Research and application of compound viscosity reducer in ultra-heavy oil wells

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Introduction

- **Heavy oil is an important part of the world's oil and gas resources, accounting for 53% of the total resources. In China, the exploitation of heavy oil is becoming more and more important as a result of reducing of light oil reserves. Heavy oil resource has the characteristic of high density, high viscosity , poor fluidity and difficult mining technology .It is very important to develop a new type of efficient viscosity reducer for heavy oil.**

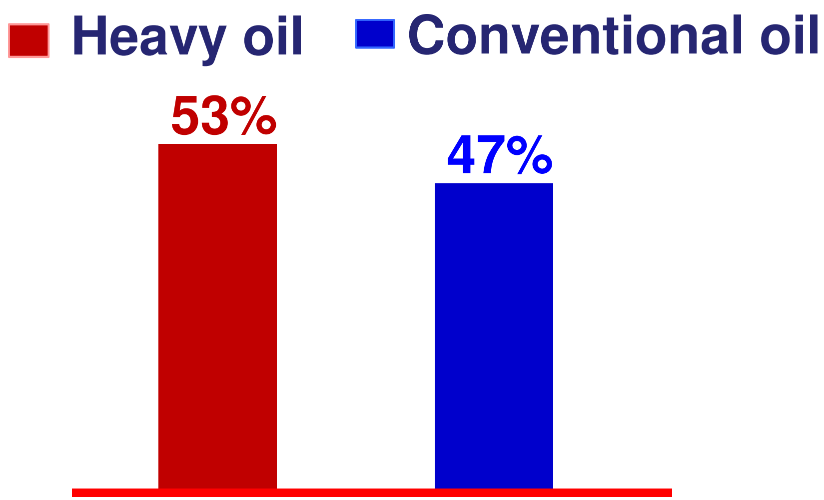

Fig.1 Proportion of the world oil reserves

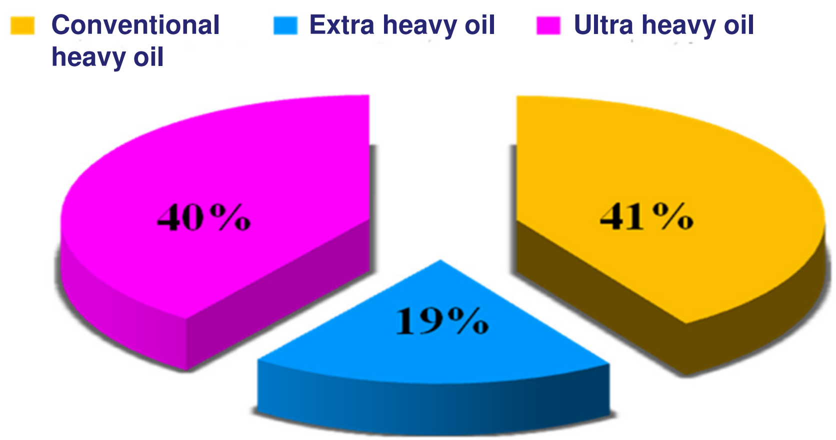

Fig.2 Composition of heavy oil reserves in China

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Chinese Ultra Heavy Oil Analysis

- **SARA analysis**

Table.1 Group compound analysis for Chinese ultra heavy Oil

Sample	Saturates %	Aromatics%	Resin%	Asphaltene%
Ultra heavy oil	11.70	41.86	18.16	28.28

Group components is important for crude oil quality. Asphaltene content of the Chinese ultra heavy crude oil was 28.28%, resin and asphaltenes have 46.44% in total mass. The results show that the ultra heavy oil has high resin and asphaltene contents.

Chinese Ultra Heavy Oil Analysis

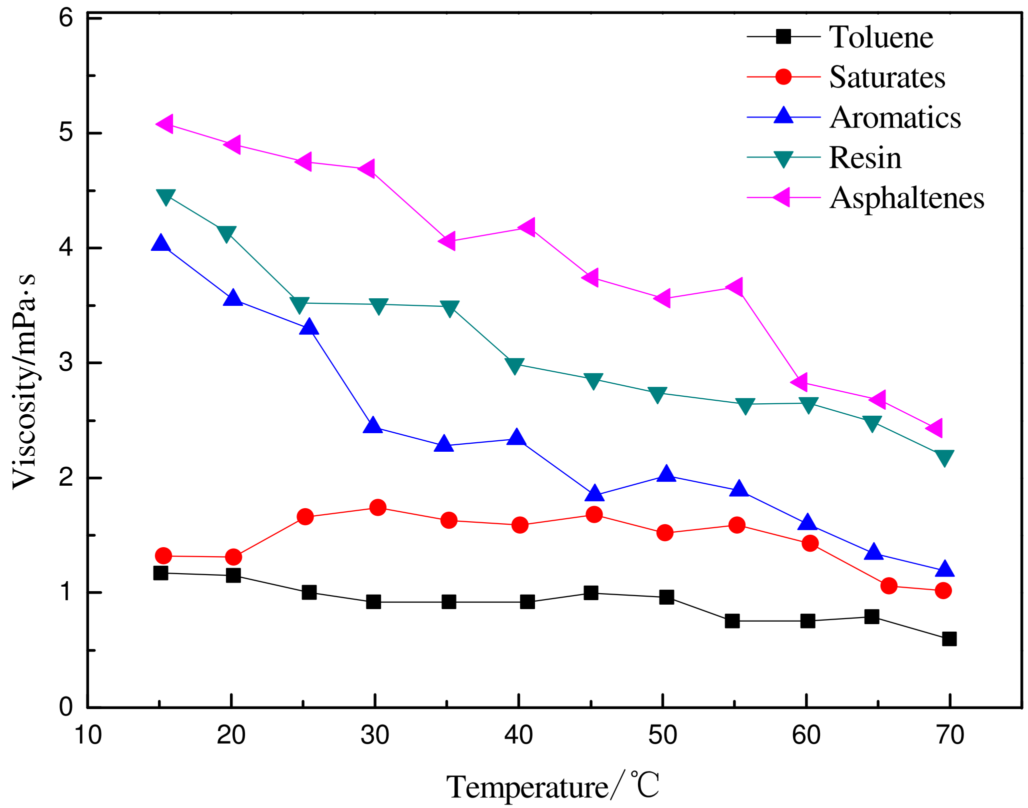

Fig.3 The influence of separated component for crude oil viscosity

The influence factors of crude oil components are in the following sequence.

Asphaltenes > Resin > Aromatics > Saturates

Chinese Ultra Heavy Oil Analysis

Viscosity-temperature properties

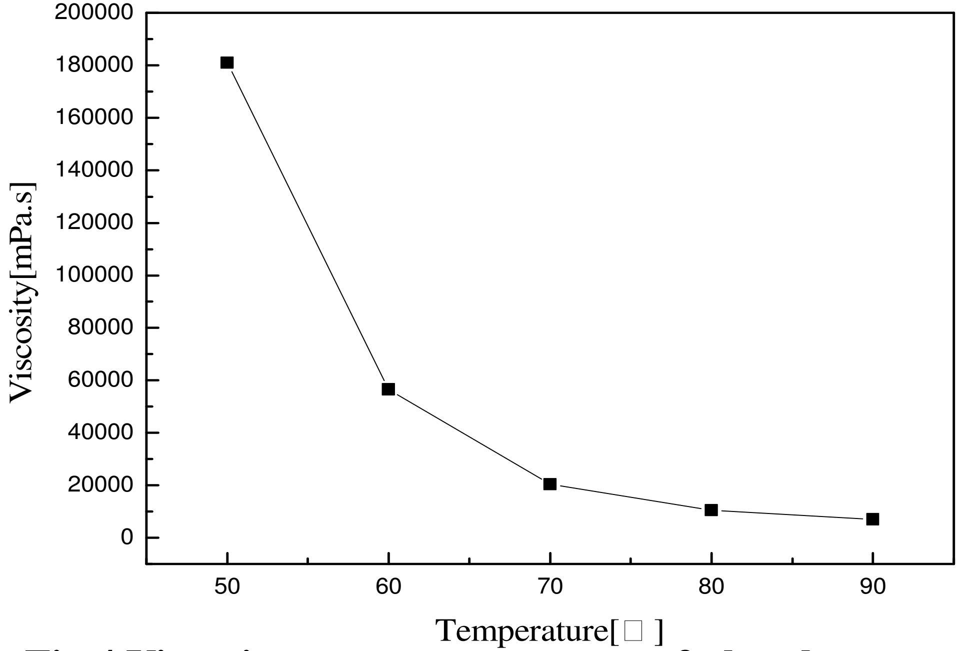

Fig.4 Viscosity-temperature curve of ultra heavy crude oil

As the temperature increases, the viscosity of the ultra heavy oil becomes lower. The viscosity of ultra crude oil is 1.81×10^5 mPa·s at 50℃, 7067 mPa·s at 90℃.

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Viscosity Reducing Experiments

- **Effect of conventional oil-soluble and water-soluble viscosity reducer**

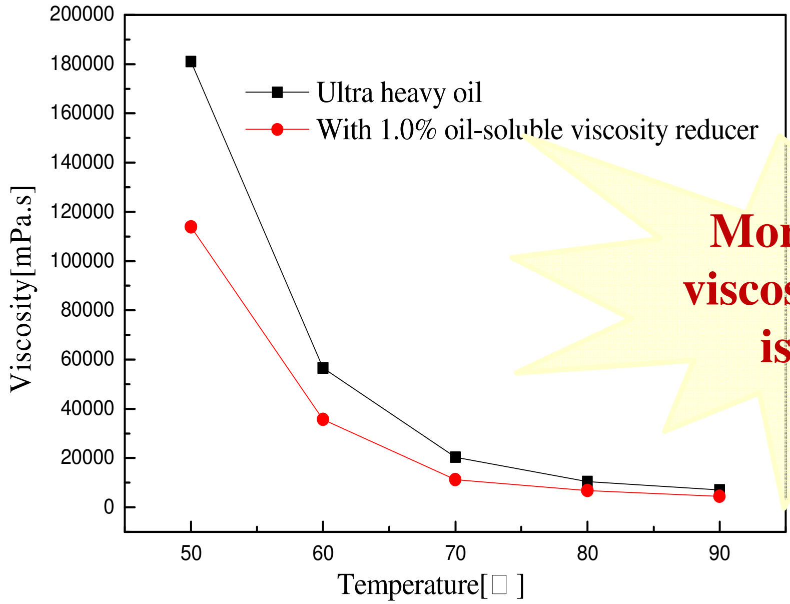


Fig.5 Effect of oil-soluble viscosity reducer

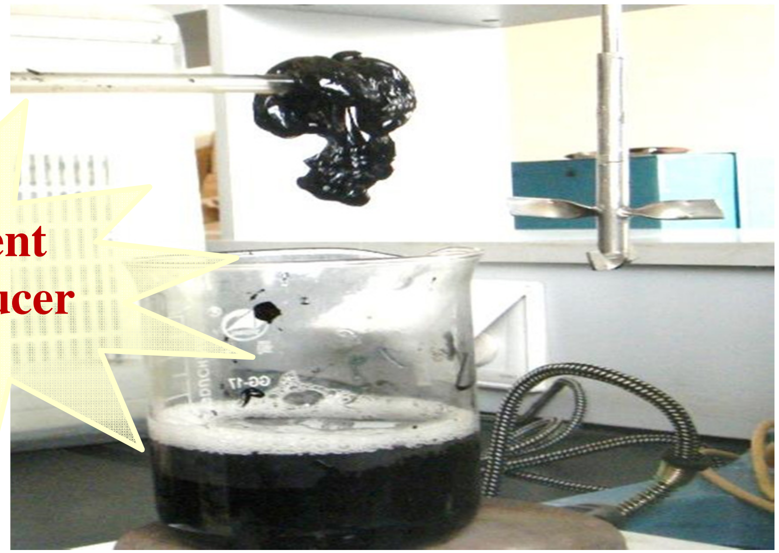


Fig.6 Effect of water-soluble viscosity reducer

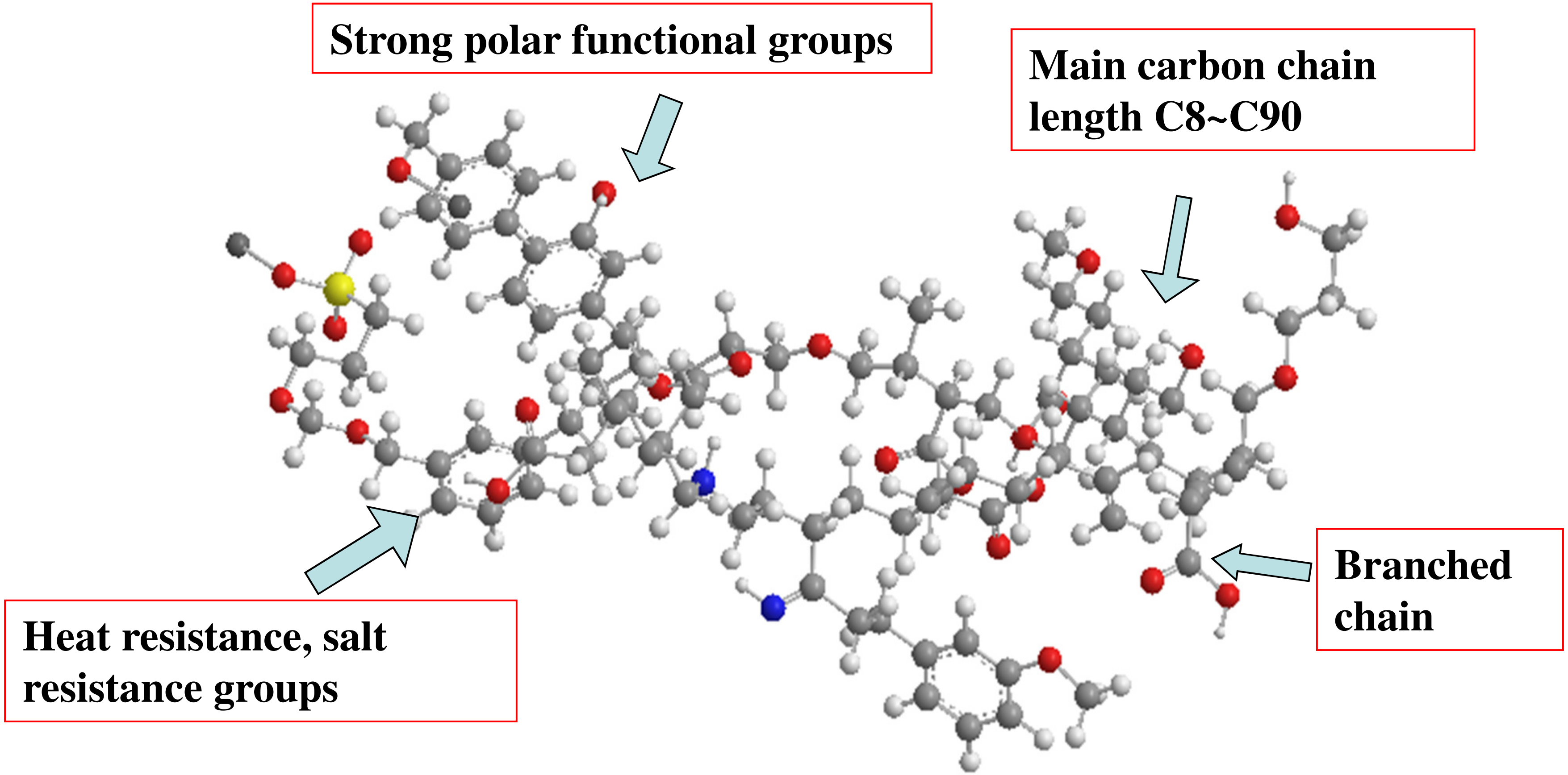
More efficient viscosity reducer is needed

The viscosity of ultra heavy oil fell from 1.81×10^{5}mPa·s to 1.13×10^{5}mPa·s at 50℃ and from 7067mPa·s to 4477mPa·s at 90℃ with 0.5wt.% oil-soluble viscosity reducer, which shows a low degree of viscosity reduction.

Commercial water-soluble viscosity reducer cannot disperse heavy components and emulsify ultra heavy oil.

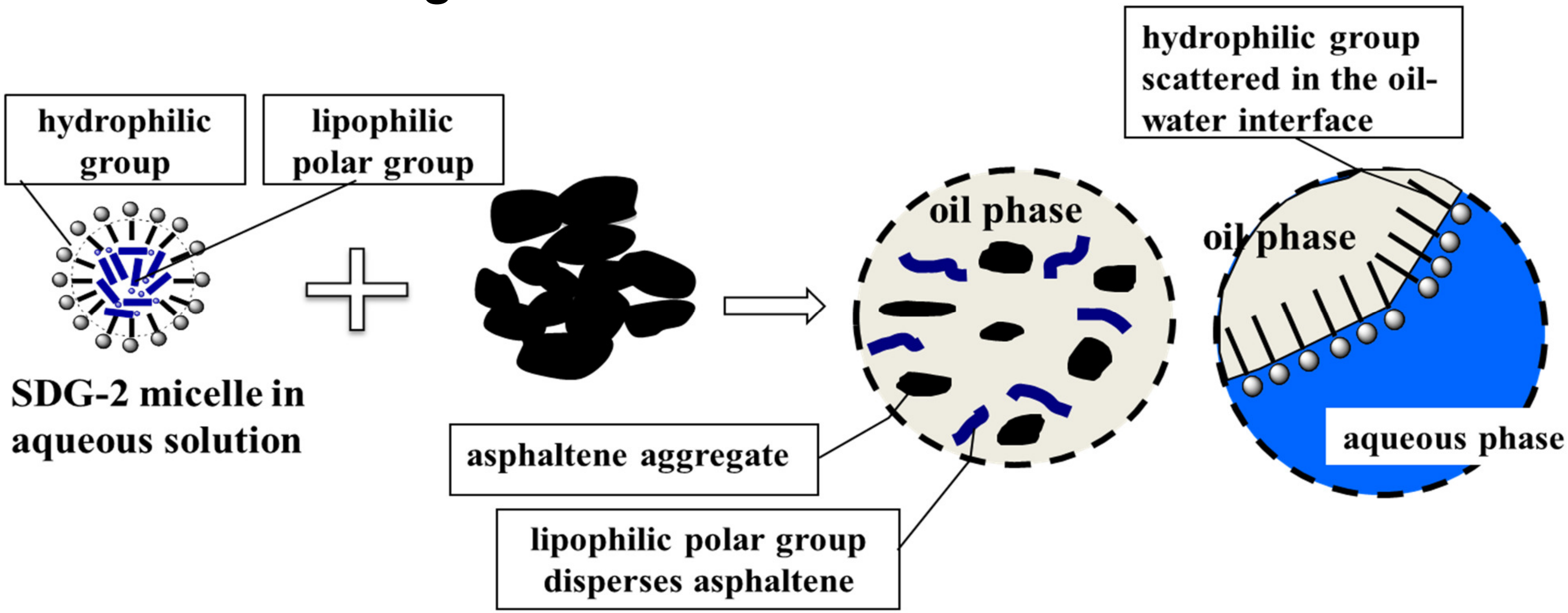
New efficient compound viscosity reducer SDG-2

- Molecular structure schematic diagram of SDG-2



New efficient compound viscosity reducer SDG-2

Mechanism diagram of action of SDG-2



High-carbon lipophilic polar groups in SDG-2 interact with resin and asphalt molecules in ultra heavy crude to hinder the asphaltene aggregate formation and salt-tolerance hydrophilic groups reduce the oil-water interfacial tension to form relatively stable O/W emulsion.

Viscosity Reducing Effect of SDG-2

Compare with oil-soluble viscosity reducer

Table.2 Effect comparison of viscosity reduction between SDG-2 and oil-soluble viscosity reducer

Viscosity reducer	SDG-2 (30% water cut)				Oil-soluble			
Temperature	50 ℃		90 ℃		50 ℃		90 ℃	
Mass ratio	viscosity mPa·s	Rate of viscosity reduction %	viscosity mPa·s	Rate of viscosity reduction %	viscosity mPa·s	Rate of viscosity reduction %	viscosity mPa·s	Rate of viscosity reduction %
0	181000	——	7067	——	181000	——	7067	——
0.2 %	4525	97.5	1456	79.4	122535	32.3	6212	12.1
0.4 %	3077	98.3	1293	81.7	87648	51.5	5524	21.8
0.6 %	2172	98.8	869	87.7	63847	64.7	4153	41.2
0.8 %	1267	99.3	452	93.6	56969	68.5	3214	54.5
1 %	905	99.5	318	95.5	52987	70.7	2958	58.1

At 50℃, when the mass ratio ranged from 0.2wt% to 1wt%, the rate of viscosity reduction ranged from 97.5%~99.5% with 30wt.% SDG-2 aqueous solution, much higher than 32.3%~70.7% with oil-soluble viscosity reducer , indicating that the effect of SDG-2 is better than oil-soluble viscosity reducer.

Viscosity Reducing Effect of SDG-2

Compare with oil-soluble viscosity reducer

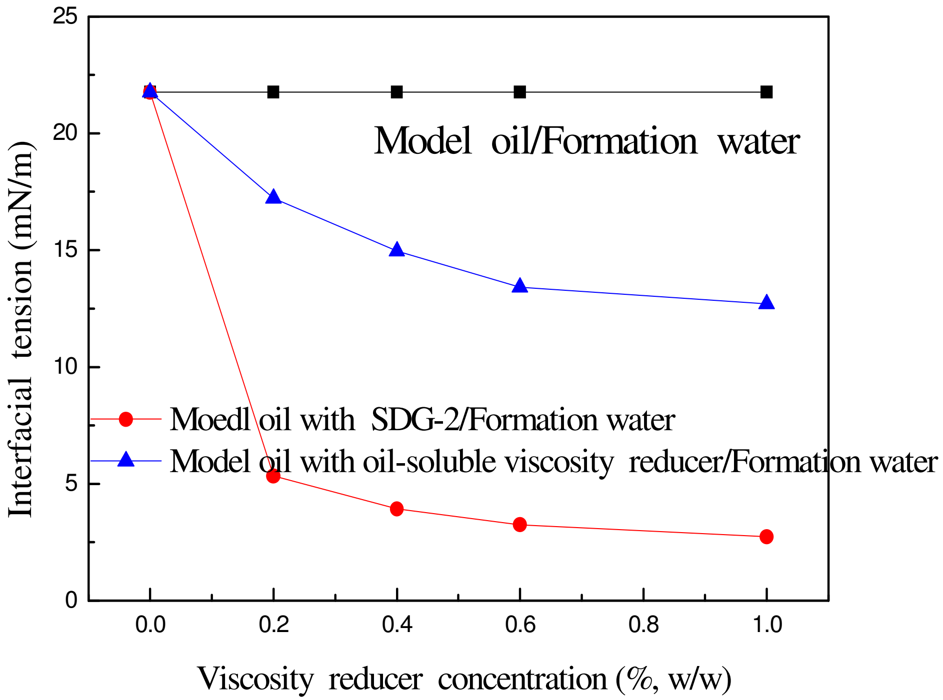


Fig.5 Comparison of oil-water interfacial tension with SDG-2 and oil-soluble viscosity reducer separately

A much lower oil-water interfacial tension with SDG-2 than that with oil-soluble viscosity reducer at the same concentration, indicating that the SDG-2 has a higher interfacial activity.

Viscosity Reducing Effect of SDG-2

Emulsification effect

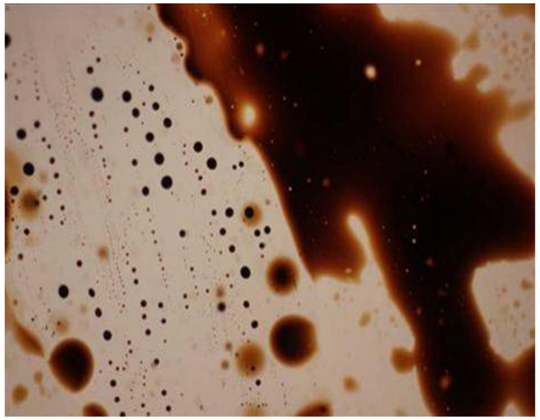


Fig.6 Oil-water mixed system without SDG-2, 100×

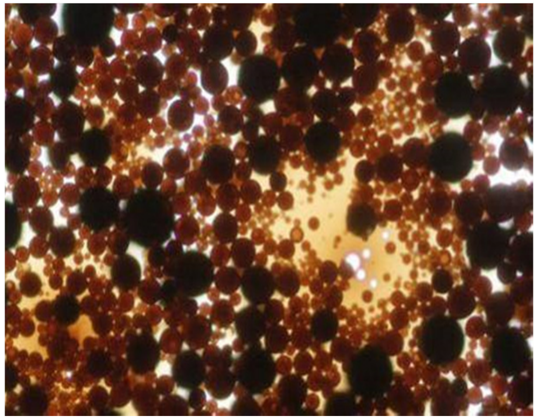


Fig.7 Oil-water mixed system with SDG-2, 100×

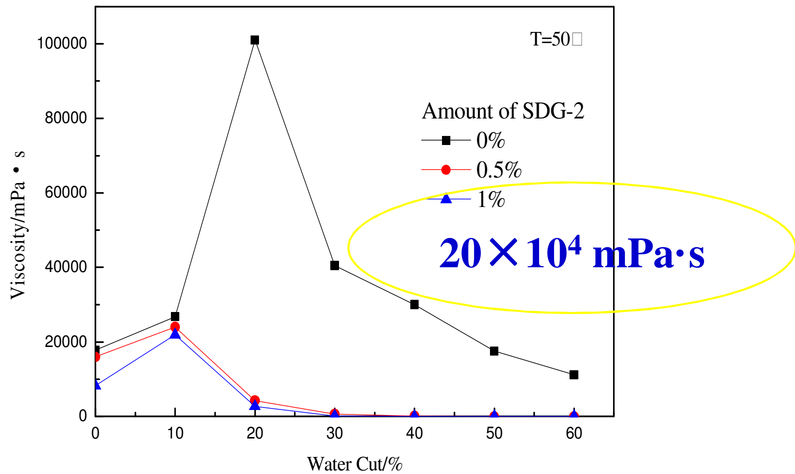
Droplet size distributions

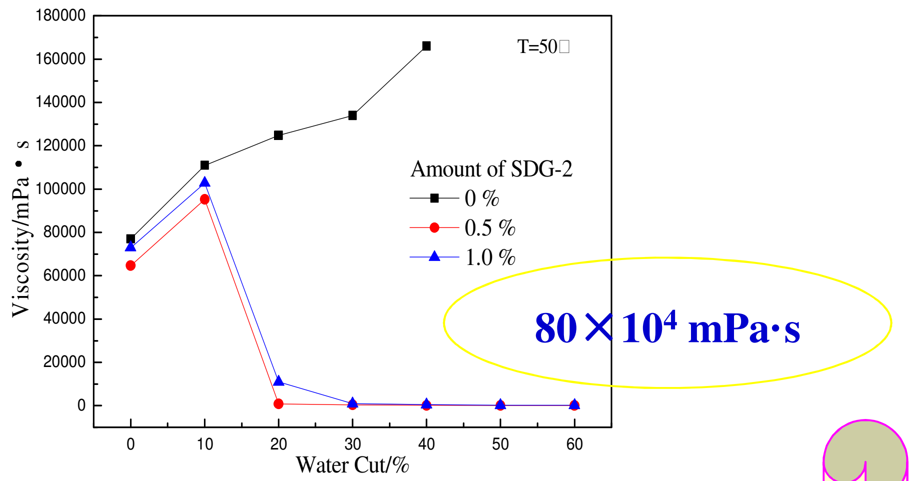
Average value: 2415.5 nm

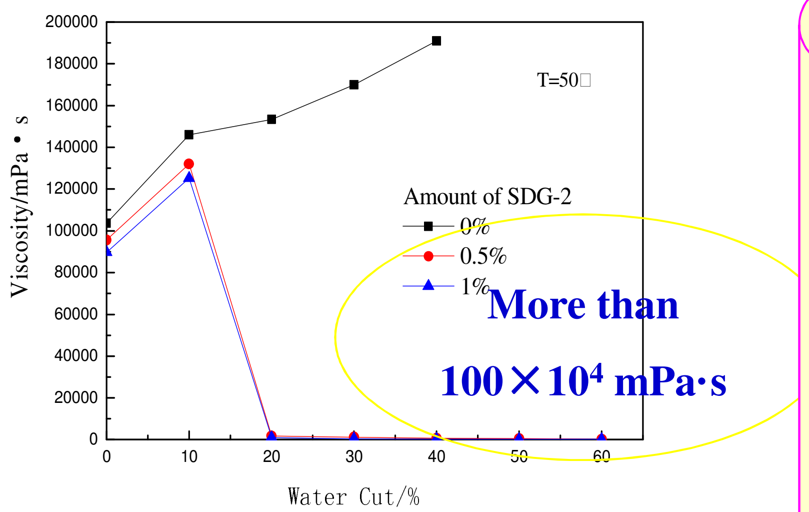
Most heavy oil block dispersed in water in sheet without the SDG-2 , after adding 1% (w/w) SDG-2 at 30% water cut, heavy oil dispersed in water in the form of small oil droplets indicated that O/ W emulsion had formed.
The mean droplet size is 4.5μm.

Viscosity Reducing Effect of SDG-2

Applicability of SDG-2 for different viscosity heavy oil







The viscosity of different heavy oil decreased obviously after adding SDG-2. Crude oil emulsion showed low viscosity as well as good flowability when water cut is more than 20%.

SDG-2 on the effect of demulsification

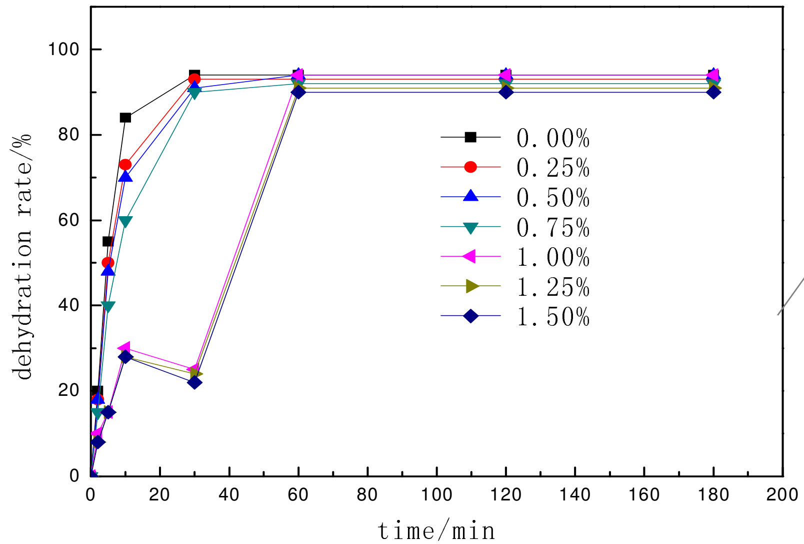
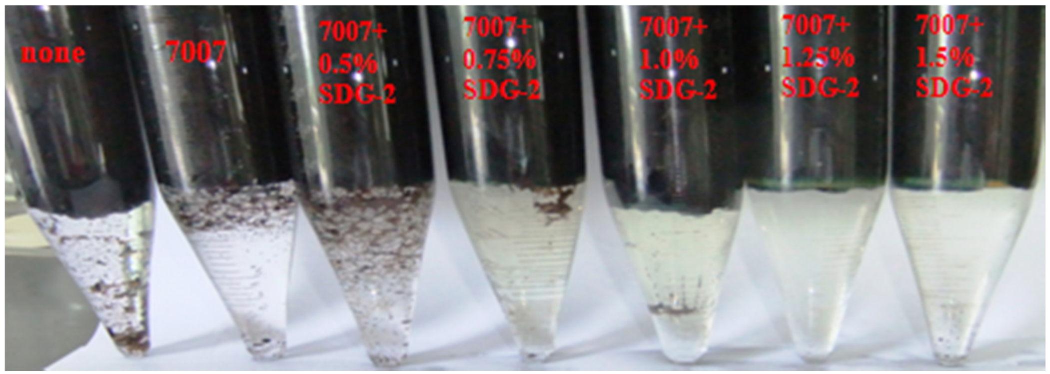


Fig.11 Influence of different amounts of SDG-2 on dehydration rate of O/W emulsification

Dehydration rates all reached more than 90% after 1h at 90℃.



Had small influence on quality of final dehydration.

Fig.12 Method of "bottle test" at 90℃

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Conclusion

① The effect of reducing viscosity with compound viscosity reducer SDG-2 was stronger than oil-soluble and water-soluble viscosity reducer. Much lower oil-water interfacial tension with SDG-2 was shown and the average emulsion droplet size was 4.5um.

② SDG-2 had a very wide scope of application that it suits for viscosity range from 1.0×10^4mPa·s to more than 1.0×10^5mPa·s ultra-heavy oil. Lipophilic group of SDG-2 can make heavy oil dispersed and dissolved, destroy heavy macromolecular structure, hydrophilic group of SDG-2 allowed oil and water to form o/w emulsion .

③ Emulsion stability strengthened gradually with the amount of SDG-2 increasing but had mild influence on final dehydration rate.

Thank you