TESTS OF POLY ACRYLIC ACID (PAA) INHIBITOR ON BARIUM SULFATE SCALE INHIBITION EFFICIENCY

by
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ABSTRACT

Injection water (containing sulfate ion) is injected into reservoir (containing barium ion), mixture of incompatible water types results in barium sulfate scale occurrence. Barium sulfate scale inhibition efficiency (%) with using poly acrylic acid (PAA) inhibitor were conducted in experimental conditions, pH (2.0, 4.0, 5.5, 7.0) 5 and 10 ppm inhibitor concentrations, and 25 and 70 °C temperatures. All laboratory tests results data show efficiency (%) value less than 50 %, except at pH 7.0 and 70 °C conditions which has a little bit higher efficiency (55.28 %). The poly acrylic acid doesn't show a good quality inhibitor, because the occurrence of barium sulfate scale can not be inhibited effectively.

Key words: barium sulfate scale, inhibition efficiency (%), PAA inhibitor.

I. INRODUCTION

Barium sulfate scale is a serious problem found in oil and gas production. It is formed caused by incompatible waters, formation water (containing barium ion) mixing with injection water (containing sulfate ion) leading to deposition of barium sulfate scale ($BaSO_4$) in the near wellbore, reservoir, production tubulars and topside equipment. Solubility of barium sulfate scale is very low, namely: 2.3 mg/l at 25°C and 3.9 mg/l at 95°C. Deposition of barium sulfate scale is a potentially damaging problem which reduces fluid flow resulting in a decline in oil production.

The best approach to solving the problems of scale formation is to prevent deposition and this is more effective than scale removal. The use of scale inhibitor can be an effective method for preventing scale although their effectiveness is controlled by experimental conditions. This paper is focused on tests of poly acrylic acid on barium sulfate scale inhibition efficiency at different pH, inhibitor concentration and temperature conditions.

II. INCOMPATIBLE WATER PROCESS IN OILFIELD

Figure 2.1 describes incompatible water process which injection water (containing 2960 ppm sulfate ion) is injected into reservoir (containing 250 ppm barium ion), when sulfate ion is mixed with barium-barium ion, result in barium sulfate scale with the following reaction

$$Ba + 2 + SO^{-}_{4} \rightarrow BaSO_4 \downarrow$$

Solution Scale

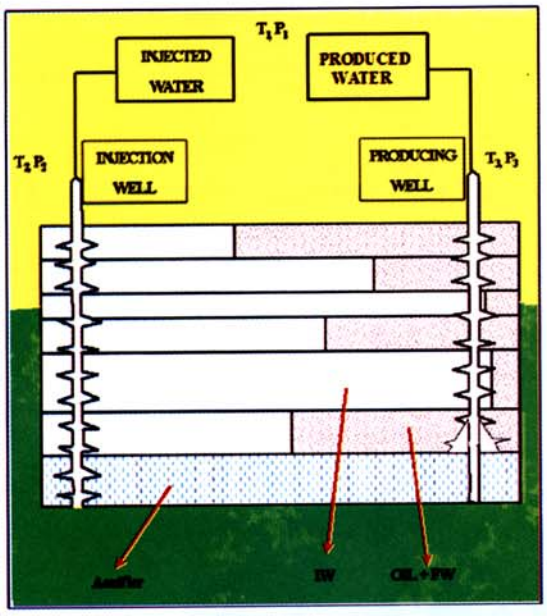

Figure 2.1
Mixture of injection water with formation water (incompatible water)

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The deposition of barium sulfate scale will reduce fluid flow and can cause a decline in oil production.

Mechanism of barium sulfate scale can be seen schematically in Figure 2.2 below.

III. FUNCTIONS OF POLY ACRYLIC ACID INHIBITOR

Poly acrylic acid (PAA) inhibitor is a type of scale inhibitor used in this research with structural formula as follows:

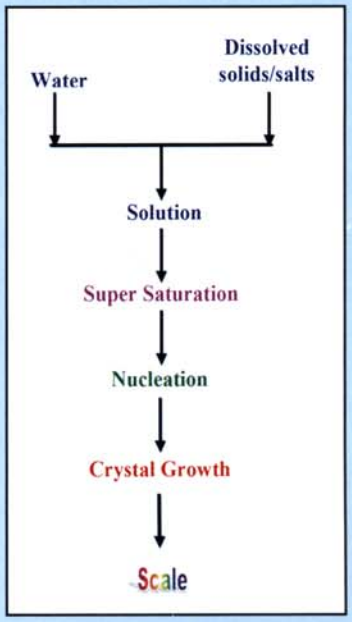

Figure 2.2
Mechanism of $BaSO_4$ scale occurrence

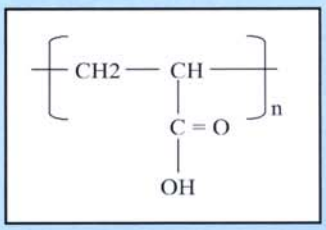

Figure 3.1
Structural formula of poly acrylic acid

Functions of inhibitor (ligand) is :

1. To break barium sulfate chain.
2. To bind Ba^{+2} ion with ligand
3. To form barium ligand reaction

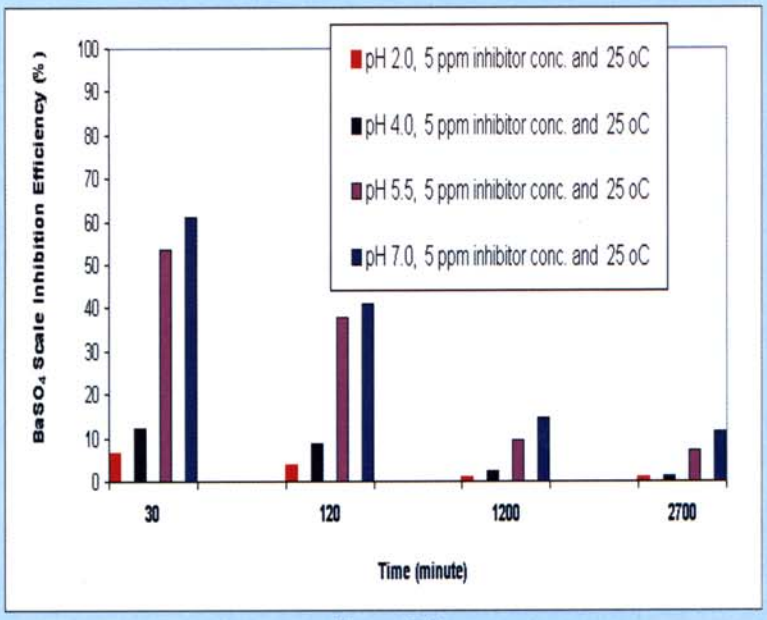

Figure 5.1
Results of barium sulfate scale inhibition efficiency at different pH, 5 ppm inihibitor concentration and 25°C conditions

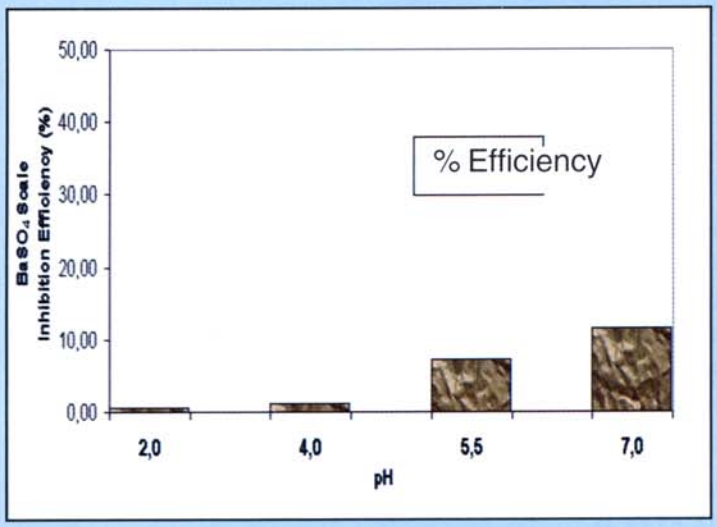

Figure 5.2
Influence of different pH on $BaSO_4$ scale inhibition efficiency at 5 ppm inhibitor and 25°C after 2700 minutes

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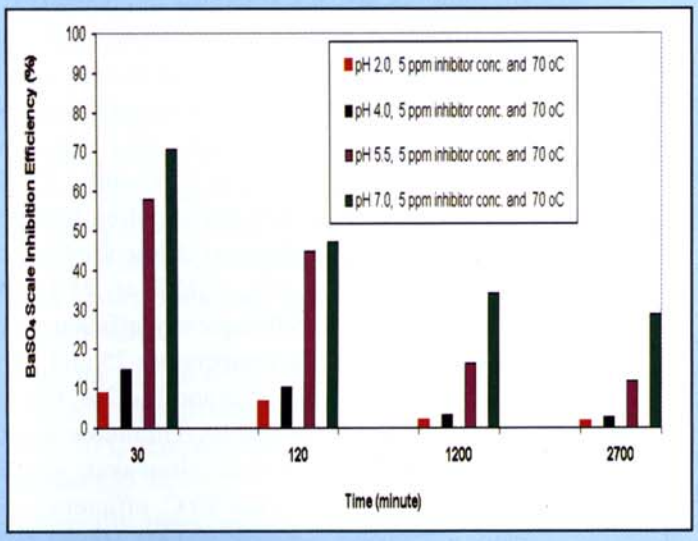

Figure 5.3
Results of barium sulfate scale inhibition efficiency at different pH, 5 ppm inihibitor concentration and 70°C conditions

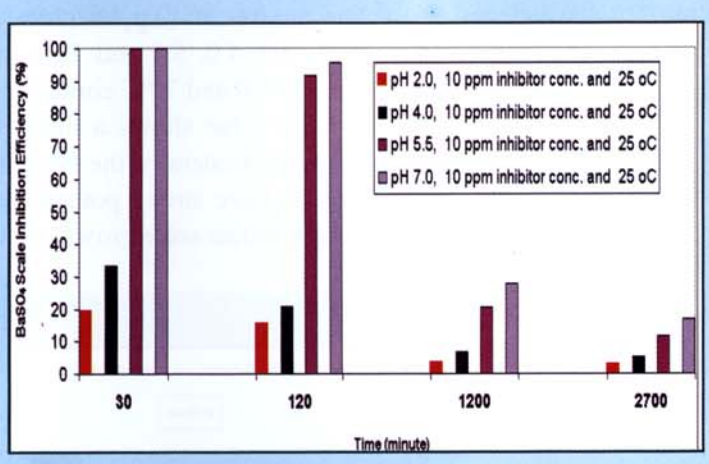

Figure 5.5
Results of barium sulfate scale inhibition efficiency at different pH, 10 ppm inihibitor concentration and 25°C conditions

This explanation can be expressed with reaction below.

$$Ba^{+2} + SO_4^{-} \rightarrow BaSO_{4\,(solid)} \downarrow$$

$$BaSO_{4(solid)} \downarrow + L \rightarrow BaL_{(solution)} + SO_4^{=}$$

$BaSO_4$ in solid form can be changed into BaL in solution form after barium ion is bound by ligand (L) as reaction above.

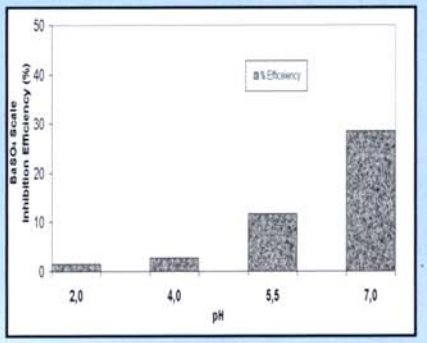

Figure 5.4
Influence of different pH on $BaSO_4$ scale inhibition efficiency at 5 ppm inhibitor and 70°C after 2700 minutes

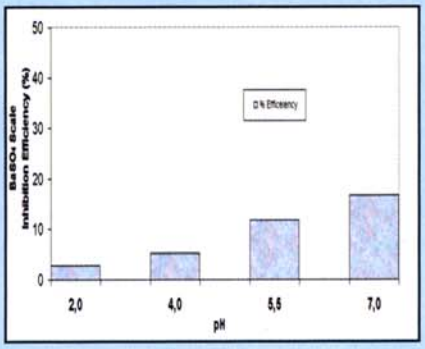

Figure 5.6
Influence of different pH on $BaSO_4$ scale inhibition efficiency at 10 ppm inhibitor and 25°C after 2700 minutes

IV. METHODOLOGY

Barium sulfate scale inhibition efficiency can be calculated with using he following equation:

$$\text{Efficiency } (\%) = \frac{(Co-Cb)-(Co-Ci)}{(Co-Cb)} x100$$

$$= \frac{(Ci-Cb)}{(Co-Cb)} x100$$

where:

Co = Initial barium concentration in Solution (t = 0).

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Cb = Barium concentration in blank Solution (no inhibitor).

V. RESULTS and DISCUSSIONS

Tests of poly acryl acid inhibitor on barium sulfate scale inhibition efficiency were carried out at different experimental conditions:

- pH 2.0, 4.0, 5.5 and 7.0.
- 5 and 10 ppm inhibitor concentrations
- 25 and 70°C temperatures

Results of barium sulfate scale inhibition efficiency laboratory tests data with using poly acrylic acid inhibitor are shown in:

a. Figures 5.1 and 5.3 for 5 ppm inhibitor concentrations, different temperatures (25 and 70°C).
b. Figures 5.2 and 5.4 for influences of pH (2.0, 4.0, 5.5, 7.0) on barium sulfate scale inhibition efficiency at 5 ppm and certain temperature (25 and 70°C).
c. Figures 5.5 and 5.7 for 10 ppm inhibitor concentrations, different temperatures (25 and 70°C).
d. Figures 5.6 and 5.8 for influences of pH (2.0, 4.0, 5.5, 7.0) on barium sulfate scale inhibition efficiency at 10 ppm and certain temperature (25 and 70°C).

5.0 ppm PAA inhibitor concentration shows that the inhibitor doesn't work effectively to prevent occurrence of barium sulfate scale at pH 2.0, and also at 25°C and 70°C. It can be seen clearly in Figures 5.2 and 5.4, then after sampling time (t = 2700 minutes), efficiency (%) values are very low around 0.60% at 25°C and 1.55% at 70°C. While, at pH 4.0 and sampling time (t = 2700 minutes), the obtained efficiency (%) values are also very low, 1.15% at 25°C and and 2.64% at 70°C. Subsequently, efficiency (%) values at pH 5.5 and temperature 25 and 70°C are still low, namely: 7.23 and 11.72%. Figures - 5.2 and 5.4 indicate that PAA inhibitor doesn't work well to inhibit barium sulfate scale growth. Next stage, at pH 7.0 and 70°C, efficiency (%) value is 2.5 times higher than at pH 7.0 and 25°C. The efficiency (%) is 11.52% at 25°C and 28.59% at 70°C. Based on these results, there are tremendous influences of pH on inhibition of barium sulfate scale occurrence.

Results of tests of PAA inhibitor on barium sulfate scale inhibition efficiency present that efficiency (%) values are low at 10 ppm inhibitor concentration, pH (2.0, 4.0, 5.5 and 7.0) and 25°C. Whereas, at pH 7.0 and 70°C conditions, efficiency (%) value shows a little bit higher (55.34%). Generally, the PAA inhibitor doesn't have strong potential to inhibit barium sulfate scale growth rate.

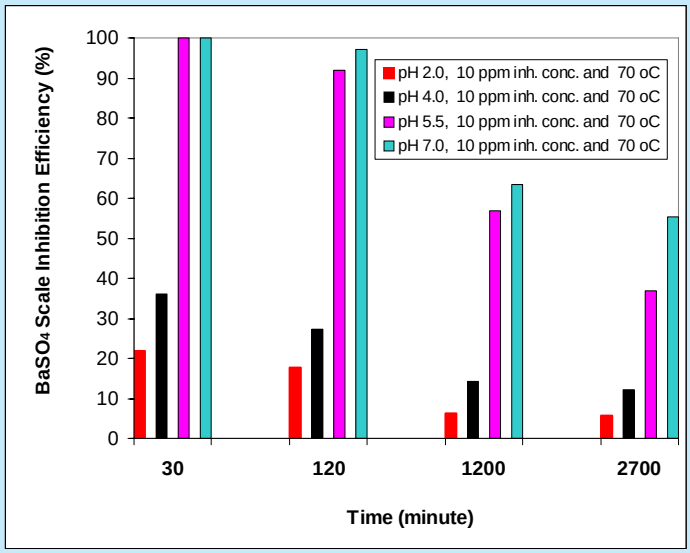

Figure 5.7
Results of barium sulfate scale inhibition efficiency at different pH, 10 ppm inihibitor concentration and 70°C conditions

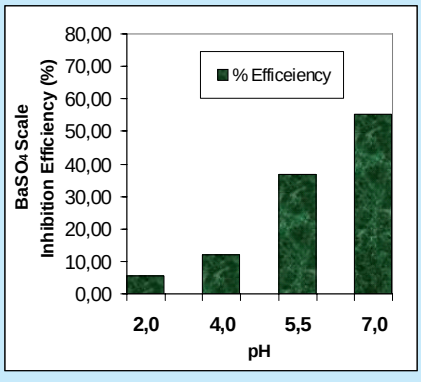

Figure 5.8
Influence of different pH on $BaSO_4$ scale inhibition efficiency at 10 ppm inhibitor and 70°C after 2700 minutes

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VI. CONCLUSIONS

All results of poly acrylic acid tests on barium sulfate scale inhibition efficiency at experimental conditions can be concluded as follows:

1. The poly acrylic acid inhibitor can not prevent barium sulfate scale occurrence well under experimental conditions, namely: at low inhibitor concentrations (5 and 10 ppm), pH (2.0, 4.0, 5.5 and 7.0) and low temperature (25^{o}C) All laboratory tests results data show less than 50% efficiency value.
2. Barium sulfate scale inhibition efficiency (%) value at 10 ppm inhibitor concentration, pH 7.0 and 70^{o}C temperature conditions is a little bit higher (55.28%)
3. Generally, based on laboratory tests results, the poly acrylic acid doesn't show a good quality inhibitor, because the occurrence of barium sulfate scale can not be inhibited effectively.

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