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Abstract

A kind of novel high temperature resistance water shutoff agent with high viscosity was synthesized using sulfonated tannin extract as main agent, paraformaldehyde as crosslinking agent, polyhydric phenol as stabilizer, urea as tackifier. Then the effects of amount of the components, pH and salinity on the gel performance of water shutoff agent were determined. The results have show that the gelling time and strength of resulting products are 48 h and 78 KPa under the conditions of sulfonated tannin extract 10 g, hydroquinone 3 g, paraformaldehyde 1.2 g, urea 1.4 g, pH = 7, salinity of 3000mg/L, according with the demand of fieldwork.

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Keywords- high temperature resistance water shutoff agent; sulfonated tannin extract; viscoelasticity; strength code method;

1 Introduction

Profile control and water shutoff is one of the most important technologies in oil field production, and the chemical modification is the corner-stone of successful profile control and water shutoff [1], which also is the most active and spectacular technology in the development of profile control and water shutoff. The profile control agents are classified as gel, resin, hydrogel, precipitation and dispersion types according to the status in the bottom. Nowadays, the synthetic polymer gel and granular agents containing AM units are commonly used. It’s imperative to stabilize oil production and control water cut with the increase of water cut in low permeability oilfield, thus profile control agents suitable for high temperature low permeability oilfield are in urgent need[2]. Due to the grain diameter, the agents successfully applied
in oil fields are not available for low permeability oilfield or super-low permeable reservoirs as well as high temperature and high salinity reservoirs [3].

Tannin extract has a rich resource, lower cost and strong chemical activity, which could be used to prepare special polymer by chemical modification [4, 5]. The application of modified tannin extract in the high temperature oil wells has been reported. The tannin extract treated by a chemical or physical process to improve its properties exhibit excellent heat resistance and salt tolerance performance. A kind of novel water shutoff agent synthesized in this paper using sulfonated tannin extract as main agent, paraformaldehyde as crosslinking agent, polyhydric phenol as stabilizer, and urea as tackifier could find application in the oil field due to the attribution of its good high temperature resistance.

2 Experimental

2.1 materials and instruments

HPAM (M=1200~1600×10⁴) was purchased from Daqing Refining and Chemical Company. Sulfonated tannin extract was obtained from Guangxi Baise Linhua Works. Hydroquinone, paraformaldehyde and urea were supplied by Shanghai Jiaoguang Plastic Trading Chemical Company, Harbin Dongfang Chemical Plant and Shenyang Xinxing Regent Factory, respectively.

2.2 Preparation of high temperature resistance plugging agent solution

HPAM (0.2 g ) and water ( 150 mL ) were added in to a flask with 0.5 h intense agitation, then sulfonated tannin extract 10 g, hydroquinone 3 g, paraformaldehyde 1.2 g, urea 1.4 g were added to the system. After 10 min intense stirring, homogeneous plugging agent solution was formed.

2.3 Gelling properties measurements

The stock solution was added to ampoule, which was sealed and stored in 120 °C incubator for a period of time. The ampoules were taken out to observe its fluidity after cooling. The standard of criterion of losing fluidity was decided by the angle between the frontier of gel and flask-wall when the ampoule is placed horizontally. If the angle is > 45°, we considered it as gel forming. The optimum gelling time was decided by the adjustment of gelling strength which was determined by strength code method.

3 Results and discussion

3.1 Effect of amounts of paraformaldehyde on gel performance

The effect of amounts of paraformaldehyde on gel performance was studied under the conditions as follow: partially hydrolyzed polyacrylamide 0.2 g, sulfonated tannin extract 10 g, hydroquinone 3 g, urea 1.4 g and water 150 mL. The results have been depicted in figure 1.

As figure 1 shown that, the gelling time decreased and gelling strength increased with the increase of amounts of paraformaldehyde. When the amount is 1.6 g, the gelling time is several hours, and the strength is invariant.
It may be attributed to the formaldehyde resulting from paraformaldehyde hydrolysis. As crosslinking and curing agent, the reaction rate increased and time shortened with the amounts of formaldehyde increased. We can control the gelling time through controlling the amount of paraformaldehyde. The gelling time was 48 h and strength was 78 kPa as the amount of paraformaldehyde was 1.6 g.

3.2 Effect of amounts of sulfonated tannin extract on gel performance

The effect of amounts of sulfonated tannin extract on gel performance was studied under the conditions as follow: partially hydrolyzed polyacrylamide 0.2 g, paraformaldehyde 1.6 g, hydroquinone 3 g, urea 1.4 g and water 150 mL. The results have been depicted in figure 2.
As seen in figure 2, the gelling time was short and strength was low when the amount of sulfonated tannin extract is small. With the increase of the amount of sulfonated tannin extract, the gelling time and strength had no significant change. The main reason may be that the ratio of sulfonated tannin extract to formaldehyde decreased, then the content of formaldehyde increased, gelling time shortened and gelling strength was low.

3.3 Effect of amounts of hydroquinone on gel performance

The effect of amounts of hydroquinone on gel performance was studied under the conditions as follow: partially hydrolyzed polyacrylamide 0.2 g, sulfonated tannin extract 10 g, urea 1.4 g, paraformaldehyde 1.6 g and water 150 mL. The results have been depicted in figure 3.
As shown in figure 3, the amount of hydroquinone has no significant influence on gelling time. Gelling strength increased with the increase of the amount of hydroquinone when it’s less than 3 g, and then had no change when it reached 3 g. Hydroquinone played a role of stabilizer in the system of water shutoff.

3.4 Effect of amounts of urea on gel performance

The effect of amounts of urea on gel performance was studied under the conditions as follow: partially hydrolyzed polyacrylamide 0.2 g, sulfonated tannin extract 10 g, hydroquinone 3 g, paraformaldehyde 1.6 g and water 150 mL. The results have been shown in figure 4.
The results have shown that the gelling time decreased and gelling strength increased with the increase of the amounts of urea. The gelling strength was invariant when the amount reached 1.4 g. As a tackifier, urea would react with formaldehyde to give urea-formaldehyde resin which is favorable to reduce the curing time. The length of main chain and the viscoelasticity of water shutoff system increased due to the formed urea-formaldehyde resin [7].

3.5 Effect of salinity on gelling performance

It could be extracted from figure 5 that gelling time and strength have been significantly reduced with the increase of the concentration of inorganic salts, as electrolyte can promote cross-linking and coagulation by compressing twin electrical layer. Ca$^{2+}$ can more significantly reduce the gelling time than Na$^+$ in theory. When the concentration of NaCl was less than 3000 mg/L, the influence of salinity was comparatively small.
Figure 5 Effect of salinity on gelling performance

4 Conclusions

The optimum formula of the novel high temperature resistance water shutoff agent synthesized using sulfonated tannin extract as main agent was composed of HPAM 0.2 g, sulfonated tannin extract 10 g, hydroquinone 3 g, paraformaldehyde 1.2 g, urea 1.4 g. Under the above conditions, the gelling time was above 50 h, gelling time was 78 kPa. And the gelling time could be adjusted through the modification of the amounts of paraformaldehyde according to the site requirements. The synthesized quaternary system with high viscoelasticity has excellent comprehensive properties and low costs. It is resistant to high temperature (120 °C), and could find application in high temperature low permeability oilfield.

References


