Effect of electromagnetism on the formation of calcium carbonate crystals: presence of calcite and aragonite

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INTRODUCTION

- The formation of scale in hot water systems is a problem.
- These scales produce long-term economic losses in domestic and industrial installations.
- The classical techniques to soften water modify the chemical composition.
- Electromagnetic techniques is using as an alternative without altering the quality of the water [1].
- How these techniques prevent scale formation is not entirely clear.
- One of the theories proposed the appearance of aragonite (less encrusting) than calcite (encrusting) [2].
- The TK3K electromagnetic equipment, patented by the company Ecotecnica Energy System, is used.

RAPID CONTROLLED PRECIPITATION (RCP)

- Commercial calcium carbonate (320 ppm) was dissolved in distilled water by bubbling CO_2.
- A supersaturated solution to be generated (at pH of approximately 5.8).
- This solution was recirculated in the experimental setup until reaching pH 7 (Figure 1).
- Two couples of experiments were done: with the equipment turned off or on.
- The controlled rapid precipitation tests was performed:
  - 500 mL of water were stirred at 600 rpm for 3 hours
  - Room temperature of 23 ± 0.3 ºC
  - Relative humidity 30-35%
  - Ambient CO_2 concentration 400- 450 ppm
- The stirring causes the dissolved CO_2 pass to gas phase, raising the pH of the medium and producing the precipitation of the calcium carbonate that was supersaturated (Figure 2), according to:

$$2HCO_3^- \leftrightarrow CO_2 + CO_3^{2-} + H_2O$$

$$CaCO_3\downarrow \leftrightarrow Ca^{2+} + CO_3^{2-}$$

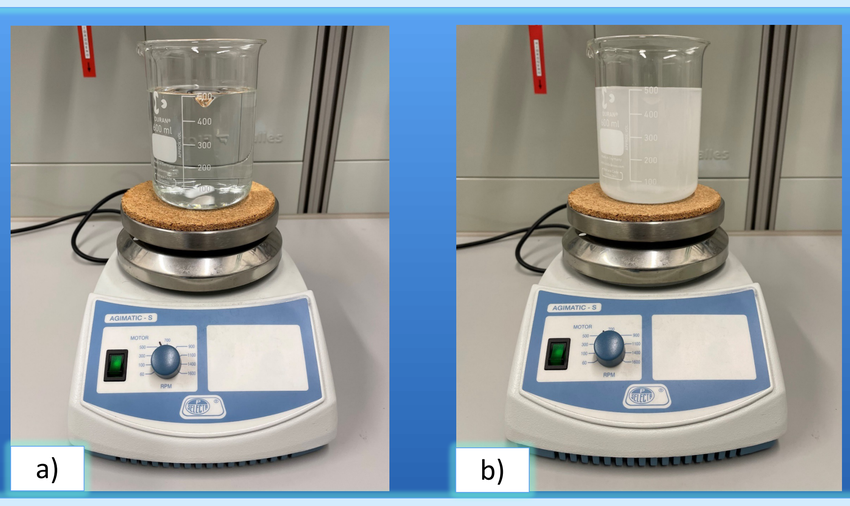

Figure 2. Rapid controlled precipitation (RCP) test: a) initially b) finally

RESULTS AND CONCLUSIONS

- The RCP test it´s a good tool to provoke the precipitation of calcium carbonate.
- The crystals formed can be observed using a polarized light optical microscope.
- This simple technique is a cheaper alternative to the used of SEM microscopy, to distinguish the mineral phases.
- Samples subjected to treatment present aragonite (Figure 4. b)), which does not appear in the untreated samples. Samples untreated present only calcite (Figure 4. a)).

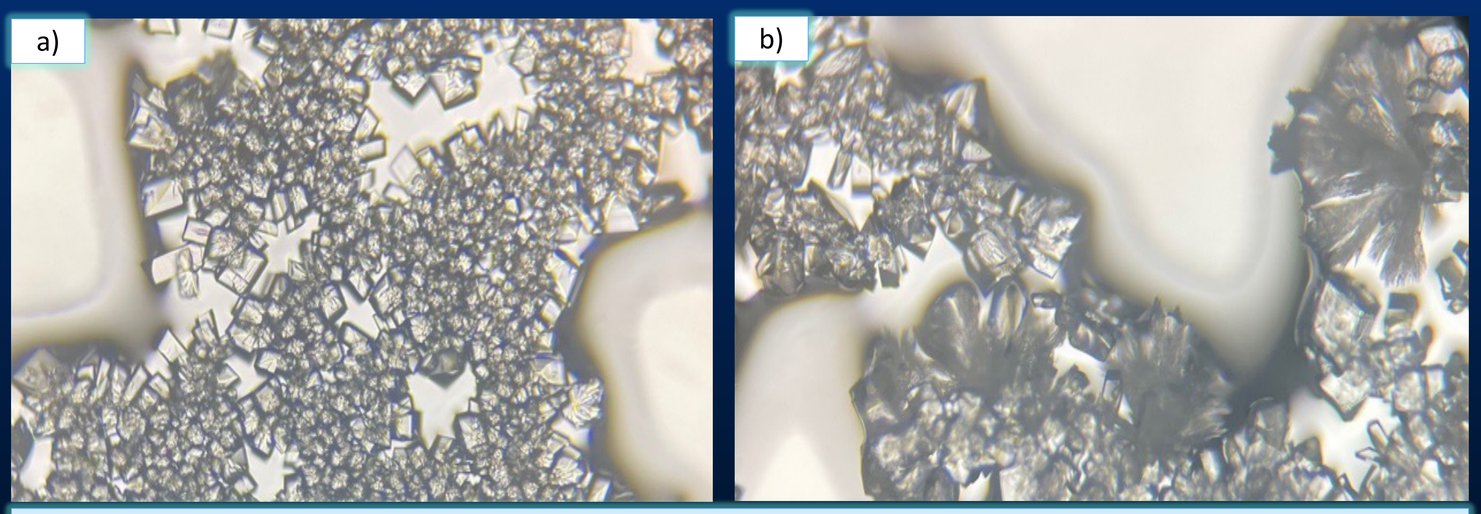

Figure 4. Calcite in untreated samples (a) and mix of calcite and aragonite in treated samples (b)

OBJECTIVE

- The rapid controlled precipitation (RCP) test [3] is used to promote the calcium carbonate precipitation in water with or without electromagnetic treatment.
- Visual study of crystals formed using polarized light optical microscopy

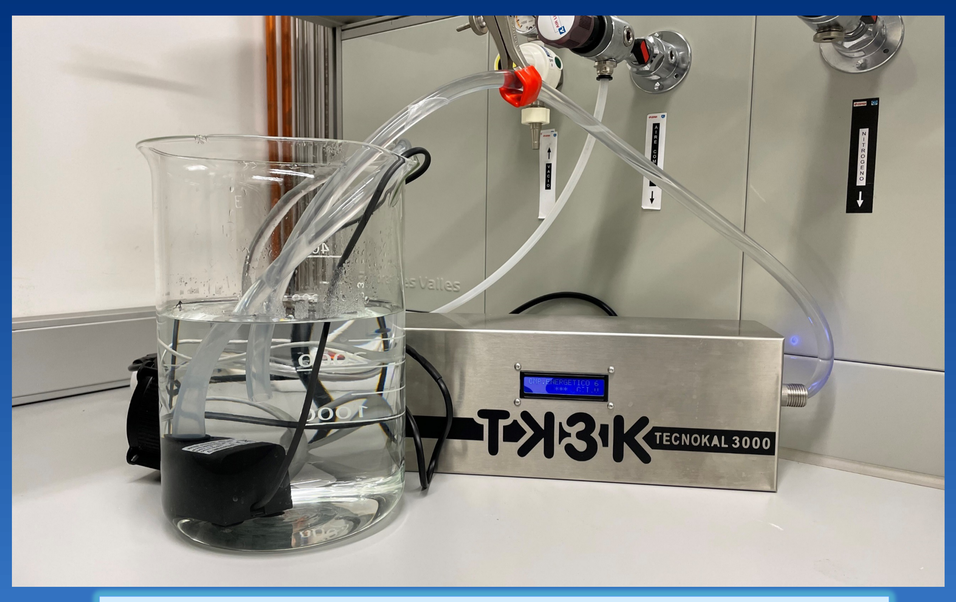

Figure 1. Experimental setup for electromagnetic treatment

DETERMINATION OF CRYSTALS

- The salts obtained in the experiment are analyzed by polarized light optical microscopy to distinguish the mineral phases.
- Calcite has a rhombohedral structure that is seen as cubes under the microscope (Figure 3. a)) .
- Aragonite has an orthorhombic structure that looks like needles under the microscope [4] (Figure 3. b)) .

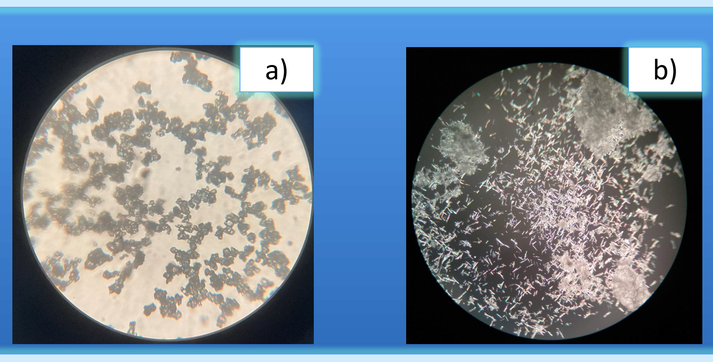

Figure 3. Calcite (a) and aragonite (b) seen with a polarized light optical microscope

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