

# EFFECT OF POLYACRYLATE CONCENTRATION ON HOMOGENEOUS AND HETEROGENEOUS PRECIPITATION OF SCALE

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## **Abstract**

Scaling is a common problem in domestic, commercial and industrial process where water is used. One of the most effective methods of controlling crystallization fouling is the addition of chemical inhibitors to potentially scaling waters. For reducing calcium carbonate scale formation different concentrations of polyacrylate (RPI2000) was added. The results show that this inhibitor is capable of inhibiting the formation of limestone deposit and inhibits the scale formed on the walls. Calcite growth rate is reduced and the inhibiting effect occurs at very low concentration. The precipitation ratio ( $\tau$ ) reached 0%, therefore a reduction of 24% compared to the raw water. This inhibitor extends the degassing phase. IR analyses demonstrated modifications in crystalline structure.

Keywords: Water, Inhibitor, Calcium carbonate, Polyacrylate, Calcite growth rate, IR.

## **1. INTRODUCTION**

Several underground sources of water were exploited to satisfy the great need for fresh water. In the East of Algeria, the city of Constantine called for its water supply, the Hamma groundwater resource. The high content of hydrogen carbonate and calcium justify the very important scaling power, it contains 82 % by mass of these ions.

Scale deposit is a major concern in different facets of industrial processes and domestic installations. It can cause numerous technical and economical problems. According to S. N. Kazi (2012) [1], an additional cost is imposed by fouling of heat transfer equipment in industries (Table 1). Few studies have been undertaken to determine the fouling related costs in industry. Fouling costs can generally be divided into four major categories, such as: increased capital expenditure, energy costs, maintenance costs, cost of production loss and extra environmental management cost.

Various physical [2-3] and chemical methods [4-5] were used to prevent scaling. The physical methods were developed but the efficiency of these treatments is still a controversial question and it is not possible to get a clear explanation of the phenomenon. The most common and effective scale control method is the addition of small concentrations of inhibitors to the water [6-7-8-9].

In the present work, we investigated the effect of RIP2000 on the precipitation of  $\text{CaCO}_3$  by the use of chemical anti-scaling method. The ratio between homogeneous and heterogeneous nucleation was determined. Formed scales were characterized by IR spectroscopy.

Table 1: Estimated fouling costs incurred in some countries.

Country	Fouling costs US \$ million	GNP (1984) US \$ million	Fouling costs % of GNP
USA (1982)	3860-7000 8000-10000	3634000	0.12-0.22 0.28-0.35
Japan	3062	1225000	0.25
West Germany	1533	613000	0.25
UK (1978)	700-930	285000	0.20-0.33
Australia	260	173000	0.15
New Zealand	35	23000	0.15
Total Industrial World	26850	13429000	0.20

## 2. Materials and methods

Calcium carbonate precipitation was provoked by degassing dissolved CO<sub>2</sub> by agitation. The RPI2000 was added at different concentrations in the solution at 30 °C, to optimize the effective concentration for the scaling prevention.

## 3. Results and discussion

### 3.1. CO<sub>2</sub> degasification by agitation

Figure 1 and Figure 2 show the changes of the homogeneous precipitation (%hm) and heterogeneous precipitation (%ht) for Hamma water without and with varying concentrations of RPI2000.

Such as:

- $\tau$ : the precipitation ratio. It was determined from the following equation:

$$\tau = \frac{TAC_0 - TAC_t}{TAC_0} * 100$$

Where: TAC<sub>0</sub> is the TAC at t = 0 min and TAC<sub>t</sub> is the TAC at the end of precipitation test.

-%hm: the percentage of the homogeneous precipitation.

-%ht: the percentage of the heterogeneous precipitation.

-P<sub>CO<sub>2</sub></sub>: CO<sub>2</sub> pressure in the solution.

Scale formation can occur through homogeneous and heterogeneous nucleation mechanisms.

We observe that the heterogeneous precipitation decreases and the homogeneous precipitation increases. We can conclude that 0.06 mg/L of RPI2000 is capable of

inhibiting the formation of germs of calcium carbonate and inhibits the scale formed on the walls. Calcium carbonate forms in the bulk of solution instead of the walls.

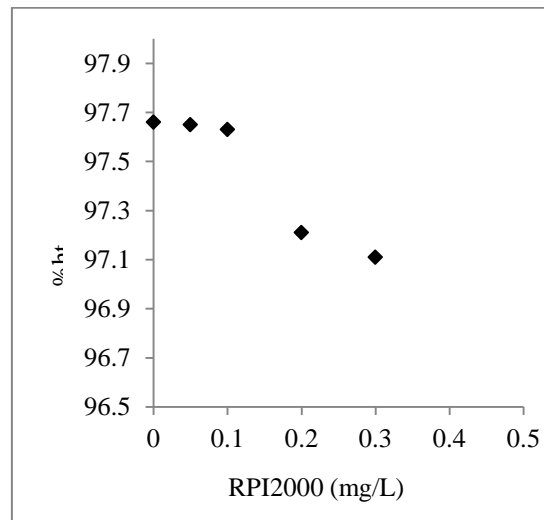


Fig 1: Variation of the %ht versus RPI2000 concentrations.

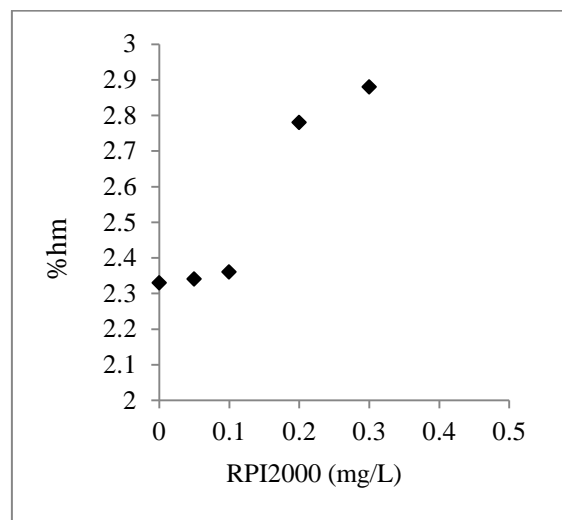


Fig 2: Variation of the %hm versus RPI2000 concentrations.

The crystalline growth rate was strongly affected. It decreases by ~14% in the presence of 0.6 mg/L of RPI2000 (Figure 3).

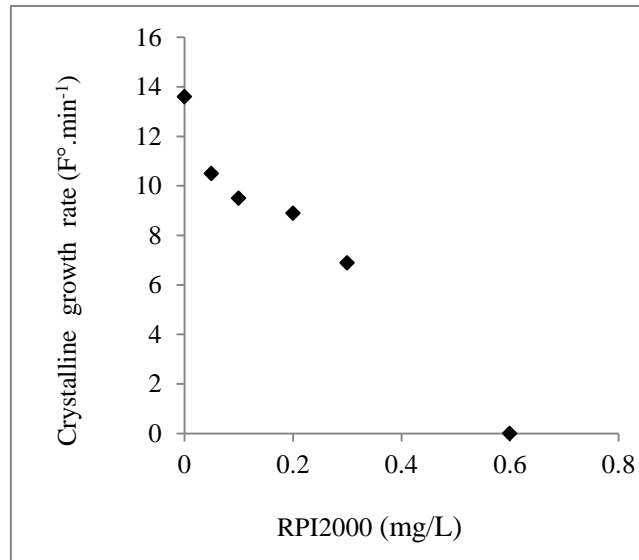


Fig 3: Variation of the crystalline growth rate versus RPI2000 concentrations.

The precipitation ratio ( $\tau$ ) reached 0%, therefore a reduction of 24% compared to the raw water (Figure 4).

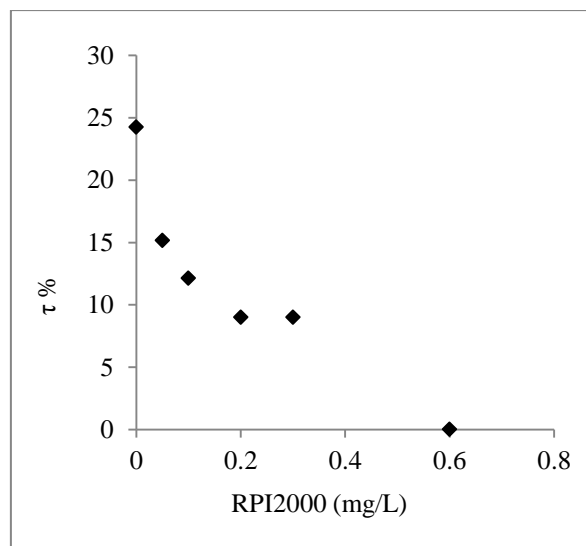


Fig 4: Variation of the precipitation ratio versus RPI2000 concentrations.

Figure 5 shows the  $P_{CO_2}$  variation as function of the added RPI2000 quantity at 30 °C. This inhibitor extends the degassing phase which retards the germination of  $CaCO_3$  crystals.

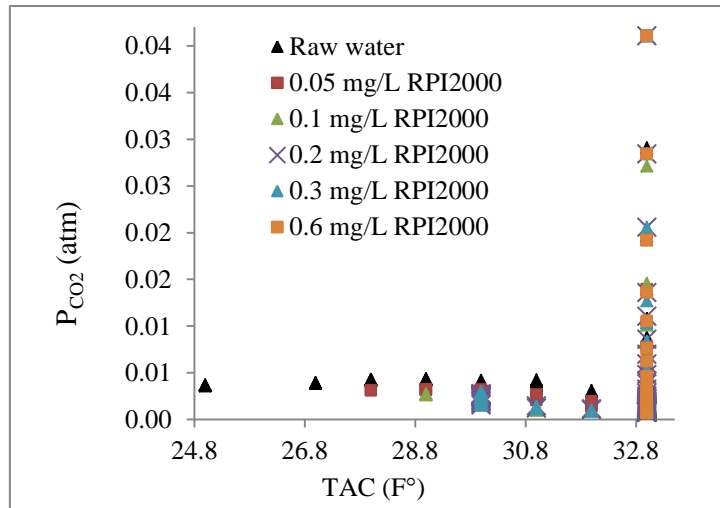


Fig 5:  $P_{CO_2}$  variation as function of the added RPI2000 quantity at 30 °C.

### 3.2. Interpretation of FTIR data

The Fourier transformed infrared (FTIR) spectrum of precipitated scale products in absence and presence of inhibitor is shown in Figure 6. For raw water, simultaneous occurrence of peaks at 711, 871 and 1417  $cm^{-1}$  confirmed the presence of calcite as was the most predominant crystalline form. The appearance of peaks at 850, 1082 and 1803  $cm^{-1}$  shows the presence of a small amount of magnesian calcite and aragonite. For treated water, the appearance of new peaks were observed at 1160 and 1159  $cm^{-1}$  confirmed the presence of carbonate monohydrate, thus new peaks at 1533 and 1535  $cm^{-1}$  indicate the increase of aragonite. These values are compared with the data published by Eva Loste et al. [10] and Gopi et al. [11].

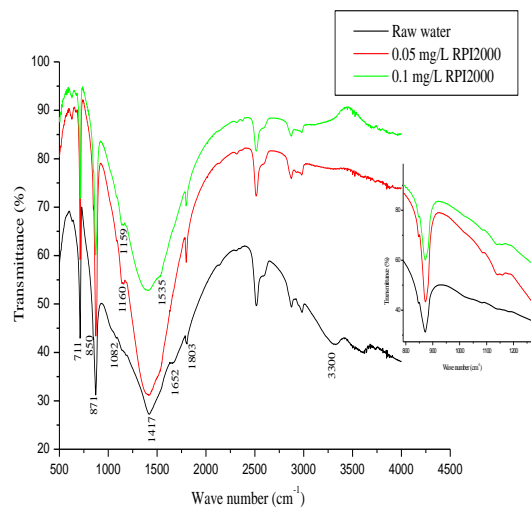


Fig. 6: FTIR spectra of precipitated scale products in absence and presence of 0.05 mg/L and 0.1 mg/L of RPI2000

## Conclusion

For reducing calcium carbonate scale formation different concentrations of polyacrylate (RPI2000) was added. The results show that this inhibitor is capable of inhibiting the formation of limestone deposit and inhibits the scale formed on the walls. The inhibiting effect occurs at very low concentration. The Fourier transformed infrared (FTIR) spectra of precipitated scale demonstrated modifications in crystalline structure.

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