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Making a device for forced crystallization in magnetic and electric environment

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Abstract. The Earth's magnetic field is, besides its protective role, important in the biochemical structuring of the elements in the living, biological body. The permanent electric field that envelops the planet's surface brings extra effervescence to life. The structure of different chemical and biochemical compositions is due to a cumulus of both magnetic and electric synchronous fields. In different parts of the globe there are different fields, and / or different angles of the field's manifestation. These elements can or cannot bring about changes in the structuring of ionic, biological solutions, which the formed team intends to study. Making such an experimental device is difficult since magnetic and electrical field accuracy is required, as well as the smallest deviation possible produced by the surrounding equipment. The device will successfully simulate extreme areas found on Earth. The studies are a logical continuation of the experiments made beforehand, starting in 2010, which highlighted the structural changes that plants have when electrical and magnetic changes occur in the environment. The device is part of a project of the National Committee on Antarctic Research, supported by the Romanian Academy; part of the Strategic Plan for Antarctic Research 2016 - 2020, 4. Thematic Area - *Frontier Science: Antarctica - Terrestrial Analogue for Outer Space*.

1. Introduction

The studies at the Ecology University of Bucharest, at Hofigal S.A. [1 - 3] and at Politehnica University of Bucharest [4, 5] have shown that the ionic structure changes are amplified or diminished in different electric and magnetic fields. In this article the authors proposed to realize a study in which to observe the dynamic of the crystallization of different ionic solutions in electric and magnetic fields [6, 7].

An experimental basis already exists and these studies will continue to a next stage that is necessary to advance with the understanding of the cellular internal mechanism in various terrestrial electrical or magnetic fields and beyond [6, 7].

2. The making of the experimental device

The studies conducted at during 2016 and 2018 showed that the ionic structure changes are amplified or diminished in different electric fields. The study proposed is complex because there are many variables to analyse, both separately and in different combinations. For this purpose, we developed an experimental device that generates different magnetic and electric fields in different shapes and angles. The device part making, that creates a constant and uniform electric field to study the influence of the



electric field orientation over some ionic solutions, started from the classical hypothesis of physics that belongs to field lines in the electric and magnetic field. This device was made by calculating the construction of an experimental condenser, which has inside a glass Petri capsule. This capsule contains the solutions that will be subjected to the desired influences and which will be subsequently studied by crystallization [8, 9]. For this it was necessary to make calculations starting from the radius of the Petri capsule, which is $r_{CP} = 2\text{cm}$, where the radius of the sample have a maximum value of $r_m = 1.5\text{cm}$. In order to achieve a constant electric field, studies in the field show us that the capacitor must have plates at least twice the size of the studied sample. In conclusion, we decided that the radius of the capacitor plates is $r_c = 2r_{CP} = 4\text{cm}$. The distance between the capacitor plates must be at least the radius of the plates. For safety, the distance between the plates was calculated by the formula $d_c = 2r_{CP} + 1 = 5\text{cm}$ as in figure 1.

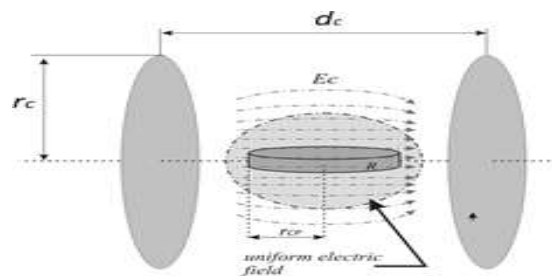


Figure 1. The proposed experimental capacitor.

Considering the distance between the 5 cm plates, the field strength will be $E_c = 1\text{kV/m}$. The studies to be made to highlight the ionic solutions structuring in different magnetic fields require the introduction of certain Petri capsules of certain dimensions. The distance between the coils must be optimal to maintain the uniformity of the magnetic induction in the space bounded by the Petri capsule. From this viewpoint, the mathematical calculation of the coils and the distance between them is made according to the dimensions of this dish. According to SR EN 61000-4-8 National Standard (the correspondent of the standard IEC 61000-4-8) on electromagnetic compatibility [10], it is necessary that the current intensity is constant within the required limits to keep the magnetic field fluctuations below 8% relative to the reference value as in figure 2.

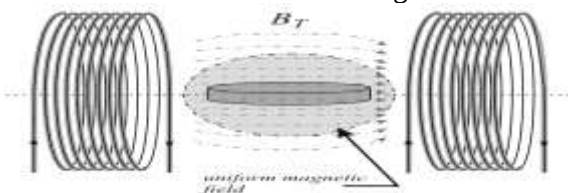


Figure 2. The structure of the magnetic induction B_T for a Helmholtz type coil.

The magnetic field area in which the Petri test capsule is placed has to represent a sphere with a radius between 1/2 and 1/3 compared to the diameter of the Helmholtz [11] type coils as in figure 2. For the calculation of the coil construction, we also started from the radius of the Petri capsule $r_{CP} = 2\text{cm}$ from which we deduced the inner radius of the coil $r_{co} = 3r_{CP} = 6\text{cm}$. By optimizing the power of the external generator with the constructive possibilities of the Helmholtz coil, the maximum magnetic induction of the coil was finally obtained as 5 mT. After doing these calculations, we dealt with the 3D design of the device that allowed a concrete constructive visualization as in figure 3.



Figure 3. Top view, two lateral views and angle view of the device.

3. Materials and study method

The studies focused on using a solution of distilled water with salt (NaCl - 10%). This substance was placed in drops of 4 ml with a graduated dropper into 40 mm diameter PETRI capsules in one drop for each study in the centre of the capsule. Each capsule was numbered and written into a table, recording the intensity and direction of the electric and magnetic field to which it was subjected, the working time and the ambient temperature.

For this article, we will analyse the arrangement on the same plane of the magnetic and electric fields, both perpendicular to the ground. The exposure time to the two fields was of 24 hours. After the studies were carried out, each capsule was set up on a device that kept the temperature constant for the water evaporation at 40° C for about 12 hours. After the evaporation, we could observe the crystallization of NaCl ionic solutions. The analysis was performed using a microscope with lenses of 1x-3x-4x and a 5MB camera with a magnification of 10x. The images are in JPEG format and in order to keep the observations result unaltered, we applied no other forms of processing than the cuttings from the original photo and brightness.

4. Results and discussions

The crystallization of the 10% NaCl in neutral environment has a specific cubic shape with compact, transparent and bright facets as in figure 4, having different dimensions, from about 0.5 mm to 1.5-2 mm. A few areas are found around crystals that are uniformly crystallized. This crystallization is specific for the NaCl.

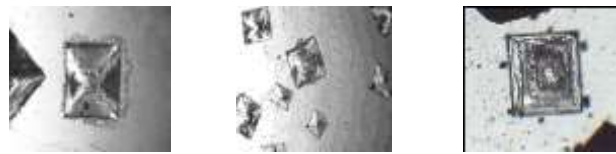


Figure 4. Crystallization in neutral environment for NaCl (Magnification 30 x – 10x – 30x).

For the following studies, we took into consideration the sample of the 10% salt distilled water in a static magnetic field of 0.5 mT and 5 mT.

The images show that the crystallization cubic structure is respected in the magnetic environment as well, but the dimensions are smaller. We can note that there is a significant difference between the crystals bonding areas, an area that is called amorphous. When crystallizing in a 0.5mT magnetic field, there is no significant difference in the dimensions of a crystal, but certain crystals have some rounding at the ends, and other crystals have certain ramified growths. These ramifications have a "tree branch" structure as in figure 5.



Figure 5. 10% NaCl crystallization in magnetic field of 1mT (Magnification 40 x).

In the case of the 5mT magnetic field crystallization, the changes are more visible. Typically, there is a central crystal with much smaller dimensions than a crystal developed in neutral environment (the magnification is of 0.1-0.2 mm) around which a tree structure is formed. This structure is relatively uniform, respecting a fractal pattern. In other areas this tree structure is missing, but the crystal changes its shape radically, showing a development that gives the feeling of a rotation as in figure 6.



Figure 6. 10% NaCl crystallization in magnetic field of 5mT (Magnification 40 x – 10x - 40x).

With regard to the crystallization of the 10% salt solutions in electric field, studies were carried out at 0.1kV and at 1kV. The sample subjected to an electric field of 0.1 kV has a slight tendency to magnify the crystal's dimensions and to arrange the areas near the crystal. This arrangement usually occurs starting from the middle of a crystal's side. We may also find twinned crystals, showing two or more growth germs as in figure 7.



Figure 7. 10% NaCl crystallization in electric field of 0,1kV (Magnification 30 x – 10x - 40x).

With regard to the crystal obtained from a 10% NaCl solution in 1kV electric field, several complex forms are observed. We find quite significant the arrangements of the adjacent areas that were not absorbed into the central crystal. Another aspect to be noticed is the elongation in a certain direction of the crystal, giving the sensation that there is a new growth germ as in figure 8.



Figure 8. 10% NaCl crystallization in electric field of 1kV (Magnification 30 x – 30x - 40x).

The exposure of the 10% saline solution to a 0.1 kV and 0.5 mT electric field has several effects: the crystals tend to be smaller than in a neutral environment and around these crystals there is sometimes a pronounced arrangement of the remains, which oscillates between the tendency to arrange specifically electric (right angles) or the tendency to arrange specifically magnetic (angles of 30° – 60°) or mixed as in figure 9.



Figure 9. 10% NaCl crystallization in electric field of 0.1kV and magnetic field of 0.5mT (10x–30x-30x).

The exposure of the 10% saline solution to a 1kV and 0.5mT electric field develops a pronounced growth towards the electrical form but a magnetism-specific phenomenon still appears. In some areas there is a slight growth of the crystals, a sign that the magnetic effect occurs, but the crystals grow one after the other, showing a growth starting from several polarized germs on the line, or a migration of a crystallization germ into the electric field produced by the device. Another tendency is the specifically electrical one, to create duplications at the peaks, as pronounced growths, but in the structure formation of the area near the central crystal we observe that the remains are arranged in angles of 30° – 60°, which again shows the influence of the field magnetic as in figure 10.



Figure 10. 10% NaCl crystallization in electric field of 1kV, magnetic field of 0.5mT (10x–30x–detail).

The exposure of the 10% saline solution to a 0.1 kV and 5 mT electric field creates the trend to sharply shrink crystals and arrange them around a central crystal. The arrangement is specifically magnetic, with the difference that the ramifications are not explicitly seen anymore, but their ordering is found to be magnetic. Another phenomenon is noted. There is a difference between the crystal and the orderly magnetic growth, as if the crystal tends to maintain certain autonomy from the rest of the structures as in figure 11.



Figure 11. 10% NaCl crystallization in electric field of 0.1kV and magnetic field of 5mT (10x–10x–30x).

Finally, the sample subjected to an electric field of 1kV and 5mT has a very diverse behaviour across the whole surface of crystallization. Magnetic growths with abundant ramifications are observed, but with larger crystals than in a magnetic field, which shows the influence of the crystal's growth from the electric field as in figure 12, left; an aggressive electrical development - a much larger crystal than the majority in the immediate vicinity of a typically magnetic growth - small crystals arranged like a tree as in figure 12, middle; a mix of growth at first electrical and then through the influence of the magnetic field there is a development on angles of 30°– 60° towards the exterior as in figure 12, right.



Figure 12. 10% NaCl crystallization in electric field of 1kV and magnetic field of 5mT (30x -30x-30x).

This arrangements diversity shows us that the ionized solutions react quickly to the influence of these two fields. The crystals structure starts from the bonds that occur in the ionic solution even from the liquid phase. When exposed to an electric field, the cubic shape with straight facets is preserved-which shows us that 90° NaCl specific ionic bonds are accentuated. In the case of the exposure to a pronounced magnetic field the bonds do not exactly respect the cubic ionic shape. There is a tendency to grow like a branch, generally like a tree without bonding into a large and compact crystal. The bonds of 30° – 60° represent a specific of the magnetic field exposure and it is a phenomenon worth studying in the future. It is very likely that quantum / atomic analysis is needed to explain this particularity. We will continue the studies on the influence of electric and magnetic fields in different exposures. The experimental device can develop different electrical and magnetic intensities at different angles, and even at different values of their fluctuation. The study can be conducted at different times, temperature, humidity, etc.

5. Conclusions

The device made through the steps explained above is conceived as a prototype that will be used for studies of the substances crystallization in magnetic fields and at different temperatures that successfully simulate extreme areas found on Earth. The studies on the structuring of the ionic liquid solutions in magnetic and electric field are important for the comparative analysis of the changes that may occur in the connection between living and the non-living matter in different geographic areas. These studies are part of a project of the National Committee on Antarctic Research, supported by the Romanian Academy; part of the Strategic Plan for Antarctic Research 2016 - 2020, 4. Thematic Area - *Frontier Science: Antarctica - Terrestrial Analogy for Outer Space*.

References

- [1] Marosy Z I 2010 *Doctoral Thesis University Transilvania from Brasov* (in Romanian)
- [2] Marosy Z I and Kacso L 2010 *Environmental Engineering and Management Journal* **9** 1503-8
- [3] Kacso L, Marosy Z I and Sima I 2011 *Romanian Journal of Optoelectronics* **16** 79-90
- [4] Mândrea L, Marosy Z I and Costea M 2017 *The 10th International Symposium on Advanced Topics in Electrical Engineering*, March 23-25, Bucharest, WOS:000403399400098
- [5] Constantinescu C and Marosy Z I 2017 *Ecologica Universitaria* **1**(201) 83-9
- [6] Freitas A M B et al. 1999 *Cryst. Res. Technol.* **34** 1239-44
- [7] Kobe S et al. 2001 *JMMM* **236** 71
- [8] *High-voltage test techniques Part 1: General definitions* 2010 IEC 60060-1:2010 Std
- [9] *High-voltage test techniques Part 2: Measuring systems* 2010 IEC 60060-2:2010 Std
- [10] *Electromagnetic compatibility Part 4: Testing and measurement techniques Section 8, Basic EMC standard* SR EN 61000-4-8 / CEI 61000-4-8.
- [11] David J D and Ronald J C 1994 *US Army Research Laboratory*, 2800 Powder Mill Road, AD-A286 08, ARL-TN-35, 94-34824