Synthesis and analysis of foam drainage agent for gas well in Jilin Oilfield

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Abstract. The gas well in Jilin oil field has the characteristics of large temperature variation range and high condensate oil content. So the foam drainage agent of the gas well in Jilin oil field needs to have the performance of oil resistance and less effected by temperature. In this paper, a main foaming agent named lauramidopropyl betaine (LAB) and two kinds of auxiliary foaming agent named sodium alcohol ether sulphate (AES) and lauramidopropylamine oxide (LAO). Through the evaluation of the static foaming capacity and dynamic liquid carrying capacity, the AES is more suitable for LAB. The foaming agent with 70% LAB and 30% AES has 138mm foam height with ROSS-Miles equipment; stirring foam volume can reach 480mL, the half-life of foam is 52s. When the ventilation volume is 8L/min the liquid carrying capacity of 10% of the condensate oil content reached 82g. When the foaming agent concentration is 2%, the liquid carrying capacity of 10% of the condensate oil content reached 75g. When the aeration rate reaches 8-10L/min, the liquid carrying capacity of foam drainage agent can reach the best. The foam drainage agent can retain the performance after 120 ℃ aging for 12h, these performances above can satisfy the requirements for gas well foam drainage in Jilin Oil Field.

1. Experimental part

1.1. Experimental materials
Experimental Materials: Lauric acid, N,N’-Dimethyl-1,3-propanediamine, Propylene diamine, Hydrogen Peroxide(30%), Sodium chloroacetate, Lauryl alcohol, Epoxide, Sulfamic acid, Sodium hydroxide, Potassium hydroxide, Concentrated sulfuric acid, both are analytical pure. The experimental water is the water sample of gas wells in Jilin oil field (4000mg/L); Condensate oil samples from Jilin Oilfield.

1.2. Experimental instruments
(1) Liquid carrying test equipment, (2) Shanghai Lin Lin Electronic Technology Co.Ltd. GHX series oil bath pot, (3) Shanghai Bank Equipment Co. Ltd. 2151 standard Roche foam tester.

1.3. Synthesis of blowing agent
The dodecanol was chosen as the starting agent, and the starting agent was introduced into the autoclave, 0.5% KOH was added as catalyst, and after evacuation under nitrogen protection conditions, ethylene oxide was added dropwise, heat preservation for 30 minutes after the addition until the pressure is...
negative. The product of small molecule was removed by vacuum cooling, then the fatty alcohol polyoxyethylene ether was obtained. Weigh the prepared fatty alcohol polyoxyethylene ether into the three-necked flask, using sulfamic acid as sulfation reagent, and then adding 0.5% concentrated sulfuric acid as a catalyst, after 2.5h, the reaction was terminated, after cooling, sodium hydroxide was added at room temperature to neutralize the excess sulfamic acid and the ammonium salt was converted into sodium salt. Finally, the effective content of AES solution was 30%.

2. Evaluation of foaming performance

2.1. Evaluation of Roche Foaming Performance

Roche foaming performance is using Ross-Miles foam tester on the impact of surfactants to evaluate the ability to foam, in the experimental method, 297.0 g of distilled water was weighed, and then added in 3.0 g of the foaming agent, followed by gentle stirring to disperse the solution. The 50 mL of the formulated foaming agent solution was slowly poured into the bottom of the Roche foam tester with glass rod, another 200mL solution was placed in the funnel device of the foam tester, the funnel placed in the bubble above the instrument to open the valve, so that the solution evenly outflow, until the solution flowing out then reading the foam height. And at 65 °C for 15 min, the foam height was read again. The experimental data is shown in Fig.1.

As can be seen from Figure 1, after joining AES, LAB has higher foam height and foam stability compared with LAB added LAO, It can be concluded that after joining the LAB, AES is better than LAO and LAB in the foaming capacity and stability.

2.2. Foaming ability and half-life test

The foaming agent can quickly generate a large amount of foam under the condition of high speed stirring, the foaming and stabilizing ability of the foaming agent can be judged by the amount of foam produced and the rate of foaming under the same conditions. The experimental procedure is to take 100.0 g of distilled water and add 1.0 g of foaming agent, then put the foam into the 500mL cylinder, at this time the foam volume is the foaming volume. We record the time at which the solution at the bottom of the graduated cylinder reaches 50 mL, this time is half-life, the experimental data are shown in table 1.
As can be seen from Table 1, the foam formed by high-speed stirring compared to the large foam formed by the Roche foam will form more subtle micro-foam. So the water loss of this bubble is slower than the big bubble, and the liquid film formed between the foams has a larger relative surface area, therefore, the stabilizing effect of LAO on LAB is more obvious than that of AES on LAB, this is due to the high degree of similarity between the lipophilic groups of LAO and the lipophilic groups of LAB, the formation of double-layer film on the surface of the liquid film will form a symmetrical structure, more balance21d. So foam has a longer half-life which formed by LAO and LAB.

2.3. Foaming agent dynamic carrying capacity test
The dynamic liquid carrying capacity test of foam drainage agent is a method to simulate the formation process of foam drainage agent bring formation water into the ground, it is an important index to evaluate the performance of foam drainage agent. The oil samples and condensed oil samples from the gas wells of Jilin Oilfield were selected as experimental liquids, According to the conditions of the bottom of oil well in Jilin oilfield as the experimental condition of dynamic liquid carrying experiment: The experimental temperature is 60 °C, The condensate oil content is 10% mass fraction. Take 100.0g prepared oil water samples, add 1.0g foaming agent after mixing slowly, ventilation volume is 8L/min, and record the quality of liquid within 15min, the experimental data shown in Table 2.

### Table 2 The amount of liquid in different foaming agents

| Foaming agent type | Liquid carrying capacity /g |
|-------------------|-----------------------------|
| AES+LAB           | 82                          |
| LAO+LAB           | 68                          |

3. Formula optimization of foam drainage agent

3.1. Determination of the concentration of foaming agent
The oil samples from Jilin Oilfield were selected as water-based liquids, the dynamic carrying capacity of the foam drainage agent was tested when the condensate oil content was 10%, 20%, 30% and 40%, respectively. The experimental temperature was 60 °C, the concentration of foaming agent was 0.5%, 1%, 1.5%, 2%, 2.5%, and 3% respectively, ventilation is 8L/min. The experimental data are shown in figure 2. Indicating that the concentration of 2.0% is the appropriate concentration.

![Figure 2 The effect of different oil content and the amount of foaming agent](image-url)
As can be seen from Figure 2, with the increase of condensate oil content, foaming agent carrying capacity will be affected, if foaming agent is added less, when the condensate oil content is high, the liquid cannot be taken out of the container, at this time, liquid carrying capacity of 0. With the increase in the amount of foaming agent used, the influence of condensate oil on liquid carrying capacity is smaller, when the foaming agent reaches 2.0g, in 40% of the condensate oil conditions can still reach 75g carrying liquid. Indicating that the concentration of 2.0% is the appropriate concentration.

3.2. Effect of ventilation on carrying capacity
In the process of foam drainage, the vapor liquid ratio has a great influence on the production of foam, if the vapor liquid ratio is too small, will lead to the production of less foam, and the foam generation rate is less than the rate of death of the foam, which cannot bring liquid; if the vapor liquid ratio is too large, it will cause the gas slippage and reduce the gas lift efficiency. So the appropriate vapor liquid ratio has a great influence on the carrying capacity of the foaming agent. The change of ventilation volume from 4L/min to 10L/min was used to study the effect of ventilation volume on the liquid carrying capacity of foaming agent, the experimental temperature was 60 °C, the concentration of foaming agent was 1.0%, and the condensate mass fraction is 10%.

![Fig. 3](image)

As can be seen from Figure 3 that with the increase in ventilation, the liquid carrying capacity of the foam drainage agent increases, but when the air volume exceeds 9L/min, the liquid carrying capacity will decrease slightly, so the most suitable ventilation should be 8~10L/min.

3.3. Foaming agent temperature resistance
As the temperature of the bottom of the gas field in Jilin oil field changes greatly, some gas wells bottom temperature can reach 80 ~ 90 °C, so the foam drainage agent needs to have the ability to resist aging of 120 °C, the prepared foaming agent was placed in a high temperature aging tank and heated at 120 °C for 12 h, and then determine the performance change between the foaming agent has been aging and the foaming agent before aging. The mass fraction of the foaming agent used in the experiment was 1%, the condensate oil content was 10%, and the experimental temperature was 60 °C. The experimental data are shown in Table 3.
Table 3 Performance changes of foaming agents before and after aging

| Experimental conditions | Liquid carrying capacity/g | Foaming volume/ml | Half-life/s | Roche bubble height/mm |
|-------------------------|---------------------------|-------------------|------------|------------------------|
| Before aging            | 82                        | 480               | 520        | 138                    |
| After aging             | 80                        | 480               | 510        | 130                    |

4. Conclusion

1. In this paper, through the synthesis of three kinds of surfactants and complex, obtained a low price, green, temperature and oil-resistant foam drainage agent, and has a good foaming ability and foam stability.

2. The effect of different condensate content on the liquid carrying capacity of foam solution with different mass fraction was studied experimentally, and the relationship between the amount of ventilation and the amount of dynamic foaming liquid carrying capacity. When the foaming agent reaches 2.0g, in 40% of the condensate oil conditions can still reach 75g carrying liquid. Indicating that the appropriate concentration is 2.0%. And with the increase in ventilation, the liquid carrying capacity of the foam drainage agent increases, but when the air volume exceeds 9L/min, the liquid carrying capacity will decrease slightly, so the most suitable ventilation should be 8~10L/min.

Acknowledgements

This research is supported by China National Natural Funds project “Selection of Oil Soluble Resin Double Crosslinking Gel Plugging Agent” (No. 51374071).
This work is supported by PetroChina Innovation Foundation (2016D- 5007- 0201). Corresponding Author is XU Jianjun.

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