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CRYSTALLIZATION OF SODIUM CHLORINE SOLUTIONS IN VARIABLE MAGNETIC FIELD

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Abstract: *Modern technologies are focused on finding a solution referring to materials structuring using minimum technological and economical resources. According to the studies issued by A. Freitas and F. Landgraf referring to the crystallization of dia-magnetic and para-magnetic solutions, it was developed a procedure supporting a controlled self-structured crystallization. The pointing out and the imagistic analysis of the crystallization patterns, according to static or variable magnetic field's intensity, can offer a clue referring to matter's behavior manner in several situations. Knowing the apparition manner of new crystallization centers and a crystal's increasing manner can help us understand matter's natural mechanisms and maybe, why not, copy them.*
Keywords: *magnetism, electro-magnetism, crystallization, sodium chloride*

1. MAGNETIC FIELD'S INFLUENCE OVER SUBSTANCES CRYSTALLIZATION

Magnetic field's influence over some crystallization parameters for zinc sulfate – copper sulfate and water solutions were investigated during some experiments by A. M. B. Freitas and F. J. G. Landgraf, from University Sao Carlos and from the Technological Researches Institute from Sao Paulo, Brasilia.
The solutions were exposed to magnetic fields, with several intensities, up to a maximum of 0.7 T. There were observed important differences between dia-magnetic and para-magnetic solutions, resulting a certain difference between the manners a magnetic field can change the crystallization structure of water solutions, depending on the material.
The study starts from the desire to find diverse and adequate manners for crystallizing different salts in a mixture of substances, for separating a product from another product. It was found out, e.g., that the exposure to the magnetic field increases the rate of $MgSO_4$ nucleation. Also, it was remarked that the presence of a magnetic field in a $CaCO_3$ solution supported the apparition of precipitates, a nucleation rate decrease, a crystals decrease and a change in sedimentation morphology.
According to the studies, it is remarked an important difference between the crystallization phenomena at 0.3 T or 0.7 T, the effective existence of the magnetic field changing the crystalline internal structure of dia-magnetic solutions, not acting over para-magnetic solutions. This situation gives us an idea over the fact that there can be studied water solutions structuring and arranging phenomena also to low magnetic intensities, these phenomena pointing out being important for different substances or other parameters like the exposure period.

2. DESCRIPTION OF THE STUDY DEVICE AQUA LP – 01 (Fig. 1)

a. The device TA – is a charger. It includes the power transformers necessary for the device's functioning, connected to the power cable CR and to cable CA towards AQUA device. It has three fusible fuses for securing the entire assembly, two leds (La and Lb) for checking the empty or loaded functioning, an opening and closing switch (Ki).
b. The device AQUA is the apparatus for loading the solution from the recipient R. It includes the apparatus's electrical device, the two loading coils (B1, B2), is connected to cable CA from the charger TA and to the programming cable CP.

c. The recipient R is a brown pharmaceutical bottle of 20 ml, with a cork (for securing from light).
d. The two coils (B1, B2) are connected to the electronic device generating the magnetic field, the power in the coils being controlled by the switch RP (power adjustment) on AQUA device. The coils' functioning is controlled as wave phase shift by switches K1 and K2 for every coil. Every switch has a working led indicating the functioning in different phase shifts specific for the study (L1 and L2).
e. The cable CP is connected to the control system (SC), being a computer generating the working protocol, the electrical signal and the wave shape for the variable magnetic field.

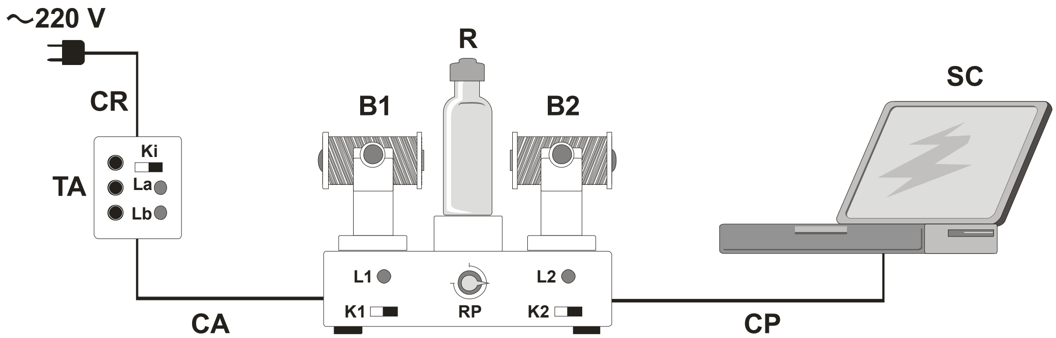


Fig. 1: Basic scheme of the experimental device AQUA LP – 01

3. STUDY MATERIAL AND METHOD

3.1 Study Material

The studies focused on pointing out the differences in the crystallization of salted water solution (NaCl - 5%) naturally, in static magnetic field and in time variable magnetic field.
According to these experiments, there were elaborated study protocols, the concrete working manner, the laboratory tools use and the final comparative analysis manner. For this, there were studied the following types of water solutions:
a. Sample 1, salted table water, noted as ASC, kept in pharmaceutical bottle of 100 ml;
b. Sample 2, tap water from the potable water source, mixed with salt, noted as ASR, kept in pharmaceutical bottle of 100 ml;
c. Sample 3, distilled water, mixed with salt, noted as ASD, kept in pharmaceutical bottle of 100 ml.

3.2 Study Method

The salted water solution is loaded in AQUA device for a certain period of time and using some graded droppers, there are put four drops of this solution in Petri capsules and than they are dried at a constant temperature of 27^{o}C. The final study is based on the observation using the microscope of the salted solutions crystallizing manner. There were used the microscope's facilities, the 10x ocular for viewing and study and the objectives 4x and 10x. The system is endowed with a mini-camera with specialized software for PC, the used software being Ulead Video 7 SE. The mini-camera can make pictures with the resolution of 1024 x 768 pixels. The digital increase capacity is of 10x, keeping the objectives of 4x or 10x. As a conclusion, the effective increase of salt crystals in this study was performed between 40x (for the objective of 4x) and 100x (for the objective of 10x) - digital and optic, but enough to point out the effective shape and structure characteristics.
For maintaining the observations results, there were not applied other images processing manners than the ones offered by the digital camera, keeping the maximum offered luminosity.

4. STUDIES AND EXPERIMENTAL RESULTS

4.1 Study over the crystallization manner of different types of salted waters

In the first study sessions, it was monitored the pointing out of crystallization differences between different samples of salted water using tap water, table water and distilled water. There were compared these crystallization shapes for creating a study basis.

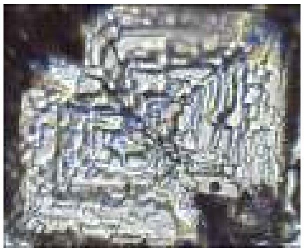


Fig. 2: Rough crystallization, non-homogenous structuring

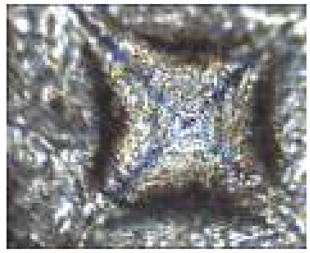


Fig. 3: Simple crystallization, homogenous structuring

Fig. 4: Compact crystallization, harmonious structuring

a) The salted tap water crystallized in less ordered shapes and with rough aspect. The pictures made using the video camera of the microscope showed a certain tendency of structuring in successive layers. The crystallization shape is unclear, due to this reason being relatively difficult to find ordered structures, they being mixed with rests of amorphous, unordered crystals (Fig. 2).

b) The table water crystallized relatively similar, with the visible difference that the shapes became almost pyramidal. An observable aspect on the pictures, the pyramidal crystal's base is not completely squared, has a certain arch shape, comparative to tap water's crystal, the difference being significant. Another aspect worth to indicate is the apparition of an undifferentiated field around the crystals. If the tap water crystallized singularly – lacking sometimes around crystals and other crystallization shapes, for ASC it is a compact mass around the small pyramids, observable on pictures. The number of crystals is smaller than the ones in the tap water, but they are compact and complete (Fig. 3).

c) The distilled water has a special crystallization. It respects the pyramidal shape, but this time the successive layers are very difficult distinguished. They seem to be compact shapes and sometimes shiny, aspect showing an increased finesse for the surfaces. Their shape and arranging are more refined and without restructuring mistakes. For most crystals, we can see the points. It is respected the field around the crystals as for ASC but it is predominant the pyramidal crystallization, more than for ASC, less than for ASR. As a principle, the crystalline shapes are grouped and seldom are the shapes separated, this aspect being remarked for all ASD samples (Fig. 4).

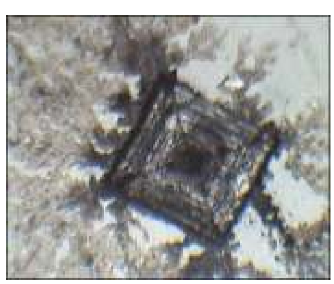
A conclusion of the first working session was that tap water includes a multitude of chemical substances influencing the salted solution crystallization. For the distilled water, we observe ordered and coherent crystallization – conferring in the first phase an advantage. Still, for pointing a certain characteristics and for observing the influencing manner of ions in water, it was used for the following studies table water with a relatively small content of ions – ASC.

4.2 Pointing out the crystalline structuring differences of salted solutions in static magnetic field

For the next studies, it was used a sample of table water with salt - ASC in a static magnetic field of 0.5 mT.

The salt crystals created in natural environment are bigger and show non-crystallized rests (Fig. 5 a), comparative to the structure of the crystals observed in salted water solutions in magnetic field (Fig. 5 b).

(a



(b

(c

Fig. 5: The salt crystals structured in static magnetic field **(b** and **c)** have similar shapes with the ones structured in neuter environment **(a)**. There is still a significant difference observable for not crystallized remains

Both for the neuter environment and for the magnetic one, it is specific the cubic crystallization shape, with right edges and crystals' sizes are bigger, about 0.7 - 1 mm for an edge of the crystallization base (only a little bigger than those from natural crystallization). For ASC salted crystals structured in magnetic field, there is a significant difference between crystals link areas – area called amorphous. In entire mass, there are formed structures as tree branches with a great visual diversity (Fig. 5 b and c).
Within the performed study, it is remarked a little different tendency when crystallizing in static magnetic field North (Fig. 6 a) or South (Fig. 6 b). It is observed, for North magnetism, that the shape and arranging is more pregnant than for the crystallization of water solution in South magnetic field. The entire amorphous non-crystallized mass of ASC is ordered and arranged in tree branches shapes, existing a permanent relation between two crystals and it was observed that during crystallization in South magnetic field, there are often fractal specific arranging areas not linked to a certain crystallization center, situation remarked for ASC crystalline structures charged in North static magnetic field (Fig. 6 c).


(a **(b** **(c**

Fig. 6: The salt structures formed in North magnetic field **(a)** are different from the arranging manner in South magnetic field **(b** and **c),** for the same type of water

4.3 Crystalline structure of salted water in variable magnetic field

The studies are completed by salted water crystallization manner in variable magnetic field. The parameters change in time created in the solution a change of the response manner. When analyzing using the microscope, we can observe three distinct crystallization manners. Some are found also for natural crystallizations (Fig. 7 a), some are found when crystallizing in static magnetic field (Fig. 7 b) and some are completely new and are found only for the solutions structured in variable magnetic field (Fig. 7 c).

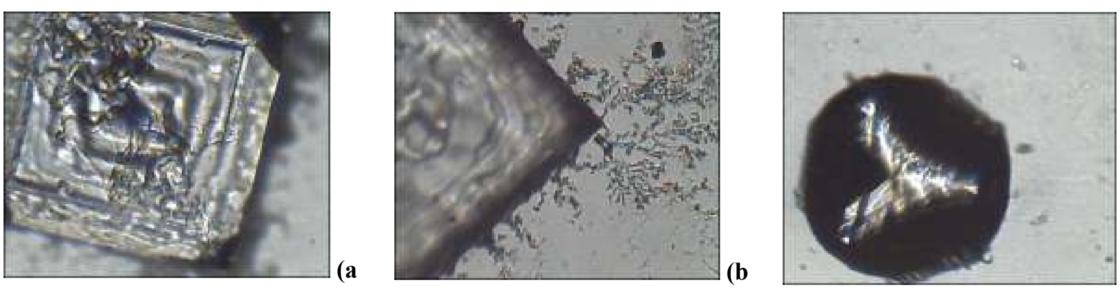

(a **(b** **(c**

Fig. 7: The crystallization in variable magnetic field shows a multitude of shapes and structures

A special aspect when crystallizing in variable magnetic field is the fact that the amorphous area is almost inexistent. The ions in the solution are absorbed an integrated in tree branch shapes, as shown in Fig. 7 b or in hybrid crystals like in Fig. 7 c. Also, during a virtual analysis, it is remarked that the number of crystals in solution increased and their sized varies between 0.7 - 1 mm (at crystal's base) up to 0.05 - 0,1 mm for special crystals as the type in Fig. 7 c. This aspect is not observed nor for the natural crystallization or in static magnetic field. For them, the crystals maintain their size and shape but the difference is the area's arranging called - amorphous. It is obvious the dynamicity of crystals shapes, structures and sizes. Another aspect coming from these observations is crystals clarity and brightness, depending on solution's internal composition – comparison between Fig. 7 a and Fig. 7 c.

5. CONCLUSIONS

The water NaCl 5% solution reacts actively to an outer magnetic field. Even the field's intensity is of 0.5 mT, we can say that there are changes in the internal structure observed at microscope. The solutions were loaded for 24 ore for every sample, at constant temperature of 27^0C. When arranging in Petri capsules, there were used typical, graded droppers – every drop of solution having 0.03 ml.

Along with these measures, we tried to avoid some other possible influences during crystallization. The laboratory is not yet endowed with a humidity and pressure sensor and we could say that there is a factor that can change the solution's drying parameters. For avoiding certain study mistakes, we remade the experiences in many phases and the obtained result was the same. The salted water natural crystallization is cubic and it is observed a pretty large amorphous mass, representing impurities crystallizations.

The crystallization in magnetic field maintained relatively the crystals' original shape and size but it is observed a special arranging of the amorphous area. These two crystallization shapes are remarked for variable magnetic field but there were found out some impurities crystallizations not appeared in other environments.

These studies are the starting point for observing the crystallization manner of different substances in magnetic environments of different frequencies and intensities. Using a low intensity magnetic field, there can be supported industrial used waters purging processes. Also, this procedure is indicated for melts or other liquid composite materials structuring.

An appropriate example for this study confirming in the same time these studies' necessity are the studies issued by Salvatore Torquato from the research team from IBM, who intends to create a mechanism appropriate for silicon's natural crystallization in predefined shapes. These preoccupations are aligned to self-structuring mechanism discovery where, we think, we can have a significant share.

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