

Inhibition of scaling water in Tiznit region by "LEVALL®10"

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Abstract: Eliminating the formation of calcium carbonate deposits in potable water pipes presents a challenge for water treatment systems. The use of inhibitors is one of the best techniques to prevent or delay the formation of these deposits. It is therefore essential to find a new generation of scale inhibitors, which is distinguished, on the one hand, by a better inhibiting effectiveness of calcium carbonate, and, on the other hand, by their ecological effect due to the respect of health and environment norms.

Keywords: Scaling power; Potable water; LEVALL®10; Calcium carbonate; Inhibitor; Phosphate.

Introduction

The water resources of Tiznit city and the surrounding rural municipalities are very limited. The exhaustion of water requirements (needs) of this area is made from the dam of Youssef Ibn Tachfine located in one of the arms of Oued Massa, from Reggada source located in the platform of Ouled Jerrar and from Talaint wells, distant respectively of 32.8 km, 20 km and 24 km away from Tiznit city. The exploitation of Reggada source water began in 1996. Two thirds of this water is used to provide, potable water for hundreds of (douars) in Tiznit region. Youssef Ibn Tachfine dam's water and Talaint wells are mainly intended to supply Tiznit city. During the water flow, the phenomenon of scaling in the pipeline transportation of this water samples are observed mainly under the effect of a degasification of the water and the very low solubility limit of calcium carbonate^{1,2}. Tiznit region is fed with groundwater and surface resources with a high hardness. This has led to the formation of hard deposits adhering to the inner walls of drinking water pipes. The identification and characterization of these scale deposits formed in water pipes were carried out according to standard methods³. Thus, we are interested in this work to the study of this phenomenon of scaling which ranked first of our research works.

The use of inhibitors is one of the best techniques to prevent or delay the formation of these deposits. It is therefore essential to find a new generation of scale inhibitors, which is characterized, on the one hand, by a better inhibiting effectiveness of calcium carbonate, and, on the other hand, by their ecological effect due to the respect of health and environment norms. The

food products have become a source of inhibitors with high added value. These types of inhibitors do not contain heavy metals or toxic compounds and they are biodegradable.

During our work, we are interested in a first moment to characterization of the tartars collected in the water system of Talaint, from another side to study the effect of food inhibitor of trade name "LEVALL®10" on the water scaling power scaling power of drinking water of the Talaint.

Material and Methods

Characterisation of the tartars collected from the reservoir of talaint:

The identification and characterization of the obtained tartars were performed through chemical Analysis using X-Ray photoelectron spectrometry XPS ESCALAB 250, examination by X-ray diffraction kind XPERT-PRO, thermal analysis DTA/TGA (simultaneous thermal analyzer) using equipment kind Netzsch STA409C, analysis by X-ray fluorescence using a spectrophotometer such AXIOS, and analysis by Scanning electron microscope analysis (SEM).

Characterization of the scaling power of drinking water of the reservoir of talaint:

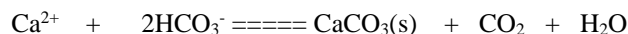
The kinetic characterization of the scaling power of drinking water of Talaint wells was studied by means of the method LCGE⁴⁻⁷. Its principle based on the accelerated formation of deposits of calcium carbonate under the effect of degassing of the studied water, usually atmospheric air, according to the following reaction:

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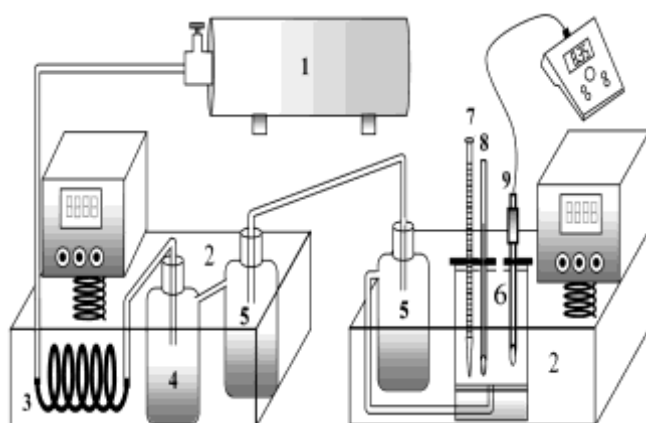
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The statement of the pH values and the concentration of Ca^{2+} ion in the course of time, consequently, allow making a description of the

kinetics of precipitation. The experimental installation is shown in Figure 1.



- 1.Stripping gas
2. Thermostat baths
- 3.Immersion circulator-heating
- 4.Humidifier
- 5.Humidity traps
- 6.Workcell
7. Simple taken for dosage of $[\text{Ca}^{2+}]$
- 8.Temperature probe
- 9.pHmeter.

Figure 1. Experimental set-up of the LCGE method.

Results and Discussion

Characterisation of the tartars collected from the reservoir of Talaint

X-ray Photoelectron Spectrometry (XPS)

The XPS spectra obtained for sample collected from the Talaint water system is shown in Figures 2. They have been calibrated with respect to the main component C1 peak C-C /C-H set at 285 eV.

Each energy peak corresponds to one type of atom only; the oxygen element (O1s) found at an energy of 532 eV, calcium at 346 eV, carbon at 285 eV, traces of silicon at 102 eV and iron at 710 eV.

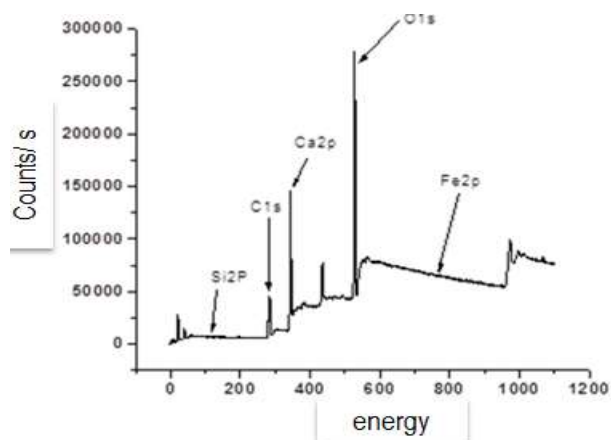


Figure 2. Sample collected from the Talaint

Thermal Analysis

For the study of the thermal evolution of these tartar, we used the thermogravimetric analysis (TGA) and differential thermal analysis (DTA). This thermal

The main peaks of oxygen, calcium and carbon indicate that the collected tartar depositis mainly composed of calcium carbonate (CaCO_3).

Characterization by X-ray diffraction (XRD)

XRD study was performed by means of a powder diffractometer type XPERT-PRO. The diffractogram obtained is shown in Figures 3, the tartar collected in Talaint reservoir is mainly composed of calcium carbonate with calcite structure, the thermodynamically more stable form of all varieties of calcium carbonate ⁸, and some traces of silica.

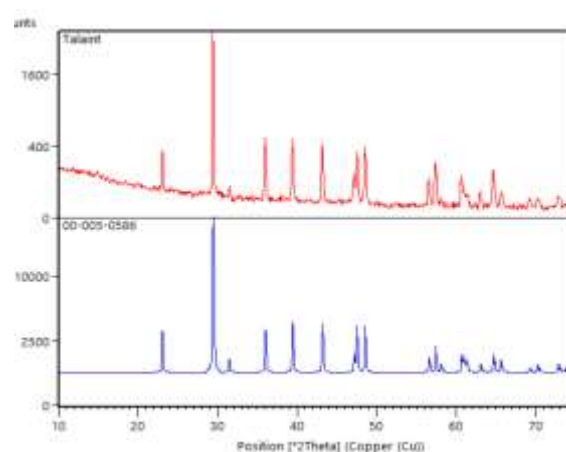


Figure 3. Diagram of tartar collected in the Talaint

behavior is studied for temperatures between 25 and 800 °C. The TGA and DTA curves of the tartar collected from Talaint water system is shown in

Figures 4. The DTA curve (B) for these sample reveal endothermic peak at temperature 748 °C, which corresponds to the decomposition of calcium carbonate, as shown in the TGA curve (A) of these tartar, showing a mass loss at this temperature ^{9,10}.

Chemical decomposition of calcium carbonate leads to the formation of calcium oxide and release of CO₂ gas, as illustrated in the following chemical reaction:

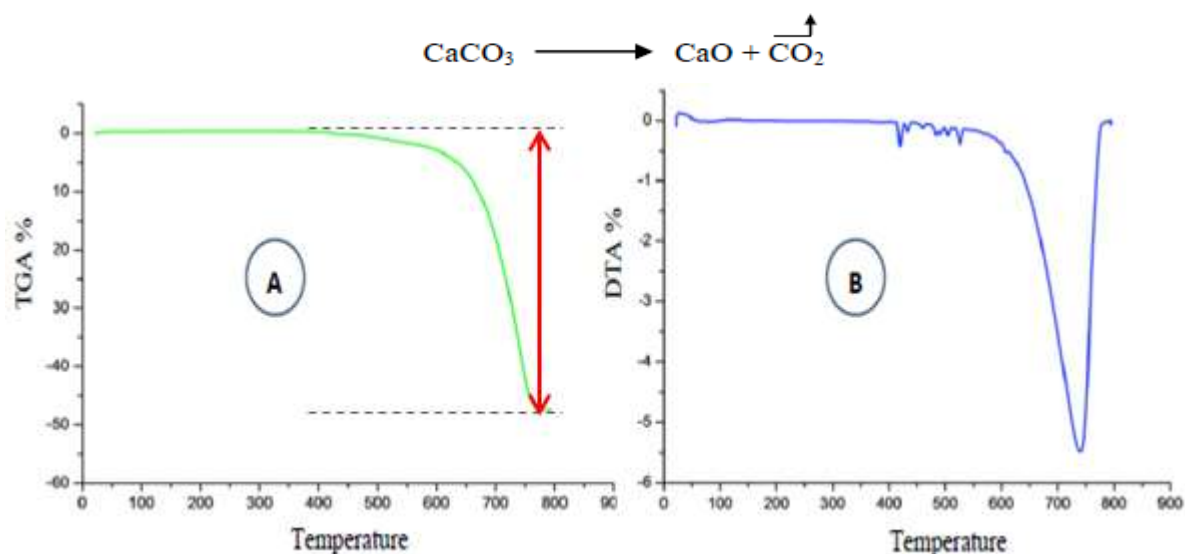


Figure 4. Thermal analysis TGA (A) and DTA (B) of collected tartar in the Talaint network

X-ray Fluorescence analysis (XRF)

Using this technique, we can identify the constituents of the sample collected in the Talaint

water system (Table 1) and determine the concentrations by means of the emission of characteristic X-rays ¹¹.

Table 1. Chemical compositions of scale deposits collected within the Talaint water system.

Composition	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	SO ₃	K ₂ O	Na ₂ O	P ₂ O ₅	L.O.I*	CaCO ₃
Scale	0.45	0.12	0.03	54.22	0.37	0.00	0.18	0.03	0.05	43.69	96.82

*Loss on Ignition Analysis

Quantitative analysis by XRF of the tartar collected in Talaint water system coupled with their previous experimental results have confirmed that these tartar is formed of calcium carbonate (96.8 %). However, it is to note the presence of some traces of silica, magnesium oxide and potassium.

Inhibition of Scaling by a food product phosphate based

Application for pure water at 40°F

"LEVALL®10" is a food compound, complex, pulverulent and soluble in the water, with a white powdery appearance. It contains 64.5% of phosphoric anhydride (P₂O₅) and 28.5% of Na₂O. This product is currently used as a food additive. The study was carried out in the temperature of 25°C, by means of the technical LCGE on pure calco-carbonic water with 40°F. Always proceeding by increasing amounts;

the amount of designated tartrifuge (a product used to prevent the formation of scale) for each test was introduced before the start of the manipulation. In all cases, the presence of tartrifuge does not modify the values of the TAC and TCa measured before the start of the experiment. The statement of the pH values and the concentration of Ca²⁺ ion in the course of time allow making a description of the precipitation kinetics of calcium carbonate ¹².

The experimental results (Figures 5-7) obtained allow us to conclude that germination time in the case of the calco-carbonic solution at 40°F is 16 minutes without inhibitor. The addition of 0.3 mg/L of "LEVALL®10" to the solution makes it possible to avoid the precipitation of calcium carbonate under the conditions of the experiment, that is to say the total inhibition of scaling.

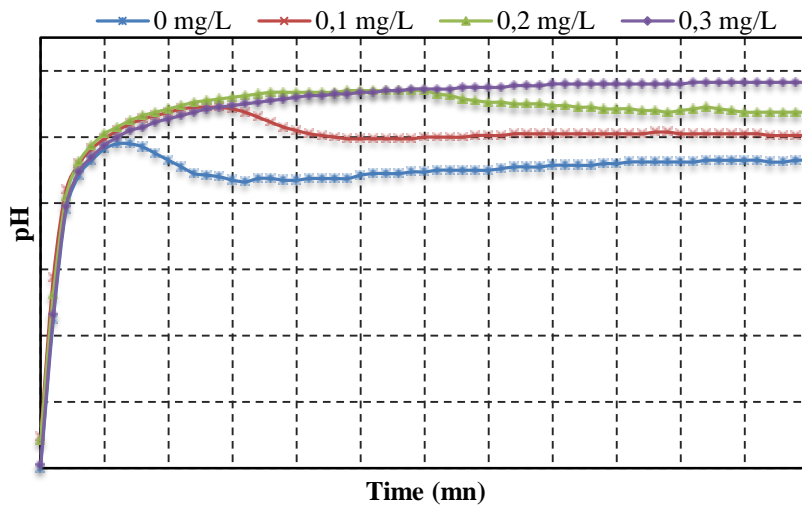


Figure 5. Variation of pH according to the time of the tests with inhibitor LEVALL®10

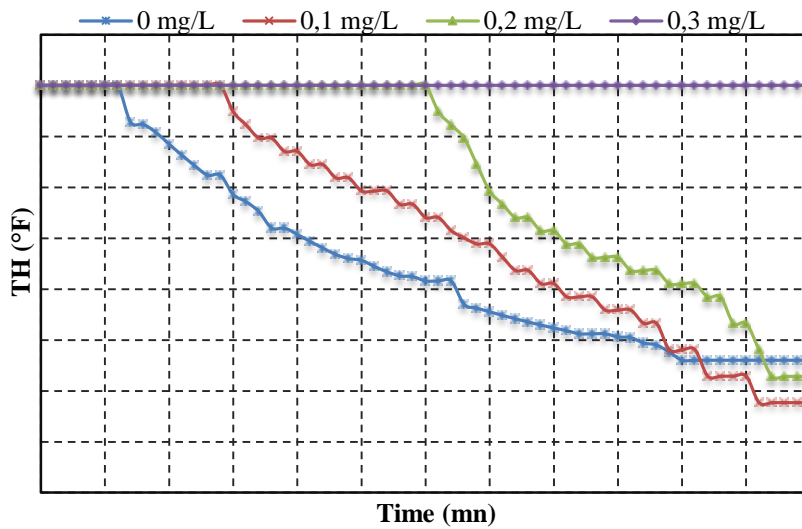


Figure 6. Variation of TCa according to the time of the tests with inhibitor LEVALL®10

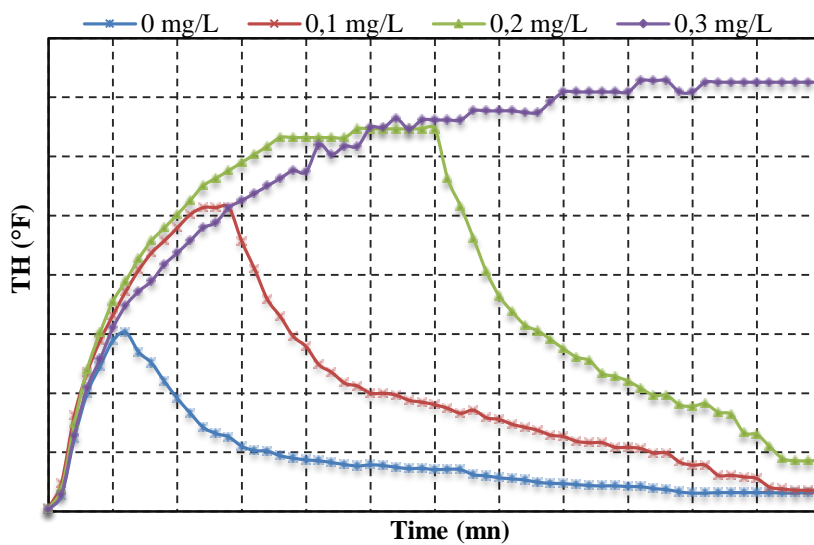


Figure 7. Variation of the rate of super saturation β_{cal} according to the time of the tests with inhibitor LEVALL®10.

The analysis of these curves result in the values shown in Table 2.

Table 2. Germination time (T_g), pH of germination (pH_g), supersaturation coefficient overlooked to the calcite (β_{calcite}) and precipitation speed of calco-carbonic solution at 40 °F added in creasing quantities of LEVALL®10.

Concentration in mg/l	T_g (mn)	pH_g	β_{calcite}	Diffusionnel calcite		Reddy calcite	
				$K_D(\text{mn}^{-1})$	R^2	$K_R (\text{°F}^{-1}\cdot\text{mn}^{-1})$	R^2
0	16	7,96	26,92	$1,45\cdot 10^{-2}$	0,980	$6,4236\cdot 10^{-4}$	0,990
0,1	28	8,18	51,37	$1,32\cdot 10^{-2}$	0,969	$5,6504\cdot 10^{-4}$	0,934
0,2	60	8,28	64,67	$1,84\cdot 10^{-2}$	0,943	$9,7128\cdot 10^{-4}$	0,880
0,3	-	-	-	-	-	-	-

The analysis of these results made it possible to come up with the following findings:

- The time of germination increases with the concentration of scale preventive. From the concentrations higher or equal to 0.3mg/L (effective concentration) the inhibition becomes total and the precipitation is not observed during the test ⁶.
- The pH at the point of germination of the treated water increases with the concentration of the inhibitor, it increases from 7.96 per 0 mg/L to 8.28 per 0.2 mg/L. The fall in pH is clearly evident in the test without the inhibitor, whereas when the concentrations are increasing, this fall becomes less remarkable.

- The degree of supersaturation at the time of germination undergoes an increase after the introduction of the scale preventive. It then ranges from 26.92 to test at 0 mg/L to 64.67 at 0.2 mg/L of scale preventive.
- The precipitation follows a Reddy model concerning the test without inhibitor. It is modelled by the diffusion model for tests with the inhibitor.

Application to potable water of Talaint

This study was carried out by means of the LCGE at a temperature of 25°C. Figures 8-10 represent curves LCGE of the natural water after adding increasingly quantities of the food product phosphate based.

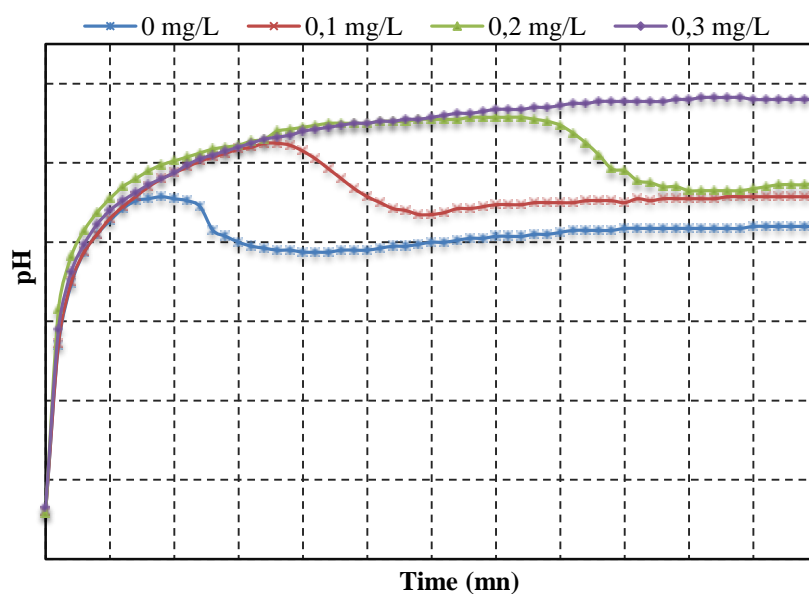


Figure 8. Curves pH according to the time of the tests with natural water added with the increasing concentrations in LEVALL®10.

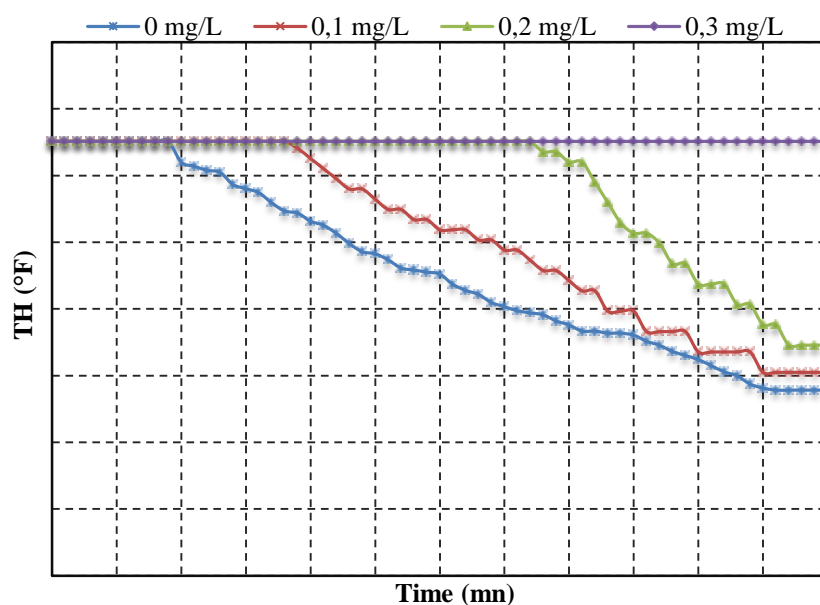


Figure 9. TH curves according to the time of the tests with natural water added with the increasing concentrations in LEVALL®10.

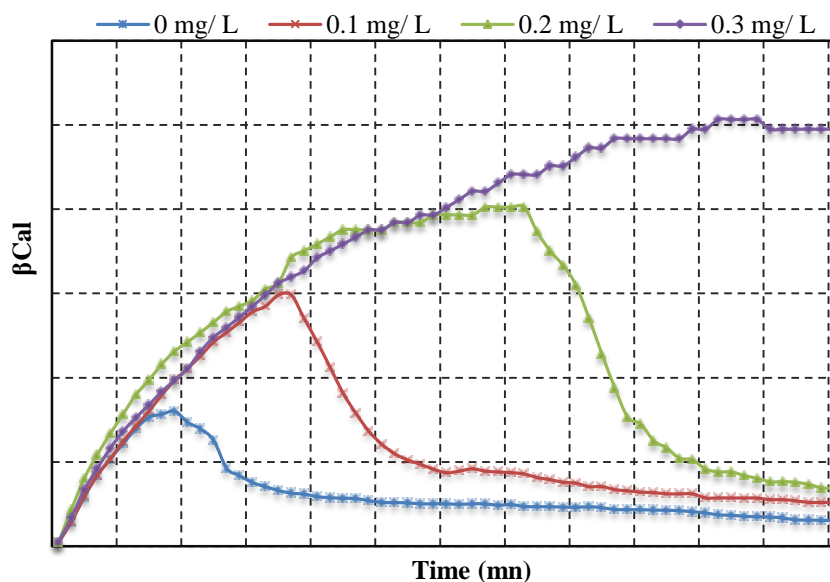


Figure 10. Variation of the coefficient of supersaturation according to the time of the tests with natural water added with the increasing concentrations in LEVALL®10.

The analysis of these curves leads to the values presented in Table 3.

Table 3. Germination time (T_g), pH of germination (pH_g), coefficient of supersaturation overlooked to the calcite (β_{calcite}) and precipitation speed of the natural water added with the increasing quantities of LEVALL®10.

Concentration in mg/l	T_g (mn)	pH_g	β_{calcite}	Diffusionnel calcite		Reddy calcite	
				K_D (mn^{-1})	R^2	K_R ($^{\circ}\text{F}^{-1}.\text{mn}^{-1}$)	R^2
0	18	8,83	320,32	$4,36.10^{-3}$	0,994	$8,62.10^{-4}$	0,996
0,1	36	9,1	596,47	$4,26.10^{-3}$	0,983	$8,15.10^{-4}$	0,979
0,2	74	9,23	745,74	$8,32.10^{-4}$	0,985	$1,78.10^{-4}$	0,976
0,3	-	-	-	-	-	-	-

Indeed, we notice that in the presence of the chemical inhibitor, the curves of precipitation of calcium carbonate undergo modifications:

- The time of germination is in clear increase compared to the control test. Scaling is completely inhibited for a concentration 0.3 mg/L, under the conditions of the experiment.
- The pH at the point of germination of the treated water increases with the concentrations of the inhibitor, it moves from 8.83 per 0 mg/L to 9.23 per 0.2 mg/L. The fall of the pH appears clearly in the test without inhibitor, whereas when the concentrations are increased, the fall becomes less remarkable ⁶.
- The rate of supersaturation at the time of germination undergoes an increase after the introduction of the scale preventive. Then it varies from 320.32 for the test with 0 mg/L to 745,74 per 0.2 mg/L of scale preventive.
- The precipitation follows a Reddy model in the test without inhibitor. It is modeled by the diffusional model for tests with the inhibitor.

Conclusion

The technical analysis allowed concluding that Talaint tartar is formed mainly of calcium carbonate variety calcite.

The LCGE technique, based on the accelerated formation of deposits of calcium carbonate under the effect of degassing of the studied water, allowed us to evaluate the power scaling of these potable waters.

Indeed, the application of this technique on the pure calco-carbonic water (40°F), allowed us to essentially bring out the inhibiting character of scaling of the food product phosphate based LEVALL[®]10.

The experimental results allowed us to conclude that germination time in the case of the calco-carbonic solution at 40°F is 16 minutes without inhibitor; the addition of 0.3 mg/L of food product phosphate based LEVALL[®]10 to the latter makes it possible to avoid the precipitation of calcium carbonate under the conditions of the experiment, which is the total inhibition of scaling. The study carried out on the potable water of Talaint showed that 0.3 mg/L of the food product phosphate based completely inhibits the precipitation of calcium carbonate under the conditions of the experiment.

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