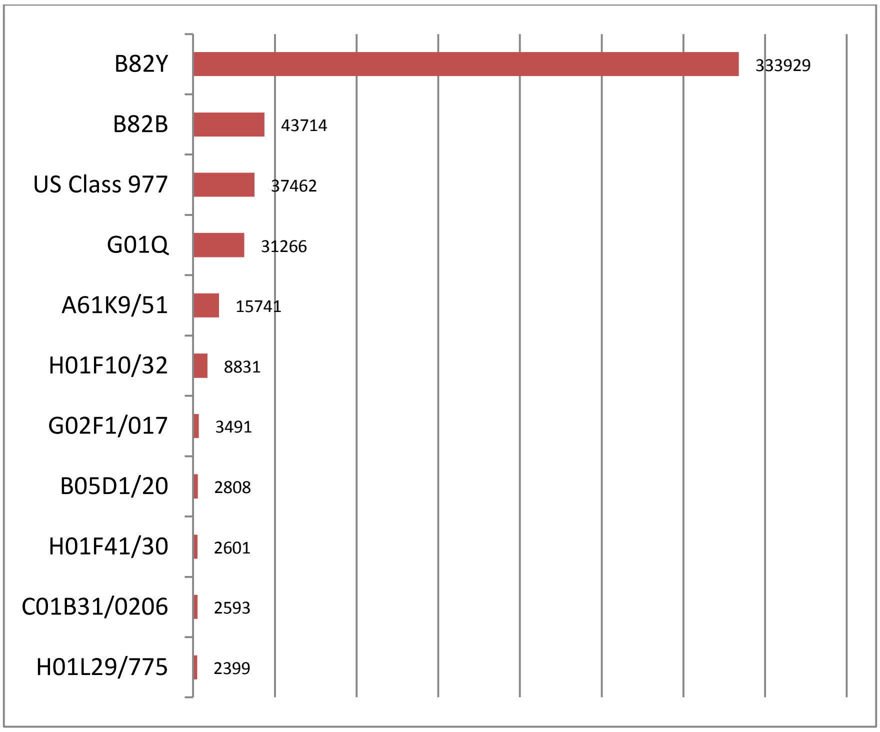

Fig. 32: Patent Distribution of the classifications used for the master patent query

6.3 Patent database identification

As we have seen in chapter 3.1.6 patent information is available in different types of sources, from which nowadays most of it is retrieved online via internet accessible databases. For a patent analysis in general and the nanotechnology analysis in particular the right source had to be chosen in order to meet the criteria's discussed in earlier chapter.

Regarding the databases we considered the following ones of interest for this study (Table 28). They are all well known products, recognized from patent information professionals and thus can be considered as state of the art in patents databases (Intellogist2011):

Database	Description	Type of database	URL
Invenes	Public patent database from the Spanish Patent and Trademark office	National	http://invenes.oepm.es
PatFT / AppFT	Public patent database from the US Patent and Trademark office	National	http://patft.uspto.gov
Espacenet	Public patent database from the European Patent Office (EPO)	Multinational	http://espacenet.com
Patentscope	Public patent database from the World Intellectual Property Organization (WIPO)	Multinational	https://patentscope.wipo.int
Depatisnet	Public patent database from the German Patent Office	Multinational	https://depatisnet.dpma.de
Google Patents	Public patent database from the company Google	Multinational	http://google.com/patents
Questel Orbit	Commercial patent database from the company Questel	Multinational	https://www.orbit.com
Thomson Innovation	Commercial patent database from the company Thomson Reuters	Multinational	https://www.thomsoninnovation.com
Patbase	Commercial patent database from the company Minesoft	Multinational	https://www.patbase.com

Table 28: Patent databases considered for the study

In order to evaluate which of these databases could be used for our study we established three main criterias that had to be met by the following order:

1. *Availability criteria*
2. *Coverage criteria*
3. *Functionality criteria*

Availability criteria

Availability criteria referred to if the database was physically available for the study. As we can see in the following table (Table 29) the commercial databases Questel Orbit, Thomson Innovation and Patbase were discarded due to their non availability at the authors patent centre and due to their high acquisition costs.

Database	Annual licence cost*	Availability at patent centre
Invenes	Free of charge	YES
PatFT / AppFT	Free of charge	YES
Espacenet	Free of charge	YES
Patentscope	Free of charge	YES
Depatisnet	Free of charge	YES
Google Patents	Free of charge	YES
Questel Orbit	High	NO
Thomson Innovation	High	NO
Patbase	High	NO
Red = failed criteria led to exclusion from the study * High: >1000€ per year ; Medium: 500-1000 € per year		

Table 29: Availability of patent databases

Coverage criteria

Coverage criteria referred if the database met the country coverage needs for the present study. As outlined in chapter 6.1.2 we want to locate nanotech patents with Spanish authorship from all over the world, therefore we were looking for a database with worldwide coverage and naturally including Spanish patents.

As can be seen in Table 30 Invenes, the database from the Spanish patent office, only provides coverage of patents registered for the Spanish territory. This left us no possibility to analyse patents from other countries with Spanish participation and thus was discarded from the study.

PatFT and AppFT, the databases by the US Patent and Trademark Office have been used in several nanopatent studies due to the importance of the American market (Huang 2004, Bass 2010, Leydesdorff 2012, Barirani 2013). But it has several downsides which led us to exclude it from this study: First there is the "home advantage" bias since, proportionate to their inventive activity, US applicants tend to file more patents in their home, and second the coverage is US only which leaves us no possibility to analyse patents outside the US market.

Finally Google Patents was excluded, although increasingly popular due to its easy to use and to the popularity of the well known search engine, it was discarded since it only covers European (EP) and US Patent records and no Spanish patents.

Database	Coverage of Spain	Worldwide coverage*
Invenes	YES	NO (only Spain)
PatFT / AppFT	NO	NO (only USA)
Espacenet	YES	YES
Patentscope	YES	YES
Depatisnet	YES	YES
Google Patents	NO	NO (only EP and US)
Red = failed criteria led to exclusion from the study ** worldwide coverage for patent databases can be considered if they cover more than 50 countries/ patent authorities (e.g. Espacenet covers over 90 patent authorities)		

Table 30: Coverage of patent databases

Functionality criteria

Functionality criteria were the features the database had to offer in order to be able to retrieve the patent data according to the delineations described in earlier chapters and to process the established search strategy with its lexical query and the identified relevant classifications. The following criteria had to be met:

- Searchable country of residence of inventor and applicant (in order to limit results to Spanish authorship)
- CPC patent classification support (for the reasons outlined in chapter 6.2.2)
- Patent family data (for the reasons outlined in chapter 6.1.4)

Database	Searchable country of residence	CPC support	Patent family data
Espacenet	YES	YES	YES
Patentscope	NO (only PCT patents)	NO	NO

Depatisnet	YES	NO	YES
Red = failed criteria led to exclusion from the study			

Table 31: Functionality criteria of patent analysis tools for the study

The three databases Espacenet, Patentscope and Depatisnet showed to have similar features and data coverage. In this regard we would like to point out that in the context of the present nanotechnology technology watch study this database comparison was analysed more in depth and published recently (Jürgens & Herrero-Solana 2015). As a conclusion of the study we can remark:

- Patentscope, a database managed by the World Intellectual Property Organisation (WIPO) is a powerful database with good country coverage, but was not considered for this study since the search fields required for the geographical limitation to Spanish authorship of the patents (applicant country and inventor country) were only available to PCT patent documents, excluding therefore all other potential countries or patent authorities (WIPO 2013). Furthermore Patentscope did not support the CPC classification and family grouping, both another important criterias.
- Depatisnet from the German Patent Office is another superior database which showed to have good search functionality, but was discarded for its lack of CPC support.
- Espacenet from the European Patent Office was the most appropriate database since it met all basic criterias and therefore was chosen as patent data source for the present study.

Espacenet advantages

- Espacenet uses the EPO master documentation database (DOCDB) which is the database with one of the best patent coverages worldwide[95]
- Espacenet has a full integration of the CPC scheme (since the EPO is managing the classification together with the US patent office)
- Espacenet has data export features: A patent search result can be exported to CSV or XLS format. This was especially relevant for the next step in the present nanotechnology technology watch process, which is the analysis of the data (see next chapter).

[95] Espacenet coverage data: http://ep.espacenet.com/help?topic=coverageww&locale=en_EP&method=handleHelpTopic

Espacenet downsides

As a downside of Espacenet we had to consider the limitations that this free of charge database has in the search and export functionality which both restrict the maximum number of search terms per query (10) and number of records to download at once (500). Since the lexical query used in this study had more keywords (see chapter 6.2.1) this was initially a problem. We solved it by splitting up the lexical query in several search runs in order to avoid the restriction (see chapter 6.5). Once exported the results we merged the data to a common data set and was then imported in the patent analysis tool we describe in the following chapter.

6.4 Used patent analysis tool

In order to identify a suitable patent analysis tool for our study we followed a similar approach as for the database selection. As described in chapter 4.1.7 the most important patent analysis tools on the market are the following ones (Table 32):

Name	Annual licence cost*	Availability at patent centre
Thomson Analyzer	High	NO
Vantage point	High	NO
STN AnaVist	High	NO
Matheo Patent	Medium	YES
Patstat	Medium	NO
Red = criteria for exclusion from the study * High: >1000€ per year ; Medium: 500-1000 € per year		

Table 32: Patent analysis tools comparison

Why Matheo Patent?

Matheo Patent is a powerful patent analysis tool developed by the French software company Matheo Software[96] and used in the Patent Information Centre where the author is working since 2007. We considered it suitable for the present study for the following reasons:

[96] http://www.matheo-software.com/

- It is a recognized analysis tool specialized in technology watch analysis (Muñoz Durán 2006, Vergara et al 2006), used in several technology watch departments of multinational companies (e.g. Danone, EADS or SanofiAventis)[97], and in several comparable patentometric studies (Dou 2004, Dou 2007, Baaziz 2013, Plaza et al 2011).
- We had previous experience working with the tool as we had used it for the patent analysis in several technology watch studies from the author (Jürgens et al 2007, 2008, 2009).

How does Matheo Patent work

As described in chapter 4.1.7Matheo Patent is a desktop based software which can import patent data from different patent databases (e.g. Espacenet as it was our case), generating a data set which can then be manipulated and analysed. Furthermore the software offers multiple tools in order to generate the visualizations we described in chapter 4.1.6.

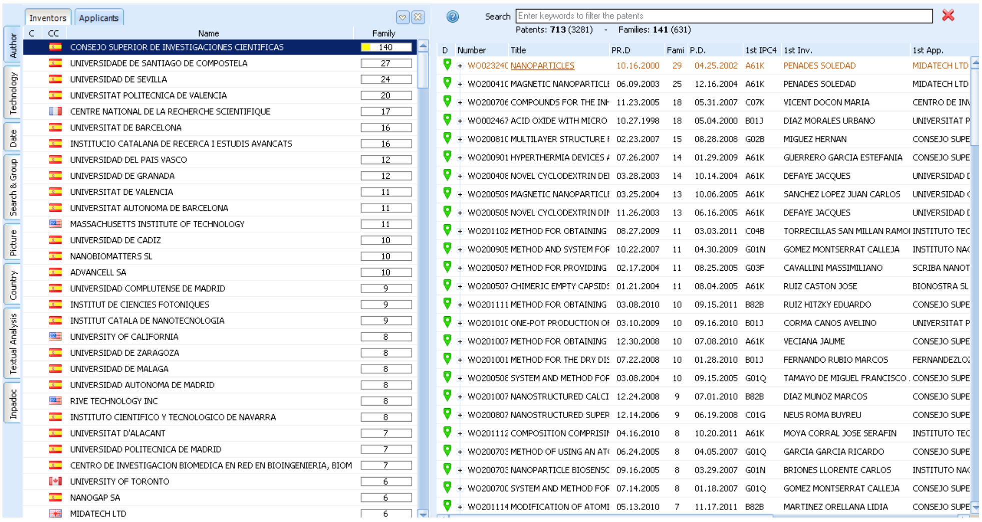

Fig. 33: Matheo Patent main screen with Nanotechnology dataset

In the context for this study we want to point out the following features used for the nanotechnology patent data set of our analysis:

- Data harmonization tools:
    - Entity and person name cleaning: Algorithm to find similar names
    - Empty country cleaning
- Data analysis tools for the creation of the indicators (see also chapter 6.8)
    - Matrix generation

[97] http://www.matheo-software.com/references/

  - Ranking list generation
  - Data export to excel
- Data visualization tools
  - Cross reference analysis network map generation

6.5 Data retrieval & generation of data set

The following table (Table 33) describes the search query used for the patent retrieval according to the search strategy defined in chapter 6.2:

Search steps	Established search criteria	ESPACENET search query Smart Search command line search mode[98]
#1	*Year restriction*	PD=2004:2014
#2	*Country affiliation restriction (Spain) of applicants*	PA=[ES]
#3	*Country affiliation restriction (Spain) of inventors*	IN=[ES]
#4	*International Patent Classifications (IPC) & Cooperative Patent Classifications (CPC)*	IC=(B82 OR G01Q OR A61K9/51 OR H01F10/32 OR G02F1/017 OR B05D1/20 OR H01F41/30 OR C01B31/0206 OR H01L29/775)
#5	*CALQ with added Spanish keywords in Title or Abstract**	TA=(nano* not nano2 not nano3 not nanog not nanosecond* not nanosegund* not nanomol* not nanogram* not nanoplankton* not nanoplancton* or "atom* scale" or "escala* atomic*" or "atomic layer deposition*" or "deposicion* de capa* atomic*" or "giant magnetoresist*" or "magnetorresistencia* gigante*" or graphen* or grafen* or dendrimer* or fulleren* or "c-60" or "langmuirblodgett*" or mesopor* or "molecul* assembl*" or "ensambla* molecul*" or "molecul* wire*" or "alambr*+ molecul*" or "hilo* molecul*" or "porous silicon*" or "silicon* porosa" or "quantum dot*" or "puntocuantic*" or "quantum well*" or "pozocuantic*"

[98] The definitionofthe Smart Search commandlinefieldnamescanbefound in theappendixofthepresentstudy

		or "quantum comput*" or "computa* cuantic*" or "ordenador* cuantic*" or "quantum wire*" or "alambre* cuantic*" or "hilo* cuantic*" or qubit* or "self assembl*" or “autoensambla* or molecul*” or supramolecul* or supermolecul* or "ultrathin film*" or "ultra thin film*" or "lamina ultra-delgada*" or "lamina ultra delgada*")
*As mentioned in chapter 6.3 Espacenet showed to have limitations regarding the maximum numbers of keywords in each search. Therefore our query was separated in several parts and the retrieved patent lists were exported and later integrated in the same data set which was then imported into Matheo Patent.		

Table 33: Search query for patent retrieval in Espacenet command line search

The search steps were then combined with a Boolean AND / OR combination as explained in the following figure (Fig. 34):

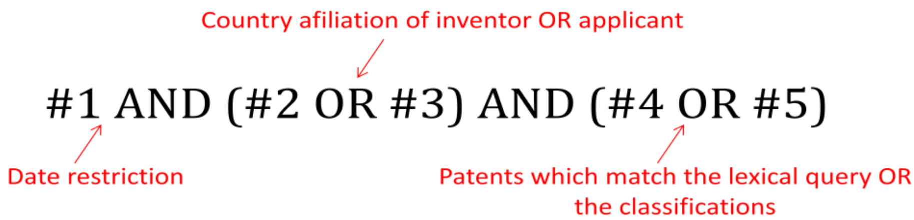

Fig. 34: Combination of search steps with Boolean commands

The query generated a data set was imported into Matheo Patent (Fig. 35). The following table shows the number of records retrieved.

Search steps	Established search criteria	Patents records retrieved in DOCDB[99]
#1	*Year restriction*	35.671.714
#2	*Country affiliation restriction (Spain) of applicants*	439.710
#3	*Country affiliation restriction (Spain) of inventors*	346.221
#4	*International Patent Classifications (IPC) & Cooperative Patent Classifications (CPC)*	424.021
#5	*CALQ with added Spanish keywords in Title or Abstract**	503.813

[99]DOCDB isthemaster database of the European Patent Office and is the data source of Espacenet.

#6	*#1 AND (#2 OR #3) AND (#4 OR #5)*	**3481 patents in 665 families**

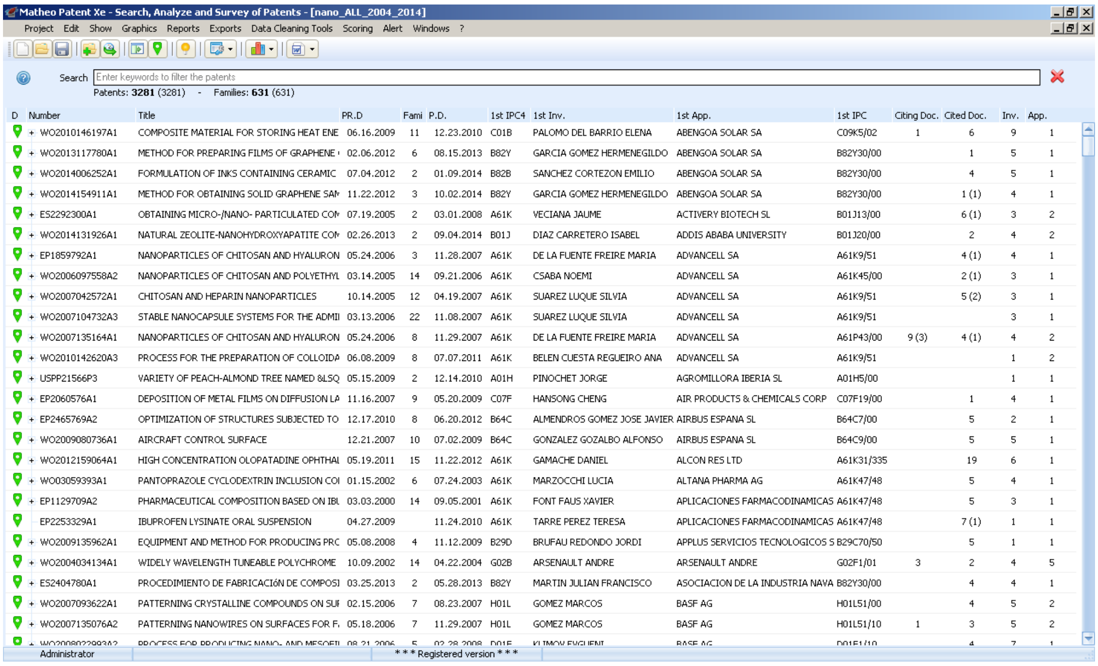

Fig. 35 Nanotechnology Dataset in Matheo Patent (after data harmonization)

6.6 Data harmonization

As it also happens in bibliometrics with article data, when analyzing patent data, the name of one and the same author or entity, often tend to appear in different spelling variations in the databases (Peeters 2010). The different variations in both person names and entity names is due to the fact that a patents are published through different authorities and over extended time periods which often lead to inconsistent data where the same organization or individual appear in different spelling variations, spelling mistakes or typographical errors (Magerman 2006). When working with larger data sets, as it was the case with the present study, this issue had to be addressed since it could have distorted the statistics and led to skewed results.

The process to correct these data entries and to standardize the naming, especially of the patentee data (Inventor/applicant), is called patent data harmonization (or data normalization in the Spanish realm).

For patent data several harmonization initiatives have been developed over the last years. Magerman (2006) developed an automated harmonization method, which was later complemented by harmonizing manually the patentee names of more than 400 top patenting organizations (Peeter 2010).

Thoma et al (2010) described how applicant names with dictionary- and rule-based approaches were harmonized and linked with company accounting data. Callaert et al (2011) outlines the methods for regionalisation, sector allocation and name harmonisation which are used for EUROSTAT statistics from the European Union.

We took the common harmonization rules outlined in these studies as a basis for the data harmonization. Although Callaert et al (2011) describes a special harmonization table for use in databases [100] we opted for an own, manual, data harmonization process since many entities of the Spanish nanotechnology domain were not part of the harmonization tables.

6.6.1 Harmonization rule set used

In the following section we describe the harmonization issues we encountered and the rules we established for the normalization of the patent data set.

General rules

A part from the spelling variations we established the following harmonization rules:

- All names (applicants & inventors) were written in capital letters, institutions belonging to the subset of the Spanish research council CSIC were marked with lower case writing
- All non English characters were replaced (e.g. Ö => O)

No patent titles

Some foreign patent records of the patent family (especially Japanese patent) did not have an English title in the record. In these cases an English title from another patent of the same family was used (e.g. from an EP or PCT patent document).

[100] ECOOM-EUROSTAT-EPO PATSTAT Person Augmented Table (EEE-PPAT)

No Country assignation in applicant / inventor

Empty Country fields were replaced with country value from patents from the same patent family if available.

Entity names (companies, organisations, etc.)

The harmonization of the patent applicant data (Institutions, organizations) was one of the major problems because the same applicant name often appeared in several different forms as can be seen in the examples of the following table (Table 34):

Name variations to be harmonized	Examples
Abbreviations	UNIV SEVILLA INST CAT NANOTEC
Acronyms vs. Full name	CSIC / CONSEJO SUPERIOR DE INVESTIGACION CIENTIFICA
Original language vs. English translation	UNIVERSIDAD DE SEVILLA / UNIVERSITY OF SEVILLE INSTITUT CATALA DE NANOTECNOLOGIA / CATALAN INSTITUTE OF NANOSCIENCE AND NANOTECHNOLOGY
Typographical errors	UNIVERSITY OF *GRENADA*
Wrong acronym interpretation	WIPO => WORLD INTELECTUAL PROPERTY *OFFICE*
Addition of the legal form	NANOBIOMATTERS SL / NANOBIOMATTERS S.L. / NANOBIOMATTERS SOCIEDAD LIMITADA

Table 34: Applicant data harmonization examples

That is why we established the following rules for entity names (companies, organisations, etc.)as described in the following table:

Case	Applied harmonization rule
Person names and company names in the applicant field.	We gave preference to the company name and harmonized the whole patent family accordingly.
Patent documents with a person name in the applicant field and in	We gave preference to the company name and harmonized the whole patent family accordingly.

another patent from the same family with a company name in the applicant field[101].	
Patent documents where the applicant was a research institution.	We checked if the entity forms part in Scimago Institutional Ranking (SIR)[102] and took the harmonized SIR name. In case that there was no SIR record available: ○ for foreign (no Spanish) research entities: we took the English name and not the original language name e.g. "UNIV DANMARKS TEKNISKE => TECHNICAL UNIVERSITY OF DENMARK" ○ for everything else: we took the name as mentioned in the PDF frontpage of the PCT or EP publication (if available).
Patent documents where the applicant was a company.	○ we took the name as mentioned in the PDF frontpage of the PCT or EP publication (if available). ○ If not, we took the name from the company's website (if available) ○ In case of sub-companies , the matrix company was chosen (e.g. CARL ZEISS SMS GMBH => CARL ZEISS) ○ Attention had to be taken in case we had the same company name, but different legal entity eg. MERCK (US and DE)
Patent documents from multinational companies with affiliates located in a country other than that of the parent company.	We matched the patent data with ownership information we retrieved from other patent family members and gave preference to the host company. For example: COGNIS IBERICA (ES) => COGNIS (DE)

Table 35: Entity names harmonization rules

Harmonization rules for person names (inventors or applicants)

Harmonizing the persona name data (e.g. the inventor names) was also a challenging task for this study. Since we want to identify patents with Spanish authorship, naturally most of the

[101] This can be the case when, for example, the company owner filed the first priority patent at a time when the company was not founded yet.
[102]SCImago Institutions Rankings is a highly recognized science evaluation resource to assess worldwide universities and research-focused institutions http://www.scimagoir.com/

patents we were dealing with had non-English inventor and often have spelling errors in the databases. This is a common known problem in many bibliographic databases (patents but as well as in scientific publication databases), and in our case we had to face especially with the two following problems:

- Spanish names have 2 last names
- Spanish special characters

Common problems were that the two last names were mixed up, or the last name was considered first name or vice versa. Another problem we had to deal with were the special characters used in Spanish language like the "ñ" or the accents used in many names e.g. the "é".

In order to harmonize the patents, once downloaded the data set, we identified person name variations (of inventors or individual applicants) by comparing each name with all other similar names in order to match names that appear to be similar but differ because of spelling or language variations.

For this procedure we used the data cleaning functionality of the Matheo Patent Software, that identified similar names and let the user assign one (correct) version to all the others as shown in the example in Fig. 36.

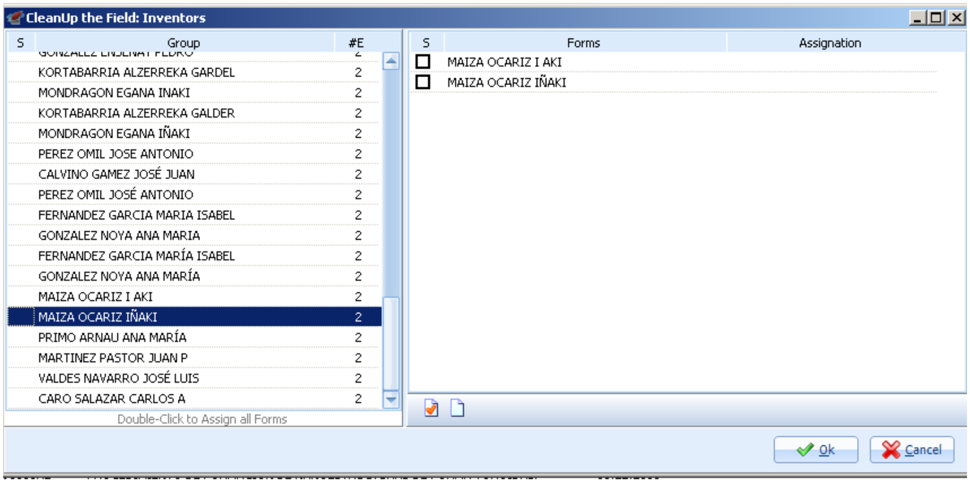

Fig. 36: Matheo Patent name harmonization function

In the following table we sum up the most important harmonization rules we applied for person names (Table 36).

Case	Applied harmonization rule
Multiple variants in the order of First Names, Last names. Same authors with different order in their names were considered by the database as distinct authors.	We changed the person name orders according to the following rule: "LAST NAME 1 LAST NAME 2 FIRST NAME 1 FIRST NAME 2" This was done because the majority of names had already this format and it is the most common one with Spanish names in harmonized databases.
Some authors had their academic titles and were also interpreted by the database as different author.	We deleted academic titles (like Dr.).
Non Spanish authors had a Spanish country affiliation or had the Spanish country code (ES) in their name e.g. the Dutch inventor: "VAN ES MART BEERENS"	○ We deleted records of obviously non Spanish authors. ○ In doubt we cross checked in Internet sources where CVs were available (like Research Gate and Linkedin)
Spanish authors have non-spanish country affiliation.	We checked the country assignation and corrected it if necessary by looking up: ○ the country assignation in the frontpage of the full patent documents ○ Cross checked with Internet sources where CVs were available (like Research Gate and Linkedin) e.g.: The inventor ARRIETA ANTONIO had a German country assignation in patent EP1646057A2 (DE) and we changed it to the correspondent Spanish assignation (ES)
Single characters in the name (ARRIETA ANTONIO J)	We deleted it.
Missing characters in names	We completed obvious missing characters in names FRANCISCO JAVIE => FRANCISCO JAVIER

Table 36: Person names harmonization rules

6.6.2 CSIC harmonization

CSIC stands for "Consejo Superior de Investigaciones Científicas" (Spanish National Research Council).[103] It is the largest Spanish public research institution with the highest patent output in Spain (Etxabe et al 2012).

From a bibliometric viewpoint it has the particularity of having multiple research institutions throughout Spain but with all patent records filed under the same name and address data of the host entity (the CSIC). This fact distorts the statistics for this applicant since it does not reveal the geographical origin of the invention, nor does it show any collaboration on a research centre level.

As the outcome of preliminary nanotech patent searches showed us that the CSIC is one of the main patenting entities in our study we decided, for the reasons mentioned before, to identify the CSIC research centres of each patent that we have retrieved for the present study.

Fig. 37 Screenshot of the CSIC harmonization spreadsheet used for this study

6.6.3 Results of the harmonization process

The following table shows the results of the before mentioned harmonization process of the retrieved nanotech patent data set (Table 37). We managed to reduce the total patent record set by 203 records (34 families) and via the name harmonization we reduced the number of applicants by 105 and the inventors by 164 person names.

	Before data harmonization	After data harmonization	# records harmonized
Total patent document set (record count)	**3481**	3278	203

[103] http://www.csic.es/

Total patent document set (family count)	**665**	631	34
Applicants	2012	1907	105
Inventors	2256	2092	164
CSIC	1 entity	39 CSIC institutions	39

Table 37: Harmonization results

6.7 Patent record counting

Regarding the counting methods for the generation of the before mentioned indicators we have to deal with similar problems as they occur in the world of bibliometrics, especially with the indicators which are related with authors since the counting of co-authored papers is a subject of debate regarding the question if the individual authors should all have assigned full credit (whole counting), or only the correspondent share divided by the numbers of total authors (fractional counting) should be used (Okubo 1997).

Counting of country cooperation has a similar problematic, for example, if fractional counting is applied, each country affiliation of applicants would be given a proportional part of patents and as a consequence, the sum of country totals would add up to the sum of the total number of patents (Palmberg 2009).

Regarding the present study we used whole patent counts in our analyses for the following reasons:

- In general, for scientists and politicians who use science indicators, whole counting is far more comprehensible and easy to interpret. (Leydesdorff, 1991)
- When counting authors many bibliometricians argue that fractional counting is an inferior procedure and think that equal counting of all authors is in most cases the best solution (Van Raan and Tijssen, 1990).

6.8 Used indicators

The following table outlines the indicators (as explained in chapter 4.1.5) which were applied in this nanotechnology study, with the corresponding metrics, data output and types of graphical visualization (Table 42).

Performance Indicators

Indicator	Metrics	Data output	Visualization
Patent country output	Patent document counts per applicant country of residence	Ranked list	Pie Chart
Papers country output	Scientific publication counts per author country of residence	Ranked list	Pie Chart
Technological distribution	Patents filed (priority) / CPC	Ranked list	Bar Graph
Technology evolution	Patent counts in technology field / year (priority date and publishing date)	Ranked list	Bar Graph
Publications per patent office	Patent application published / patent authority	Ranked list	Bar Graph
Country of Applicants co-occurrence	Applicant country / Applicant country	Matrix	Network map
Country of Inventors co-occurrence	Inventor country / Inventor country	Matrix	Network map
Top applicants Geographic coverage	Ratio patent application published / family size	Ranked list	Choropleth map
Applicants (per patent family & records)	Patent family/records counts per applicant	Ranked list	Bar Graph Scattergraphs
Applicants (per article publication)	Paper counts (published) per applicant	Ranked list	Bar Graph Scattergraphs
Patent internalization rate of applicants	Patent document counts (published) per applicant / Patent family counts per applicant	Ranked list	Bar Graph
Inventors (per patent family & records)	Patent family/records per inventor	Ranked list	Bar Graph

Table 38: Performance indicators used in study

Technology network indicators

Indicator	Metrics	Data output	Visualization
Applicant technology network	CPC / applicant	Matrix	Network map
Inventor technology network	CPC / inventor	Matrix	Network map

CPC Technological Network	CPC / CPC	Matrix	Matrix

Table 39: Technology indicators used in study

Collaboration indicators

Indicator	Metrics	Data output	Visualization
Applicant collaboration network	Applicant / Applicant	Matrix	Network map
Inventor co-authorship collaboration network	Inventor / Inventor	Matrix	Network map
Inventor-Applicant collaboration network	Inventor / Applicant	Matrix	Network map

Table 40: Collaboration indicators used in study

Patent value indicators

Indicator	Metrics	Data output	Visualization
Top Inventors per patent	Inventors counts / Patent document	Ranked list	Table
Top Applicants per patent	Applicants counts / Patent document	Ranked list	Table
Top Family size per patent	Patents application published / family members	Ranked list	Table
Inventors per applicant	Inventors counts / applicant	Ranked list	Table
Inventors ratio	Number of inventors / patent family	Ranked list	Table
Top forward cited patents	Number of citing patents / patent	Ranked list	Table
Top forward cited applicants	Number of citing patents / applicant	Ranked list	Table
Citation Ratio	Number of forward citations / patent family	Ranked list	Table

Table 41: Patent family & geographic coverage indicators used in study

Text mining indicators

Indicator	Metrics	Data output	Visualization
Title Co word Analysis	Textmining keywords in patent title	Matrix	Network map

Table 42: Text mining indicators used in study

7 Results

This chapter is the core part of the present study since it will show the results we have obtained following the methodology and the search strategy outlined in previous chapters.

7.1 Performance indicators

7.1.1 Spanish nanotechnology in a global context

World patent output

By launching our established search query to the total worldwide database and to applicant/inventor affiliations of seven important Nano output countries (Li 2007) we could see how the Spanish nanotechnology is behaving compared to an international basis (figure 1).

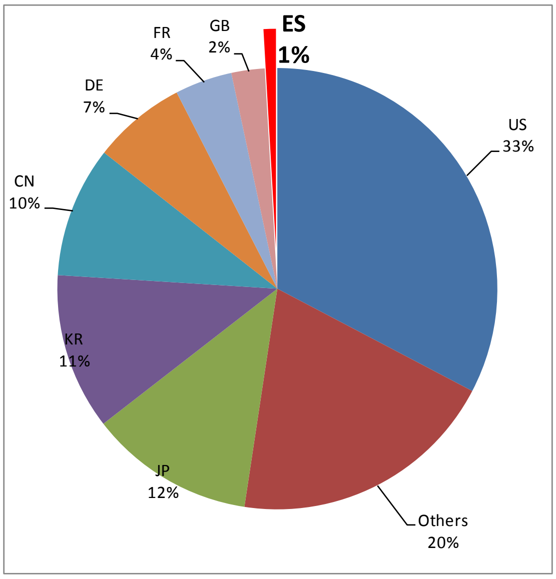

Fig. 38: Worldwide nanotech patenting output. Source: Espacenet

Only 1% of the total nanotechnology related patents had Spanish authorship, whereas the strongholds of nanotechnology patenting lies within the USA with 33%, following Japan (12%), South Korea (11%) and Germany with 7%. The most productive European country after Germany is France (4%) and Great Britain with 2% of the worldwide nanotechnology patent output.

The same search was then used on the Scopus database of scientific publications[104] in order to compare the patent dimension with the scientific volume of each country. In the latter, Spain showed to have, with 2%, a twice as high percentage in scientific publications than with patents. Also China had remarkably more nanotechnology related articles than patents (16% vs. 10 %). Whereas the share of France and Germany remained similar to the US, Japan and South Korea showed to have a significantly higher nanotech patent output than paper production as can be seen in the following figure (Fig. 39).

It seems then that we are facing two types of countries. On the one hand we have a group that would be composed of United States, Japan and South Korea where the production of patents is relatively higher than the production in papers. On the other hand we have a group with the opposite behaviour, which include especially China and to a lesser extent Spain and United Kingdom. Both groups devote significant financial resources to the development of knowledge, however, the first appears to have greater capacity to transfer to the productive sector while the second might not be taking advantage of all the knowledge invested. The explanation for the Chinese case might be related to a certain lack of "patent culture" which had such resonance over the past years of its strong growth in GDP. Deepening this line is beyond the scope of this work, but we think it can be a future line of research very interesting.

In the case of Spain (and perhaps Great Britain) we believe that is because there has been a great incentive to increase scientific size in this country in recent decades, but this incentive was focused on the academic and public sector and entrepreneurship and innovation seemed to have received less attention. This effect seems more balanced in the case of other European countries like France and Germany.

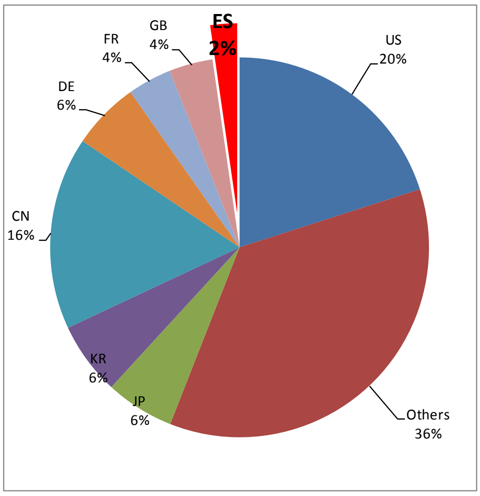

Fig. 39: Worldwide nanotech papers output. Source: Scopus

[104] www.scopus.com

World thematic classification

Next, we wanted to see Spain's thematic specialization in nanotechnology and its differences to the rest of the world. The figure Fig. 40 shows the patents with Spanish authorship (left) and the worldwide (right) classified by the main groups of the Cooperative Patent Classification (CPC, see also chapter 3.1.5).

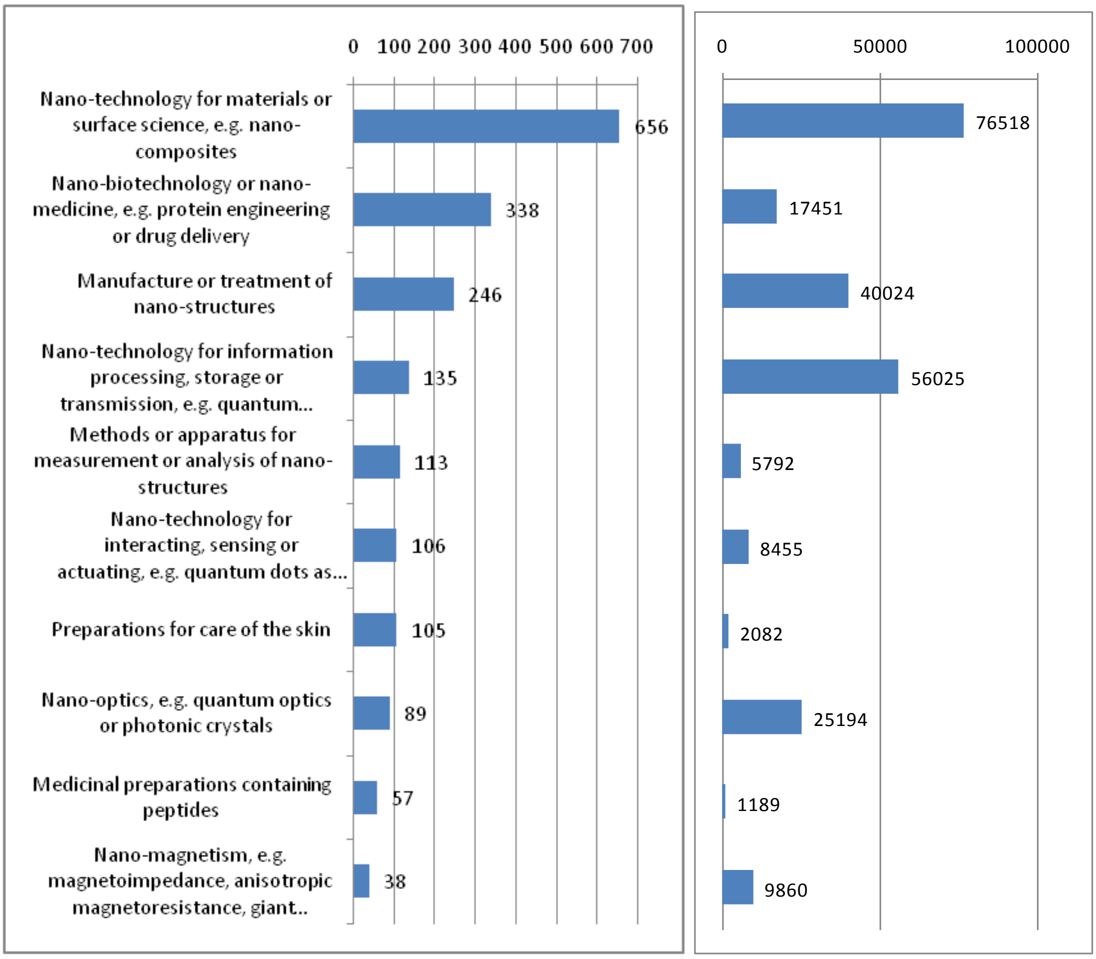

Fig. 40: Nanotechnology specialization Spain (left) vs. worldwide patent production. Source: Espacenet

As we can see most nanotechnology patents with Spanish authorship turned out to be classified related to Nanocomposites(#1), followed by Nano-Biotechnology/Nano-Biomedicine (#2) and Nanostructures (#3) and Nanotechnology related to Information processing (#4) as can be seen in Table 43.

We could detect some differences in the ranking, especially for the patents related to Nano-Biotechnology/Nano-Biomedicine and to Nanostructures, that are both ranked 3 positions higher than on a worldwide level, and Nanotechnology in Cosmetics ("Preparation for care of the skin") which are ranked 2 positions higher, whereas nano-optics, nano-magnetism and nanotechnology for information processing is ranked lower.

Description	# rank ES	# rankWorld	rankdifference
Nano-technology for materials or surface science, e.g. nano-composites	1	1	0
Nano-biotechnology or nano-medicine, e.g. protein engineering or drug delivery	2	5	+3
Manufacture or treatment of nano-structures	3	3	0
Nano-technology for information processing, storage or transmission, e.g. quantum computing or single electron logic	4	2	-2
Methods or apparatus for measurement or analysis of nano-structures	5	8	+3
Nano-technology for interacting, sensing or actuating, e.g. quantum dots as markers in protein assays or molecular motors	6	7	+1
Preparations for care of the skin	7	9	+2
Nano-optics, e.g. quantum optics or photonic crystals	8	4	-4
Medicinal preparationscontainingpeptides	9	10	+1
Nano-magnetism, e.g. magnetoimpedance, anisotropic magnetoresistance, giant magnetoresistance or tunnelingmagnetoresistance	10	6	-4
white: same ranking ES-World Light green: Spain higher ranked than World Light red: Spain lower ranked than World			

Table 43: Nanotechnology specialization ranking Spain vs. worldwide. Source: Espacenet

When comparing the segmentations shares to the total data set, as showed in the following figure (Fig. 40), we get more detailed information. Although, patents classified as Nanocomposites are both ranked # 1 in both realms, in Spain the share is considerable higher than on a worldwide level with 21% vs. 15%. The differences become even more evident with patents classified as Nano-Biotechnology/Nano-Biomedicine with an 11% share in patents with Spanish authorship vs. only 3 % in patents from all authors.

On the other hand there are also some areas where Spain has a lower share in its thematic segmentation. That is the case especially for Nanotechnology patents related to Information processing (4% ES vs. 11% world) and Nano-optics (3% ES vs. 5% world).

We can therefore say that the Spanish thematic profile is biased towards the production of nanomedical components, proteins cosmetics and drugs. At the same time there is a deficit in the field of patents related to nano-optics, nano-magnetism and nanotechnology for information processing. In the general field of material science the volume is equivalent to the world.

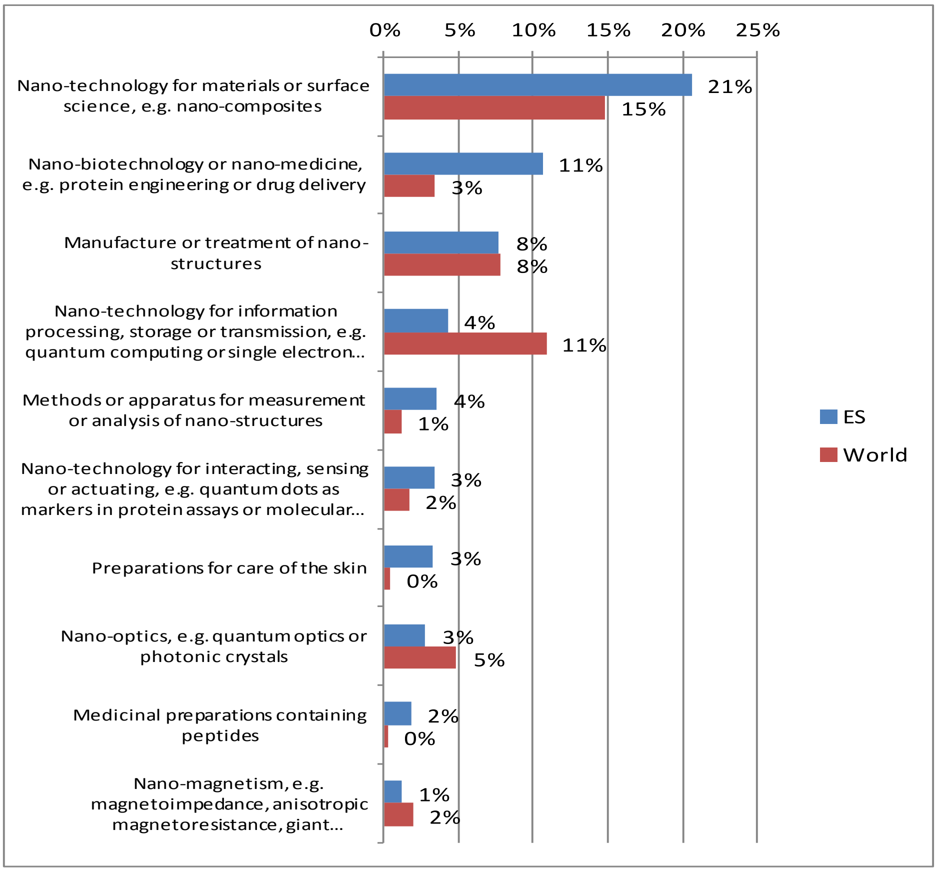

Fig. 41: Patents classification distribution Spain vs. worldwide

7.1.2 Temporal evolution

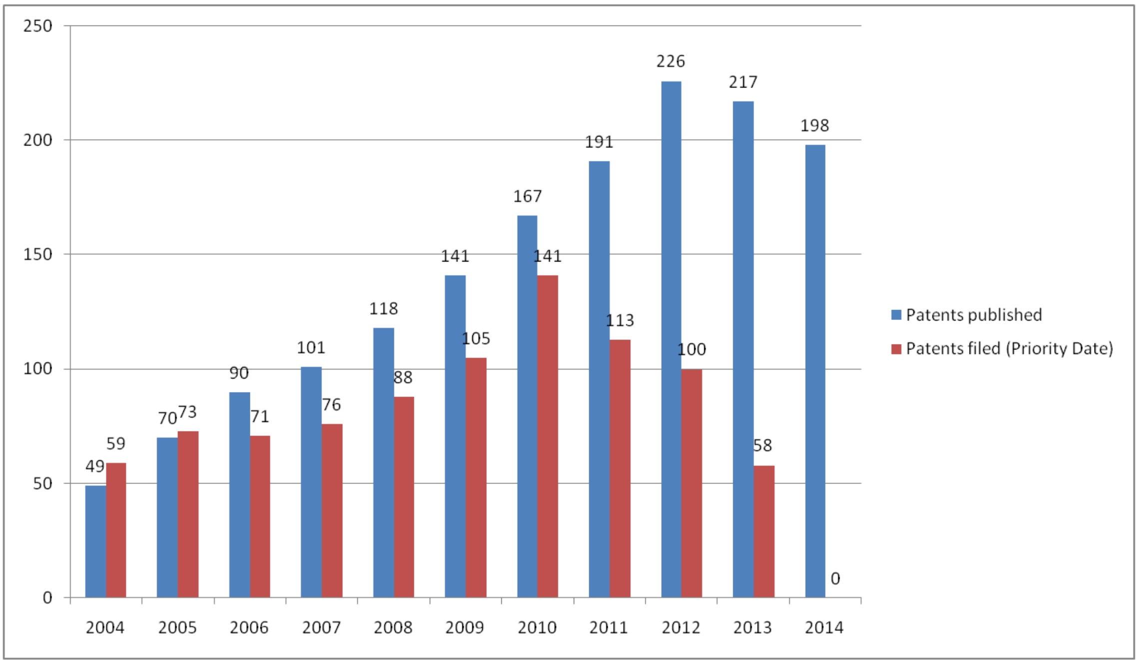

Fig. 42: Patents with Spanish participation (inventor or applicant)

When analyzing the evolution of patenting activity of the Spanish nanotechnology sector a constant increase in patent filing could be observed till the year 2010 (Fig. 42). From then on patent filing activity dropped to nearly a third (141 patents filed in 2010 vs. 58 patents filed in 2013), although this data has to be considered with care for the following reasons:

In the trend analysis we deal with two date fields: Patents filing date is the day the patent was registered at the patent office for the first time (the priority date). The problem with this indicator is, that in most patent systems the patent is kept secret for at least 18 months after filing, and therefore the data is only available as an indicator with a considerable time lag in the data sources (see also chapter 3.1.1).

Since the latest data retrieval or this study was done in January 2015, no filing data was available till mid 2013. Therefore no records for filed patents were available in 2014 and for 2013 it could be considered that only half of the filed patents were retrieved. This leads to an estimated result in number of filed patents in 2013 similar to the figure of 2012.

In any case one can say that the growth of this sector in Spain is sustained and if we consider that many applications are filed but not published yet, the growth will continue in the coming years.

7.1.3 Patent internationalization

By identifying the patent authorities where the applicants file their patents we can see which countries or patent systems (see chapter 3.1.3) were considered of interest for the applicant to protect their invention. As shown in Fig. 43 as expected from patents with Spanish authorship most patents were filed at the Spanish patent office (ES), but closely followed by filings of PCT applications (WO) at the World Intellectual Property Organization. The third and fourth most important patent filing destination was the US and the European Patent Office (EP).

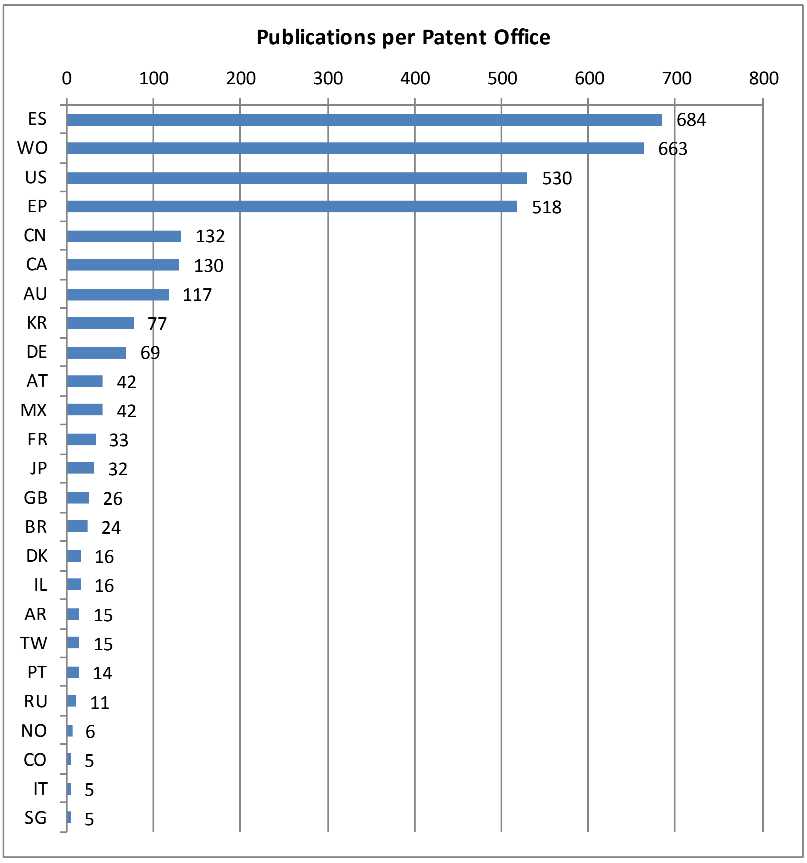

Fig. 43: Publications per patent office. Source: Espacenet

There is no doubt that the patenting destination by patent office is clearly influenced by the geographical context. Spain (ES) and the European (EP) and international patents system PCT (WO) are the top three levels, although at fourth position we have the United States (US).

While it is beyond the immediate area of Spain, the US productive system is the only country that can be considered a proxy of the world economic system and therefore need to be present. Of the rest, it is striking how little interest of Spanish companies and institutions can be noticed in Japan, comparing to China, which seems to have overtaken it as a more desirable patenting destination for Spanish nanotechnology.

7.1.4 Country collaboration

Another interesting finding was the collaboration behaviour of the patents in our retrieved dataset. Regarding the co-patenting of Spanish applicants (institutions and companies), which can be considered as institutional collaboration by co-filing a patent (see also chapter 4.1.5), most collaborations were done with applicants from Germany (8) followed by Great Britain (7) and the United States (6) as can be observed in the following network map (Fig. 44).

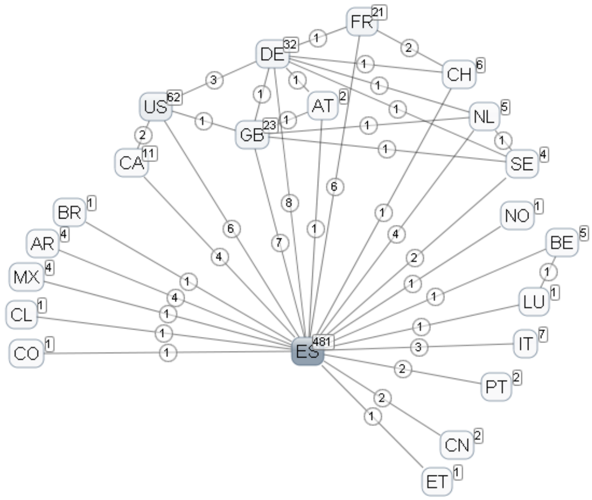

Fig. 44: Country of Applicants co-occurrence (per family count)

Whereas this collaboration figure is relatively low, the co-authorship of inventors from Spain with inventors from other countries is considerably higher. As we can see in the network map (Fig. 45), most collaboration in nanotechnology patents is done with inventors from the US, followed by Germany, Great Britain and France.

However, we have to be careful because sometimes appears a Spanish inventor (working at a Spanish institution) collaborating with other foreign inventor (of a foreign institution), but in the applicant field appears only the foreign institution. The ability to quantify to what extent there are inventors who patent outside the institution could give us an idea of the degree of intellectual loss of the Spanish institutions themselves.

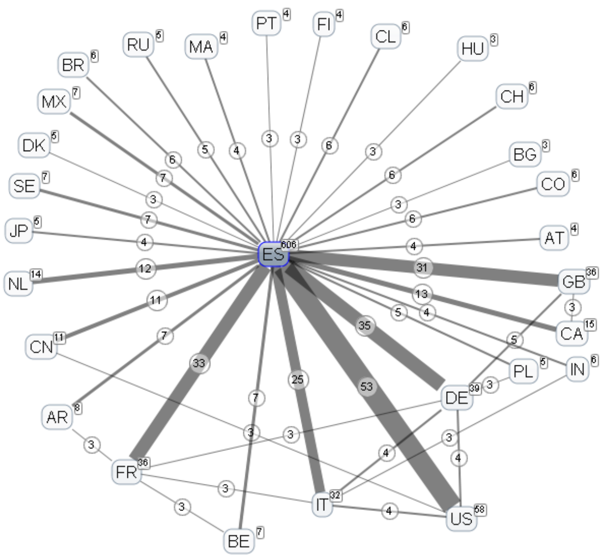

Fig. 45: Country ofinventorsco-occurrence(per family) (min. 2 pairs)

7.1.5 Geography

Another important question we wanted to answer is where, in geographic terms, has the invention its origin. In order to find this out, we identified the Spanish province of residence of all applicants and could then calculate the nanotechnology patent output per geographic region as can be seen in the following map (Fig. 40).

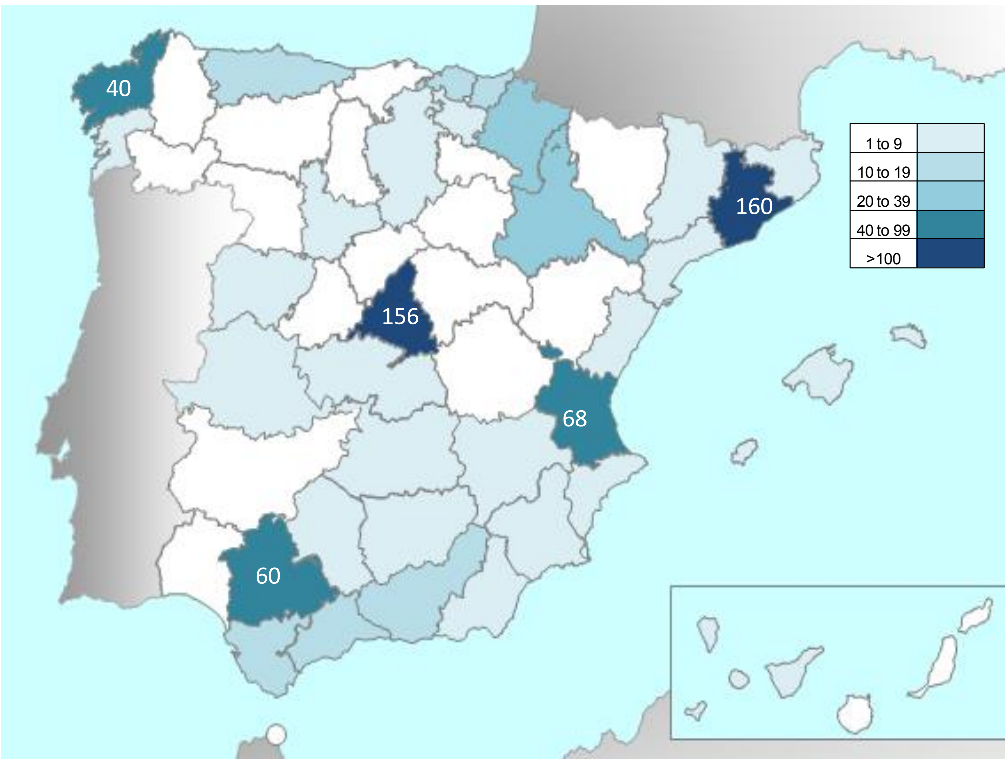

Fig. 46: Output per province (patent family)

As can be seen, two hot spots of Nanotechnology patent generation become clearly visible with nearly the same amount of nanotechnology related patents generated in the analyzed timeframe of this study: Barcelona and Madrid. After that, we can point out three other important regions where nanotechnology related patents are generated: the province of Valencia, Seville and La Coruna in the north west of the country.

The following table give the full information of the geographical dispersion of the Spanish nanotechnology entities (Table 44), ranked by patent family:

# rank	Spanish province	Patent families
1	Barcelona	160
2	Madrid	156
3	Valencia	68
4	Sevilla	60
5	La Coruña	40
6	Navarra	26
7	Zaragoza	22
8	Granada	18
9	Vizcaya	18
10	Asturias	16
11	Guipúzcoa	11
12	Cádiz	10
13	Málaga	10
14	Alicante	9
15	Tarragona	9
16	Valladolid	6
17	Castellón	5
18	Ciudad Real	5
19	Burgos	4
20	Córdoba	4
21	Almería	3
22	Álava	2
23	Albacete	2
24	Cáceres	2
25	Murcia	2
26	Gerona	1
27	Islas Baleares	1
28	Jaén	1
29	Lérida	1
30	Pontevedra	1
31	Salamanca	1
32	Santa Cruz de Tenerife	1
33	Toledo	1

Table 44: All sectors per province (ranking per patent family, whole counting)

7.1.6 Sector analysis

After putting the data in global context we wanted to know more about its structure in Spain, and which sectors play an important role. For this we assigned the following six categories to the Spanish applicants of the data set:

- CSIC
- University
- Company
- Other research centre
- Hospital
- Private person

As can be seen in Fig. 47 most patents originate from universities (37%), followed by private companies (24%), the CSIC (20%) and other research centres (16%). It is interesting to see the large number of patents applied by individuals (44). While it is very common that people apply for patents on a personal basis, this is usually not common in highly complex technological areas such as the nanoworld, which require equipment and infrastructure which usually is not available on a domestic scale. Tracking this behaviour might be an interesting line for future research.

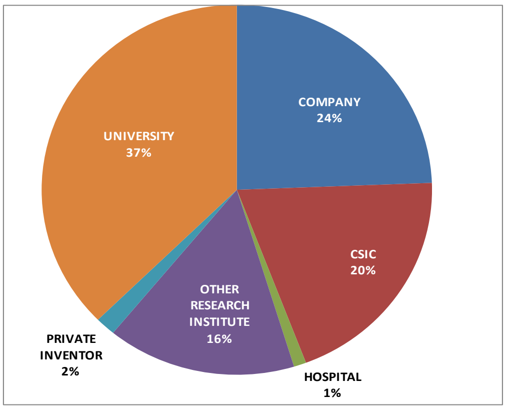

Fig. 47: Origin of patent output per sector in Spain

Next we compared the sector output with the correspondent scientific papers production[105] (Fig. 48) and could see similar shares with an increase of the share of universities as the main nanotech paper producer and with the significant decrease of the private companies who showed to have nearly no nanotechnology related scientific papers, standing in contrast to its high share in patent output, a behaviour directly related with the comparison on a national basis, as explained in the beginning.

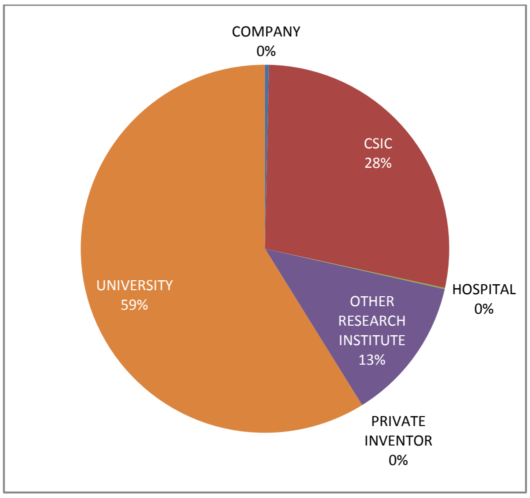

Fig. 48: Origin of scientific paper output per sector in Spain. Source: SCImagoIR

[105]By querying the paper output in the nanotechnology categroy of the SCIMAGO Intitutions Ranking (www.scimagoir.com)

7.1.7 Institutions

Now that we have seen where the focal points were located, the next step was to find out who are the important players in the area. Therefore this chapter will present our findings regarding the Spanish applicants working in the field.

The figure Fig. 49 gives a ranking of the Spanish applicants with most patent families. As we have explained earlier, a patent family stands for one invention, which means that this ranking shows the most inventive applicants.

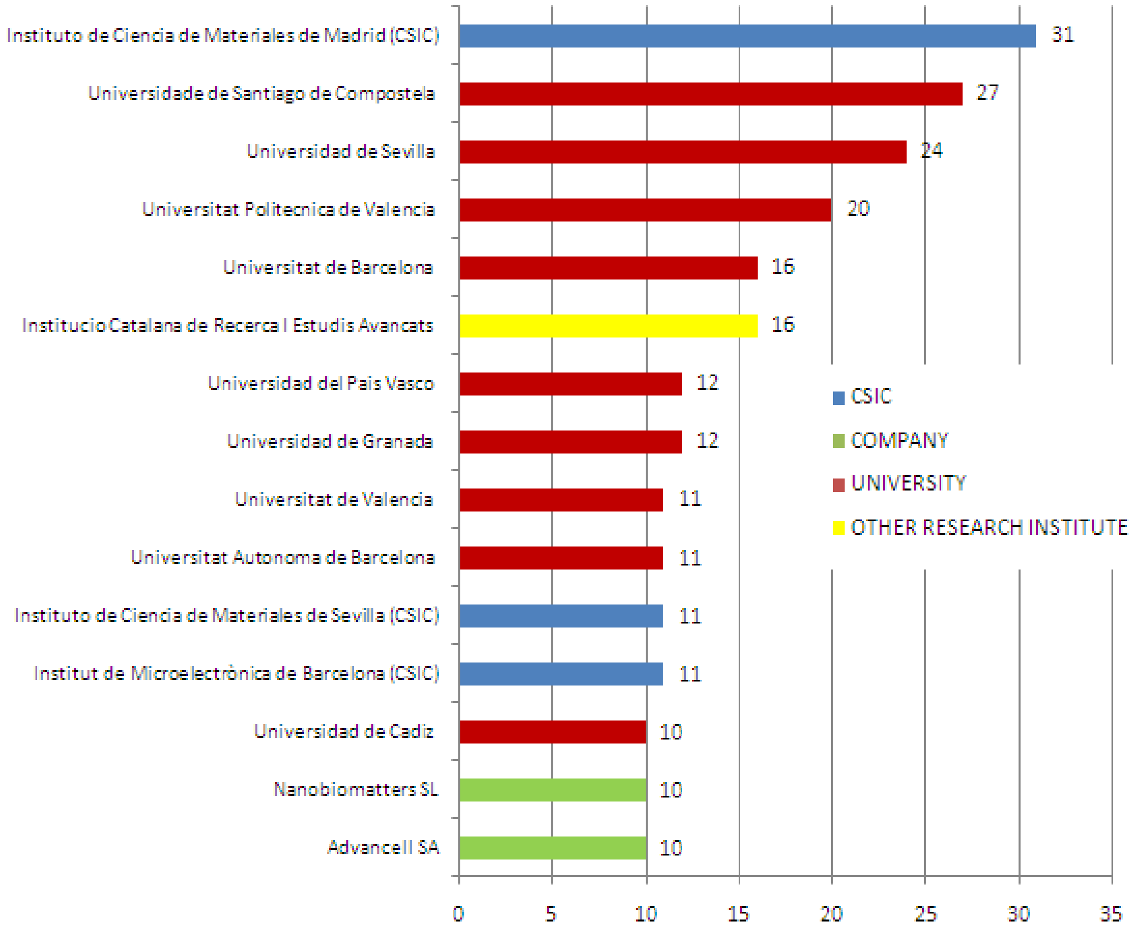

Fig. 49: Top 15 Spanish applicants (ranked per patent family counts)

The most inventive applicants was the CSIC research centre Instituto de Ciencia de Materiales de Madrid (ICMM), followed by the Universidade de Santiago de Compostela and the Universidad de Sevilla. Their inventive strength is an important factor why their correspondent Spanish regions are amongst the top, as outlined in the chapter before.

In the case from the region of Barcelona the inventive strength is diversified into more than one main nanotechnology patenting entity: the strongholds are the Institucio Catalana de Recerca I Estudis Avancats (ICREA) a public-private research centre, its two main universities, Universitat de Barcelona and Universitat Autonoma de Barcelona and the CSIC centre Institute of Microelectronics of Barcelona (IMB-CNM).

The private companies are only represented at the end of the ranking (at position #13 and #14 respectively): the company Advancell SA also based in Barcelona and the most active company in terms of patenting in this study[106], and Nanobiomatters SL a Valencia based company and second most active company in patenting.

By looking at the total number of patent records the Spanish applicant ranking changes slightly (Fig. 50). As outlined in chapter 4.1.5, when considering the number of patent records we do not evaluate the inventiveness but moreover the willingness of the applicant to extend its invention to multiple countries or patent systems in order to extend its protection. It can therefore be seen as a value indicator, showing the effort of the applicant in internationalizing its invention. Regards to the outcome of the ranking we can observe that the CSIC centre ICMM lowered its rank whereas the Universidade de Santiago de Compostela and the Universidad de Sevilla are leading in terms of total published nanotechnology patent documents. Remarkably the two private companies (Advancell and Nanobiomatters) also climbed up the ranking, now on position #4 and #6 respectively.

[106]Although it ceased its economic activity when this study was created. Source: http://www.lavanguardia.com/20140228/54402644347/advancell-presenta-concurso-voluntario-y-reduce-estructura-aintzane-gastesi.html

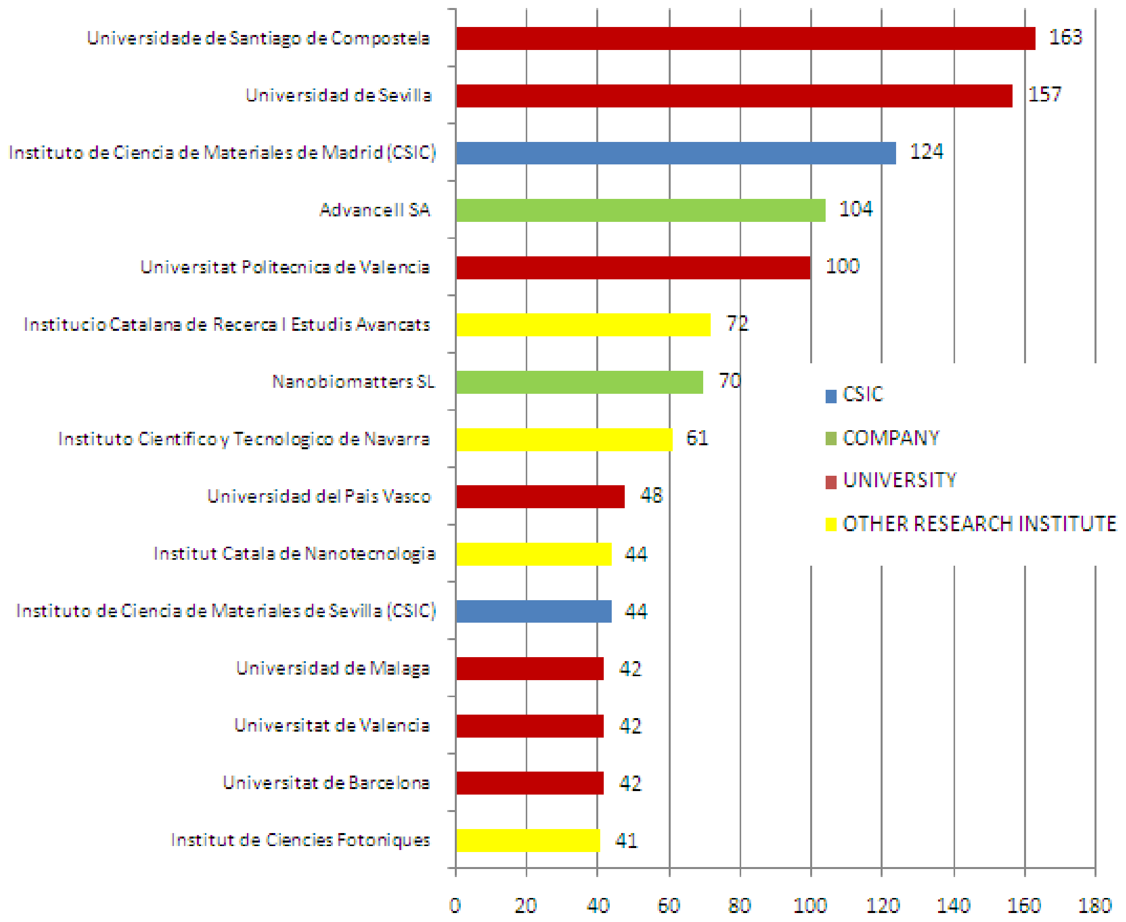

Fig. 50 : Top 15 Spanish applicants (ranked per patent publication counts)

Providing the patent family output and the patent record output we could calculate the ratio of the patent family and the total record counts which we call patent internalization ratio (Patent IR) . This can help us to see in what dimension the applicants internationalize or extend its invention to several countries (creating a patent document for each country).

Applicants (All sectors)	Patent families	Patent records	Patent IR (records/family)
Salvat Lab Sa	1	20	20
Grifols Sa	2	35	17,5
Interquim Sa	1	14	14
Silicalia Sl	2	26	13
Dendrico Sl	1	13	13
Tcd Pharma Sl	1	13	13
Nylstar Sa	1	12	12
Hospital De La Santa Creu I Sant Pau	1	11	11
Hospital Universitari Germans Trias I Pujol	1	11	11

Tolsa Sa	1	11	11
Advancell Sa	10	104	10,4
Biolan Microbiosensores Sl	1	10	10
Histocell Sl	1	10	10

Table 45: Top applicants by patent internalization ratio (min. 10)

As can be seen in Table 45 this calculation generated a significantly different ranking result, including mostly private companies that own few inventions (1 to 2 patent families) but have extended these inventions to many countries. Leading the ranking is the company SALVAT, a pharmaceutical company based in Barcelona, which showed to have one invention that generated 20 patent documents. Followed by GRIFOLS, another Barcelona based pharmaceutical company that has two inventions that generated 35 patents.

Here we are dealing with companies whose business model rely heavily on innovation and therefore cannot afford to leave it unprotected in too many countries in the world. It is a different behaviour than we can find in the universities or the CSIC.

In the following tables we have applied the patent internalization indicator to the sectors defined earlier in order to detect the entities which extended their patents to foreign countries and thus showed to provide an effort in internationalizing its technology.

Since we wanted to focus on institutions and companies, we did not analyze the patent output of private persons more in detail. Furthermore we put together the results of the sectors OTHER RESEARCH CENTRE & HOSPITAL since the latter only showed to have very few records as seen in chapter 7.1.6.

# rank	Applicants (Sector: CSIC)	Patent families	Patent records	Patent IR (records/family)
1	Instituto de Química Avanzada de Cataluña (CSIC)	4	33	8,25
2	Instituto de Investigaciones Biomédicas de Barcelona (CSIC)	1	7	7
3	Centro de Investigación en Nanomateriales y Nanotecnología (CSIC)	7	40	5,714
4	Instituto de Microelectrónica de Madrid (CSIC)	9	39	4,333
5	Instituto de Ciencia de Materiales de Madrid (CSIC)	31	124	4
6	Instituto de Ciencia de Materiales de Sevilla (CSIC)	11	44	4
7	Laboratorio de Física de Sistemas Pequeños y Nanotechnología (CSIC)	3	11	3,667
8	Instituto de Agroquímica y Tecnología de Alimentos (CSIC)	6	21	3,5
9	Instituto de Cerámica y Vidrio (CSIC)	9	31	3,444
10	Instituto de Tecnología Química (CSIC)	9	31	3,444
11	Centro Nacional de Investigaciones Metalúrgicas	1	3	3

	(CSIC)			
12	Estación Experimental del Zaidín (CSIC)	1	3	3
13	Institut de Microelectrònica de Barcelona (CSIC)	11	30	2,727
14	Instituto de Ciencia de Materiales de Aragón (CSIC)	5	13	2,6
15	Institut de Ciència de Materials de Barcelona (CSIC)	7	18	2,571

Table 46: Top 15 CSIC institutions (ranking per patent IR)

Surprisingly the Instituto de Ciencia de Materiales de Madrid as the CSIC institution with the most patents is not the one whose ratio of internationalization is the highest (Table 46). Leading the ranking is the Instituto de Química Avanzada de Cataluña with 4 inventions that have been extended to 33 patent authorities.

# rank	Applicants (Sector: Company)	Patent families	Patent records	Patent IR (records/family)
1	Salvat Lab SA	1	20	20
2	Grifols SA	2	35	17,5
3	Interquim SA	1	14	14
4	Silicalia SL	2	26	13
5	Dendrico SL	1	13	13
6	Tcd Pharma SL	1	13	13
7	Nylstar SA	1	12	12
8	Tolsa SA	1	11	11
9	Advancell SA	10	104	10,4
10	Biolan Microbiosensores SL	1	10	10
11	Histocell SL	1	10	10
12	Lipotec SA	5	40	8
13	Bionanoplus SL	2	16	8
14	Digna Biotech SL	1	8	8
15	Itaca SAu	1	8	8

Table 47: Top 15 Companies (ranking per patent IR)

As we have observed before in the general ranking of all applicants, the private companies, although having only few inventions compared to the research centres, showed to have the highest patent ratio of internationalization (Table 47). Most of them are small and medium sized companies (SME) from the pharmaceutical sector, where it is not unusual that the business model of the whole company relies on a single (patented) pharmaceutical component. This could explain the importance for the companies to extend this patent to the most countries possible in order to secure commercial monopolies in these countries.

# rank	Applicants (Sector: University)	Patent families	Patent records	Patent IR (records/family)
1	Universidad de Alcala	2	19	9,5
2	Universidad Rey Juan Carlos	1	7	7
3	Universidad de Sevilla	24	157	6,542
4	Universidade de Santiago de Compostela	27	163	6,037
5	Universidad de Murcia	1	6	6
6	Universitat Rovira I Virgili	3	17	5,667

7	Universidad de Malaga	8	42	5,25
8	Universitat Politecnica de Valencia	20	100	5
9	Universidad del Pais Vasco	12	48	4
10	Universitat Pompeu Fabra	2	8	4
11	Universidad de Jaen	1	4	4
12	Universidad de Mondragon	1	4	4
13	Universitat de Valencia	11	42	3,818
14	Universidad Complutense de Madrid	9	34	3,778
15	Universidad de Zaragoza	8	30	3,75

Table 48: Top 15 Universities (ranking per patent IR)

In the university ranking of patent internalization the two nano patenting powerhouses (Universidad de Sevilla and Universidade de Santiago de Compostela) fall on rank 3 and 4 and the universities Universidad de Alcala and Universidad Rey Juan Carlos are leading the ranking, both with relatively low inventive patent output (2 and 1 inventions respectively) but high patent externalization effort (Table 48).

# rank	Applicants (Sector: Other research centre & Hospitals)	Patent families	Patent records	Patent IR (records/family)
1	Hospital de La Santa Creu I Sant Pau	1	11	11
2	Hospital Universitari Germans Trias I Pujol	1	11	11
3	Centro Nacional de Tecnologia Y Seguridad Alimentaria	2	16	8
4	Institut Quimic de Sarria	1	8	8
5	Instituto Nacional de Investigacion Y Tecnologia Agraria Y Alimentaria	1	8	8
6	Instituto Cientifico Y Tecnologico de Navarra	8	61	7,625
7	Instituto Nacional de Tecnica Aeroespacial Esteban Terradas	4	23	5,75
8	Centro Tecnologico L'Urederra	2	11	5,5
9	Instuto Tecnologico del Embalaje Transporte Y Logistica - Itene	2	11	5,5
10	Fundacion Agencia Aragonesa Para La Investigacion Y desarrollo	2	10	5
11	Ikerlan Centro Tecnologico	2	10	5
12	Hospital General Universitario Gregorio Maranon	1	5	5
13	Institut Catala de Nanotecnologia	9	44	4,889
14	Institut de Ciencies Fotoniques	9	41	4,556
15	Institucio Catalana de Recerca I Estudis Avancats	16	72	4,5

Table 49: Top 15 Research Centres & Hospitals (ranking per patent IR)

Finally, in the ranking of other research entities, two hospitals are leading the ranking, the Hospital de La Santa Creu I Sant Pau and Hospital Universitari Germans Trias I Pujol (Table 49).

7.1.8 Patent output vs. scientific paper output

After having identified the main entities of the Spanish nanotechnology landscape it was of interest to compare their patenting with their scientific publishing behaviour in order to see some kind of correlation. The chart in Fig. 52 shows the distribution of the main applicants and visualizes their output in patents families and papers.

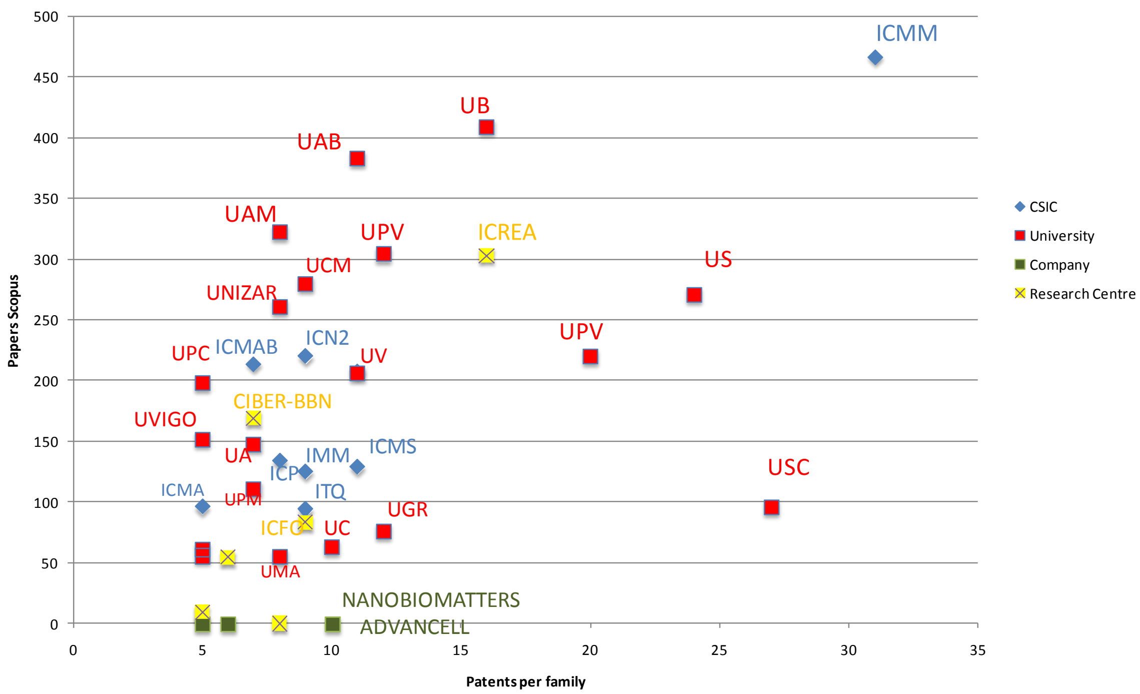

Fig. 51: Paper and patent output (per family) of applicants per sector

We can see the top applicants, the Spanish universities of Santiago de Compostela (USC) and Seville (US) in the right side, followed with some distance from the Universidad Politecnica de Valencia (UPV). Although the USC has the highest patent output, it has a moderate paper output comparing to the other universities (in red).

The most productive entity in both, patent families and papers is the Instituto de Ciencia de Materiales de Madrid (ICMM). The most productive in paper publishing turned out to be the two universities of Barcelona (UB and UAB), although the latter have far less patents compared to the ICMM. Non university and CSIC research centres which we can point out is the Institució Catalana de Recerca i Estudis Avançats (ICREA) with a relatively high patent and paper output. The top patenting companies, like ADVANCELL and NANOBIOMATTERS (in green), barely published scientific papers related to nanotechnology (therefore most companies are visualized on the x-axis with no vertical elevation).

The next graph (Fig. 52) uses patent record counts that, as we have outlined before, can be considered as an indicator for internationalisation. Also here, the ICMM demonstrates its dominant position having most patent records and published papers, but the internationalization behaviour of USC and US is higher that ICMM. In this way, these universities works like companies.

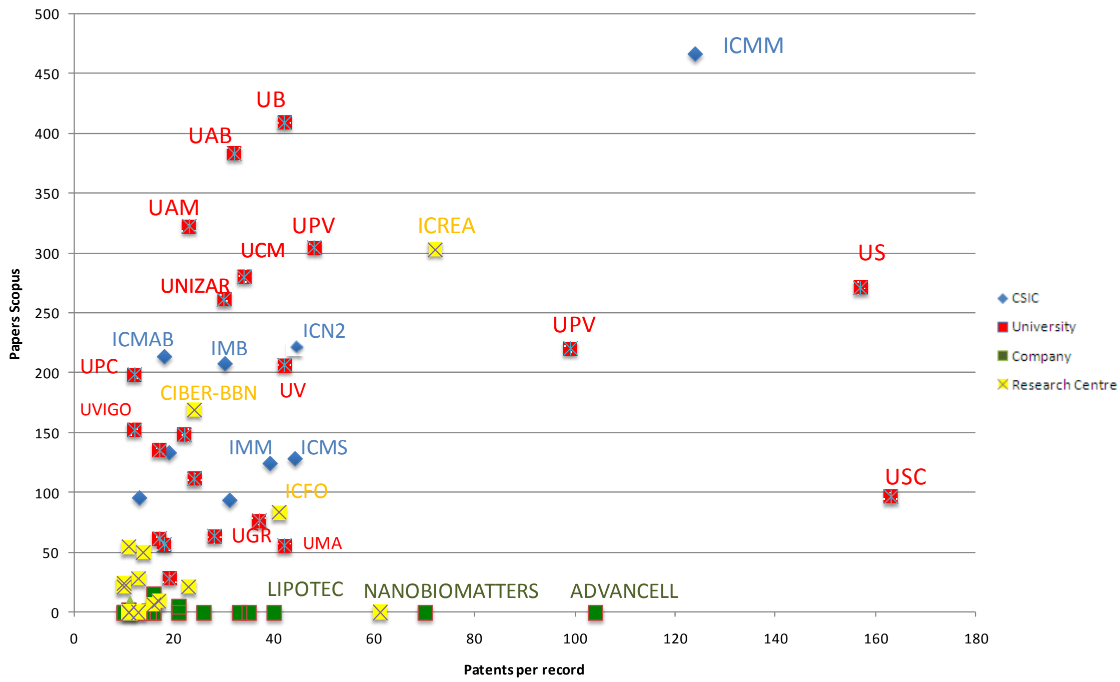

Fig. 52: Paper and patent output (per records) of applicants per sector

7.2 Technology network indicators

Technology network indicators analyze patent classifications and proved to be another very valuable indicator for technology watch activities since every patent is classified with one or more classes according to its technological field as we have described earlier (see 3.1.4).

7.2.1 Applicant technology networks

We can analyze the relationships between company/institution and technological domains. For this, we have identified the institutions which had at least three patents in common in the same technical field defined by the patent classification CPC.

This analysis helped us to identify common thematic areas of institutions which is very useful for a technology watch activity since it helps to find partners which work in a similar technological field. The following figures will show us a couple of examples that our analysis revealed.

In Fig. 53 become visible that the Universida de Sevilla and two CSIC research centres share a common technological field of patenting which is nanotechnology related to medicinal preparations.

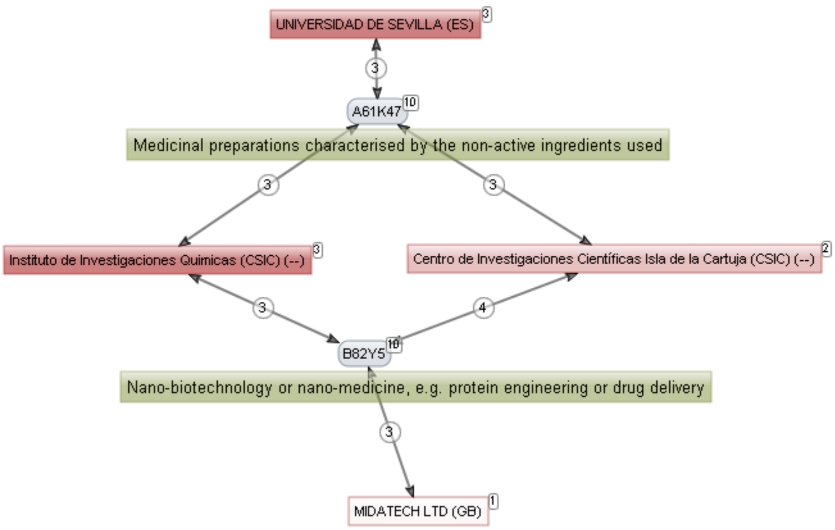

Fig. 53: Technology networks of top patenting institutions (I)

In the next figure we could detect a common technological expertise of two CSIC research entities in the field of nanocomposites.

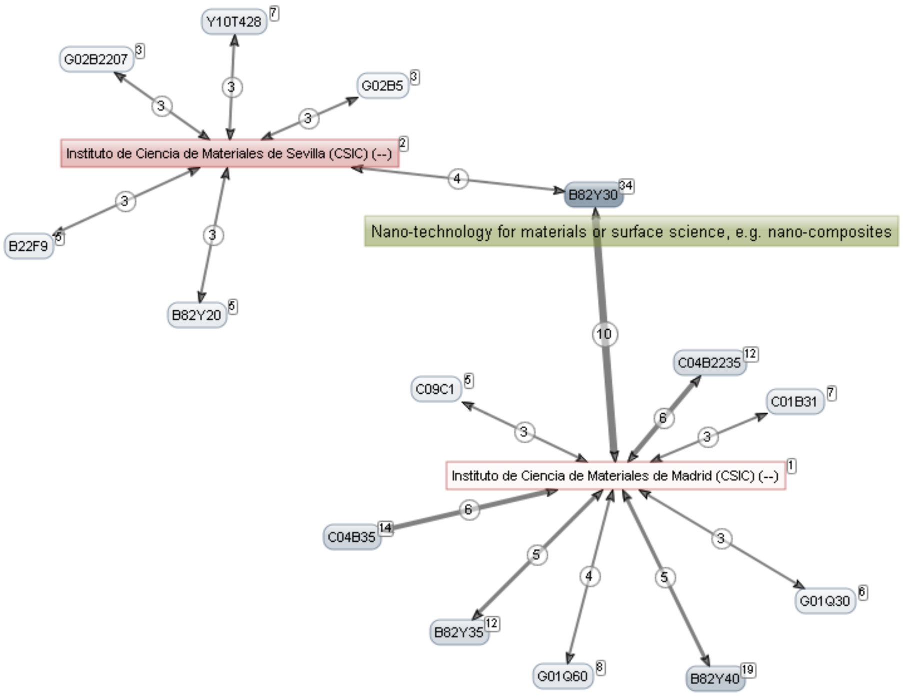

Fig. 54: Technology networks of top patenting institutions (II)

7.2.2 Inventor technology networks

Next we show inventor technology networks that helped us to identify common research areas of the inventors. Since the inventor network is far bigger than the applicant one (as we see in 7.1.4), we limited the networks to the technological fields which had at least 6 inventors associated to it. The following figures show the outcome of the inventor technology network analysis. In each classification symbol we have added the thematic description for better understanding.

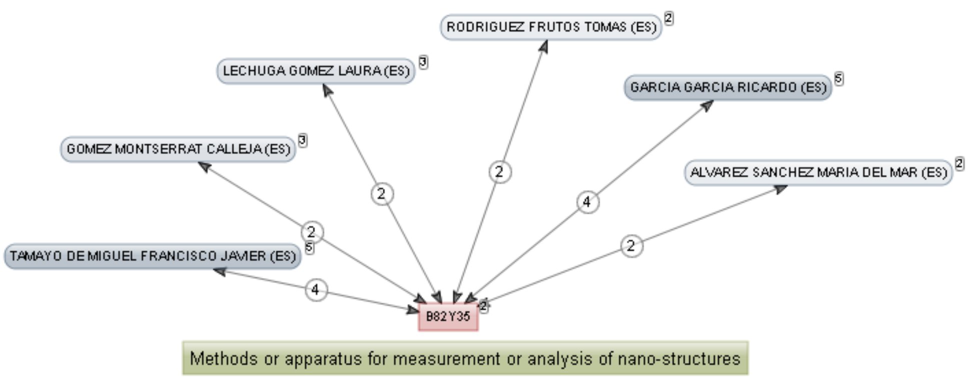

Fig. 55: Technology networks of CSIC researchers (I)

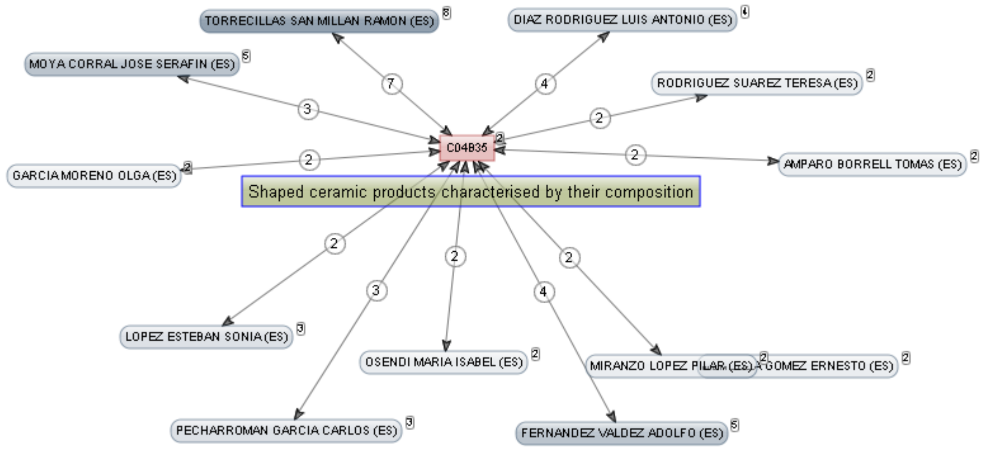

Fig. 56: Technology networks of CSIC researchers (II)

7.2.3 CPC technological networks

Finally we also analyzed the co-occurrence of the patent classifications in order to find out possible relationships between technological domains. As we have described earlier patents can be classified with more than one classification (see also chapter 3.1.4). This gave us the possibility to see how the thematic areas of our nanotechnology patent set are connected to each other. As can be seen in Fig. 57 we have detected three main areas which are connected to each other by co-classification: Catalysts, Cosmetics and Medicine and Pharmaceutical.

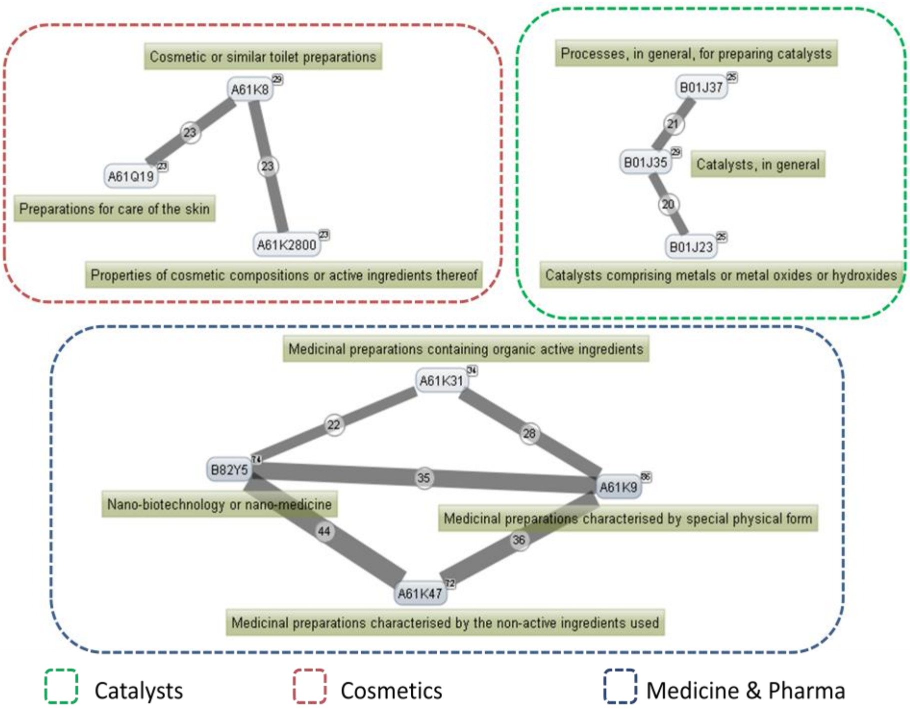

Fig. 57: CPC technological networks

7.3 Collaboration indicators

As we have mentioned in chapter 4.1.6 collaborations were visualized in our study with network maps where the entities are connected to each other in the form of a node and link diagram.

The following figure (Fig. 58) shows the network cloud of inventor co-authorship that we create out of the whole data set. By zooming in we can detect separate inventor networks (red square) and by further close-up the relationships become visible (blue and green square).

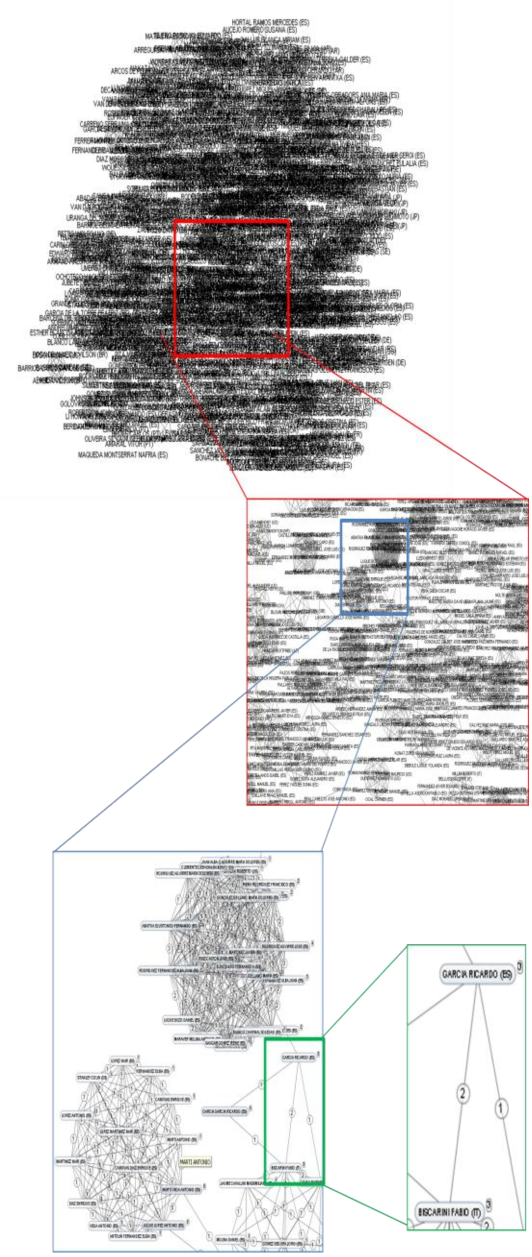

Fig. 58: Visualization of the Inventor co-authorship network of the whole dataset of this study and zoom example

7.3.1 Applicant collaboration

In this chapter we present the patent collaborations of the main nanotechnology applicants with other applicants (besides the top 3 which have been described earlier). Of the data set we identified all entities that had minimum collaboration with five other entities:

- *Instituto de Ciencia de Materiales de Madrid*
- *Universidad de Sevilla*
- *Universidad de Santiago de Compostela*
- *Universidad Politecnica de Valencia*
- *Universidad de Barcelona*
- *Institució Catalana de Recerca Estudis Avançats*
- *Universidad del Pais Vasco*
- *Institut de Microelectrònica de Barcelona*
- *Instituto de Ciencia de Materiales de Sevilla*
- *Universidad de Granada*
- *Universidad Autonoma de Barcelona*

The following figures show the correspondent network maps that make evident the collaboration behaviour of the entities.

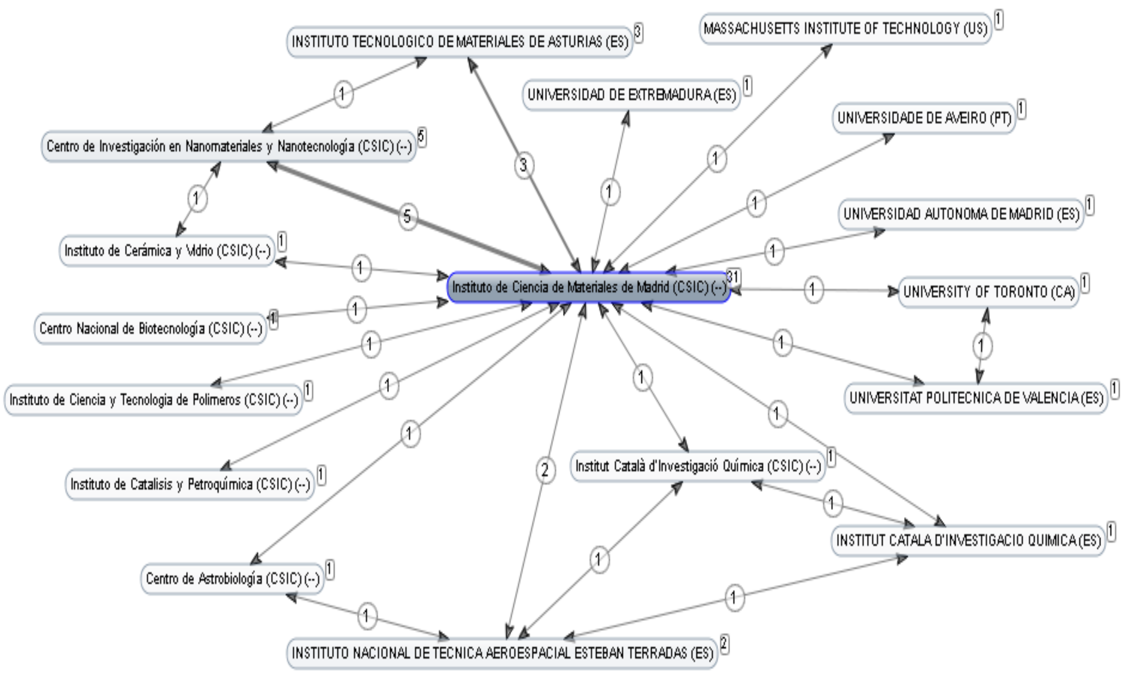

Fig. 59: Applicant collaboration from ICMM (min 2 pairs)

As we can see in Fig. 59 the ICMM, as one of the most important patenting institutions in the Spanish nanoworld (as we have identified earlier), proved to have a extensive collaboration network with other institutions, with 5 patents in common with the Centro de Investigacion en Nanomateriales y Nanotecnologia, followed by 3 patents in common with the Instituto tecnologico de Materiales de Asturias. We can further point out the international collaborations which became evident by the co patenting with the prestigious Massachusetts Institute of Technology (1) and another patent in common with the Canadian University of Toronto and the Portuguese University of Aveiro.

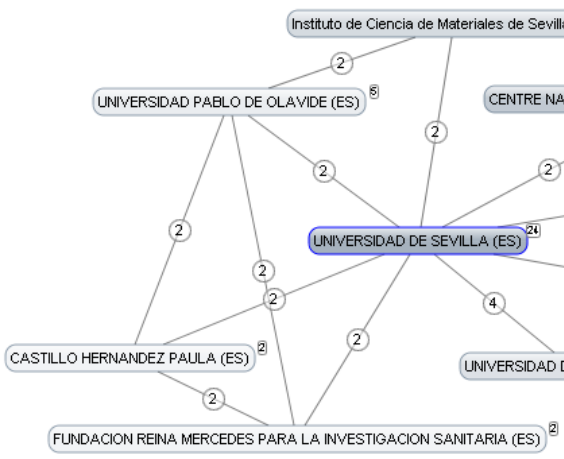

Fig. 60: Applicant collaboration from Universidad de Sevilla (min 2 pairs)

The Universidad de Sevilla showed to have two collaboration clusters, one to the left in the network map (Fig. 60) with entities in its geographical proximity (all andalusian institutions) and to the right a collaboration with the French University Joseph Fourier and the national French research council (CNRS).

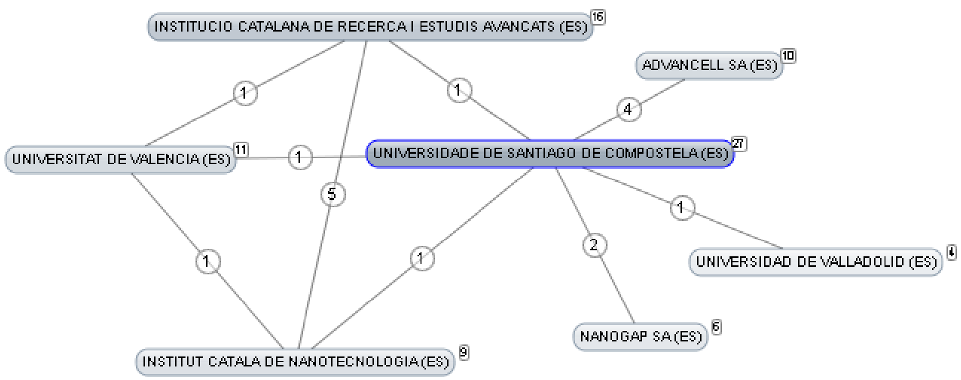

Fig. 61: Applicant collaboration from Universidad de Santiago de Compostela (min 1 pairs)

The Universitat Politecnica de Valencia had only one strong collaboration with 8 patents in common with the CSIC centre Instituto de TecnologiaQuimica and a single international patent collaboration with the Canadian University of Toronto (Fig. 62).

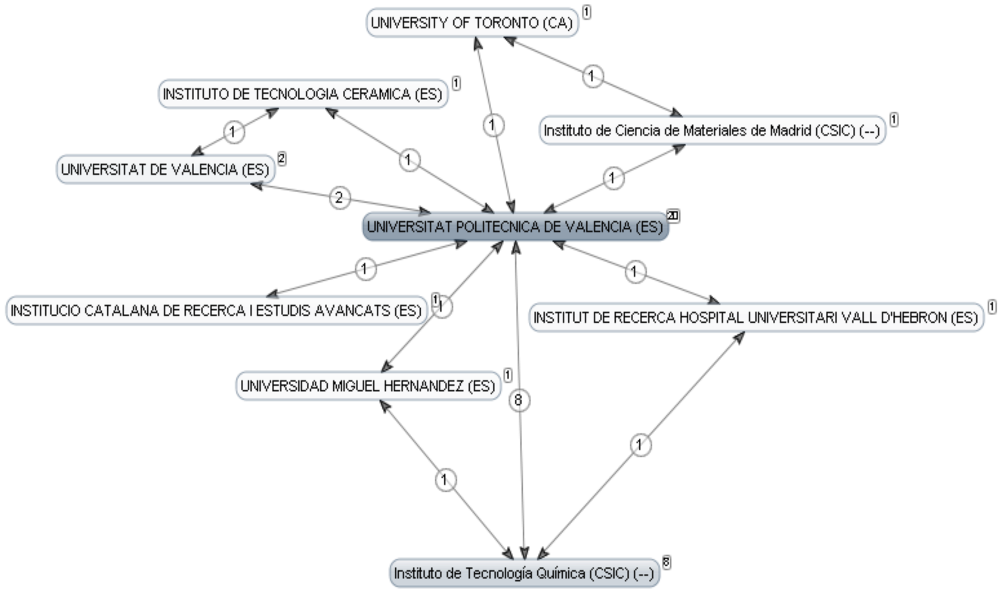

Fig. 62: Applicant collaboration from Universidad Politecnica de Valencia (min 1 pairs)

The Universitat de Barcelona has its strongest collaboration with 3 patents with the research centre of the same city, the Institut de Recerca Biomedica Barcelona and one international collaboration with the German University of Cologne (Univ Köln) (Fig. 63).

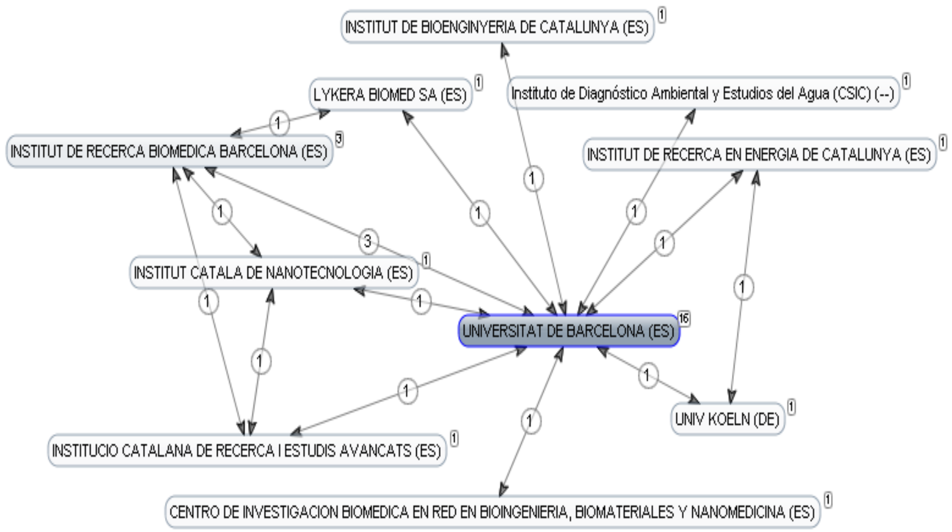

Fig. 63: Applicant collaboration from Universidad de Barcelona (min 1 pairs)

As seen in Fig. 64 the catalane research centre Institucio Catalane de Recerca I Estudis Avancats showed to have most patents also with institutions in its geographical proximity, with the Institut de Ciences Fotoniques (6 patents) and the Institut Catala de Nanotecnologia (5 patents). As for the international co-patenting the centre works together with the French CNRS and the French Commissariat Energie Atomique.

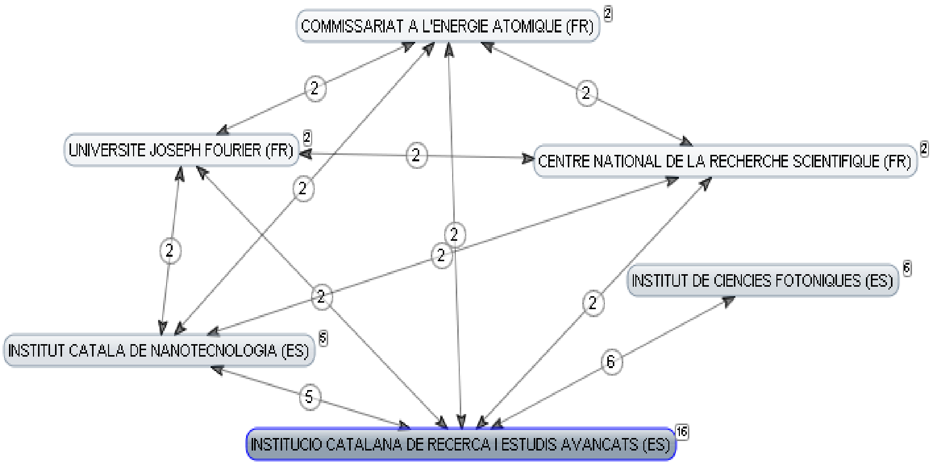

Fig. 64: Applicant collaboration from ICREA (min 2 pairs)

The Universidad del Pais Vasco is the institution with most international collaborations, co-patenting with entities from Argentina, Chile, Netherlands, Sweden, Great Britain and Germany. Although, the numbers of copatenting was relatively low with mostly only one patent in common (Fig. 65).

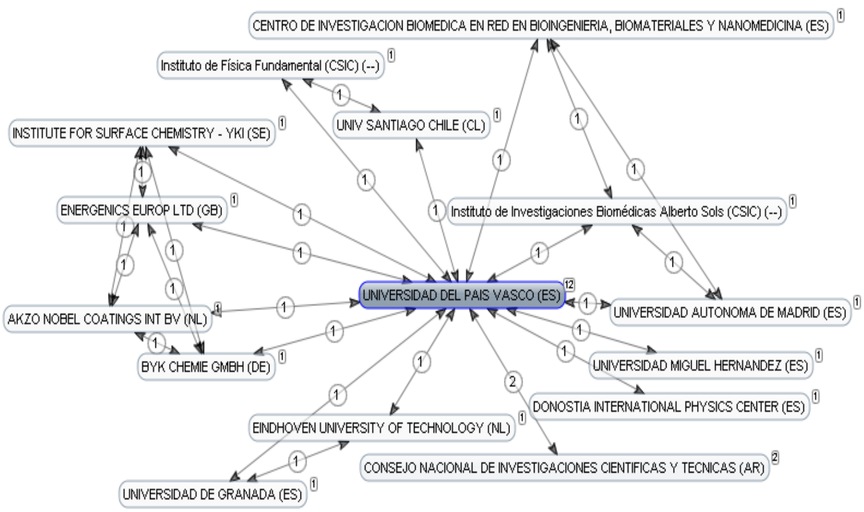

Fig. 65: Applicant collaboration from Universidad del Pais Vasco (min 1 pairs)

The CSIC institution Institute de Microelectronica de Barcelona (IMB) points out with two international patent collaborations with the Swiss Ecole Polytechnique Federale de Lausanne and the German research centre Helmholtz Zentrum für Materiales und Energie (Fig. 66).

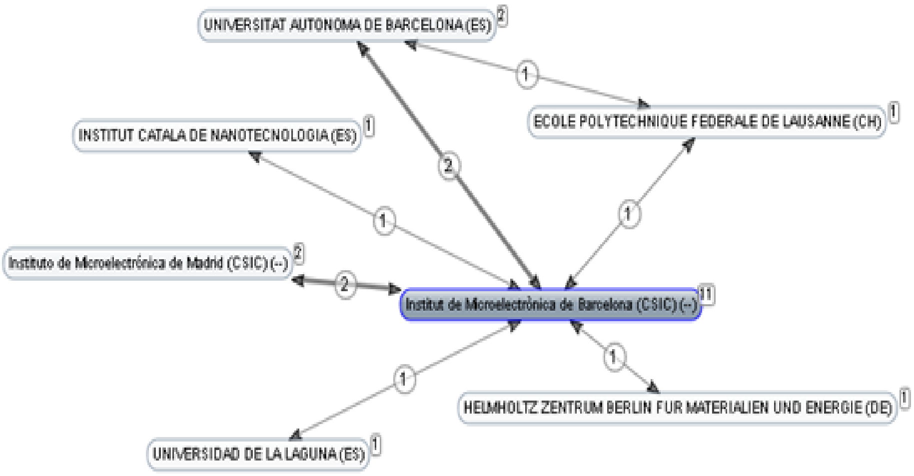

Fig. 66 : Applicant collaboration from Institut de Microelectrònica de Barcelona (CSIC)

The Seville based CSIC centre Instituto de Ciencia de Materiales de Sevilla had no focal points in collaboration (Fig. 67), although two patent collaborations with Latin American institutions, the Argentinean Research council Consejo Nacional de Investigaciones and the Columbian Universidad Nacional de Colombia.

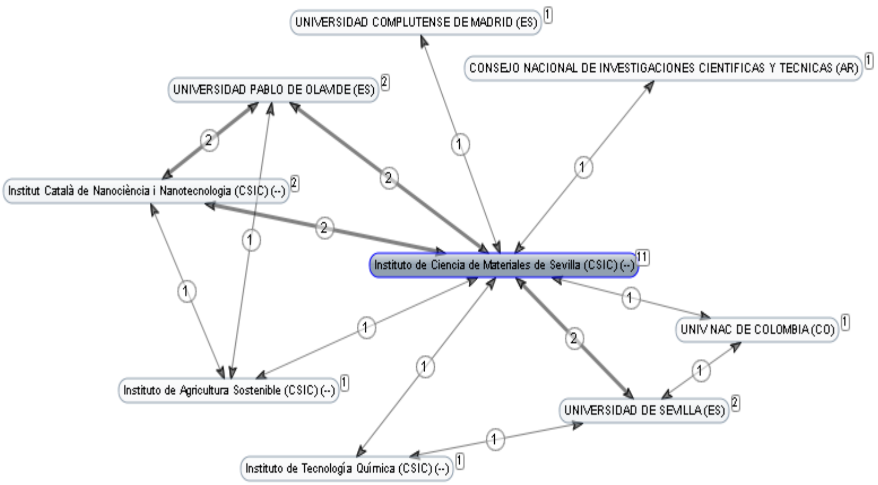

Fig. 67: Applicant collaboration from Instituto de Ciencia de Materiales de Sevilla (CSIC)

The University of Granada showed to have patent collaboration with mainly universities from other andalusian universities and research centres, with the exception of one common nano related patent with the Dutch University of Eindhoven.

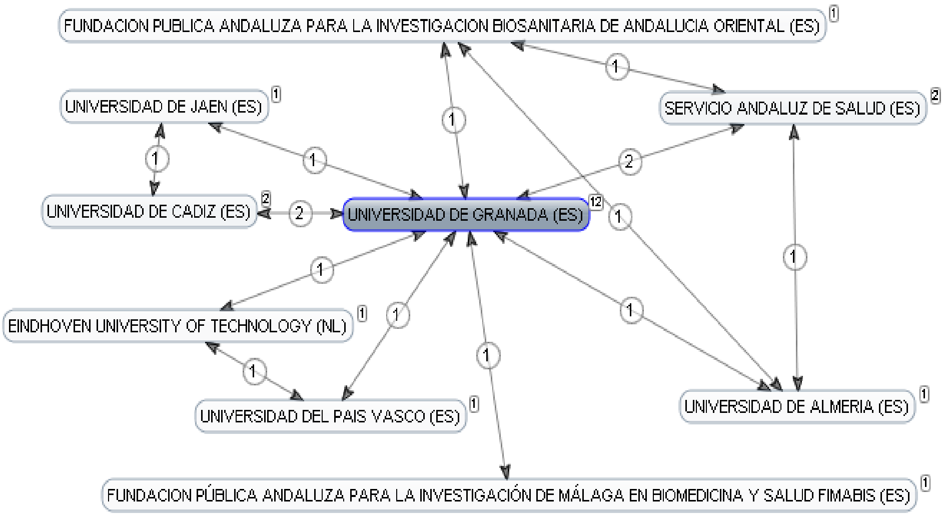

Fig. 68: Applicant collaboration from Universidad de Granada (min 1 pairs)

Finally, the University of Barcelona, collaborated with two private companies (GRIFOLS and ASCAMM) and two international entities, the Chinese University of Beijing and the Swiss Ecole Polytechnique Federale de Lausanne.

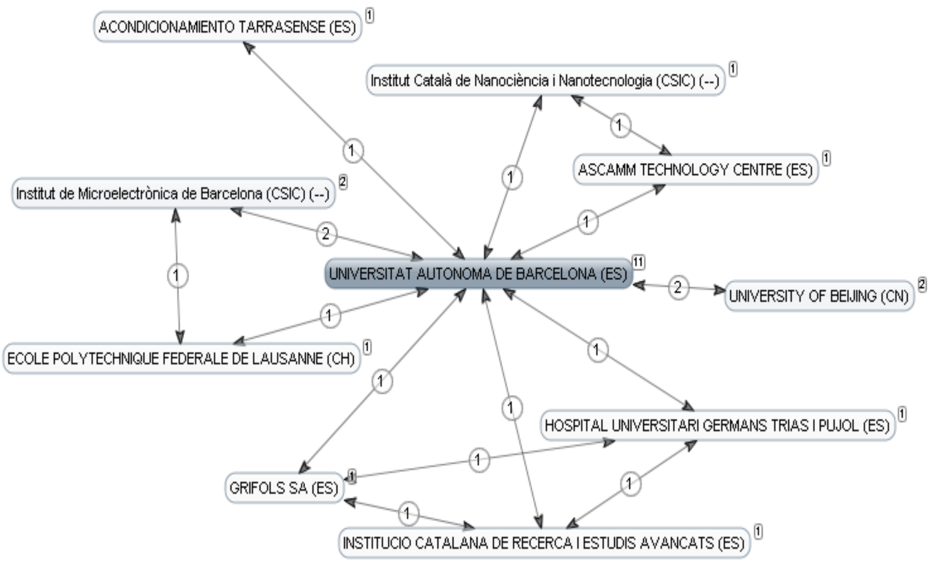

Fig. 69: Applicant collaboration from Universidad Autonomade Barcelona (min 1 pairs)

7.3.2 Inventors

After having seen the essential patent applicants it was of interest to know who are the most productive inventors in the field. Table 50 shows the ranking of the top 15 inventors. In this case patent family was used for the ranking since for a inventor it is more important to know the inventive effort (reflected in numbers of inventions). The patent extension/internalization is more important for applicants since it determines the economical potential gain that the patent can generate.

# rank	Inventors	Patent families	Patent records	Patent IR (records/family)
1	LAGARON CABELLO JOSE MARIA	16	93	6
2	ALONSO FERNANDEZ MARIA JOSE	15	132	9
3	GANAN CALVO MIGUEL ALFONSO	12	97	8
4	GARCIA MARTINEZ JAVIER	10	72	7
5	LOPEZ QUINTELA MANUEL ARTURO	10	58	6
6	IRACHE GARRETA JUAN MANUEL	9	85	9
7	MIGUEZ HERNAN	9	67	7
8	PENADES SOLEDAD	8	84	11
9	CORMA CANOS AVELINO	8	50	6
10	TORRECILLAS SAN MILLAN RAMON	8	47	6
11	TAMAYO DE MIGUEL FRANCISCO JAVIER	7	45	6
12	BARRERO RIPOLL ANTONIO	6	49	8
13	ISABEL VILA PENA ANA	6	46	8
14	MOYA CORRAL JOSE SERAFIN	6	36	6
15	GOMEZ MONTSERRAT CALLEJA	6	23	4

Table 50: Top 15 Spanish inventors (per patent family counts)

We have indentified three researchers which are the most productive in terms of Nanotechnology patent output:

- Jose Maria Lagaron Cabello (#1 in patent families and #3 in patent records)
- Maria Jose Fernandez Alonso (#2 in patent families and #1 in patent records)
- Alfonso Miguel Gañan Calvo (#3 in patent families and #2 in patent records)

In our case study in chapter 7.6 we will analyze more in depth these three top researchers of the Spanish nanotechnology world.

7.3.3 Inventor co-authorship

Next we analyzed the co-authorship behaviour of the inventors. This helped us to locate groups of inventors that work together, which can be members of the same research group or also reveal cross-institutional or international author collaborations.

We limited the inventor networks to more than two connected nodes that are not connected to each other (in order eliminate the network display of a single patent, which would not provide with useful information).

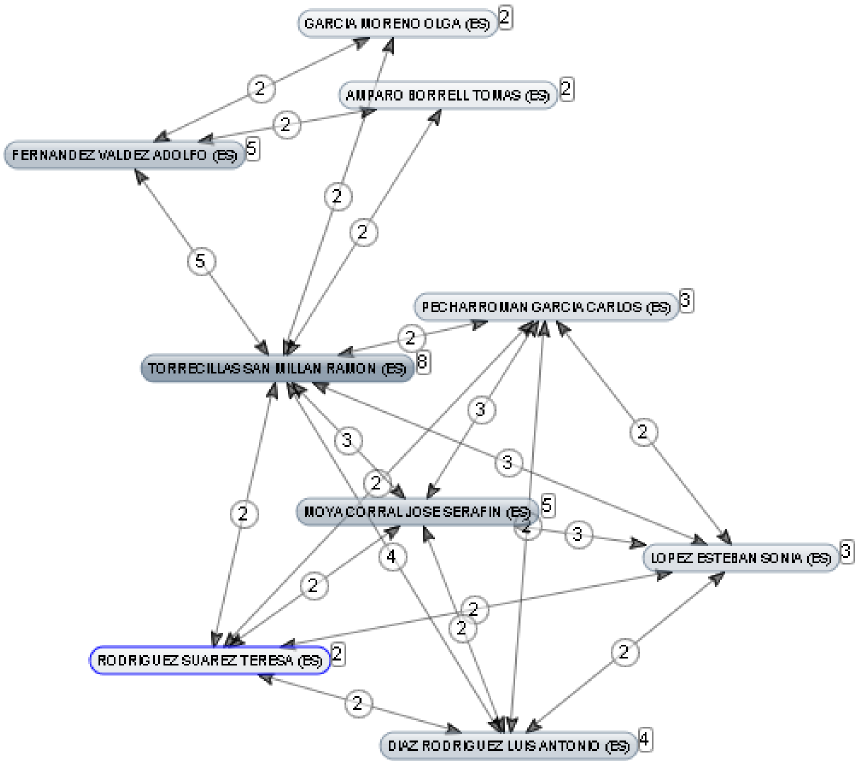

Fig. 70: Inventor co-authorship network 1

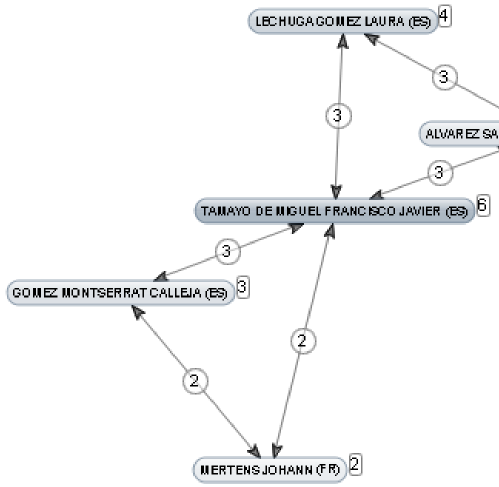

Fig. 71: Inventor co-authorship network 2

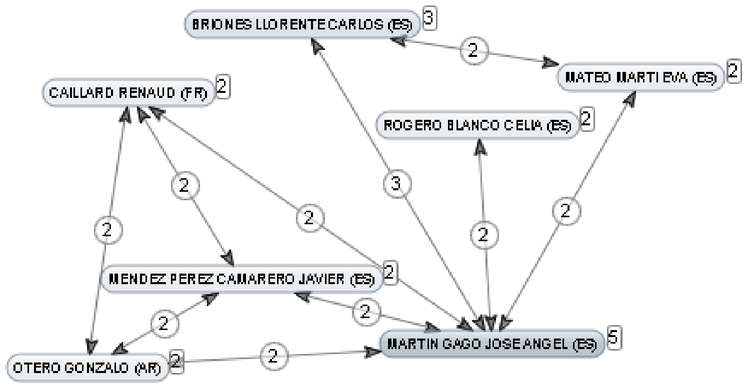

Fig. 72: Inventor co-authorship network 3

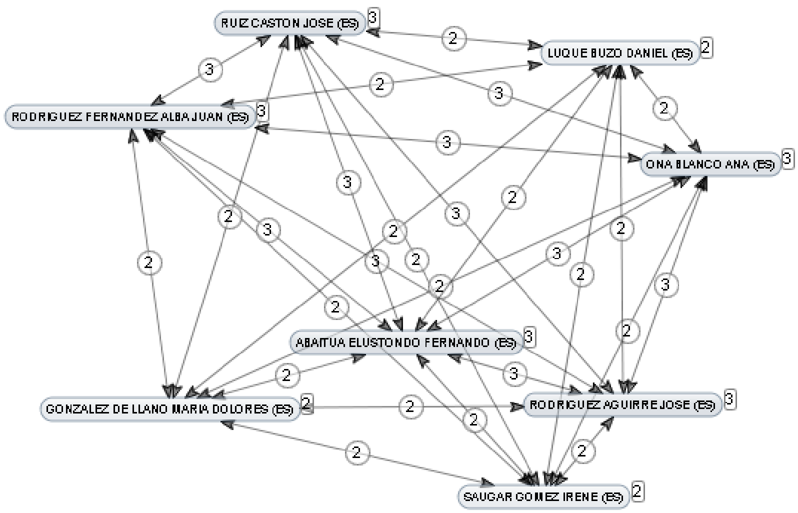

Fig. 73: Inventor co-authorship network 4

7.4 Patent value indicators

From our data set, the nanotechnology patents that showed to have the highest number of inventors, applicants, family members and number of forward citations (citations received) were identified (full list in Appendix).

We then calculated the citations received per applicant and could generate the citation ratio indicator which shows us the ratio of citations received per invention of the applicant (Table 51). Furthermore with the number of inventors we calculated the number of inventors of every applicant and generated the ratio inventors per patent of the most cited documents.

Applicant	# of inventors	Inventors ratio	Citations received	Citation ratio
Bionostra SL	26	8,67	15	5,00
Centro de Estudios e Investigaciones Tecnicas de Gipuzkoa	3	1,50	9	4,50
Oryzon Genomics SA	9	9,00	4	4,00
Grifols SA	7	3,50	5	2,50
Instituto de Ciencia de Materiales de Aragón (CSIC)	8	1,60	11	2,20
Universidad Complutense de Madrid	43	4,78	12	1,33
Instituto Nacional de Tecnica Aeroespacial Esteban Terradas	20	5,00	4	1,00
Instituto de Carboquímica (CSIC)	6	3,00	2	1,00
Advancell SA	18	1,80	9	0,90
Instituto de Microelectrónica de Madrid (CSIC)	19	2,11	6	0,67
Universidade de Vigo	20	4,00	2	0,40
Universidad de Sevilla	92	3,83	9	0,38
Instituto de Ciencia de Materiales de Sevilla (CSIC)	20	1,82	4	0,36
Instituto de Agroquímica Y Tecnología de Alimentos (CSIC)	14	2,33	2	0,33
Universidad Politecnica de Madrid	25	3,57	2	0,29
Universitat de Barcelona	64	4,00	4	0,25
Universitat Politecnica de Valencia	71	3,55	4	0,20
Instituto de Ciencia de Materiales de Madrid (CSIC)	82	2,65	6	0,19
Universidade de Santiago de Compostela	103	3,81	3	0,11

Table 51: Top applicants ranked by number of forward patent citations

As we can see, the private company Bionostra not only received the highest number on patent citations, but also had the highest ratio per invention (patent family). This could be interpreted that the patent portfolio of Bionostra has influenced quite a lot of subsequently filed patents since they referenced the technology from Bionostra.

Regarding the inventors ratio the patents from Bionostra and Oryzon Genomics had most inventors comparing to their inventive output.

7.5 Text mining indicators

Finally, we used the built-in functionality of the patent analysis software tool to analyze the text corpus of the patent set via text mining techniques (see also chapter 4.1.6) in order to reveal possible keyword clusters which can help us to further thematically categorize the patent data set. We launched a Co-word analysis in the title field of all patent documents and generated the map as shown in the following figure.

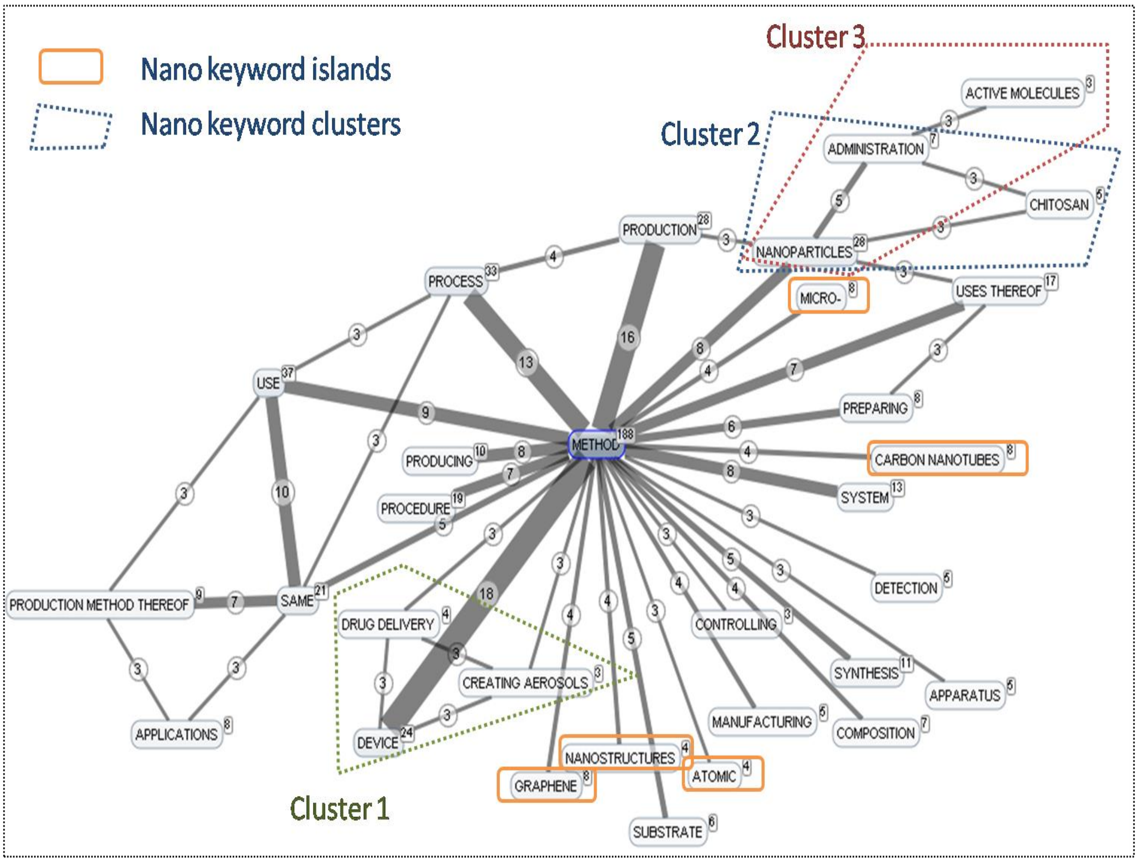

Fig. 74 : Title coword analysis

We could detect some specific relevant keywords which we labelled "keyword islands" since they had no proximity to other keywords like "Graphene", "Carbon Nanotubes" which are highly relevant nanotechnologies as we have seen in the introductory part of the present study (chapter 2.1).

Furthermore we identified 3 thematic clusters according to the proximity of the analyzed keywords as can be seen in the following figure (Fig. 74):

- Cluster 1: drug delivery devices with aerosols
- Cluster 2: administration of nanoparticles with chitosan
- Cluster 3: administration of nanoparticles with active molecules

All three clusters correspond to field of Nano-Biotechnology/Nano-Biomedicine and thus this finding directly correlates with the thematic specialization of Spanish nanotechnology, as outlined in chapter 7.1.1. , and helps us to confirm this result.

7.6 Case study: Patent analysis of top inventors

In this chapter we did an exemplary patent analysis of the three most active inventors in terms of patent output which we identified in chapter 7.3.2 :

- Jose Maria Lagaron Cabello (#1 in patent families and #3 in patent records)
- Maria Jose Fernandez Alonso (#2 in patent families and #1 in patent records)
- Alfonso Miguel GañanCalvo (#3 in patent families and #2 in patent records)

We analyzed two indicators: The institutional applicants of their patent inventions visualized by Inventor-Applicant network maps and the thematic classification of their patents visualized by Inventor-Technology network maps.

Jose Maria Lagaron Cabello

As seen in Fig. 75 Jose Maria Lagaron Cabello is the author in one patent with the Mexican university “Queretaro”, in 6 patents with the Instituto de Agroquímica y Tecnología de Alimentos (IATA) from the CSIC and in 10 patents from the company NANOBIOMATTERS SL.

As it turns out he is a researcher at the IATA and is the founder of the Spin Off company NANOBIOMATTERS[107].

[107107] Source: https://www.linkedin.com/in/jose-maria-chema-lagaron-a5506417

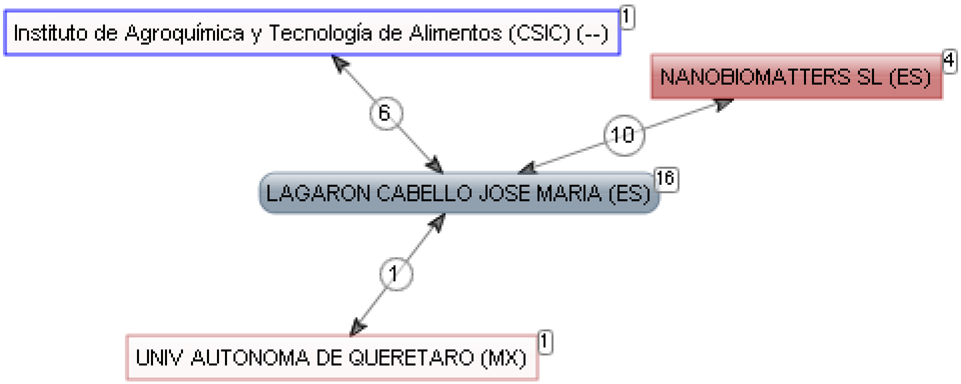

Fig. 75: Inventor-Applicant network of "Jose Maria Lagaron Cabello"

Regarding his technological specialization the patent analysis reveals us that he is working in the field of Nanocomposites and Nanoparticles, since most of his patents have been classified accordingly as shown in Fig. 76.

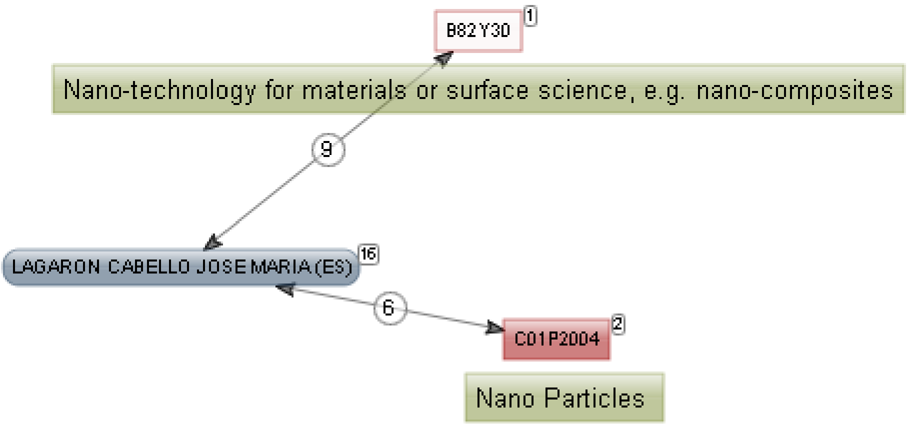

Fig. 76: Inventor-Technology network of "Jose Maria Lagaron Cabello"

María Jose Alonso Fernández

According to the patent analysis, María Jose Alonso Fernández is the author one patent of the company BIOIBERICA SA, 8 patents from the company ADVANCELL SA and 9 from the University of Santiago de Compostela.

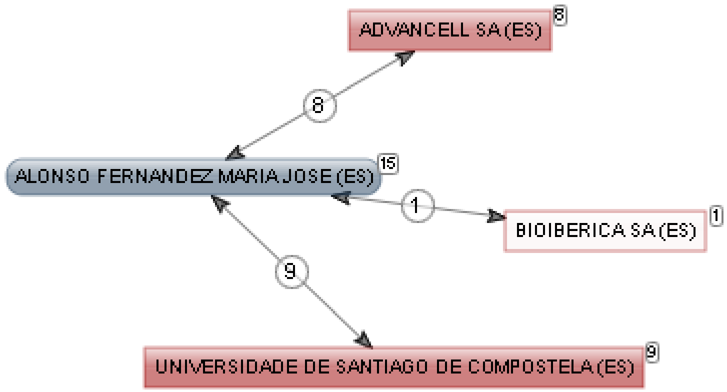

Fig. 77: Inventor-Applicant network of “María Jose Alonso Fernández”

According to the classification analysis her patent portfolio is mainly related to the field of Nanocapsules as can be seen in the following inventor-technology network map (Fig. 76).

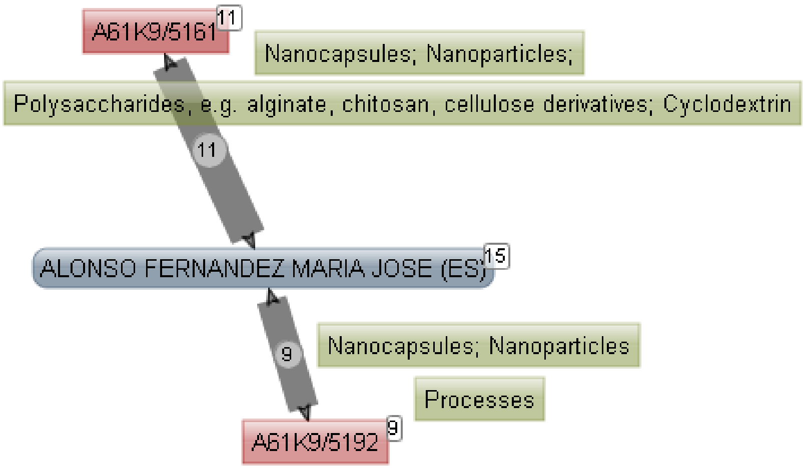

Fig. 78: Inventor-Technology network of “María Jose Alonso Fernández”

As it turns out, María Jose Alonso Fernández works as a researcher at the University of Santiago de Compostela and her research involves the use of nanotechnologies to design innovative nanomedicines[108].

[108]Source: https://www.linkedin.com/in/maria-jose-alonso-0a71a210

Alfonso Miguel GañánCalvo

Finally, the patent analysis of the inventor Alfonso Miguel Gañán Calvo, has revealed that he has authored all his 16 patents with the University of Seville and one of it also with the University of Malaga.

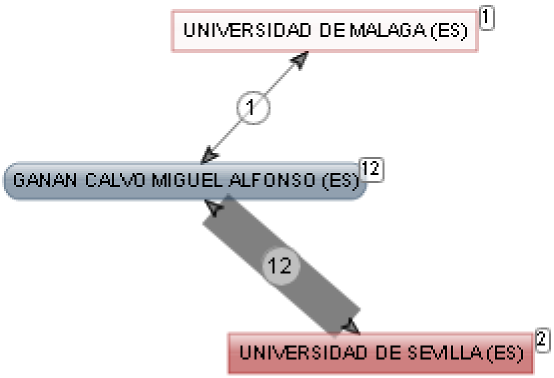

Fig. 79: Inventor-Applicant network of "Alfonso Miguel GañánCalvo"

The inventor-technology network map of his patents furthermore showed a strong affinity to Nano-Composites related to spraying or atomizing apparatus according to the classifications.

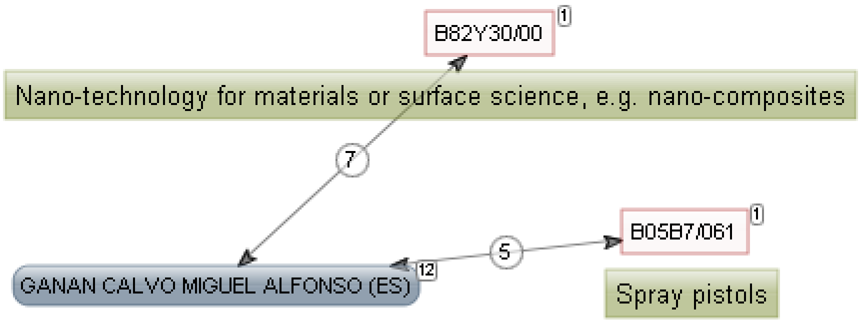

Fig. 80: Inventor-Technology network of "Alfonso Miguel GañánCalvo"

As it turns out Alfonso Miguel Gañán Calvo is a main researcher in mechanical fluids in the University of Seville[109].

[109] https://www.linkedin.com/in/alfonso-ga%C3%B1%C3%A1n-calvo-73130621

8 Conclusions

8.1 Conclusiones (Español)

Contexto global

La nanotecnología Española en su contexto global ha revelado que estamos ante dos tipos de países. Por un lado tenemos un grupo compuesto por Estados Unidos, Japón y Corea del Sur donde la producción de patentes es relativamente mayor que la producción científica. Por otra parte tenemos un grupo con el comportamiento contrario, donde destacan especialmente China y en menor medida España y el Reino Unido.

España interviene, de una o de otra, en el 1% de la patentes sobre nanotecnología en el mundo, pero al mismo tiempo tiene más del doble de la representación por *papers* científicos. No cabe duda que el país ha hecho un gran esfuerzo por fortalecer el ámbito científico, pero lo ha hecho poniendo énfasis en el sector público y académico. La iniciativa de la empresa privada no ha tenido la misma suerte en los últimos años. En los datos China parece tener el mismo comportamiento que España, aunque sus razones pueden ser diferentes y estar más orientadas a una diferencia cultural (que se va lentamente cambiando) sobre la percepción de los procesos de patentamiento.

Perfil temático

Por su propia definición el campo de la nanotecnología instrumental y de naturaleza multidisciplinar, abarcando grandes y muy diferentes disciplinas científicas. El perfil temático español también es multidisciplinar, pero con un sesgo diferente, ya que predominan (en términos porcentuales relativos) los códigos de clasificación relacionados con la nano-medicina y nano-biotecnología. Al contrario, se puede apreciar un déficit en las patentes relacionadas con la nano-óptica, el nano-magnetismo y las tecnologías "nano" de la información y comunicación (TIC). En el campo de las ciencias de materiales, la producción es en términos relativos equivalente a la del resto del mundo.

Evolución temporal

La evolución temporal de España es sostenida desde hace varios años. En las gráficas se percibe claramente un declive en últimos años, tanto de las patentes presentadas como de las publicadas, sin embargo este es un efecto esperable que se origina en el periodo de estudio que tienen todas las solicitudes y que es de al menos 18 meses.

Producción por provincias

Si miramos el origen de las patentes por provincias encontramos, como no podía ser de otra manera, dos grandes focos: Madrid y Barcelona. Un poco más atrás destacan las provincias de Valencia, Sevilla y La Coruña. En el resto de provincias la presencia en casi inexistente.

Producción por sectores

Si analizamos la producción de patentes por sectores encontramos que entre los solicitantes predominan las universidades (37%), seguidas por la empresa privada (24%), el CSIC (20%) y otros centros de investigación (16%). Cuando hacemos los mismo con los documentos científicos, encontramos los siguientes: universidades (59%), CSIC (28%), otros centros (13%), y empresas (1%). Se corrobora, por tanto, el comportamiento indicado al principio de las conclusiones.

Instituciones y empresas

Cuando entramos en detalle dentro de cada sector, nos encontramos que dentro de los solicitantes (*applicants*) dominan instituciones públicas. Del mundo universitario destacan la Universidad de Sevilla y la Universidade de Santiago de Comspostela, a las que se le puede sumar un poco más atrás la Univertat Politécnica de Valencia. En el CSIC destaca, tanto por su producción en patentes y *papers*, el Instituto de Ciencia de Materiales de Madrid. Finalmente, cierran el listado de solicitantes destacados las empresas Advancell (actualmente en concurso de acreedores) y Nanobiomatters. Si tenemos en cuenta la suma de esfuerzo tanto en el campo de las patentes como en el producción científica, el centro más destacado, sin lugar a duda es el Instituto de Ciencia de Materiales de Madrid.

Citas a patentes

De forma remotamente parecida a la de los trabajos científicos, es posible medir la citas recibidas por una patente de parte de otra patente, aunque no es una práctica tan generalizada como en el caso de los primeros. En nuestro estudio la institución que ha recibido la mayor cantidad de citas por patente es la empresa Bionostra.

Internacionalización

La cantidad de oficinas y registros donde se presenta una solicitud de patente, nos puede dar una idea del esfuerzo que el solicitante y/o el inventor está dispuesto a hacer para garantizarse la exclusividad de su innovación. España suele aparecer en mayor medida en la propia oficina española, en la europea, la mundial y la de los Estados Unidos. El resto de las oficinas de mundo aparecen en menor grado, ya que se necesita de un gran esfuerzo para estar en la mayoría de ellas. Pero hay solicitantes que hacen ese esfuerzo.

Por ello, en esta tesis proponemos un sencillo indicador, la tasa de internacionalización, que es un cociente entre la cantidad de registros de patentes (en diferentes oficinas) y las familias de patentes (el invento o innovación en sí). Cuando analizamos la tasa de internacionalización en España, nos encontramos que los valores más altos los presentan las empresas, que por regla general, tienen una o dos familias de patentes, pero cuyos tasas rondan los 17-20 (Salvat y Grifols). Se trata, por tanto, de empresas cuyo modelo de negocio se basa en la protección de esas innovaciones y por tanto que están dispuestas a tal esfuerzo.

Luego vienen los hospitales, con pocas patentes y altas tasas, y a continuación las universidades y los centros del CSIC. Aquí podemos indicar que ciertas universidades parece tener mayor capacidad de internacionalización que los centros de CSIC, aunque en principio podría pensarse lo contrario. Si no tenemos en cuenta las dos primeras universidades (con una o dos patentes) las que realmente destacan son la Universidad de Sevilla y la Universidade de Santiago de Compostela. Ambas presentan un comportamiento tal que amerita por si mismo un posterior estudio de sus respectivas OTRI.

Colaboración internacional

Además de la internacionalización, un indicador interesante es el de la colaboración de solicitantes españoles con solicitantes de otros países del mundo. Aquí nos encontramos que los países con los que más se colabora son Alemania, Reino Unido y Estados Unidos. A nivel de instituciones la colaboración del Instituto de Ciencias de Materiales de Madrid es una de las más altas, aunque la más internacional corresponde a la Universidad del País Vasco (Argentina, Chile, Holanda, Suecia, Reino Unido y Alemania).

Por otra parte, se verifica una mucho más nutrida colaboración cuando se mira el campo inventor. Este comportamiento *a priori*contraintuitivo nos lleva directamente a la conclusión siguiente: solicitantes e inventores.

Solicitantes e inventores

Los tres inventores más activos son: Jose Maria Lagaron Cabello del Instituto de Agroquímica y Tecnología de Alimentos (IATA), Maria Jose Fernandez Alonso de la Universidade de Santiago de Compostela y Alfonso Miguel Gañan Calvo de la Universidad de Sevilla. Cabe destacar que la vinculación de inventor con el solicitante es un trabajo complicado ya que las patentes, a diferencia de los documentos científicos, no establecen una vinculación clara entre *inventors* y *applicants*.

De hecho, llama la atención la cantidad de patentes solicitadas a título particular. Si bien es muy frecuente que haya personas que solicitan patentes a título personal, esto no suele ser común en áreas de una complejidad como la nanotecnología, ya que el equipamiento e infraestructura necesaria para el trabajo excede largamente el ámbito domestico. El seguimiento de este tipo de comportamiento podría ser una buena línea de investigación futura.

Indicadores tecnológicos de red

Además de todos los indicadores mencionados, la potencia de análisis de Matheo Patent permite la obtención de indicadores de red que complementan a los anteriores y los potencian. Estas redes nos indican la especialización temática de los solicitantes más destacados como la Universidad de Sevilla (preparados medicinales) , o el Instituto de Ciencia de materiales de Sevilla y el de Madrid (nanocompuestos).

También es posible definir *clusters* temáticos. En el caso de nuestro estudio pudimos identificar tres principales: 1) *drug delivery devices with aerosols*, 2) *administration of nanoparticles with chitosan*, y 3) *administration of nanoparticles with active molecules*.

Líneas futuras

El trabajo presentado en esta tesis será sin duda continuado en el futuro inmediato. Para el desarrollo de la misma se puso en juego un considerable *expertise* (herramientas, métodos, técnicas, etc.), que será de utilidad en futuras investigaciones. Pero creemos que este conocimiento no solo sera de útil para la investigación. Lo sera también para el diseño e implementación de servicios de vigilancia tecnológica e inteligencia competitiva que puedan ser de interés a empresas e instituciones públicas con necesidades de potenciar su conocimiento y control del mundo de la patentes, no solo en el campo de la nanotecnología, sino también en otros campos. La potenciación del tejido de transferencia tecnológica es una asignatura pendiente en España y tarde o temprano deberá ser asumido no solo por las administraciones sino también por la sociedad productiva toda en su conjunto.

8.2 Conclusions (English)

Global context

The Spanish nanotechnology in its global context has revealed that we are facing two types of countries. On the one hand we have a group comprising the United States, Japan and South Korea where the production of patents is relatively higher than the scientific production. On the other hand we have a group with the opposite behaviour, which include especially China and to a lesser extent Spain and the United Kingdom.

Spain forms part in 1% of the patents on nanotechnology in the world, but has more than double the representation for scientific papers. There is no doubt that the country has made great efforts to strengthen the scientific field, but it has an emphasis on public and academic sectors. The private enterprise initiatives have not had the same luck in recent years. Regarding the data China seems to have the same behaviour as Spain, though their reasons may be different and be more oriented to cultural differences (to be slowly changing) due to the perception of importance of patenting.

Thematic profile

By its own definition the field of nanotechnology is of multidisciplinary nature, encompassing large and very different scientific disciplines. The Spanish thematic profile has a multidisciplinary character, but with a different bias since classification codes related to nano-medicine and nano-biotechnology prevail (relative in percentage terms). On the contrary we found a deficit in patents related to nano-optics, nano-magnetism and "nano" technologies of information and communication technologies (ICT). In the field of materials science related to nanocomposites, production is equivalent in relative terms to the rest of the world.

Temporal evolution

The temporal evolution of Spain has found to be steady for several years. In the graphs we can see a decline in recent years, both patents filed as published, however this is an expected effect that originates in the study period of filed patents which generates a time lag of at least 18 months.

Output per Spanish provinces

If we look at the origin of patents by provinces two hot spots of Nanotechnology patent generation become clearly visible with nearly the same amount of nanotechnology related patents generated in the analyzed timeframe of this study: Barcelona and Madrid. After that, we can point out three other important regions where nanotechnology related patents are generated: the province of Valencia, Seville and La Coruna in the north west of the country. In the other provinces the presence is almost nonexistent.

Output per sector

If we analyze the patent output according to its applicant’s sector affiliation the universities are prevalent (37%), followed by private enterprises (24%), the CSIC (20%) and other research centres (16%). When we do the same analysis with scientific papers, we find the following: universities (59%), CSIC (28%), other centres (13%) and businesses (1%). This confirms us the behaviour mentioned earlier in the conclusions.

Institutions and companies

When we look at each sector in more detail, we find a strong presence of the public institutions. From the academic world we can point out the Universidad de Sevilla and the Universidade de Santiago de Compostela, followed by the Universitat Polytechnic of Valencia. Among the CSIC stands out in both, its production of patents and papers, the Instituto de Ciencia de Materiales de Madrid. The only two companies which appear in the ranking are Advancell (now in bankruptcy) and Nanobiomatters. Considering the amount of effort invested in both, the field of patents and in scientific production, the foremost centre is undoubtedly the Institute of Materials Science of Madrid.

Internationalization

Analyzing the number of offices and records where a patent application has been filed can give us an idea of the effort that the applicant and / or inventor is prepared to assume in order to guarantee the commercial monopoly of their innovation.

As expected from patents with Spanish authorship most patents were filed at the Spanish patent office, but closely followed by filings of PCT applications at the World Intellectual Property Organization and patent filings at the US and the European Patent Office (EP). The remaining worldwide offices appear to a lesser extent, since it requires a great effort to patent, although, there are few applicants who make that effort.

Therefore, in this thesis we propose a simple indicator, the rate of internationalization, which is a ratio between the number of patent registrations (in different offices) and patent families (the invention or innovation itself). When we analyze the rate of internationalization in Spain, we find that the highest values are presented by the companies, which generally have one or two families of patents, but whose rates are around 17-20 (Salvat and Grifols). It is, therefore, companies whose business model is based on the protection of such innovations and therefore are willing to such an effort.

Then we have the hospitals, with few patents and high rates, then the universities and the CSIC. Here we can point out that surprisingly some universities appear to have higher capacity of internationalization than the CSIC centres. If we ignore the first two universities (with one or two patents) the institutions which really stand out are the Universidad de Sevilla and the Universidade de Santiago de Compostela. Both have such a positive productive behaviour that a further study of their technology transfer offices (TTO) would be of interest for a future line of study.

International collaboration

In addition to internationalization, an interesting indicator is the collaboration of Spanish applicants with other countries. Here we find that the countries which cooperates the most are Germany, United Kingdom and the United States. At the institutions level of collaboration, the Instituto de Ciencias de Materiales de Madrid collaborates with most entities, although the Universidad del País Vasco has the highest numbers of international collaborations (with Argentina, Chile, the Netherlands, Sweden, United Kingdom and Germany).

When studying the the co-authorship of inventors from Spain with inventors from other countries the collaboration was considerably higher. This, a priori counter intuitive behaviour, leads us directly to the next conclusion: applicants and inventors.

Applicants and inventors

The three most active inventors are: Jose Maria Cabello Lagaron from the Instituto de Agroquímica y Tecnología de Alimentos (IATA), Maria Jose Fernandez Alonso of the Universidade de Santiago de Compostela and Alfonso Miguel Gañan Calvo from the Universidad de Sevilla. It is important to point out that the linkage of an inventor to the applicant is not a trivial task since patents, unlike scientific documents, do not establish a clear link between inventors and applicants. Furthermore it is interesting to see the large number of patents applied by individuals. While it is very common that people apply for patents on a personal basis, this is usually not common in highly complex technological areas such as the nanoworld, which require equipment and infrastructure which usually is not available on a domestic scale. Tracking this behaviour might be an interesting line for future research.

Technology network indicators

Besides all the mentioned indicators, the analysis functionality of the used software tool (Matheo Patent) allows obtaining network indicators that complement and enhance the above. We used these networks to indicate the thematic specialization of the most outstanding applicants like the Universidad de Sevilla (medicinal preparations), or the Instituto de Ciencia de Materiales de Sevilla and the Instituto de Ciencia de Materiales de Madrid (nanocomposites). It was also possible to define thematic clusters. For our study we could identify three main ones: 1) drug delivery devices with aerosols, 2) *administration of nanoparticles with chitosan*, y 3) *administration of nanoparticles with active molecules.*

Future lines of research

The work presented in this thesis will certainly be continued in the near future. For its development a considerable expertise was applied (tools, methods, techniques, etc.) that will be useful in future research. But we believe that this knowledge will not only be useful for research. It will also be helpful for the design and implementation of technology watch and competitive intelligence services that may be of interest to companies and public institutions in need of enhancing their knowledge and control of the world of patents, not only in the field of nanotechnology, but also in other fields. The enhancement of the field of technology transfer is a pending task in Spain and eventually initiatives must be taken not only by governments but also by the productive society as a whole.

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Appendix

Espacenet command line field identifiers[110]

Field identifiers	Description
IN	inventor
PA	applicant
TI	title
AB	abstract
PR	priority number
PN	publication number
AP	application number
PD	publication date
CT	citation/ cited document
CPC	Cooperative Patent Classification
IA	inventor and applicant
TA	title and abstract
TXT	title, abstract, inventor and applicant
NUM	application, publication and priority number
IPC	all current and previous versions of the IPC
CL	IPC and CPC

[110]Source: http://worldwide.espacenet.com/help?locale=en_EP&method=handleHelpTopic&topic=fieldidentifier

Applicants list

(alphabetical order, threshold: min 2 patent records)

Applicant	patent family	patent records	Spanish province	Sector
ABENGOA SOLAR SA (ES)	4	21	Sevilla	COMPANY
ACONDICIONAMIENTO TARRASENSE (ES)	1	2	Barcelona	COMPANY
ACTIVERY BIOTECH SL (ES)	2	4	Navarra	COMPANY
ADVANCELL SA (ES)	10	104	Barcelona	COMPANY
AGROMILLORA IBERIA SL (ES)	1	2	Barcelona	COMPANY
APLICACIONES FARMACODINAMICAS SA (ES)	2	13	Barcelona	COMPANY
APPLUS SERVICIOS TECNOLOGICOS SL (ES)	1	4	Barcelona	COMPANY
ASCAMM TECHNOLOGY CENTRE (ES)	1	2	Barcelona	OTHER RESEARCH INSTITUTE
ASOCIACION DE LA INDUSTRIA NAVARRA (ES)	1	2	Navarra	OTHER RESEARCH INSTITUTE
BIOIBERICA SA (ES)	1	2	Barcelona	COMPANY
BIOLAN MICROBIOSENSORES SL (ES)	1	10	Vizcaya	COMPANY
BIONANOPLUS SL (ES)	2	16	Navarra	COMPANY
BIONOSTRA SL (ES)	3	21	Madrid	COMPANY
BIOSEARCH SA (ES)	1	2	Granada	COMPANY
CAMPOS MARTIN GEMMA (ES)	1	2		PRIVATE INVENTOR
CANICIO CONSULTING CHEMIST SL (ES)	1	2	Barcelona	COMPANY
CARBUROS METALICOS SA (ES)	3	16	Barcelona	COMPANY
CASTILLO HERNANDEZ PAULA (ES)	2	3		PRIVATE INVENTOR
CELLERIX SL (ES)	1	5	Madrid	COMPANY
CENTRE DE RECERCA EN SALUT INTERNACIONAL DE BARCELONA (ES)	1	1	Barcelona	OTHER RESEARCH INSTITUTE
Centro de Astrobiología (CSIC)	5	5	Madrid	CSIC
Centro de Biología Molecular (CSIC)	1	1	Madrid	CSIC
CENTRO DE ESTUDIOS E INVESTIGACIONES TECNICAS DE GIPUZKOA (ES)	2	6	Guipúzcoa	OTHER RESEARCH INSTITUTE
CENTRO DE INVESTIGACION BIOMEDICA EN RED EN BIOINGENIERIA, BIOMATERIALES Y NANOMEDICINA (ES)	7	24	Madrid	OTHER RESEARCH INSTITUTE
CENTRO DE INVESTIGACION COOPERATIVA EN BIOMATERIALES (ES)	4	14	Guipúzcoa	OTHER RESEARCH INSTITUTE
Centro de Investigación en Nanomateriales y Nanotecnología (CSIC)	7	40	Asturias	CSIC
CENTRO DE INVESTIGACION PRINCIPE FELIPE (ES)	1	20	Valencia	OTHER RESEARCH INSTITUTE
Centro de Investigaciones Científicas Isla de la Cartuja (CSIC)	4	4	Sevilla	CSIC

Centro Nacional de Biotecnología (CSIC)	5	5	Madrid	CSIC
Centro Nacional de Investigaciones Cardiovasculares (CSIC)	1	1	Madrid	CSIC
CENTRO NACIONAL DE INVESTIGACIONES CARDIOVASCULARES (ES)	2	6	Madrid	OTHER RESEARCH INSTITUTE
Centro nacional de Investigaciones Metalúrgicas (CSIC)	1	3	Madrid	CSIC
CENTRO NACIONAL DE TECNOLOGIA Y SEGURIDAD ALIMENTARIA (ES)	2	16	Navarra	OTHER RESEARCH INSTITUTE
CENTRO TECNOLOGICO AVANZADO DE LA PIEDRA - CTAP (ES)	1	2	Almería	OTHER RESEARCH INSTITUTE
CENTRO TECNOLOGICO DEL MUEBLE Y LA MADERA (ES)	1	1	Murcia	OTHER RESEARCH INSTITUTE
CENTRO TECNOLOGICO L'UREDERRA (ES)	2	11	Navarra	OTHER RESEARCH INSTITUTE
COMBINO PHARM SL (ES)	1	3	Barcelona	COMPANY
CONSORCIO DE INVESTIGACION BIOMEDICA EN RED EN BIOINGENIERIA BIOMATERIALES Y NANOMEDICINA (ES)	1	3	Madrid	OTHER RESEARCH INSTITUTE
CONSTRUCCIONES AERONAUTICAS - EADS (ES)	1	4	Sevilla	COMPANY
CORPORACION ALIMENTARIA PENASA (ES)	1	1	Asturias	OTHER RESEARCH INSTITUTE
DAS NANO SL (ES)	1	1	Navarra	COMPANY
DE LA PENA-ALONSO RAQUEL (ES)	1	1		PRIVATE INVENTOR
DENDRICO SL (ES)	1	13	Madrid	COMPANY
DIGNA BIOTECH SL (ES)	1	8	Navarra	COMPANY
DONOSTIA INTERNATIONAL PHYSICS CENTER (ES)	1	2	Vizcaya	OTHER RESEARCH INSTITUTE
EM SILICON NANO TECHNOLOGIES SL (ES)	1	2	Valencia	COMPANY
ENDEKA CERAMICS SA (ES)	1	2	Castellón	COMPANY
ENDOR NANOTECHNOLOGIES SL (ES)	2	9	Barcelona	COMPANY
ENOC SOLUTIONS SL (ES)	1	5	Islas Baleares	COMPANY
Estación Experimental del Zaidín (CSIC)	1	3	Granada	CSIC
ESTEVE LABOR DR (ES)	1	4	Barcelona	COMPANY
EUROORTODONCIA S L (ES)	1	2	Madrid	COMPANY
FABRICA NACIONAL DE MONEDA Y TIMBRE (ES)	3	13	Madrid	OTHER RESEARCH INSTITUTE
FARMAPROJECTS SAU (ES)	1	2	Barcelona	COMPANY
FARMHISPANIA SA (ES)	2	14	Barcelona	COMPANY
FERNANDEZLOZANO JOSE FRANCISCO (ES)	1	1		PRIVATE INVENTOR
FICO MIRRORS SA (ES)	1	7	Lérida	COMPANY
FUNDACION AGENCIA ARAGONESA PARA LA INVESTIGACION Y DESARROLLO (ES)	2	10	Zaragoza	OTHER RESEARCH INSTITUTE
FUNDACION CETENA (ES)	1	2	Navarra	OTHER RESEARCH INSTITUTE
FUNDACION CIDETEC (ES)	1	4	Vizcaya	OTHER RESEARCH INSTITUTE

FUNDACION IDICHUS (ES)	1	3	La Coruña	OTHER RESEARCH INSTITUTE
FUNDACION PARA LA INVESTIGACIÓN BIOMÉDICA DEL HOSPITAL UNIVERSITARIO LA PAZ (ES)	1	2	Madrid	HOSPITAL
FUNDACION PARA LA INVESTIGACIÓN Y DESARROLLO EN TRANSPORTE Y ENERGÍA (ES)	1	2	Valladolid	OTHER RESEARCH INSTITUTE
FUNDACION PROGRESO Y SALUD (ES)	1	1	Sevilla	OTHER RESEARCH INSTITUTE
FUNDACION PUBLICA ANDALUZA PARA LA INVESTIGACION BIOSANITARIA DE ANDALUCIA ORIENTAL (ES)	2	3	Granada	OTHER RESEARCH INSTITUTE
FUNDACION PÚBLICA ANDALUZA PARA LA INVESTIGACIÓN DE MÁLAGA EN BIOMEDICINA Y SALUD FIMABIS (ES)	1	2	Málaga	OTHER RESEARCH INSTITUTE
FUNDACION REINA MERCEDES PARA LA INVESTIGACION SANITARIA (ES)	2	5	Sevilla	HOSPITAL
FUNDACION TECNALIA (ES)	2	4	Vizcaya	OTHER RESEARCH INSTITUTE
FUTURE FIBRES RIGGING SYSTEMS SL (ES)	1	1	Valencia	COMPANY
GAMESA SA (ES)	2	11	Álava	COMPANY
GARCIA GARCIA-TUNON MIGUEL ANGEL (ES)	1	1		PRIVATE INVENTOR
GENERALITAT DE CATALUNYA (ES)	1	2	Barcelona	OTHER RESEARCH INSTITUTE
GENETRIX SL (ES)	1	1	Madrid	COMPANY
GOLDEMAR SOLUTIONS SL (ES)	1	2	Barcelona	COMPANY
GRAPHENEA SA (ES)	1	3	Guipúzcoa	COMPANY
GRIFOLS SA (ES)	2	35	Barcelona	COMPANY
GRUPO ANTOLIN INGENIERIA SA (ES)	4	15	Burgos	COMPANY
GUZMAN DE VILLORIA ROBERTO (ES)	2	7		PRIVATE INVENTOR
HISTOCELL SL (ES)	1	10	Vizcaya	COMPANY
HOSPITAL DE LA SANTA CREU I SANT PAU (ES)	1	11	Barcelona	HOSPITAL
HOSPITAL GENERAL UNIVERSITARIO GREGORIO MARANON (ES)	1	5	Madrid	HOSPITAL
HOSPITAL UNIVERSITARI GERMANS TRIAS I PUJOL (ES)	1	11	Barcelona	HOSPITAL
IKERLAN CENTRO TECNOLOGICO (ES)	2	10	Guipúzcoa	OTHER RESEARCH INSTITUTE
INAEL ELECTRICAL SYSTEMS SA (ES)	1	1	Toledo	COMPANY
INFINITEC ACTIVOS SL (ES)	1	2	Barcelona	COMPANY
INNOVACIONES FISICAS Y QUIMICAS SOSTENIBLES SL (ES)	1	1	Madrid	COMPANY
INSTITUCIO CATALANA DE RECERCA I ESTUDIS AVANCATS (ES)	16	72	Barcelona	OTHER RESEARCH INSTITUTE
Institut Català de Nanociència i Nanotecnologia (CSIC)	7	7	Barcelona	CSIC
INSTITUT CATALA DE NANOTECNOLOGIA (ES)	9	44	Barcelona	OTHER RESEARCH INSTITUTE
INSTITUT CATALA D'INVESTIGACIO QUIMICA (ES)	6	11	Tarragona	OTHER RESEARCH INSTITUTE
INSTITUT DE BIOENGINYERIA DE CATALUNYA (ES)	3	4	Barcelona	OTHER RESEARCH INSTITUTE

Institut de Biologia Molecular de Barcelona (CSIC)	1	1	Barcelona	CSIC
Institut de Ciència de Materials de Barcelona (CSIC)	7	18	Barcelona	CSIC
INSTITUT DE CIENCIES FOTONIQUES (ES)	9	41	Barcelona	OTHER RESEARCH INSTITUTE
Institut de Microelectrònica de Barcelona (CSIC)	11	30	Barcelona	CSIC
INSTITUT DE RECERCA BIOMEDICA BARCELONA (ES)	4	13	Barcelona	OTHER RESEARCH INSTITUTE
INSTITUT DE RECERCA EN ENERGIA DE CATALUNYA (ES)	2	2	Barcelona	OTHER RESEARCH INSTITUTE
INSTITUT DE RECERCA HOSPITAL UNIVERSITARI VALL D'HEBRON (ES)	2	7	Barcelona	HOSPITAL
INSTITUT QUIMIC DE SARRIA (ES)	1	8	Barcelona	OTHER RESEARCH INSTITUTE
Instituto Cajal (CSIC)	2	2	Madrid	CSIC
INSTITUTO CIENTIFICO Y TECNOLOGICO DE NAVARRA (ES)	8	61	Navarra	OTHER RESEARCH INSTITUTE
Instituto de Agricultura Sostenible (CSIC)	2	2	Córdoba	CSIC
Instituto de Agroquímica y Tecnología de Alimentos (CSIC)	6	21	Valencia	CSIC
Instituto de Carboquímica (CSIC)	2	5	Zaragoza	CSIC
Instituto de Catalisis y Petroquímica (CSIC)	8	19	Madrid	CSIC
Instituto de Cerámica y Vidrio (CSIC)	9	31	Madrid	CSIC
Instituto de Ciencia de Materiales de Aragón (CSIC)	5	13	Zaragoza	CSIC
Instituto de Ciencia de Materiales de Madrid (CSIC)	31	124	Madrid	CSIC
Instituto de Ciencia de Materiales de Sevilla (CSIC)	11	44	Sevilla	CSIC
Instituto de Ciencia y Tecnologia de Polimeros (CSIC)	5	9	Madrid	CSIC
Instituto de Ciencias de la Construcción Eduardo Torroja (CSIC)	1	1	Madrid	CSIC
Instituto de Diagnóstico Ambiental y Estudios del Agua (CSIC)	1	1	Barcelona	CSIC
Instituto de Física Fundamental (CSIC)	1	1	Madrid	CSIC
Instituto de Investigación en Ciencias de la Alimentación (CSIC)	2	2	Madrid	CSIC
Instituto de Investigaciones Biomédicas Alberto Sols (CSIC)	2	2	Madrid	CSIC
Instituto de Investigaciones Biomédicas de Barcelona (CSIC)	1	7	Barcelona	CSIC
Instituto de Investigaciones Quimicas (CSIC)	4	4	Sevilla	CSIC
Instituto de Microelectrónica de Madrid (CSIC)	9	39	Madrid	CSIC
Instituto de Parasitología y Biomedicina López-Neyra (CSIC)	1	1	Granada	CSIC
Instituto de Química Avanzada de Cataluña (CSIC)	4	33	Barcelona	CSIC
Instituto de Química Física Rocasolano (CSIC)	1	1	Madrid	CSIC
Instituto de Recursos Naturales y Agrobiología de Sevilla (CSIC)	1	1	Sevilla	CSIC
INSTITUTO DE TECNOLOGIA CERAMICA (ES)	2	4	Castellón	OTHER RESEARCH INSTITUTE
Instituto de Tecnología Química (CSIC)	9	31	Valencia	CSIC
INSTITUTO MADRILENO DE ESTUDIOS AVANZADOS EN MATERIALES - IMDEA (ES)	1	1	Madrid	OTHER RESEARCH INSTITUTE
INSTITUTO NACIONAL DE INVESTIGACION Y TECNOLOGIA AGRARIA Y ALIMENTARIA (ES)	1	8	Madrid	OTHER RESEARCH INSTITUTE

INSTITUTO NACIONAL DE TECNICA AEROESPACIAL ESTEBAN TERRADAS (ES)	4	23	Madrid	OTHER RESEARCH INSTITUTE
Instituto nacional del Carbon (CSIC)	1	2	Asturias	CSIC
INSTITUTO TECNOLOGICO DE LA CONSTRUCCION - AIDICO (ES)	1	2	Valencia	OTHER RESEARCH INSTITUTE
INSTITUTO TECNOLOGICO DE MATERIALES DE ASTURIAS (ES)	5	22	Asturias	OTHER RESEARCH INSTITUTE
INSTITUTO TECNOLOGICO DEL PLASTICO - AIMPLAS (ES)	2	3	Valencia	OTHER RESEARCH INSTITUTE
INSTUTO TECNOLOGICO DEL EMBALAJE TRANSPORTE Y LOGISTICA - ITENE (ES)	2	11	Valencia	OTHER RESEARCH INSTITUTE
INTENANOMAT SL (ES)	1	1	Valencia	COMPANY
INTERQUIM SA (ES)	1	14	Barcelona	COMPANY
ITACA SAU (ES)	1	8	Castellón	COMPANY
JIMENEZ EDUARDO (ES)	1	1		PRIVATE INVENTOR
KAPSID LINK SL (ES)	1	4	Madrid	COMPANY
Laboratorio de Física de Sistemas Pequeños y Nanotechnología (CSIC)	3	11	Madrid	CSIC
LACABA MARTA (ES)	1	1		PRIVATE INVENTOR
LANGARON CABELLO JOSE MARIA (ES)	1	1		PRIVATE INVENTOR
LARRANAGA OTANO MIKEL (ES)	1	2		PRIVATE INVENTOR
LARRECHEA AGESTA IGOR (ES)	1	2		PRIVATE INVENTOR
LIPOTEC SA (ES)	5	40	Barcelona	COMPANY
LIZ MARZAN LUIS MANUEL (ES)	1	1		PRIVATE INVENTOR
LLOPIS LLOPIS CARLOS (ES)	1	6		PRIVATE INVENTOR
LLOPIS LLOPIS JOSE DANIEL (ES)	1	6		PRIVATE INVENTOR
LLOPIS LLOPIS SILVIA (ES)	1	6		PRIVATE INVENTOR
LOPEZ FERNANDEZ CEFERINO (ES)	1	1		PRIVATE INVENTOR
LOPEZ QUINTELA MANUEL ARTURO (ES)	1	1		PRIVATE INVENTOR
LYKERA BIOMED SA (ES)	1	2	Barcelona	COMPANY
MADRONERO DE LA CAL ANTONIO (ES)	1	3		PRIVATE INVENTOR
MALET ENGRA GEMA (ES)	1	1		PRIVATE INVENTOR
MARQUEZ CALLE DIEGO FERNANDO (ES)	1	1		PRIVATE INVENTOR
MARTIN ISABEL GARCIA (ES)	1	1		PRIVATE INVENTOR
MARTÍNEZ DE LA FUENTE JESÚS (ES)	1	2		PRIVATE INVENTOR
MEDICHEM SA (ES)	1	1	Barcelona	COMPANY
MESSEGUER PEYPOCH ANGEL (ES)	1	1		PRIVATE INVENTOR
MIGUEL SALA MIRIAM (ES)	1	1		PRIVATE INVENTOR
MIGUEL SAN JOSE DANIEL (ES)	1	2		PRIVATE INVENTOR

MIGUEZ HERNAN (ES)	3	29		PRIVATE INVENTOR
MINERA CATALANO ARAGONESA SA (ES)	2	10	Zaragoza	COMPANY
MIRAVETE DE MARCO ANTONIO (ES)	2	7		PRIVATE INVENTOR
MONDRAGON MARTINEZ LAURA (ES)	1	1		PRIVATE INVENTOR
MOURE FERNANDEZ ALEJADRA (ES)	1	1		PRIVATE INVENTOR
MUNOZ SAIZ MANUEL (ES)	1	3		PRIVATE INVENTOR
NANOATE SL (ES)	1	4	Madrid	COMPANY
NANOBIOMATTERS SL (ES)	10	70	Valencia	COMPANY
NANODRUGS SL (ES)	2	7	Albacete	COMPANY
NANOGAP SA (ES)	6	33	La Coruña	COMPANY
NANOIMMUNOTECH SRL (ES)	1	5	Pontevedra	COMPANY
NANOZAR SL (ES)	1	4	Zaragoza	COMPANY
NLIFE THERAPEUTICS SL (ES)	1	3	Granada	COMPANY
NUNEZ CLAZADO MARIA EUGENIA (ES)	1	1		PRIVATE INVENTOR
NYLSTAR SA (ES)	1	12	Gerona	COMPANY
ORYZON GENOMICS SA (ES)	1	7	Barcelona	COMPANY
ORZAEZ CALATAYUD MAR (ES)	1	1		PRIVATE INVENTOR
PANGAEA BIOTECH SL (ES)	1	2	Barcelona	COMPANY
PASEK MINERALES SAU (ES)	1	1	Asturias	COMPANY
PEREZ PAYA ENRIQUE (ES)	1	1		PRIVATE INVENTOR
PHARMA MAR SA (ES)	2	6	Madrid	COMPANY
POC MICROSOLUTIONS SL (ES)	1	2	Guipúzcoa	COMPANY
PRUNERI VALERIO (ES)	1	1		PRIVATE INVENTOR
REPSOL SA (ES)	1	2	Madrid	COMPANY
SAICA PACK SL (ES)	1	6	Zaragoza	COMPANY
SALVAT LAB SA (ES)	1	20	Barcelona	COMPANY
SANCHEZ CARLOS (ES)	1	6		PRIVATE INVENTOR
SANCLIMENS PEREZ DE ROZAS GLORIA (ES)	1	1		PRIVATE INVENTOR
SENSOTRAN SL (ES)	1	7	Barcelona	COMPANY
SERVICIO ANDALUZ DE SALUD (ES)	3	5	Sevilla	HOSPITAL
SERVIZO GALEGO DE SAUDE - SERGAS (ES)	1	3	La Coruña	HOSPITAL
SILICALIA SL (ES)	2	26	Valencia	COMPANY
SOLUCIONES NANOTECNOLOGICAS SL (ES)	1	2	Zaragoza	COMPANY

SOLUTEX SL (ES)	1	2	Madrid	COMPANY
SOTO COSTAS RAMON FRANCISCO (ES)	1	1		PRIVATE INVENTOR
TCD PHARMA SL (ES)	1	13	Valladolid	COMPANY
TOLSA SA (ES)	1	11	Madrid	COMPANY
UNIVERSIDAD AUTONOMA DE MADRID (ES)	8	23	Madrid	UNIVERSITY
UNIVERSIDAD CARLOS III DE MADRID (ES)	3	6	Madrid	UNIVERSITY
UNIVERSIDAD COMPLUTENSE DE MADRID (ES)	9	34	Madrid	UNIVERSITY
UNIVERSIDAD DE ALCALA (ES)	2	19	Madrid	UNIVERSITY
UNIVERSIDAD DE ALMERIA (ES)	2	3	Almería	UNIVERSITY
UNIVERSIDAD DE CADIZ (ES)	10	28	Cádiz	UNIVERSITY
UNIVERSIDAD DE CASTILLA-LA MANCHA (ES)	5	17	Ciudad Real	UNIVERSITY
UNIVERSIDAD DE CORDOBA (ES)	2	6	Córdoba	UNIVERSITY
UNIVERSIDAD DE EXTREMADURA (ES)	2	5	Cáceres	UNIVERSITY
UNIVERSIDAD DE GRANADA (ES)	12	37	Granada	UNIVERSITY
UNIVERSIDAD DE JAEN (ES)	1	4	Jaén	UNIVERSITY
UNIVERSIDAD DE LA LAGUNA (ES)	1	2	Santa Cruz de Tenerife	UNIVERSITY
UNIVERSIDAD DE MALAGA (ES)	8	42	Málaga	UNIVERSITY
UNIVERSIDAD DE MONDRAGON (ES)	1	4	Guipúzcoa	UNIVERSITY
UNIVERSIDAD DE MURCIA (ES)	1	6	Murcia	UNIVERSITY
UNIVERSIDAD DE NAVARRA (es)	5	7	Navarra	UNIVERSITY
UNIVERSIDAD DE OVIEDO (ES)	1	2	Asturias	UNIVERSITY
UNIVERSIDAD DE SALAMANCA (ES)	1	2	Salamanca	UNIVERSITY
UNIVERSIDAD DE SEVILLA (ES)	24	157	Sevilla	UNIVERSITY
UNIVERSIDAD DE VALLADOLID (ES)	4	9	Valladolid	UNIVERSITY
UNIVERSIDAD DE ZARAGOZA (ES)	8	30	Zaragoza	UNIVERSITY
UNIVERSIDAD DEL PAIS VASCO (ES)	12	48	Vizcaya	UNIVERSITY
UNIVERSIDAD MIGUEL HERNANDEZ (ES)	2	6	Alicante	UNIVERSITY
UNIVERSIDAD NACIONAL DE EDUCACION A DISTANCIA (ES)	3	5	Madrid	UNIVERSITY
UNIVERSIDAD PABLO DE OLAVIDE (ES)	5	18	Sevilla	UNIVERSITY
UNIVERSIDAD POLITECNICA DE MADRID (ES)	7	24	Madrid	UNIVERSITY
UNIVERSIDAD PUBLICA DE NAVARRA (es)	1	2	Navarra	UNIVERSITY
UNIVERSIDAD REY JUAN CARLOS (ES)	1	7	Madrid	UNIVERSITY
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA (ES)	27	163	La Coruña	UNIVERSITY
UNIVERSIDADE DE VIGO (ES)	5	12	La Coruña	UNIVERSITY

UNIVERSITAT AUTONOMA DE BARCELONA (ES)	11	32	Barcelona	UNIVERSITY
UNIVERSITAT D'ALACANT (ES)	7	22	Alicante	UNIVERSITY
UNIVERSITAT DE BARCELONA (ES)	16	42	Barcelona	UNIVERSITY
UNIVERSITAT DE VALENCIA (ES)	11	42	Valencia	UNIVERSITY
UNIVERSITAT JAUME I DE CASTELLO (ES)	1	2	Castellón	UNIVERSITY
UNIVERSITAT POLITECNICA DE CATALUNYA (ES)	5	12	Barcelona	UNIVERSITY
UNIVERSITAT POLITECNICA DE VALENCIA (ES)	20	100	Valencia	UNIVERSITY
UNIVERSITAT POMPEU FABRA (ES)	2	8	Barcelona	UNIVERSITY
UNIVERSITAT ROVIRA I VIRGILI (ES)	3	17	Tarragona	UNIVERSITY
VICAR SA (ES)	1	4	Valencia	COMPANY
VICENT DOCON MARIA JESUS (ES)	1	1		PRIVATE INVENTOR
VILA PENA ANA ISABEL (ES)	2	3		PRIVATE INVENTOR
YFLOW SL (ES)	1	4	Málaga	COMPANY

Inventors list

(alphabetical order, threshold: min 2 patent records)

Inventors	Patent Families	Patent Publications
ABAITUA ELUSTONDO FERNANDO	3	15
ABARGUES LOPEZ RAFAEL	5	12
AGUEROS BAZO MAITE	4	33
ALMINANA DOMENECH NURIA	3	24
ALONSO FERNANDEZ MARIA JOSE	15	132
ALVAREZ SANCHEZ MARIA DEL MAR	3	15
ARANDA GALLEGO PILAR	2	14
ARRUEBO GORDO MANUEL	3	12
AUCEJO ROMERO SUSANA	2	11
AZCARATE IZASKUN GOÑI	2	16
BARRERO RIPOLL ANTONIO	6	49
BEGONA SEIJO REY MARIA	3	21
BENITO JUAN	2	20
BERTRAN SERRA ENRIC	6	22
BLANCO CANOSA JUAN BAUTISTA	3	11
BOTELLO ALFONSO FERNANDEZ	2	16
BRIONES LLORENTE CARLOS	3	20
BULTO CARULLA VICTOR	2	25
BUSOLO PONS MARIA	4	26
CALVINO GAMEZ JOSE JUAN	4	14
CAMPO RODRIGO ANA	4	15
CARRASCO OROZCO MIGUEL	5	38
CEBOLLA RAMIREZ ANGEL	4	19
CEBRIAN PUCHE JUAN	3	24
CENA CALLEJO VALENTIN	4	15
CHAVEZ DE DIEGO SEBASTIAN	4	20
CHONCO JIMENEZ LUIS	2	17
CID POYATOS PAU	2	13
CORMA CANOS AVELINO	8	50
COSTA KRAMER JOSE LUIS	2	11
DE LA FUENTE FREIRE MARIA	3	25
DE LA MATA FRANCISCO JAVIER	3	21
DEL POZO RODRIGUEZ ANA	2	12
DELGADO GONZALEZ RAQUEL	4	27
DELGADO SAN VICENTE DIEGO	2	12
DIAZ MORALES URBANO	3	34
DIAZ RODRIGUEZ LUIS ANTONIO	4	19
DOMINGUEZ PUENTE FERNANDO	2	13
DOMINGUEZ VERA JOSE MANUEL	4	14
ESPARZA CATALAN IRENE	3	25
EUGENIA NUNEZ CALZADO MARIA	2	18
FERNANDEZ CAMACHO ASUNCION	4	32
FERNANDEZ GOMEZ CHACON GERONIMO	2	11
FERNANDEZ LOZANO JOSE FRANCISCO	3	16

FERNANDEZ VALDEZ ADOLFO	5	34
FERNANDO RUBIO MARCOS	2	13
FLORES MOSQUERA MARIA	3	16
FRANCO PUNTES VICTOR	3	14
FUERTES MARRON DAVID	2	13
GALLUR BLANCA MIRIAM	2	11
GALVEZ RODRIGUEZ NATIVIDAD	4	14
GAMAZO DE LA RASILLA CARLOS	2	19
GANAN CALVO MIGUEL ALFONSO	12	97
GARCIA BARRIENTES AFRICA	3	25
GARCIA ENRIQUE	3	21
GARCIA FERNANDEZ JOSE	3	34
GARCIA FUENTES MARCOS	2	19
GARCIA GARCIA NICOLAS	3	11
GARCIA GARCIA RICARDO	5	24
GARCIA GARCIA TUNON MIGUEL ANGEL	2	11
GARCIA GOMEZ HERMENEGILDO	5	27
GARCIA JUEZ VICENTE	2	12
GARCIA MARTINEZ JAVIER	10	72
GARCIA MARTINEZ JOAQUIN CALIXTO	4	15
GARCIA MORENO OLGA	2	17
GARCIA RUPEREZ JAIME	3	16
GIL TOMAS JESUS	2	15
GIMENEZ TORRES ENRIQUE	4	28
GIRALT LLEDE ERNEST	3	14
GOMEZ CORDON JULIO	3	15
GOMEZ GARCIA MARTA	3	32
GOMEZ MONTSERRAT CALLEJA	6	23
GOMEZ RAMIREZ RAFAEL	3	21
GONZALEZ DE LLANO MARIA DOLORES	2	12
GONZALEZ FERRERO CAROLINA	2	18
GONZALEZ LOSCERTALES IGNACIO	4	31
GONZALEZ NAVARRO CARLOS JAVIER	2	18
GUERRA NAVARRO JAVIER	4	14
GULLON IGNACIO MARTIN	2	12
GUZMAN DE VILLORIA ROBERTO	3	11
HERNANDO GRANDE ANTONIO	2	16
HERRERO CHAMARRO MARIA ANTONIA	4	15
HESHAM SALMAN	5	46
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IRACHE GARRETA JUAN MANUEL	9	85
ISABEL VILA PENA ANA	6	46
JORDA BENEYTO MARIA	2	11
LAGARON CABELLO JOSE MARIA	16	93
LALLAVE RIVAS MANUEL	2	11
LECHUGA GOMEZ LAURA	4	18
LITRAN RAMOS ROCIO	2	16
LIZ MARZAN LUIS	3	14
LLORDES ANNA	3	17
LOPEZ ESTEBAN SONIA	3	15
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LUQUE LOPEZ ANTONIO	5	19
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MARTI VEGA ANTONIO	5	17
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MARTIN LOMAS	4	68
MARTINEZ ABIETAR ALEJANDRO JOSE	5	21
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MARTINEZ SANZ MARTA	3	13
MASPOCH COMAMALA DANIEL	3	24
MEJIAS ROMERO JOSE ANTONIO	4	16
MENDOZA GOMEZ ERNESTO	4	11
MERINO GUIJARRO SONIA	4	15
MERINO SANCHEZ CESAR	4	13
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MILLAN ESCOLANO ANGEL	3	17
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MUNOZ FERNANDEZ MARIA ANGELES	3	21
OJEDA MARTINEZ DE CASTILLA	2	12
ONA BLANCO ANA	4	24
ORTEGA LOPEZ PAULA	2	18
ORTIZ MELLET CARMEN	3	34
PALACIO FERNANDO	3	17
PECHARROMAN GARCIA CARLOS	4	19
PENA GULIN OSCAR	2	11
PENADES SOLEDAD	8	84
PEREZ MARTINEZ FRANCISCO CARLOS	4	14
PEREZ RAMIREZ JAVIER	2	11
PI SUBIRANA RAFAEL	2	13
RABANAL ANGLADA FRANCESC	2	11
REMUNAN LOPEZ CARMEN	2	25
RIVAS REY JOSE	4	27
ROCA CABARROCAS PERE	2	14
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RODRIGUEZ FRUTOS TOMAS	2	12
RODRIGUEZ GASCON ALICIA	2	12
RODRIGUEZ LOPEZ JULIAN	4	15
RODRIGUEZ VIEJO JAVIER	3	28
ROGERO BLANCO CELIA	2	12
ROJAS RUIZ TERESA	2	16
ROMAN GARCIA ELISA	3	11
ROMO HUALDE ANA	2	18
RUBIO CARRERO NOELIA	4	11
RUBIO GARCIA JAVIER	2	12
RUIZ CASTON JOSE	3	15
RUIZ HITZKY EDUARDO	3	17
RUIZ MOLINA DANIEL	3	17

SALA VERGES SANTIAGO	2	22
SALAZAR CARO CARLOS	4	14
SANCHEZ BARREIRO ALEJANDRO	5	24
SANCHEZ GARCIA MARIA DOLORES	2	12
SANCHEZ LOPEZ JUAN CARLOS	3	19
SANCHEZ VERDU MARIA DEL PRADO	4	15
SANCHIS BRINES FRANCISCO ANTONIO	2	24
SANCHIS KILDERS PABLO	4	14
SANTAMARIA RAMIRO JESUS	4	19
SANTIAGO REDONDO MARTA	2	11
SAUGAR GOMEZ IRENE	2	11
SEIJO REY BEGONA	5	15
SERNA PEREDA CARLOS	3	11
SERRAMIA LOBERA MARIA JESUS	2	16
SOLINIS ASPIAZU MARIA ANGELES	2	12
SUAREZ LUQUE SILVIA	2	30
TAMAYO DE MIGUEL FRANCISCO JAVIER	7	45
TARRE PEREZ TERESA	2	15
TORRECILLAS SAN MILLAN RAMON	8	47
TORRES LOPEZ DOLORES	2	13
VALERO ROMERO ELSA	3	12
VALLET REGI MARIA	3	11
VAZQUEZ FERNANDEZ PACHECO ESTER	5	17
VECIANA JAUME	5	39
VELEZ ORIA SERGIO	2	11
VENTOSA RULL NORA	3	24
VILA JATO JOSE LUIS	2	24
VILADOT PETIT JOSEP LLUIS	3	22
ZADERENKO GARCIA ANA PAULA	5	18

Nanopatents with most inventors

Patents with most number of inventors (threshold 10 inventors)

# of Inventors	Patent title	First Applicant	Patent number
15	METHOD FOR PRODUCING BIOSENSORS	NANOATE SL	WO2012017116A2
14	METHOD FOR PRODUCING A NANOCOMPOSITE DISPERSION COMPRISING COMPOSITE PARTICLES | OF INORGANIC NANOPARTICLES AND ORGANIC POLYMERS	UNIVERSIDAD DEL PAIS VASCO	WO2014005753A1
14	PROCEDIMIENTO PARA LA FABRICACIóN DE SUPERCRISTALES COLOIDALES CON CAMPOS ELECTROMAGNETICOS ALTAMENTE LOCALIZADOS Y SU UTILIZACIóN PARA LA DETECCION Y MONITORIZACIóN DE ANALITOS	UNIVERSITAT ROVIRA I VIRGILI	ES2502665A1
12	NOVEL CARBOSILANE DENDRIMERS, PREPARATION METHOD THEREOF AND USE OF SAME	DENDRICO SL	WO2007010080A3
11	NANOSTRUCTURED SUPERCONDUCTING MATERIAL OF TYPE REBA2CU3O7 (RE=RARE EARTH OR YTTRIUM) WITH A HIGH DENSITY OF VORTEX ANCHORING CENTRES AND PREPARATION METHOD THEREOF	Institut de Ciència de Materials de Barcelona (CSIC)	WO2008071829A1
11	DEVICE FOR THE SELECTIVE DETECTION OF BENZENE GAS, METHOD OF OBTAINING IT AND DETECTION OF THE GAS THEREWITH	UNIVERSITAT ROVIRA I VIRGILI	WO2011055298A1
11	NOVEL AMPHIPHILIC CYCLODEXTRIN DERIVATIVES	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	WO2008009831A2
11	DENDRIMERS AS NON-VIRAL VEHICLES FOR GENE THERAPY	UNIVERSIDAD DE CASTILLA-LA MANCHA	WO2011107648A1
11	NON-VIRAL VECTORS FOR GENE THERAPY	UNIVERSIDAD DE CASTILLA-LA MANCHA	WO2012017119A2
11	DEVELOPMENT AND USE OF POLYMER NANOPARTICLES COMPRISING POLY(EPSILON-CAPROLACTONE) AND DOXORUBICIN	UNIVERSIDAD DE GRANADA	WO2012104461A1
11	CARBON NANOHORNS COMPRISING DENDRIMERS ON THEIR SURFACE AS NON -VIRAL VECTORS FOR GENE THERAPY	UNIVERSIDAD DE CASTILLA-LA MANCHA	WO2012017118A1
11	DENDRIMERS AS NON-VIRAL VEHICLES FOR GENE THERAPY	UNIVERSIDAD DE CASTILLA-LA MANCHA	WO2011107647A1
11	NANOPOROUS ACTIVATED CARBONS AS ADDITIVES IN TOBACCO FOR REDUCING THE EMISSION OF TOXIC PRODUCTS	UNIVERSITAT D'ALACANT	WO2014154920A1
10	CHIMERIC EMPTY CAPSIDS OF THE INFECTIOUS BURSAL DISEASE VIRUS (IBDV), OBTAINMENT PROCESS AND APPLICATIONS	BIONOSTRA SL	WO2005071069A1
10	MULTIFUNCTIONAL NANOSTRUCTURES AS TRIMODAL MRI/OI/SPECT DIAGNOSIS AGENTS	UNIVERSIDAD DE GRANADA	WO2011070212A2

Nanopatents with most applicants

Patents with most number of applicants (threshold 4 applicants)

# of Applicants	Patent title	First Applicant	Patent number
7	METAL NANOPARTICLES FUNCTIONALISED WITH NEUROPEPTIDE VIP AND PREPARATION METHOD	UNIVERSIDAD DE SEVILLA	WO2009095516A1
5	METHOD FOR PRODUCING A NANOCOMPOSITE DISPERSION COMPRISING COMPOSITE PARTICLES |OF INORGANIC NANOPARTICLES AND ORGANIC POLYMERS	UNIVERSIDAD DEL PAIS VASCO	WO2014005753A1
5	DEVICE FOR THE SELECTIVE DETECTION OF BENZENE GAS, METHOD OF OBTAINING IT AND DETECTION OF THE GAS THEREWITH	UNIVERSITAT ROVIRA I VIRGILI	WO2011055298A1
5	CYCLIC RGD PEPTIDES OF AMINO ACIDS BASED ON THIAZOLES OR OXAZOLES AS SELECTIVE ANTAGONISTS OF THE ALFA A?ß3 INTEGRIN	UNIVERSITAT DE BARCELONA	WO2012062777A1
5	CONJUGATES COMPRISING NANOPARTICLES COATED WITH PLATINUM CONTAINING COMPOUNDS	UNIVERSIDADE DE SANTIAGO DE COMPOSTELA	WO2010069941A1
4	METHOD FOR THE MOLECULAR DIAGNOSIS OF PROSTATE CANCER AND KIT FOR IMPLEMENTING SAME	ORYZON GENOMICS SA	WO2007093657A3
4	UTILISATION OF NANOPARTICLES OF NOBLE METALS AS IMMUNOMODULATORS AND IMMUNOMODULATOR COMPOSITION	UNIVERSIDAD DE SEVILLA	WO2010037878A1
4	IMMUNOACTIVATING CONJUGATES COMPRISING NANOPARTICLES COATED WITH PEPTIDES	UNIVERSITAT DE BARCELONA	WO2010046377A2
4	SYSTEM FOR TRANSPORTING BIOLOGICALLY ACTIVE MOLECULES, COMPRISING A NANOPARTICLE, A PEPTIDE AND A BIOLOGICALLY ACTIVE MOLECULE	UNIVERSIDAD DE GRANADA	WO2014033346A1
4	NOVEL CYCLODEXTRIN DERIVATIVES, METHOD FOR THE PREPARATION THEREOF AND USE THEREOF FOR THE SOLUBILIZATION OF PHARMACOLOGICALLY ACTIVE SUBSTANCES	UNIVERSIDAD DE SEVILLA	WO2004087768A1
4	NOVEL CYCLODEXTRIN DIMERS AND DERIVATIVES THEREOF, METHODS FOR PREPARING THEM AND THEIR USE, IN PARTICULAR, FOR SOLUBILIZING PHARMACOLOGICALLY ACTIVE SUBSTANCES	UNIVERSIDAD DE SEVILLA	WO2005054303A2
4	BIOSENSOR COMPRISING METAL NANOPARTICLES	UNIVERSIDAD DE ZARAGOZA	WO2014016465A1
4	BIODEGRADABLE BIONANOPARTICLES FOR RELEASING THE GSE24-2 PEPTIDE, METHOD FOR THE PRODUCTION THEREOF, AND USE OF SAME	UNIVERSIDAD DEL PAIS VASCO	WO2014122346A1
4	METHODS AND REAGENTS FOR EFFICIENT AND TARGETED GENE TRANSFER TO MONOCYTES AND MACROPHAGES	GRIFOLS SA	WO2010125115A1
4	METHOD FOR PRODUCING METALLIC NANOPARTICLES FUNCTIONALIZED WITH FLUORESCENT ORGANIC MOLECULES	UNIVERSIDAD PABLO DE OLAVIDE	WO2012131133A1
4	SYNTHESIS OF CATALYTIC SUBNANOMETRIC AU PARTICLES SUPPORTED ON SURFACES HAVING AMINE GROUPS	UNIVERSIDADE DE VIGO	WO2010031890A1

Nanopatents with most family members

Patents with most number of family members (threshold 15 members)

# of family members	Patent title	First Applicant	Patent Number (Family representative)
26	PROCESS FOR OBTAINING A CONCENTRATE OF VON WILLEBRAND FACTOR OR A COMPLEX OF FACTOR VIII/ VON WILLEBRAND FACTOR AND USE OF THE SAME	GRIFOLS SA	EP2078730A1
22	COMPOUNDS FOR THE INHIBITION OF APOPTOSIS	CENTRO DE INVESTIGACION PRINCIPE FELIPE	WO2007060524A1
22	STABLE NANOCAPSULE SYSTEMS FOR THE ADMINISTRATION OF ACTIVE MOLECULES	ADVANCELL SA	WO2007104732A3
22	DEVICE AND METHOD FOR CREATING DRY PARTICLES	UNIVERSIDAD DE SEVILLA	WO9930833A1
21	ACID OXIDE WITH MICRO AND MESOPOROUS CHARACTERISTICS: ITQ-36	UNIVERSITAT POLITECNICA DE VALENCIA	WO0024673A1
21	IMMUNE RESPONSE STIMULATING COMPOSITION COMPRISING NANOPARTICLES BASED ON A METHYL VINYL ETHER-MALEIC ACID COPOLYMER	INSTITUTO CIENTIFICO Y TECNOLOGICO DE NAVARRA	WO2005105056A1
20	PEGYLATED NANOPARTICLES	INSTITUTO CIENTIFICO Y TECNOLOGICO DE NAVARRA	WO2005104648A2
18	REINFORCED NATURAL OR CONGLOMERATED STONE PLATE-LIKE ELEMENT AND MULTILAYERED PROTECTIVE COATING THEREOF	SILICALIA SL	WO2010086713A1
17	HYALURONIC ACID NANOPARTICLES	UNIVERSIDADE DE SANTIAGO DE COMPOSTELA	WO2004112758A1
17	SILYL POLYMERIC BENZOIC ACID ESTER COMPOUNDS, USES, AND COMPOSITIONS THEREOF	INTERQUIM SA	WO2011045389A1
17	LIQUID ATOMIZATION PROCESS	UNIVERSIDAD DE SEVILLA	WO9743048A1
16	NOVEL CYCLODEXTRIN DERIVATIVES, METHOD FOR THE PREPARATION THEREOF AND USE THEREOF FOR THE SOLUBILIZATION OF PHARMACOLOGICALLY ACTIVE SUBSTANCES	UNIVERSIDAD DE SEVILLA	WO2004087768A1
16	HYPERTHERMIA DEVICES AND THEIR USES WITH NANOPARTICLES	Instituto de Ciencia de Materiales de Sevilla (CSIC)	WO2009013630A2
16	MULTILAYER STRUCTURE FORMED BY NANOPARTICULAR LAMINA WITH UNIDIMENSIONAL PHOTONIC CRYSTAL PROPERTIES, METHOD FOR THE PRODUCTION THEREOF AND USE THEREOF	Instituto de Ciencia de Materiales de Sevilla (CSIC)	WO2008102046A1
16	METHOD FOR MANUFACTURING MESOPOROUS MATERIALS, MATERIALS SO PRODUCED AND USE OF MESOPOROUS MATERIALS.	GARCIA-BENNET ALFONSO	WO2009101110A2
15	NOVEL CARBOSILANE DENDRIMERS, PREPARATION METHOD THEREOF AND USE OF SAME	DENDRICO SL	WO2007010080A3
15	MAGNETIC NANOPARTICLES OF NOBLE METALS	UNIVERSIDAD COMPLUTENSE DE MADRID	WO2005091704A2
15	NANOPARTICLES COMPRISING CHITOSAN AND CYCLODEXTRIN	UNIVERSIDADE DE SANTIAGO DE COMPOSTELA	WO2006128937A2
15	ACTIVE NANOCOMPOSITE MATERIALS AND PRODUCTION METHOD THEREOF	NANOBIOMATTERS SL	WO2009156975A1
15	METHOD FOR PRODUCING NANOCOMPOSITE MATERIALS FOR MULTI-SECTORAL APPLICATIONS	NANOBIOMATTERS SL	WO2007074184A1

Nanopatents with most received citations (forward citations)

Patents with most forward citations (citations received) (threshold 2 citations)

# forward citations (recieved)	Patent title	First Applicant	Patent number (family representative)
12	MAGNETIC NANOPARTICLES OF NOBLE METALS	UNIVERSIDAD COMPLUTENSE DE MADRID	WO2005091704A2
11	SYSTEMS CONTAINING MAGNETIC NANOPARTICLES AND POLYMERS, SUCH AS NANOCOMPOSITES AND FERROFLUIDS, AND APPLICATIONS THEREOF	Instituto de Ciencia de Materiales de Aragón (CSIC)	WO2008034675A1
9	NANOPARTICLES OF CHITOSAN AND HYALURONAN FOR THE ADMINISTRATION OF ACTIVE MOLECULES	ADVANCELL SA	WO2007135164A1
9	TEMPLATE-SUPPORTED METHOD OF FORMING PATTERNS OF NANOFIBERS IN THE ELECTROSPINNING PROCESS AND USES OF SAID NANOFIBERS	CENTRO DE ESTUDIOS E INVESTIGACIONES TECNICAS DE GIPUZKOA	WO2010112564A1
7	COMPOUNDS FOR THE INHIBITION OF APOPTOSIS	CENTRO DE INVESTIGACION PRINCIPE FELIPE	WO2007060524A1
5	METHODS AND REAGENTS FOR EFFICIENT AND TARGETED GENE TRANSFER TO MONOCYTES AND MACROPHAGES	GRIFOLS SA	WO2010125115A1
5	METHOD FOR THE PRODUCTION OF EMPTY VIRAL CAPSIDS IN YEASTS, SAID CAPSIDS COMPRISING PROTEINS DERIVED FROM PVP2 OF THE VIRUS THAT CAUSES INFECTIOUS BURSAL DISEASE (IBDV)	BIONOSTRA SL	WO2005105834A1
5	CHIMERIC EMPTY CAPSIDS OF THE INFECTIOUS BURSAL DISEASE VIRUS (IBDV), OBTAINMENT PROCESS AND APPLICATIONS	BIONOSTRA SL	WO2005071069A1
5	COMPLETE EMPTY VIRAL PARTICLES OF INFECTIOUS BURSAL DISEASE VIRUS (IBDV), PRODUCTION METHOD THEREOF AND APPLICATIONS OF SAME	BIONOSTRA SL	WO2004087900A1
4	HYPERTHERMIA DEVICES AND THEIR USES WITH NANOPARTICLES	Instituto de Ciencia de Materiales de Sevilla (CSIC)	WO2009013630A2
4	METHOD FOR THE MOLECULAR DIAGNOSIS OF PROSTATE CANCER AND KIT FOR IMPLEMENTING SAME	ORYZON GENOMICS SA	WO2007093657A3
4	NANOPARTICLE BIOSENSOR, METHOD OF PREPARING SAME AND USES THEREOF	INSTITUTO NACIONAL DE TECNICA AEROESPACIAL ESTEBAN TERRADAS	WO2007034021A1
4	ELECTROLUMINESCENT HYBRID MATERIAL COMPRISING A MICROPOROUS OR MESOPOROUS SOLID CONTAINING COVALENTLY-BONDED ORGANIC COMPOUNDS WHICH CONFER ELECTROLUMINESCENT PROPERTIES TO SAME	UNIVERSITAT POLITECNICA DE VALENCIA	WO2006045875A1
4	NOVEL CYCLODEXTRIN DERIVATIVES, METHOD FOR THE PREPARATION THEREOF AND USE THEREOF FOR THE SOLUBILIZATION OF PHARMACOLOGICALLY ACTIVE SUBSTANCES	UNIVERSIDAD DE SEVILLA	WO2004087768A1
3	CONJUGATES COMPRISING NANOPARTICLES COATED WITH PLATINUM CONTAINING COMPOUNDS	UNIVERSIDADE DE SANTIAGO DE COMPOSTELA	WO2010069941A1
3	METHOD FOR THE DRY DISPERSION OF NANOPARTICLES AND THE PRODUCTION OF HIERARCHICAL STRUCTURES AND COATINGS	FERNANDEZLOZANO JOSE FRANCISCO	WO2010010220A1

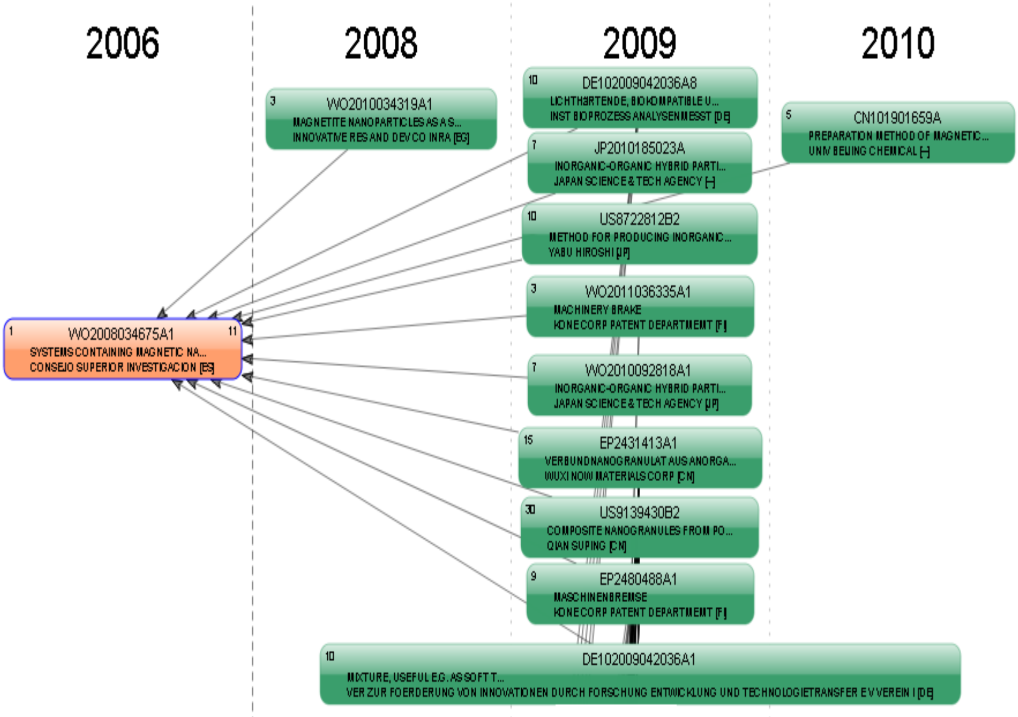
3	NEOGLYCOLIPIDS, AGGREGATES THEREOF WITH CARBON NANOTUBES, METHOD FOR OBTAINING SAME AND USE THEREOF	UNIVERSIDAD DE SEVILLA	WO2009141486A1
3	SYSTEM AND METHOD FOR THE INSPECTION OF MICRO AND NANOMECHANICAL STRUCTURES	Instituto de Microelectrónica de Madrid (CSIC)	WO2007006834A2
3	DEVICE FOR CONTROLLING AN EXCITATION SIGNAL FROM A RESONANT MECHANICAL OSCILLATING ELEMENT, MEASURING DEVICE, METHOD OF CONTROLLING THE EXCITATION SIGNAL, METHOD OF TAKING MEASUREMENTS, COMPUTER PROGRAM AND STORAGE DEVICE	Instituto de Microelectrónica de Madrid (CSIC)	WO03094173A1
2	PROCEDURE FOR THE OBTAINMENT OF NANOCOMPOSITE MATERIALS	Instituto de Agroquímica y Tecnología de Alimentos (CSIC)	WO2011138485A1
2	METHOD FOR COVERING A SPME FIBRE WITH CARBON NANOTUBES AND RESULTING SPME FIBRE	UNIVERSITAT DE BARCELONA	WO2011110717A1
2	MAGNETIC NANOPARTICLES FOR USE IN A PHARMACEUTICAL COMPOSITION	Instituto de Ciencia de Materiales de Madrid (CSIC)	WO2011095661A1
2	METHOD FOR PREPARING NANOPARTICLES OF NI-SN ALLOYS AND THE USE THEREOF IN REFORMING REACTIONS	UNIVERSIDAD DE SEVILLA	WO2010136619A2
2	NANOSTRUCTURED CALCIUM-SILVER PHOSPHATE COMPOSITE POWDER, METHOD FOR OBTAINING SAME, AND BACTERICIDAL AND FUNGICIDAL USES THEREOF	Instituto de Ciencia de Materiales de Madrid (CSIC)	WO2010072882A1
2	IMMUNOACTIVATING CONJUGATES COMPRISING NANOPARTICLES COATED WITH PEPTIDES	UNIVERSITAT DE BARCELONA	WO2010046377A2
2	SYNTHESIS OF CATALYTIC SUBNANOMETRIC AU PARTICLES SUPPORTED ON SURFACES HAVING AMINE GROUPS	UNIVERSIDADE DE VIGO	WO2010031890A1
2	COMPOSITION OF POLYMERS AND CARBON NANOTUBES, METHOD FOR PRODUCING SAME AND THE USES THEREOF	Instituto de Carboquímica (CSIC)	WO2009101231A1
2	DEVICE FOR THE OPTIMAL COUPLING OF LIGHT TO AN INTERMEDIATE BAND SOLAR CELL MADE FROM QUANTUM DOTS	UNIVERSIDAD POLITECNICA DE MADRID	WO2008099039A2
2	SYSTEM OF ORGANIC POINTS, METHOD OF OBTAINING SAME AND USE THEREOF IN THE PRODUCTION OF NANOSCOPIC DEVICES	Instituto de Ciencia de Materiales de Madrid (CSIC)	WO2007051888A1

Citation node maps of top forward cited patents

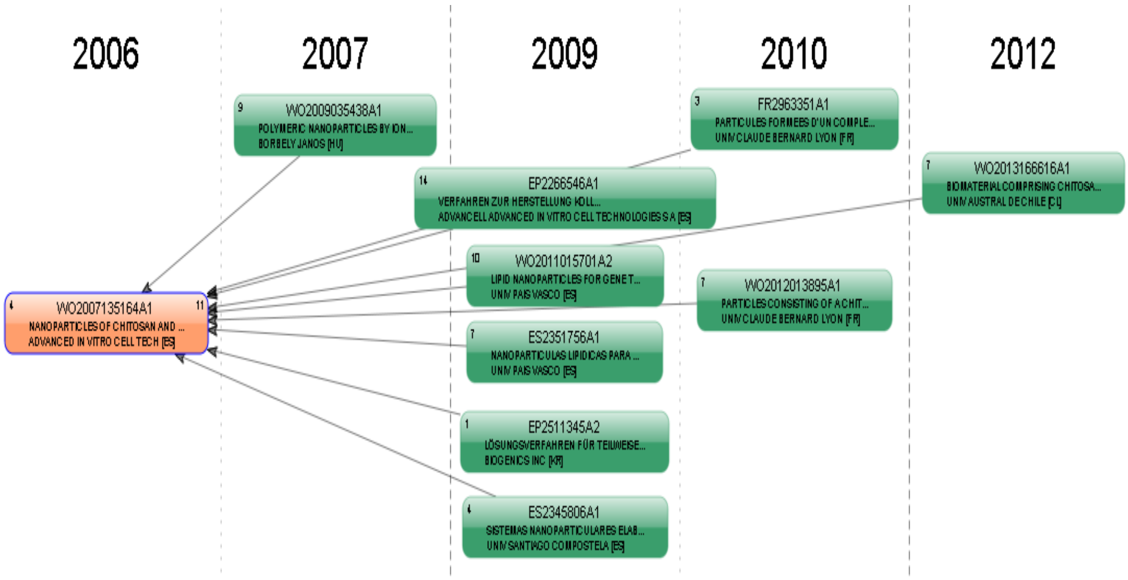
Patents with most forward citations (citations received) (threshold 2 citations)

Citation node maps of some of the top cited nanotechnology patents of Spanish applicants we have identified in the study.

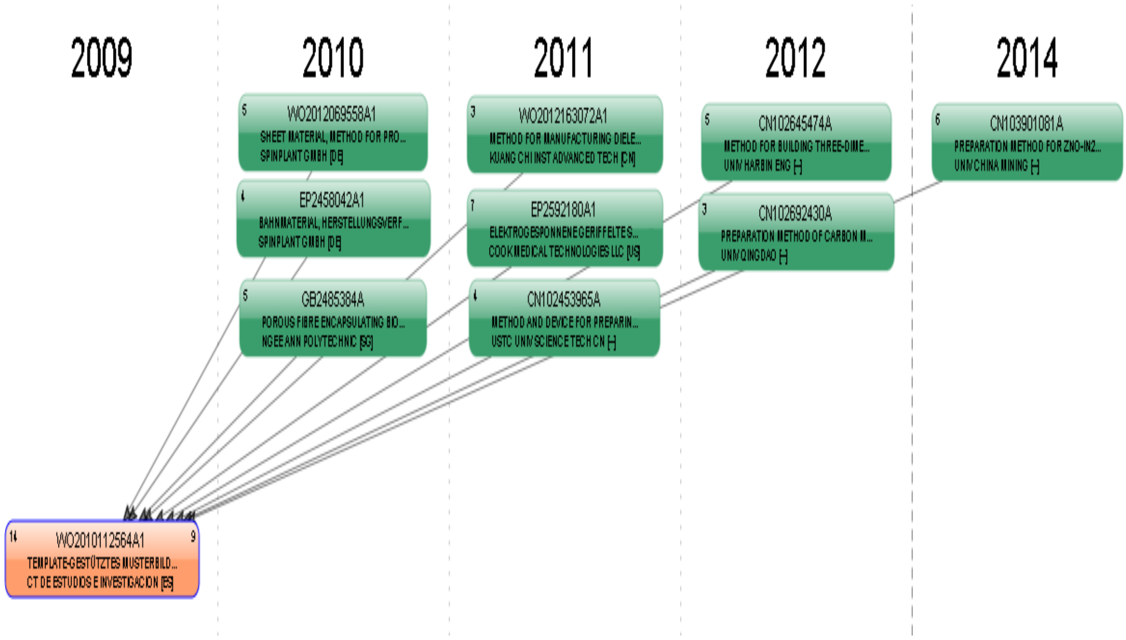
Citation analysis of patent "SYSTEMS CONTAINING MAGNETIC NANOPARTICLES AND POLYMERS, SUCH AS NANOCOMPOSITES AND FERROFLUIDS, AND APPLICATIONS THEREOF" (WO2005091704A2) from INSTITUTO DE CIENCIA DE MATERIALES DE ARAGÓN (CSIC):



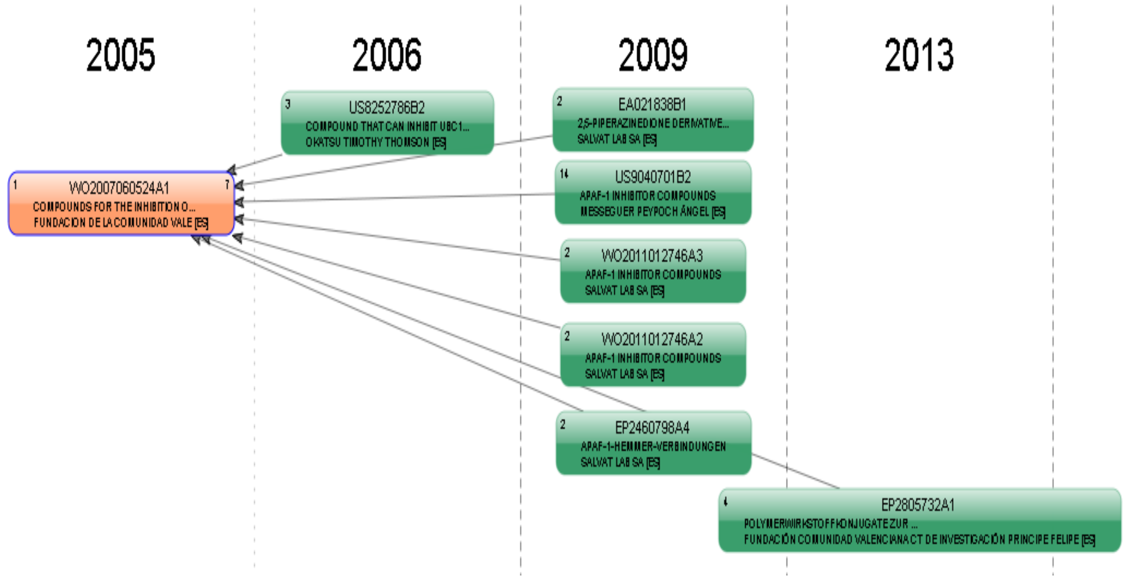
Citation analysis of patent "NANOPARTICLES OF CHITOSAN AND HYALURONAN FOR THE ADMINISTRATION OF ACTIVE MOLECULES" (WO2007135164A1) from ADVANCELL SA:



Citation analysis of patent "TEMPLATE-SUPPORTED METHOD OF FORMING PATTERNS OF NANOFIBERS IN THE ELECTROSPINNING PROCESS AND USES OF SAID NANOFIBERS" (WO2010112564A1) from CENTRO DE ESTUDIOS E INVESTIGACIONES TECNICAS DE GIPUZKOA:



Citation analysis of patent "COMPOUNDS FOR THE INHIBITION OF APOPTOSIS" (WO2007060524A1) from CENTRO DE INVESTIGACION PRINCIPE FELIPE:



Article: Espacenet, Patentscope and Depatisnet: A comparison approach

Final draft post refereeing version (supported by SHERPA/Romeo policies database[111])

Full bibliographic record:

Jürgens, B., & Herrero-Solana, V. (2015). Espacenet, Patentscope and Depatisnet: A comparison approach. World Patent Information, 42, 4-12., http://dx.doi.org/10.1016/j.wpi.2015.05.004

[111] http://www.sherpa.ac.uk/romeo/issn/0172-2190/es/

Espacenet, Patentscope and Depatisnet: a comparison approach based on a nanotech patent case

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Abstract

Espacenet, Patentscope and Depatisnet are known as the main multinational patent databases offered by patent offices which are available free of charge. As all have substantially improved in the last years, a comparison of their functionalities and capabilities are being discussed and the following aspects analysed: data coverage, search functionality, result list & bibliographic view and patent data export. Case studies are presented where the search systems are compared in the field of nanotechnology. The analysis concludes that Espacenet has the best features for searching, Patentscope the best for analysis and Depatisnet the best for complex and confidential search tasks.

Keywords:

Patent Database; Comparison; Features; Functionalities; Free of charge; Open Access

1. Introduction

Online patent search systems have evolved considerably over the last two decades; from cryptic 'text only' command-line databases accessible via modem dial-up on a costly pay per record basis, to today's sophisticated web-based search systems accessible via the Internet which are often free of charge. These free databases made patent information popular to a wider audience and have substantially improved over the last years, now offering patent search functionalities and additional features which were previously only available on commercial providers.

When it comes to know more about the pros and cons of patent databases few studies are available which compare these databases, but most of them are either outdated or do not include free of cost sources. Smith [1] compared online host patent databases available in the late eighties, Lambert [2] compared online host databases and the upcoming Internet patent databases in the late nineties and Schwander [3] evaluated patent searching resources comparing professional and free online databases in the year 2000. The more recent studies are from Stock [4] and González & Zuleta [5], both of which compared some commercial with various free providers. None of the works focused on free of cost sources or gave a direct comparison of their features and functionalities.

Regarding free patent and open access sources, Espacenet, from the European Patent Office (EPO), Patentscope from the World Intellectual Property Organization (WIPO) and Depatisnet from the German Patent and Trademark Office (DPMA) are all patent search systems offered by mayor patent authorities which do not only cover their own patent collection, but also collections from a multitude of countries– making them one of the most popular free of charge patent searching tools available.

Although there are many similarities between these three products, it is of interest to know more about each database in order to choose the right one for the purpose of the patent search. In this study we analyzed these patent search systems, taking into account all their new features and functionalities which were added in recent years and directly compared them according to four key aspects outlined in chapter 2.

The study was completed in the framework of a study about Nanotechnology patents in Spain (see Acknowledgements section), in order to find out more about the strengths and weaknesses of these patent search systems and to evaluate their potential use for this study.

2. Material and Methods

Espacenet, from the European Patent Office (EPO), Patentscope from the World Intellectual Property Organization (WIPO) and Depatisnet from the German Patent and Trademark Office (DPMA) can all be accessed on the homepage of their corresponding Patent Office, with the EPO homepage[112] and DPMA homepage[113] having direct links (Fig. 1 and 2). In the case of the WIPO homepage[114] the patent database was accessible on a sublink via the menu "References" (Fig. 3).

Fig. 1: Access to Depatisnet via DPMA Homepage

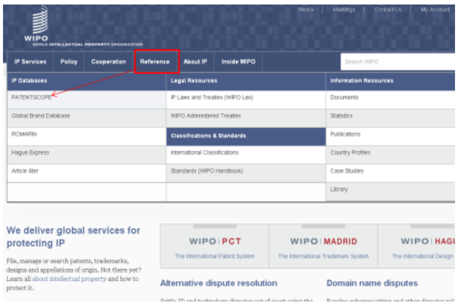


Fig. 2: Access to Patentscope via WIPO Homepage

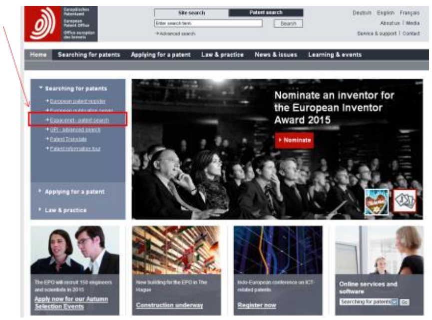


Fig. 3: Access to Espacenet via EPO Homepage

112 http://www.epo.org/
113 http://www.dpma.de/
114 http://www.wipo.int/

All databases can also be accessed via their direct webpages, Espacenet being the only one with an own domain (Espacenet.com) whereas Patentscope and Depatisnet are accessible on subdomains of the Patent Office's homepages[115].

Regarding the analysis methods all three patent searching systems were compared directly taking into account their functionalities and features identified in the time period of the study[116].

The following aspects were analyzed:

- **Data Coverage**
- **Search Functionality**
- **Result List & Bibliographic View**
- **Patent Data Export**

This direct comparison makes it easier to see the differences of each product and helps a user to understand the special features of each analyzed patent search system.

3. Results

3.1 Data Coverage Comparison

Before starting a patent search it is crucial to know the country coverage of the database, since it is of no use if a database has a good search feature but does not offer coverage for the country the searcher is interested in. Therefore, first of all, the patent data coverage of Espacenet, Patentscope and Depatisnet was analyzed. The data for this analysis was extracted from dedicated webpages provided by the corresponding Patent Offices containing statistical information about the databases [6] [7] [8].

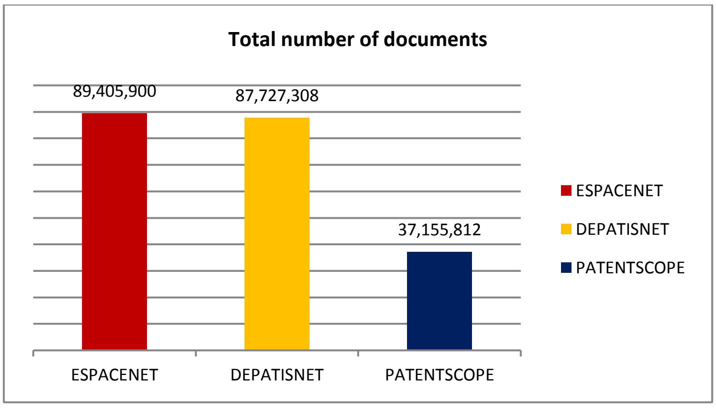


Fig. 4 Total Data Coverage

As seen in Fig.4 both Espacenet Worldwide Database and Depatisnet currently covers nearly 90 million patent documents, which makes them the two free of charge patent databases with the largest coverage. Patentscope has a substantially lower coverage with 37 million documents, but according to WIPO [9] the record counting in the Patentscope statistics is one record per invention and not per publication (e.g. patent application and patent grant) so we estimate that the comparable figures of Patentscope are 30% higher. Patentscope therefore covers approximately 50 million documents, still significantly less than Espacenet and Depatisnet.

When it comes to the coverage per countries we analyzed a sample including some mayor patenting countries and authorities (CN, JP, US, DE, EP, WO) and the patent collection of Spain (Fig. 5). Once again Espacenet and Depatisnet showed similar coverage levels in the main patent collections (WO, EP, US and JP).The German collection in Patentscope was not available at the time of the study but was to be added by the end of the year 2014 [10]. It is surprising that Espacenet shows slightly more German patent

[115] http://patentscope.wipo.int and https://depatisnet.dpma.de/DepatisNet
[116] Study conducted in July-September 2014

document records than in Depatisnet, since one would assume that the database from the German Patent Office has the most complete German collection. This finding had no evident explanation and could be explored in a more in-depth study about coverage and counting methods but would exceed the scope of this article.

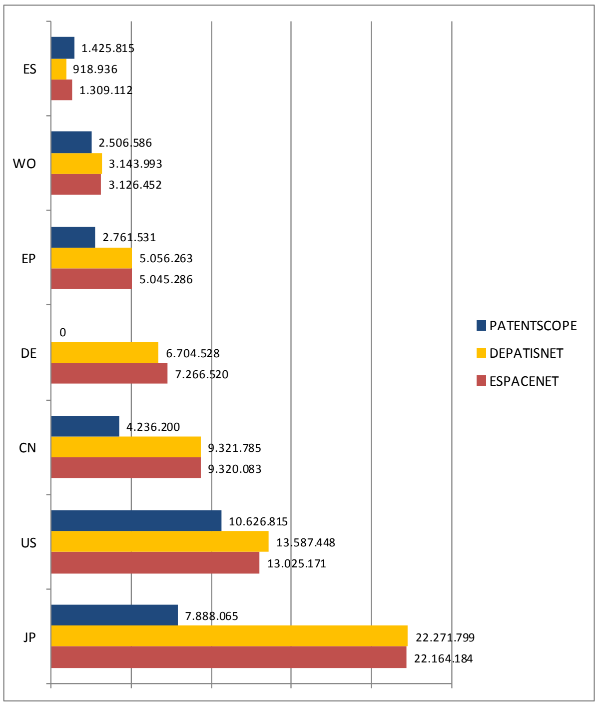


Fig. 5: Data Coverage Comparison per selected countries

Regarding the number of countries or the number of patent office collections per database a similar result is given: Both Espacenet and Depatisnet have more than one hundred patent collections (country + WO and EP collections) – figures which more than double Patentscope's total (Fig. 6).This also explains the much higher number of patent documents in their databases.

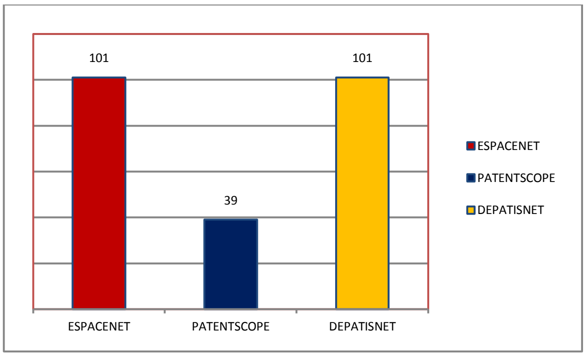


Fig. 6: Number of patent collections available

When it comes to the availability of patent documents not only as a bibliographic record but also in its full text version the comparison is in favour of Patentscope. This is due to an ongoing effort of Patentscope's to digitalize its patent collections via Optical character recognition (OCR), meaning it now provides 19 patent collections in full text, whereas Espacenet only offers full text for EP and WO documents and Depatisnet only offers full text for DE patents (Fig. 7).

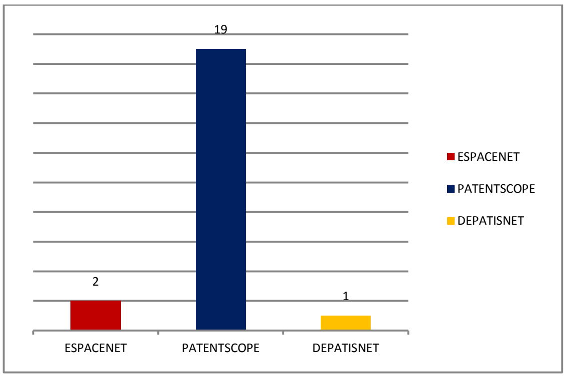


Fig. 7: Number of patent collections in Full Text

As is to be expected, full text availability can be an important aspect for a patent searcher, since sometimes it is only by studying the full document that a user can determine whether a patent is relevant or not. Therefore we concluded that regarding the aspects of coverage, both Espacenet and Depatisnet have by far the better country coverage and can be recommended if a geographically complete patent search is needed (e.g. Novelty Search).Yet when a full text search is necessary Patentscope maybe the better choice, as long as it offers coverage of the countries the searcher is interested in.

3.2 Search Functionalities

After the patent coverage, the second most important aspect was in our opinion comparing the search functionalities of each database, since it determines how powerful and complex patent searches can be completed. Firstly, we took a closer look at the search interfaces available in each database and what characteristics they offered to the patent searcher.

In patent databases one can distinguish between Number Search, Form Search and Command Line Search Interfaces. As we can see in Table 1 all three examined databases offer these types of interfaces to the users, although with different names.[117]

	ESPACENET	PATENTSCOPE	DEPATISNET
Number search	Yes ("Smart Search")	Yes ("Simple")	Yes ("Family")
Form search	Yes ("Advanced Search")	Yes ("Field Combination")	Yes ("Beginner")
Command line search	Yes ("Smart Search")	Yes ("Advanced Search")	Yes ("Expert" and "Ikofax")

Table 1: Types of available Search Interfaces

Command line searching & Search fields

Espacenet's Smart Search showed to be a "Google style" single entry multi-search field. The function is named "smart" because the search engine tries to automatically recognize the type of search field corresponding to each search term[118]. In addition, it allows command line searches using operators and field identifiers [11] - although many users are not aware of this functionality. As shown in the example in Fig. 8 operators and field identifiers were used to retrieve Nanotechnology-related patents with Bayer as an applicant, the keywords "nano" and "tube" in the abstract and 2010 as publication year.

[117] The search interface names can differ quite substantially and in some cases and could confuse the user e.g. the form search in Espacenet is called "Advanced Search" whereas the same type of search interface in Depatisnet is called "Beginner search".
[118] For example if "Bayer 1999" was entered the system will identify the German company Bayer as an applicant or inventor and 1999 as a publishing year.

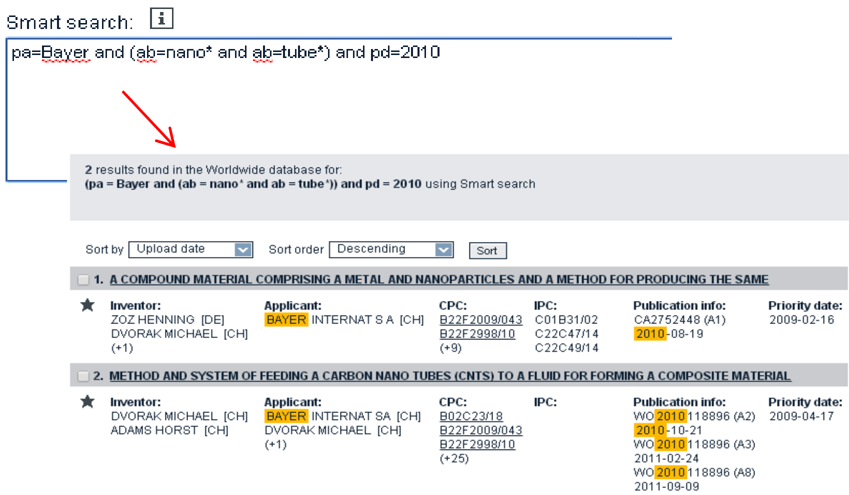


Fig. 8: Command line search with “Smart Search” mode from Espacenet

When it comes to the number of available search fields in each of their search interfaces, Patentscope provides the most powerful search interface with 51 search fields available [4], followed by 36 in the command line search of Depatisnet (Expert and Ikofax search) [5], and 16 in Espacenet´s Smart Search [6].

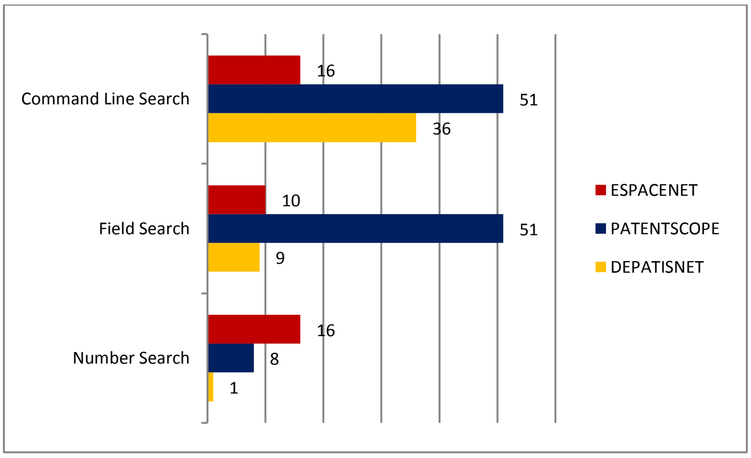
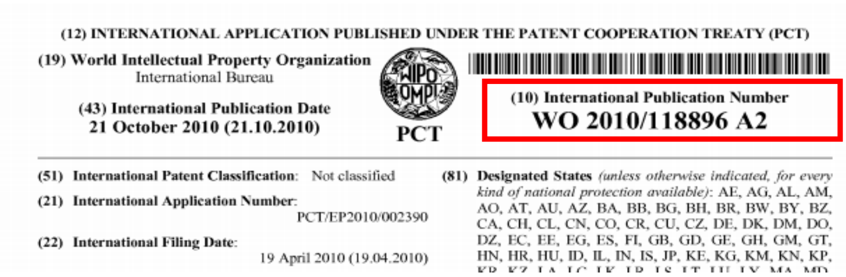


Fig. 9: Number of available Fields in each Search Interface

Number search

How number search is solved in patent databases was another important aspect to consider since unfortunately the syntax of patent publication numbers is not always the same and can differ from database to database. Compounding this problem is the fact that publication numbers can vary from one country to another.

For the comparison of how the number search engines were able to handle this problem we took a PCT patent application from a Nanotechnology-related technology entitled “*Method and system of feeding a carbon nano tubes to a fluid for forming a composite material”*, claimed by Bayer International with its corresponding international publication number “WO 2010/118896 A2” as highlighted in Fig. 10 and checked how the compared search systems were able to retrieve the document using several different possible syntax variations of the publication number.


(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 October 2010 (21.10.2010)

PCT

(10) International Publication Number
WO 2010/118896 A2

(51) International Patent Classification: Not classified

(21) International Application Number: PCT/EP2010/002390

(22) International Filing Date: 19 April 2010 (19.04.2010)

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP,

Fig. 10: Header of a PCT Patent Application Document

First of all we used the exact spelling as stated in the original PCT document with slash and spaces, assuming that this is the spelling a non-expert user would use to look up this document in a patent database. Furthermore we checked the number search capabilities of the patent search systems with simpler spelling variations (without slash, without spaces and without kind codes).

To our surprise, Espacenet and especially Patentscope had problems retrieving the document with most of the spelling variations shown in Table 2.

Syntax used	ESPACENET	PATENTSCOPE	DEPATISNET
WO 2010/118896 A2	Not retrieved	Not retrieved	Retrieved
WO 2010118896 A	Not retrieved	Not retrieved	Retrieved
WO2010118896A	Retrieved	Not retrieved	Retrieved
WO2010118896	Retrieved	Retrieved	Retrieved

Table 2: Number Search Case Study Results

Espacenet's number search engine was not very flexible when it came to interpret different spelling variations as using the PCT patent number with its slash symbol led to no results, whereas just using space symbols led to wrong results because Smart Search misinterpreted the kind code as a classification symbol and thus led to another patent (Fig.11).

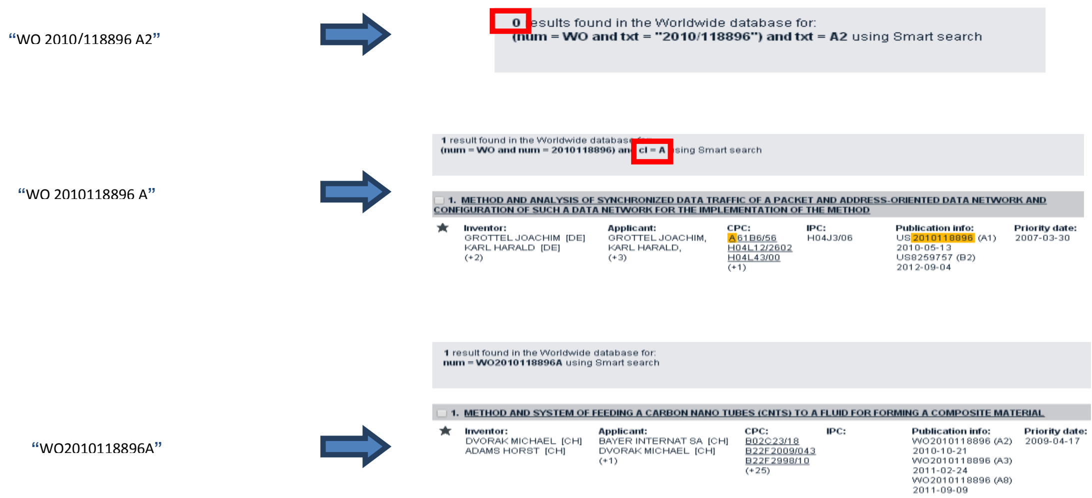


Fig. 11: Number Search Case Study with Espacenet (WO Nanotech Patent)

In this comparison only the number search of Depatisnet via its Family search interface was able to retrieve the WO Document with all the different syntaxes and in our experience was the most flexible and successful database when it came to searches with publication numbers in general.

Operators & Wildcards

When we analyzed the operators available for patent searching the three databases revealed nearly the same functionalities (Table 3), with only one point to mention – that Depatisnet is the only database offering left truncation. Left truncation can be very useful for certain types of searches and is a powerful search option not available in many databases in general since it needs a special treatment of the indexed data. Left truncation is a very powerful and rare feature that next a complex manage of text indexes and usually available only on pay systems.

		ESPACENET	PATENTSCOPE	DEPATISNET
BooleanOperators	AND	Yes	Yes	Yes
	OR	Yes	Yes	Yes
	NOT	Yes	Yes	Yes
Wildcards	Any length	Yes	Yes	Yes
	Precisely 1 character	Yes	Yes	Yes
	1 or no characters	Yes	Yes	Yes
	Right truncation	Yes	Yes	Yes
	Left truncation	No	No	Yes
	Proximity operators	Yes	Yes	Yes
Limitations	Max.search terms per field	Yes (10)	No	No
	Max. search terms per mask	Yes (20)	No	No

Table 3: Available Operators & Wildcards

Regarding the maximum search terms allowed per field and per mask it is important to point out one of the main limitations of Espacenet, which currently only allows a maximum number of 10 search terms per field and 20 per mask. For most simple searches this is not a problem and therefore many users maybe will not notice the limitation, but for patent professionals and in our experience this turned out to be one of the main downsides of Espacenet compared to the other two databases, especially when facing more complex searches.

Classifications

Patent classifications can be very helpful for effective patent searching and apart from the standard international patent classification (IPC), the more detailed cooperative patent classification (CPC) is a very powerful tool, which is why we included both in our comparison. As expected, all 3 databases have full IPC support, both as a search field in the interface and also offering access to the classification so the user can browse and lookup relevant classifications. When it comes to CPC things look different, in Patentscope CPC is not searchable and browsable, whereas in Depatisnet CPC is only searchable in their command line interface mode Ikofax (although this is not officially supported since it is not mentioned on their website). Regarding Espacenet, the full CPC support and the powerful browsing and searching function in the classification is in our experience a very positive feature of this software. Furthermore the direct integration of CPC as a popup in the result lists turned out to be very useful because it allows a quick check of the classification without having to leave the patent search interface.

Other Search Features

Besides Search Interfaces and Operators and Classification Support we also identified other search functionalities, which in our opinion are very useful and can be compared between the databases (Table 4). One example is the Saving Search Queries feature, which was only offered by Patentscope in this comparison. Another is the Search History feature, not offered in Depatisnet, but by Espacenet and Patentscope, although the Search History function in these databases only lets the user view a list of their executed search commands and does not allow users to combine the search steps with Boolean operators (a feature provided in most commercial databases). Both Saving Search Queries and Search History are saved by Patentscope on its server, which requires a (free) user registration. Espacenet does not offer User registration and saves the search history data locally on the computer which has the advantage that no registration has to be done, but the disadvantage that the data is lost once the computer is switched or the browser cache data is deleted (see also chapter 3.5).

A further feature is the RSS support function[119], which is offered by Espacenet and Patentscope and which, in our opinion, is a very useful but underrated feature, since by adding it to a RSS aggregator software it can be used to create a low cost patent monitoring and technology watch tool.

	ESPACENET	PATENTSCOPE	DEPATISNET
Saving patent lists	Yes	No	No
Saving search queries	No	Yes	No
RSS Feed for search queries	Yes	Yes	No
Search history	Yes	Yes	No

Table 4: Other Search Features

3.3 Result List & Bibliographic View

Once a search query is introduced, another important aspect to consider was how the database system displays the results to the user and what options and useful features it provides. We compared several aspects as shown in Table 5. First of all we wanted to know if the fields displayed in the result list are configurable, i.e. if the user can select the fields they want to be displayed in the result list. This was the case for Patentscope and Depatisnet but not for Espacenet, whereas the possibility of field sorting was provided by all three search systems. Unfortunately, the ability to filter the results by certain criteria (i.e. publication dates or applicants) – which is a very useful feature that exists in most commercial providers – was not available on the three search systems compared in this study.

Filtering Keyword Highlighting in the results is, in our experience, another highly useful feature, which both Espacenet and Patentscope support, but which Depatisnet does not. Regarding the presentation of miniature images (thumbnails) in the result list, only Patentscope provides the functionality, which is a powerful feature since it can help a patent searcher perform a quicker screen of the results when dealing with a larger patent result list. Another aspect compared in this study was the maximum number of results the search system was able to display, which is an important issue when large amounts of patents need to be retrieved for further processing. In this case only Patentscope showed to have no number limitation, whereas Depatisnet has a limitation of maximum 1,000 results and Espacenet 500 results.

	ESPACENET	PATENTSCOPE	DEPATISNET
Configurable fields in view	No	Yes	Yes
Sorting	Yes	Yes	Yes
Results filtering	No	No	No
Keyword highlighting	Yes	Yes	No
Image thumbnails	No	Yes	No
Family grouping	Yes	Yes	Yes (not by default)
Maximum number of results	500	unlimited	1,000

Table 5: Result List Features

The next logical step after comparing the results list was to compare the Bibliographic View of the patents and what features each system provided here. As we see in Table 6, in this comparison Espacenet proved to be the most complete solution, offering patent legal status information[120] and direct linking to

[119] RSS stands for „Rich Site Summary“ or „Really Simple Syndication“ and uses a family of standard web feed formats to publish frequently updated information

[120] via Inpadoc legal status database

citing and cited documents of the patent, which can be very useful for a patent searcher and was, in our opinion, very beneficial when comparing it to the other two search systems.

	ESPACENET	PATENTSCOPE	DEPATISNET
Link to citing documents	Yes	No	No
Link to cited documents	Yes	No	No
Link to legal status	Yes (INPADOC)	No	Yes (DE documents only)
Image thumbnails	Yes	Yes	No
Link to original document	Yes	Yes	Yes
Full document download	Yes (with CAPTCHA)	Yes	Yes (with CAPTCHA)
Patent machine translation	Yes (Google)	Yes (Google, Bing, Tapta)	No

Table 6: Bibliographic View Features

Another feature we compared was the possibility of automatic translating patents into other languages. Depatisnet offered no patent translation engine, whereas both Espacenet and Patentscope offered integrated machine translation which can translate patents into several languages. In both cases the technology comes from Google– with Patentscope also offering an alternative translation engine from Microsoft[121]. Patentscope additionally has a new translating tool developed by the company named TAPTA[122], which can be an interesting alternative for difficult translations, since it is specifically built to translate titles and abstracts and can be adapted to a technical domain. This means the translation will take into account specific vocabulary according to the technical field of the translated patent.

3.4 Patent Data Export

Finally our last aspect of comparison was the data export functionality, where we analyzed which way the databases were able to save their patent data for further processing (Table 7).

	ESPACENET	PATENTSCOPE	DEPATISNET
Nr of max. exportable patents records	500	10,000 (with priority data) / 100 (with images & abstract)	1,000
Nr of max. fields in export	24	8	9
Format	CSV, XLS	XLS	CSV, XLS
With images	No	Yes	No
With abstract	Yes	Yes	No

Table 7: Data Export Features

In this comparison Patentscope was, in our opinion, the best of the compared systems, mainly for two reasons: First of all Patentscope was the only system which also offered exporting images, which is a very useful feature when you want to export smaller lists for future integration in patent reports. The second reason is the high number of exportable patent records allowed, which is highly beneficial when a user wants to use the data for further statistical analysis. Patentscope has a new export function which allows exporting up to 10,000 patent records, which is considerably more than the maximum of 500 with Espacenet and the maximum of 1,000 records with Depatisnet.

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[121] Microsoft Bing Translator http://www.bing.com/translator/

[122] Translation Assistant for Patent Titles and Abstracts (TAPTA) https://www3.wipo.int/patentscope/translate/translate.jsf?interfaceLanguage=en

On the other hand, Espacenet showed to be the search system that had the highest numbers of exportable fields, with 24 fields, versus 8 and 9 in Patentscope and Depatisnet respectively.

3.5 Unique Features

When comparing the three patent search systems we also found some unique features, which none of the other patent search systems had.

First of all there is the My Patents List feature in Espacenet (Fig. 12). This feature, known from other database systems as ‘marked list’ lets the user mark patents, which are then saved in a separate list, independent of the search being performed. Especially when involved in iterative searches this feature can be very helpful .One thing to take into account is that Espacenet only saves this ‘favourite list’ locally, which means that the marked patents are only saved on the computer the user is working from and not on a server.

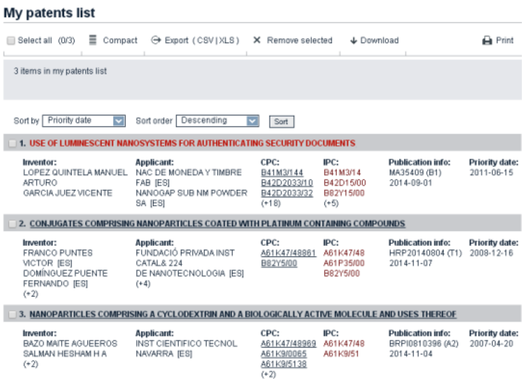

Fig. 8: Unique Feature of Espacenet - My Patents List

The unique standout feature of Patentscope is without doubt the integrated statistical analysis functionality, which allows you to obtain a statistical analysis of the results (Fig. 13), and is normally a feature only commercial providers offer. Once you have your result list in Patentscope, you can generate statistical analysis, viewable in either a table view to graph visualization. Naturally, when compared with commercial providers, the configuration possibilities and the visualization options are limited. Patentscope does not for example allow you to configure the variables of the analysis, and the applicant data is not harmonized. Nevertheless this remains a very useful feature, especially when compared to the other two free of charge database systems.

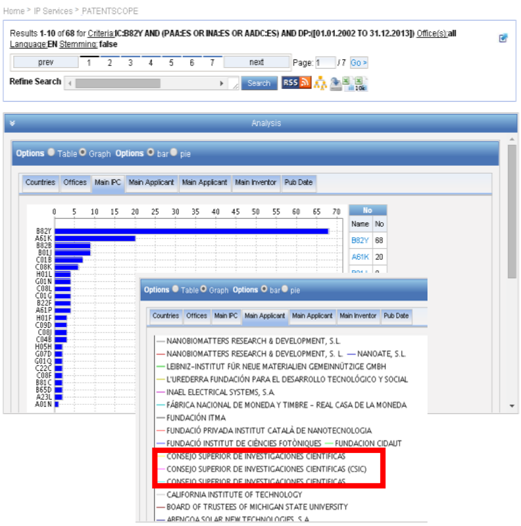

Fig. 9: Unique Feature PATENTSCOPE – Integrated Patent Statistics

Finally, Depatisnet also has its own unique feature, which does not deal directly with search functionality but rather with a more general issue. Analyzing the databases it turned out that Depatisnet is the only search system that works with the secure HTTPS protocol that encrypts the information which is being transferred from the local computer to the server to avoid wiretapping (Fig. 14). This, in our opinion, is a very important feature to take into account for patent searching, especially when dealing with highly confidential patent searches which could reveal information or leads to competitors.

Fig. 10: Unique Feature DEPATISNET - Secure HTTPS connection

4. Conclusion

As we have seen in the comparison study Espacenet and Depatisnet have the best data coverage, although Patentscope has the best full text coverage.

Regarding the database features and functionalities we can summarize the following outline:

Espacenet

Pros

- CPC searchable and features integration in search interface
- Marked patent list ("My Patents List")
- Links to cited & citing documents and legal status

Cons

- Term number limitations in the search interface

Patentscope

Pros

- Image thumbnails in result lists
- Best full text coverage
- Basic statistical analysis and patent data export capability

Cons

- Number search engine

Depatisnet

Pros

- Most versatile number search
- Left truncation in expert and Ikofax Search
- Secure HTTPS connection

Cons

- No keyword highlighting and images in bibliographic view

We have therefore concluded that of the three compared search tools:

- **Espacenet** -> best features for searching
- **Patentscope** -> best for analysis
- **Depatisnet** -> best for complex and confidential search tasks.

Nevertheless we would wish to see some features implemented in the near future which would bring the patent search experience of the compared free of cost products to a new level:

- Image thumbnails in result list within Espacenet and Depatisnet
- Statistical analysis for Espacenet and Depatisnet
- Mobile versions adapted for touch screens on smartphone's and tablets
- Possibility to filter the result list
- Possibility to combine search steps of search history

Acknowledgements

This article is based on a presentation held at the EPO - Patent information conference 2014 held at 4-6 November 2014 in Warsaw, Poland. Special thanks go to the organization team of the conference from the European Patent Office and to the CITPIA Patlib Centre Team without whom this study would never have been possible.

The authors acknowledge the support of Spanish Ministry of Science and Economy for funding the framework project “Vigilancia tecnologica de la nanotecnologia espanola a traves de sus patentes (Technology watch of Spanish Nanotechnology via its patents)”, grant by Plan Nacional de I+D+i 2008-2011, project code: CSO2012-38801, for which this study was used.

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[11 European Patent Office – Espacenet – Help - Smart search - Entering Queries http://worldwide.espacenet.com/help?locale=en_EP&method=handleHelpTopic&topic=searchquery

[12] World Intellectual Property Organization – Patentscope - National Collections – Field Definitions http://patentscope.wipo.int/search/en/help/fieldsHelp.jsf Accessed: 28.09.2014

[13] Deutsches Patent- und Markenamt – DEPATISnetHilfe - Recherchierbare Felder https://depatisnet.dpma.de/depatisnet/htdocs/prod/de/hilfe/recherchierbarefelder/index.html Accessed: 28.09.2014

[14] European Patent Office – Espacenet – Help - Smart search - field identifiers http://worldwide.espacenet.com/help?locale=en_EP&method=handleHelpTopic&topic=fieldidentifier Accessed: 28.09.2014