LEBSC
Laboratorio di Strutturistica Chimica Ambientale e Biologica
Laboratory of Environmental and Biological Structural Chemistry

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

EFFECTIVENESS OF THE EWO DEVICE IN PREVENTING LIMESTONE DEPOSITION ON DOMESTIC WATER PIPES ATTRIBUTABLE TO THE PREDOMINANT CRYSTALLISATION OF ARAGONITE RELATIVE TO CALCITE

SCIENTIFIC REPORT

Dott. Marco Lelli, Prof. Elisabetta Foresti and Prof. Norberto Roveri

LIMESTONE

Calcium-rich waters evaporate due to temperature effects, causing a progressive accumulation of calcium carbonate ($CaCO_3$) or of calcium and magnesium carbonate ($Ca\text{-}MgCO_3$), which are deposited on contact surfaces.

This phenomenon causes significant damage, in so far as these limestone deposits may cause more or less significant damage to installations, tubes and household appliances. The accumulation of limestone in a domestic environment also obliges us to consume more energy for heating and circulation of water, thereby triggering processes which entail premature ageing of household appliances in daily use.

Even if the phenomenon of limestone principally concerns hot water hydraulic circuits, in domestic installations it is appropriate to treat not only water for heating installations but also all the water which is used, both for personal use and for domestic use in general.

The attempt to avoid the formation of limestone in hydraulic installations leads to a consideration of two types of treatment:

- treatment of chemical type
- treatment of physical type

CHEMICAL TREATMENTS

The most widely used chemical treatments are those based on the removal of ions present, through the use of ion exchange resins, or those based on the principle of inverse osmosis.

Installations with resins (softeners) replace cations and anions to be removed (in order to avoid limestone Ca^{2+}, Mg^{2+} and CO_3^{2-}) present in the water with more suitable ones, during the passage of the water through a medium containing resins impregnated with salts.

Softeners are generally used when water has a hardness exceeding 25°F. / 14°dH / 2,5 mmol. This treatment is highly effective, but if used in an imprecise manner, may have the following disadvantages:

- if the resins are not frequently disinfected, during the passage of the water through the resin, bacterial flora may take root, with possible negative repercussions on the health of the consumer.
- in addition to being frequently disinfected, resins must be regenerated periodically with the salt in order to ensure continuous and correct functioning.

Inverse osmosis, on the other hand, is a filtering technique which allows water to be purified and made healthier for use in foods. This is a water filtering system which makes use of membranes to block cations contained in the water itself.

Water softened chemically with the systems described above, while containing a lesser amount of calcium and carbonate ions, does not permit the complete avoidance of formation of limestone within heating tubes and coils, but merely slows its formation over time.

PHYSICAL TREATMENT

Conversely, physical treatment generally consists of the use of a magnetic field, obtained with either permanent or temporary magnets.

The effects of magnetic fields on water were discovered in 1900 by the Danish physicist, Hendrick Antoon Lorenz, who received the Nobel prize for this in 1902.

The calcium and carbonate ions present in the water after it has been submitted to the action of a magnetic field do not permit the crystallisation of calcite, but predominantly of aragonite. Aragonite represents a polymorphous form of calcium carbonate, the crystals of which are found to have an acicular morphology and to be decidedly smaller than those of calcite, which instead forms predominantly when water is not subjected to a magnetic field.

The smaller dimensions and elongated morphology of crystals of aragonite makes it easy to draw them out of the water current, thereby preventing the formation of harmful limestone deposits.

With a suitable magnetic device, it is thus possible to control the precipitation of calcium carbonate without adding chemical compounds, permitting water to be drinkable as it stands, without altering its mineral content and its organoleptic properties.

The advantages of using a magnetic device may be summarised as follows:

- no need for maintenance through periodic additions of salts and disinfectants;
- no alteration in the mineral and organoleptic characteristics of drinking water;
- no consumption of electricity;
- no maintenance and repair of hydraulic installations and household appliances due to the accumulation of limestone in the tubes.

EWO DEVICE

The EWO device tested by us represents a development in the field of the magnetic devices mentioned above and presents a number of innovations in construction, such as the presence of an internal water vortex and the peculiarity of being composed of duplex stainless steel magnetised with the North-South polarity of the Earth's magnetic field.

The limestone encrustations present in tubes through which water flowed before subjection to the EWO device were analysed and characterised in our laboratories with chemical-physical techniques and the results compared with the encrustations present in tubes through which the same water flowed prior to passing through the EWO device.

EXPERIMENTAL TECHNIQUES

Morphological characterisation (SEM)

Structural characterisation (DRX)

Determination of hardness (French degrees)

EXPERIMENTAL RESULTS

Morphological characterisation (SEM)

The experimental data obtained is based on two different characterisations.

A first morphological characterisation was carried out on the limestone deposit obtained after the use of the EWO device and before the EWO device.

As may be observed from the scanning electron microscope images presented in figure 1, after the use of the EWO magnetic device, we may note the formation of small needle-shaped crystals (characteristic of the morphology of aragonite) with an average thickness of 1-3 microns and length of 5-15 microns. Conversely, the crystals deposited in the absence of treatment with the EWO magnetic device displayed sharply higher dimensions and a compact and massive parallelepipedal morphology (characteristic of the morphology of calcite). The length and thickness of these crystalline formations averaged around 50-60 micron. Small, non-needlelike crystals were located on the surface of the large crystalline clusters.

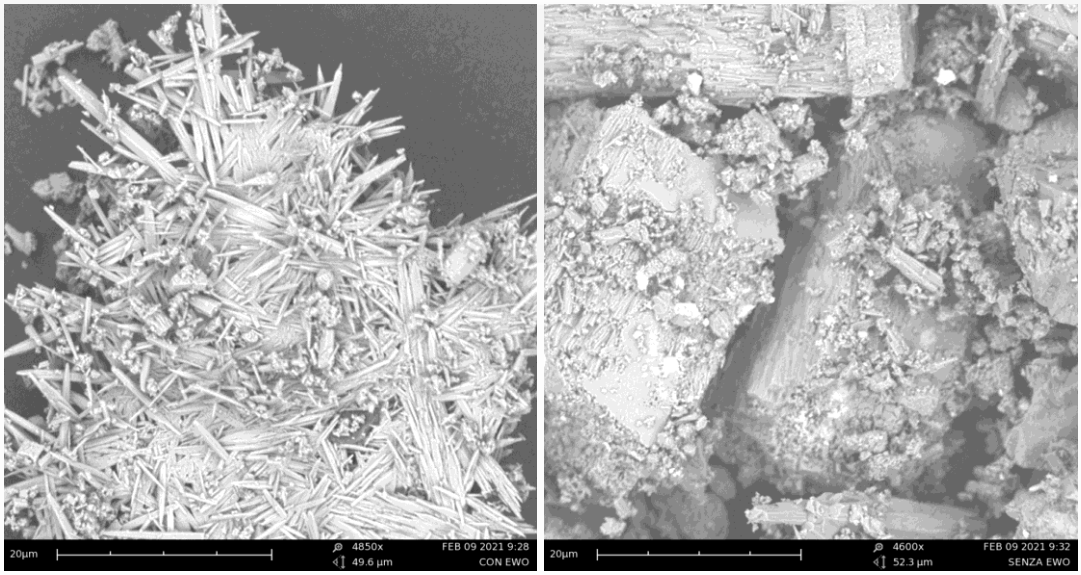

Figure 1: On the left, a limestone deposit after the EWO device, on the right a limestone deposit before the EWO device.

The aspect which nevertheless appears even more apparent is the clogging of these two different types of crystal.

Indeed, after treatment with an EWO device, the crystals of aragonite present (highlighted by the arrow in figure 2a) are less aggregated relative to the same crystals obtained before treatment with an EWO magnetic device (indicated by the arrows in figure 2b).

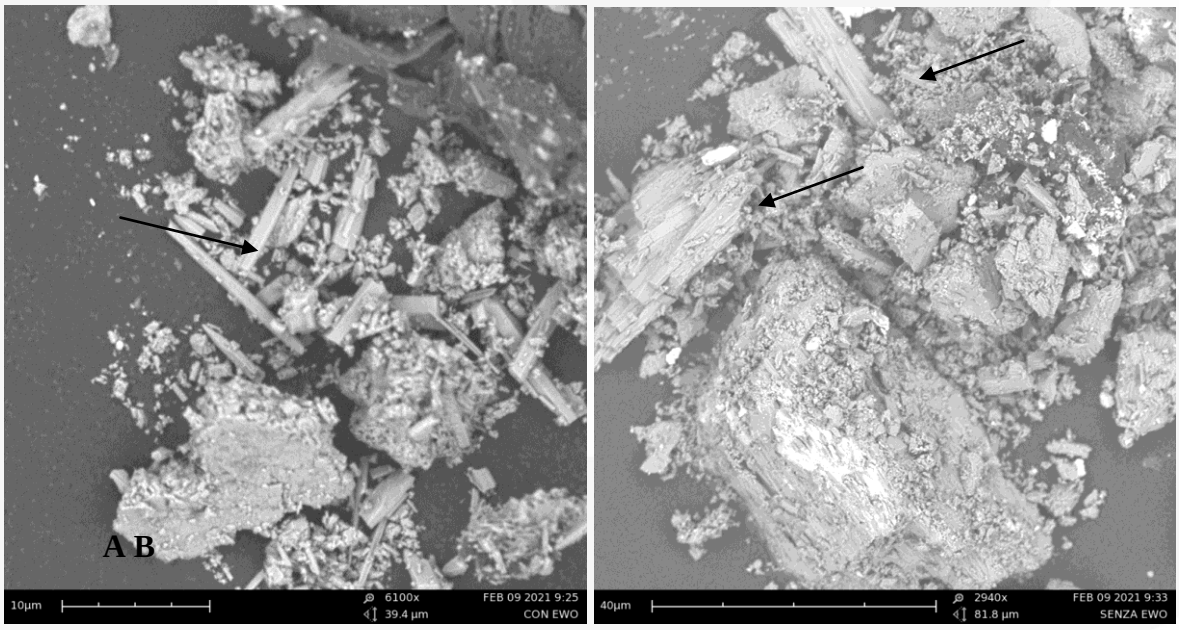

Figure 2

Different clogging of limestone after passage through the EWO magnetic device (A) and without a magnetic device (B)

Indeed, in the absence of treatment with the magnetic device, we may note how the aragonite is in any case present in the limestone deposit but in a state of greater aggregation.

Structural characterisation (DRX)

Experimental tests were subsequently carried out with x-ray diffraction techniques, using the powder method to identify the crystalline structure of the two different limestone deposits.

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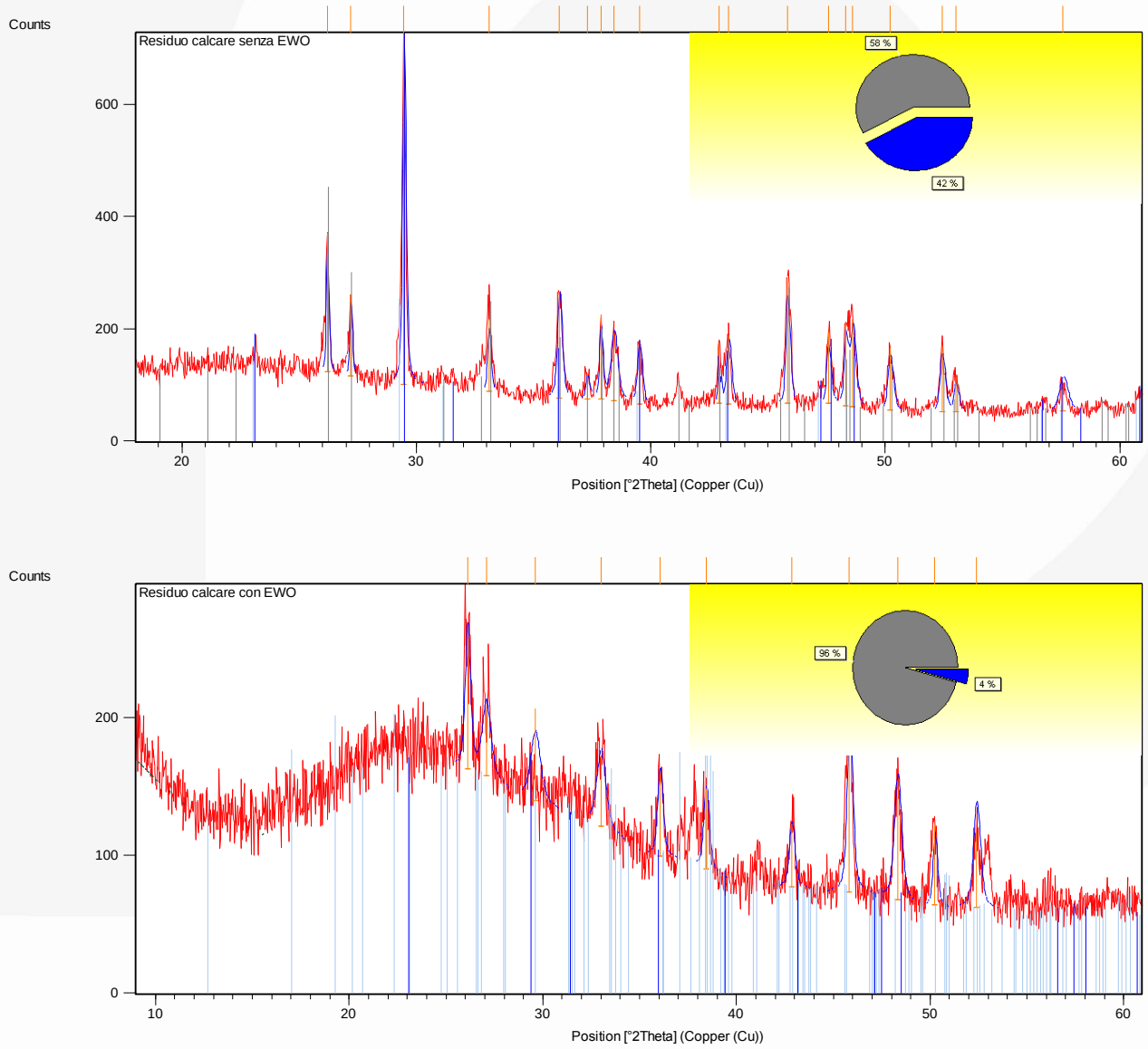

Figure 3

X-ray diffractogram carried out on a limestone deposit after an EWO device (below) and before the device (above) (the aragonite phase is shown in grey, the calcite phase in blue).

[Residuo calcare = Limestone residue, con = with, senza = without]

The results obtained clearly show how, in the absence of treatment with the EWO magnetic device, the limestone is formed by two different crystalline phases of calcium carbonate (calcite and aragonite) present in the limestone deposits in the ratio: Calcite 42% and Aragonite 58%.

Conversely, after treatment of water with the EWO magnetic device, it is possible to note how the limestone is formed of the same two phases encountered previously (calcite and aragonite), albeit with a notably different ratio: Calcite 4% and Aragonite 96%, in addition to a conspicuous quantity of amorphous phase.

It is thus evident how the presence of a magnetic field during the passage of the water favours the formation of aragonite relative to calcite.

Determination of hardness (French degrees)

Hardness of water is understood as meaning the value which expresses the content of calcium and magnesium ions (deriving from the presence of soluble salts in the water).

This term generally refers to total hardness; permanent hardness, on the other hand, expresses the quantity of cations remaining in solution after prolonged boiling, while temporary hardness, obtained as the difference between the preceding hardnesses, substantially expresses the quantity of hydrogen carbonates.

The analytic procedure to determine this value is based on the complexometric titration of calcium and magnesium ions, dissolved in a sample buffered at pH 10, with a solution of the disodium salt of ethylenediaminetetraacetic acid (EDTA) in the presence of eriochrome T as an indicator.

The hardness of the water was thus determined before and after treatment with the EWO magnetic device and we were able to note how the two values were only minimally different, 31 ± 2 French degrees before treatment and 28 ± 2 French degrees after treatment with the EWO device.

CONCLUSIONS

At the end of this enquiry, we were able to observe how the treatment of water with the EWO magnetic device did not appreciably modify the hardness of the water, which retained its mineral content, but did significantly influence the crystallisation of limestone in the pipes through which the water flows, with substantial modifications in both morphological and structural terms.

Indeed, the SEM images show how after treatment with the EWO device, the formation of aragonite is predominantly favoured relative to calcite. Furthermore, these few extensive deposits of limestone show a different aggregation for aragonite crystals, which may easily be removed from the water flow due to their small dimensions and needle-shaped morphology. These conditions probably determine less significant accumulations of limestone on the internal walls of tubes, which are definitely less massive.

Through the use of the EWO magnetic device, it is thus possible to avoid the formation of deposits of limestone on the insides of hydraulic pipes through which water runs, without modifying the chemical composition of the water itself, hence maintaining the same ionic composition.

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VIA SELMI, 2 - 40126 BOLOGNA - ITALIA TEL. +39 051-2099486 - 485 - FAX +39 051-2099593 - www.lebsc.unibo.it
Unità Operativa del C.I.R.C.M.S.B. Consorzio Interuniversitario di Ricerca in Chimica dei Metalli nei Sistemi Biologici
Via C. Ulpiani, 27 - 70126 Bari (Italia) - P.I. e C.F.: 04434750727 - Reg. Società: 29713 Tribunale di Bari - CCIAA: 314319