

Structure changes of CaCO₃ induced by the “Allotropic Cell” Device

B.E. Zendejas –Leal(1), M. A. Ramírez-Cruz(2), M. Guerrero(1), and C. Vázquez-López(1)
(1)Depto. de Física del CINVESTAV- IPN, Apdo. postal 14-740. México 07000, D.F. México.(2)CICATA-IPN, Calzada Legaria No. 694, Col Irrigación, México 11500, D.F.

The build up of scale formation in water systems is a serious problem, whose solution normally deals with costly chemical softeners. Calcium carbonate is the predominant component of scales deposited from natural water, especially in cooling and in heating water systems. There are some alternatives not involving the use of chemicals, for example, the use of magnetic fields [1]. By drawing water through a static magnetic field ($B = 0.5 \text{ T}$, flow rate $= 0.1 \text{ ms}^{-1}$), it has been claimed that it is produced a less tenacious lime scale due to a change in the crystal morphology. Another alternative is the use of the “Allotropic Cell” [2].

The “Allotropic Cell” [2] is a sealed cylindrical and hermetically closed chamber made of brass (from commercial piping alloy of 64% Cu and 32% Zn, as determined by EDS), containing a paste mixture of magnetite dust and sawdust immersed in an ascorbic acid water solution. The cells used in this work measure 2.5 cm diameter and 13cm length. The experiments were performed using a controlled supersaturated test solution prepared dissolving 1/2 g of CaCl₂ and 1/2 g of NaHCO₃ per litre of deionizer water. As treatment devices, commercial allotropic cells [3] were used, and as control devices, empty cells. The X-ray spectra obtained from filtered precipitates of non-treated and allotropized solutions are shown in Fig. 1. For the non-treated precipitate, the predomination of calcite structure is observed, while the allotropized precipitate reveals aragonite structure predomination.

The results obtained by XRD are also revealed by optical microscopy. Fig. 2 shows 100x optical micrographs of the precipitates obtained from non-treated solutions (Control samples) and from treated solutions (Cell samples), deposited on pyrex microscope slides. Images at interface means the use of a metallographic inverted microscope, and the images are taken through the pyrex glass in order to observe the CaCO₃-glass interface. Images at surface means the use of a non-inverted metallographic microscope, and the images are taken on the CaCO₃ free surface side.

It can be seen that the control solution produces mainly calcite like crystals, while the treated solution precipitates a mixture of needle like crystals (aragonitic structure) and some smaller calcite crystals. The pyrex glass-CaCO₃ interface corresponding to the treated solution has another remarkable feature: the crystal habit becomes more aggravated, and CaCO₃ exhibits cotton wool-wise shape. This can be interpreted as the inhibition effect induced by the allotropic cell. This effect is similar to those of chemical inhibitors reported by Q. Yang et al. [4].

It is rather plausible that the mechanism of influence is the electric field at the surface cell - water interface. In this case, the free energy of nucleation becomes smaller. According to Saban [5], this mechanism is very plausible when the dielectric constant of the precipitates is smaller than that of the solution, which indeed is our case.

In conclusion a scale inhibition effect of water solutions induced by a device known as “Allotropic Cell” is presented. The scale inhibition effect is related to a change of the crystallization habit of the precipitates. There is also an induced crystal structure modification of the precipitates, from calcite to a mixture of calcite and aragonite structure, with the predomination of the aragonite phase as determined by XRD measurements and by optical micrographs. The inhibition effect consists in the induced nucleation of particles which takes place in the solution rather than on the container walls. This produces a mud precipitation that falls on the bottom, which may be easily removed.

References

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Fig. 1. Structure changes induced by the allotropic treatment.

Fig. 2. Optical microscopy images of the sediments originated from non-treated solution (Control images) and from allotropic treated solutions (Cell images).

