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The Use Of Chemical Inhibitor For Prevention Of Calcium Carbonate Scaling

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ABSTRACT

The precipitation of calcium carbonate from saturated solutions was studied in the presence of organic phosphate ester as scale inhibitor. The presence of scale inhibitor in very low concentrations gave significantly lower rates of precipitation as compared to those in the absence of inhibitor. The amount of scale deposited increases as the temperature and the time are increased. The influence of phosphate ester on scale deposition clearly shows that, the dose required for inhibition is small as the temperature is low and increased as the temperature is high. The inhibitor probably act through threshold inhibition by adsorption onto the active growth sites of the initially formed crystals and aletring their morphology.

INTRODUCTION

A serious problem encountered in a number of processes from oil and gas recovery to heat exchangers, cooling towers and desalination, is the formation of scale made up from one or more sparingly soluble salts, depending on the composition of the water employed. Calcium carbonate is a salt frequently forming under conditions typically encountered in industrial processes utilizing water for cooling pourposes or in geothermal energy management[2]. Unfortunately, until now, no satisfactory way for an effective prevention of this type of scale was found. As a result a variety of promising commercial products appear in the water treatment market and research continues to develop a method which should be satisfactory both in economical and environmental terms[7].

Among the methods used to prevent the calcium carbonate scale is acidification of the water and also the chemical compounds are used to prevent and/or retard markedly the formation of the carbonate precipitate. The acidification method has the disadvantage of exposing metal surfaces to a corrosive environment while the chemical additives seem promising since only very small quantities are needed to extend the time required for the scale to start forming. For an inhibitor to be acceptable it should be able not only to prevent nucleation but also to be stable under conditions of elevated temperatures and nontoxic for environmental reasons[3,4,8].

In the present work the effect of organic phosphate ester (P.E.) as calcium carbonate scale inhibitor was investigated.

EXPERIMENTAL

$CaCO_3$ saturated solutions were prepared by simultaneously mixing equal volumes of anhydrous $CaCl_2$ ($4x10^{-3}$M) and $NaHCO_3$ ($8x10^{-3}$M) solutions and the resultant mixture incubated at 70°C for 5 hours. Organic phosphate ester also prepared as 1% solution, all these solutions were prepared in distilled water. Short time screening tests in static conditions were performed at 70 and 90±2°C to check the effective doses of the antiscalant by mixing 50 ml of each solution to form saturated solution of $CaCO_3$ with and without antiscalant for 5 hours. Among these effective doses I chose the lowest ones to study the effect of time- (in500 ml solutions mixture up to 72 hours)- on their efficiencies at the same temperature to overcome any sudden shut down for long time. Also, the antiscalant was tested in tap water by the same steps described above.

Solutions have been analyzed after every set of experiment with respect to soluble calcium ions using standard solution of EDTA, according to standard methods[1]. The differences between the soluble calcium and the total calcium present at the beginning of the experiments equivalent to the deposited calcium , the scales reduction % have been calculated as follows:

$$\text{Scale Reduction\%} = \frac{\text{Soluble Ca}}{\text{Total Ca}} \text{x} 100$$

RESULTS AND DISCUSSION

Figure 1 shows the effect of inhibitor concentration (Phosphate Ester, P.E) on the amount of calcium carbonate deposited and the scale inhibition

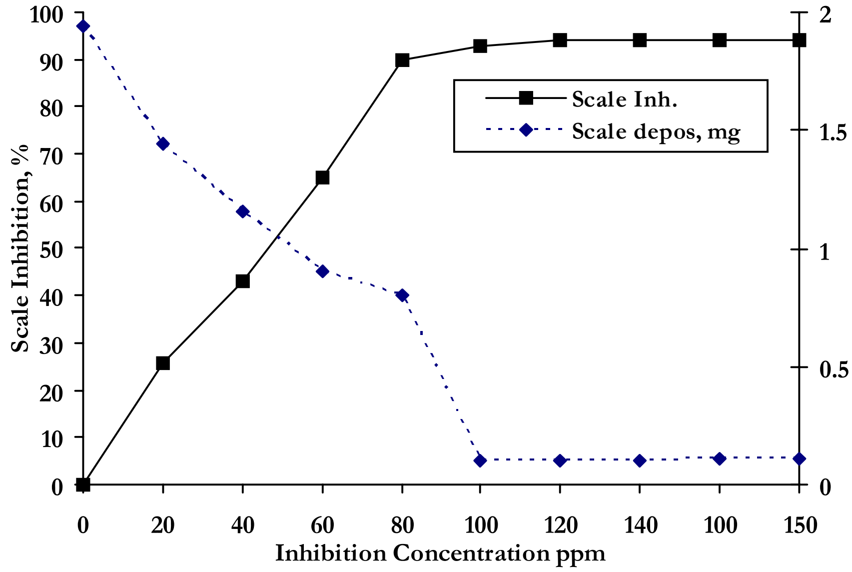

Figure 1: Effect of inhibitor concentration on the amount of scale deposited and scale inhibition % in synthetic water.

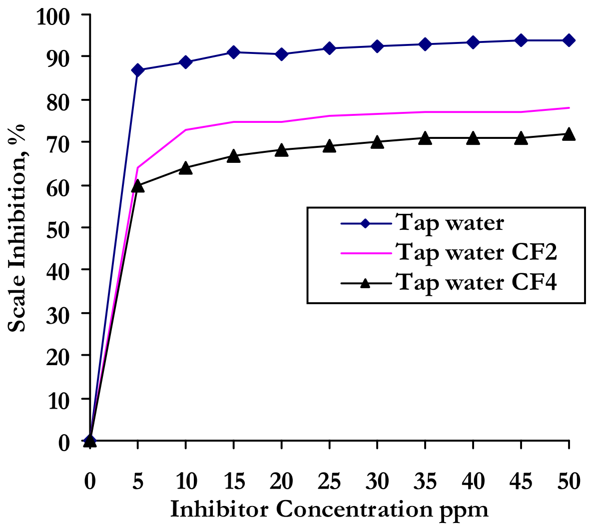

Figure 2: Effect of inhibitor concentration on the scale inhibition % in tap water.

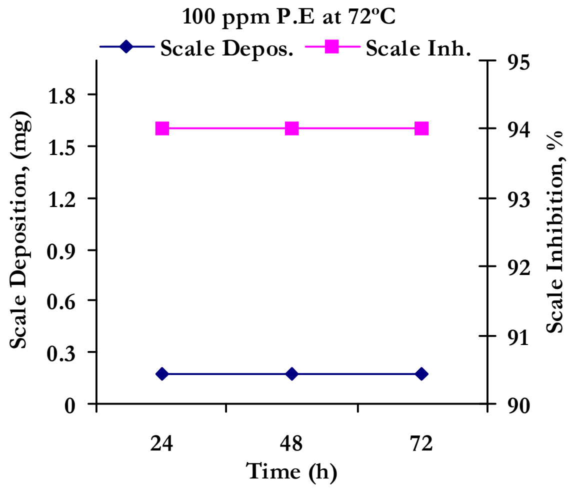

Figure 4: Effect of time on scale deposition and scale inhibition % in synthetic water in presence of 100 ppm P.E at 72ºC.

percent in synthetic water at 70±2ºC for 5 hours. An increase in the concentration of inhibitor resulted in a decrease in the deposited $CaCO_3$. The amount of deposited $CaCO_3$ at the optimum concentration (100 ppm P.E) is very small (0.1109 mg) compared to deposition during tests without inhibitor (1.9423 mg). This means that the amount of $CaCO_3$ deposited was reduced but not totally prevented by inhibitor.

A good performance of the scale inhibitor (P.E) was also shown on the scale deposition in tap water at 70±2ºC as shown in figure 2. Also, the scale inhibitor is capable to make scale inhibition even at

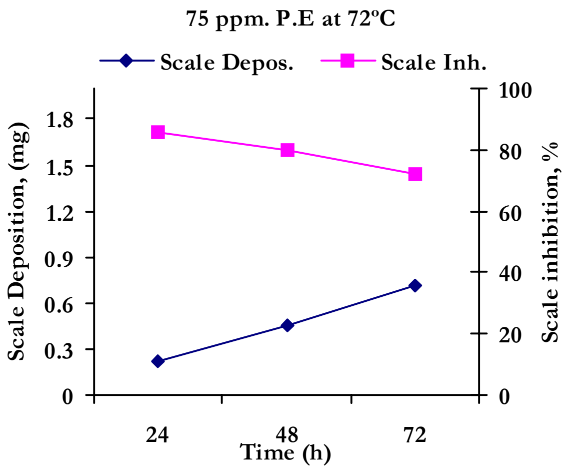

Figure 3: Effect of time on scale deposition and scale inhibition % in synthetic water in presence of 75 ppm P.E at 72ºC.

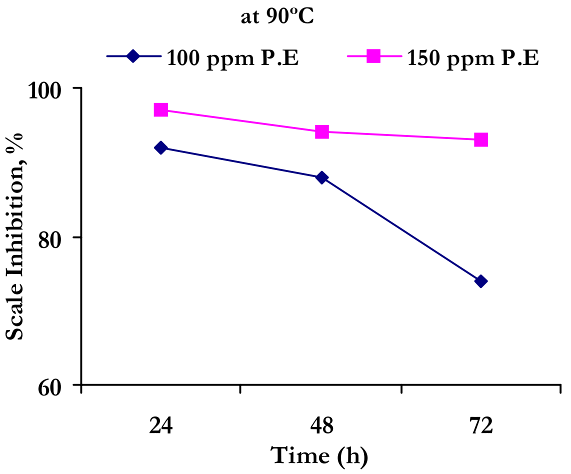

Figure 5: Effect of time on scale inhibition % in synthetic water at 90ºC

tap water of concentration factors 2 and 4(CF_2 and CF_4 means that the volume of water reduced two or four times by evaporation).

Similarly the optimum concentration of the scale inhibitor were also evaluated for long time (3 days) and at higher temperature (90ºC).

Figures 3-7 represent the effect of the lowest effective concentrations of P.E on the scale deposition and scale inhibition percent in synthetic (Figure 3-5) and tap water (Figure 6,7) for long period tests (3 days) at 70 and 90ºC respectively. In figure 3, 75 ppm of P.E. inhibitor show good inhibition for 24 h, then the scales begin to forming and increased with

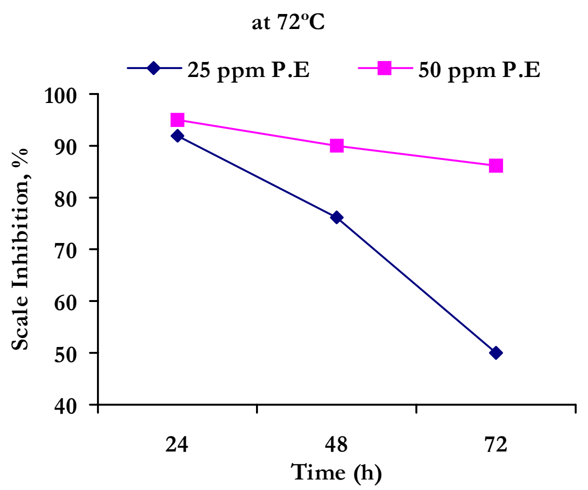

Figure 6: Effect of time on scale inhibition % in tap water at 72ºC.

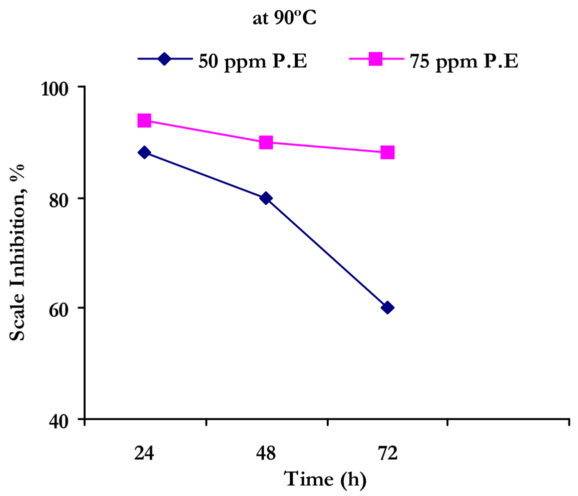

Figure 7: Effect of time on scale inhibition % in tap water at 90ºC.

time, while 100 ppm P.E keep their good inhibition during all the periods of the test as shown in figure 4. Also, the same results was obtained in figure 5, 100ppm P.E clearly indicates good scale inhibition during 24 h. at 90ºC, then tendency to deposition is increased, but 150 ppm P.E shows good inhibition from the start to the end of the test.

Figures 6,7 illustrates the effect of time and temperature on the lowest effective dose of P.E used in tap water. The same behaviour was explained previously. Finally these results give an alarm to the effect of time in static fluids due to any failure of the pumps and the concentrations used at any temperature should be chosen well.

Scale inhibitors when added to a normally scaling water, reduce, delay or prevent scale formation. The mechanisms of scale inhibition are as follow:

(a) Preventing precipitation scale crystals from adhering to surfaces, (b)Adsorbing onto the surface of incipient crystals and thereby distorting the crystal structure such that the crystal is prevented from growing. Most modern scale inhibitors function by the mechanisms called “Threshold Inhibition”[6]. In conformity with this suggestion and from the experimental results have been obtained, we guess that the scale inhibition here have been performed through threshold inhibition by surface adsorption which is used to describe substiochiometric processes involved in scale inhibition, in combination with stabilization involves the adsorption of the inhibitor onto crystal growth sites of the emberionic crystal and altering the morphology of that grow[5].

CONCLUSION

The amount of calcium carbonate scale deposited without additive is increased as the temperatures increased.

Organic phosphate ester sharply inhibits the formation of calcium carbonate scale with fewer doses as the temperature is as low as possible.

A good performance of the scale inhibitor (P.E) was shown on the scale deposition in synthetic and tap water. Also, the scale inhibitor is capable to make scale inhibition even at tap water of concentration factors 2 and 4.

Calcium carbonate scale should be inhibited by using organic phosphate ester through threshold inhibition by surface adsorption onto active growth sites of the initially formed crystals and altering their morphology.

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