Chemobrionics database

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Abstract: Given the growing importance of the field of chemobrionics since the term was coined in 2015 and the increase in the number of published papers, it has become necessary to catalogue all the papers published to date. Here we present the chemobrionics database, which lists all the chemical gardens synthesised according to their anion, cation and experimental protocol. The aim of this database is to encourage the study and dissemination of chemical gardens in order to find new experimental avenues in the field of chemobrionics. As this is such a fruitful field, the database is continuously updated.

Introduction

Chemical gardens are self-organizing structures that biomimic plant-like structures with tubes and vesicles shapes. Johann Glauber described these structures for the first time in 1646.[19] Since then, chemical gardens have attracted the attention of scientists, who have recently called this research field chemobrionics.[19] Chemobrionics can be used to study a number of subjects among which are corrosion, sensors and electrochemistry, just to name a few.[5–6] Chemobrionics can help answer the most longstanding scientific question, i.e., how did life originate, given that life could have originated in oceanic hydrothermal vents, which are natural chemical gardens.[2,4–11]

Classical experiments on chemical gardens were performed by adding to a solution of an anion a metal salt (except the too-soluble alkali metals). The metal salt can be added in solid form, as single crystal or as a pellet of polycrystalline powder, or as a second liquid. The most common anion solution used to promote the growth of chemical gardens have been silicate,[3,12–18] but many others have also been used.[3,12–18] In addition to what the classical experiments describe, other kinds of experiments have been conducted to promote the growth of chemical gardens, e.g., using gel or paste,[12–14] by corrosion,[3,15] by performing electrochemical experiments[10] or carrying out experiments in confined geometries.[5,16–18]

Therefore, taking into account the wide number of conditions to promote the growth of chemical gardens, here we present the chemobrionics database, which curates all the papers published to date about chemical gardens, to the best of our knowledge. This database is intended to be a tool for all researchers in the field of chemobrionics, where they can search for all synthesized chemical gardens and to open up new avenues of research in the field of chemobrionics.[19][20]

Results and Discussion

Since the term chemobrionics was coined in 2015, the number of publications in this field has increased. From the first description of chemical gardens by Glauber[10] in the 17th century up to and including 2015, 95 papers have been published. Since then and up to the end of 2022, when this article is written, 104 papers have been published (Fig. 1).[7] In addition, 2 papers have been already accepted and taken into account in the database (although they are not shown in figure 1).[21,22] This increase in the number of publications demonstrates the scientific interest in this field, as also testified by the award of a COST project of the European Union (COST Action CA17120 Chemobrionics).

Therefore, and in order to help the scientific community, the chemobrionics database has been designed. This database can be downloaded from zenodo repository as .csv[19] or can be consulted live on a dedicated website (Fig. 2).[30] In this database, the chemical gardens have been catalogued according to the anion and cation used, and the experimental setup. Accompanying this information are the references to the papers describing these chemical gardens. Therefore, in this database, a chemical garden with the same...
anion and cation may appear in several entries if different experimental methods have been used to synthesize it or if it has been combined with an additional ion. For example, the combination of silicate with calcium appears a total of 8 times in the database, as it has been synthesized using three different experimental approaches (solid, gel and paste), but it has also been synthesized by combining them with CO$_2$, with carbonate anion, with phosphate anion and with iron cation. These calcium silicate gardens have been described in a total of 27 different papers.

Thanks to this database, some interesting results can be extracted on the main chemical gardens on which chemobrionics research has focused. The main anion used has been silicate (53 entries in the database), followed by carbonate (35 entries) and phosphate (25 entries). In figure 3 can be seen all those anions which have more than 5 entries in the database. Among the cations, iron has been the most used cation, both +2 and +3 (32 entries), followed by calcium (31 entries) and copper (21 entries). Focusing on the methods used, using one solid phase (i.e. solid setup in the database) and mixing two liquid phases (i.e. liquid setup) have been by far the most used methods, appearing in 86 and 72 entries, respectively.
In other cases, anions and cations only appear in one entry, so that these routes of synthesis of chemical gardens are open to new experimental contributions. For instance, that is the case of aluminates,[23] chlorite[24] or tungstates,[26] for anions; and lithium,[17,26] cerium[30] or gold,[1,28] for cations.

Within the database, there are chemical gardens that can be considered special, because they cannot be differentiated by anions and cations, so the same terms appear in both fields of the database, such as ice,[28] steel,[3,15] Portland cement,[30] and xenon hydrates.[31]

It is also interesting to note that some researchers have studied natural structures that they have described as chemical gardens, although such structures are less accessible than the experimental synthesis of chemical gardens and, therefore, there are fewer references. The natural structures were composed of carbonates,[8,32] oxides,[6,33] sulfates,[34] or methane hydrates.[36]

Conclusion

In conclusion, given the increasing number of works in the field of chemobrionics, we have found it necessary to create a database to collect and catalogue them in order to facilitate the bibliographic work of future research. In addition, this database can be used to detect research gaps on which to focus future works. This database is alive and the references cited in it are periodically updated. For this reason, the zenodo repository is used for its distribution, where future updates can be easily found. Future updates of the database can be adapted to the needs of the community by making it more specific as necessary.

Supporting information

A csv file with the complete database can be found as a supplementary information. See DOI: 10.5281/zenodo.6607124

Conflicts of interest

There are no conflicts to declare.

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