Performance Evaluation of Polymer Surfactant and Their Displacement Effects

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Abstract. Polymer surfactants have distinguished features such as salt resistant, high viscosity, high emulsification property and stability, with a displacement mechanism similar to ASP flood. It is one of the trendy chemical flooding technologies. This paper includes polymer surfactant physical-chemical properties experiments and a core displacement experiment. Research shows that the viscosity, viscosity stability and salt resistance performance of polymer surfactant are better than those of conventional polymers. When the polymer surfactant concentration reaches a certain value, an emulsification phenomenon is observed in the system. The study of the performance and displacement effect of polymer surfactant will be of great significance for future industrialized application in oil displacement.

Keywords: displacement effect, performance evaluation, Polymer surfactant.

Preface

Polymer surfactant is a chemical agent developed by the Chemistry Institute of Academia Sinica. Despite its distinguished features such as being salt resistant, high viscosity, high emulsification property and stability, it is also of high technical sophistication, economic rationality and production management adaptability. It is the gordian technique for further enhanced oil recovery. Polymer surfactant flooding technology is currently at the stage of laboratory experiment and field test [1-3]. Further research is needed in the area of classifying polymer surfactant according to their types, physical and chemical properties and their displacement effects [4-6].This paper reports on an experiment to investigate the physical-chemical properties and core displacement effects of I type polymer surfactant. A comparison of polymer surfactant and conventional polymers will provide both a scientific and a theoretical basis for further enhanced oil recovery and industrialization application.

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Experiment Introduction

Quartz sand epoxy adhesive bond artificial cores, with a geometrical dimension of 30.0cm×4.5cm×4.5cm were used for the experiment. Gas logging permeability was about 2.0μm^2, the water for the experiment was from the Daqing Oilfield First Oil Extraction Plant sewage system. The oil used for the experiment has a viscosity of about 10mPa•s at 45°C and was from class 1 dewatered oil from the west block in the First Oil Extraction Plant, The polymer surfactant used was the I type developed by the Chemistry Institute of Academia Sinica, the basic physical-chemical parameters are shown in Table 1. The main experiment devices used are the RS-150 type rheometer and TX500 type interface tension instrument.

Table 1 Basic performance of Polymer surfactant

Solid content %	Hydrolysis degree mol%	Viscosity mPa.s	Insoluble Wt%	Dissolution rate h	granularity %	
					≤0.2mm	≥1.0mm
90.93	33.2	48.9	0.09	<2	2.4	3.3

1 Evaluation of the Physico-chemical Properties

(1) Salt Resistance Property

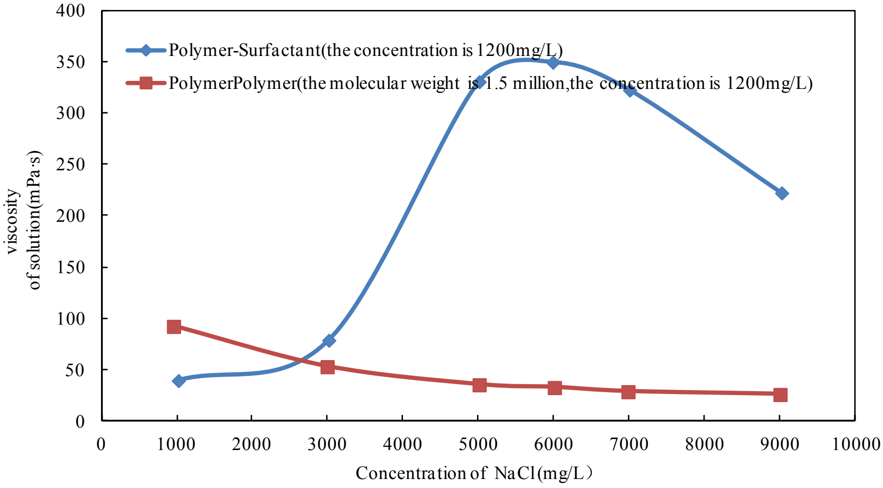

Fig. 1 The viscosity and salinity relation curves of polymer surfactant and polymer in the same concentration

Figure 1 shows that, with increasing sodium chloride concentration, the viscosity of the conventional polymer solution declined while the viscosity of the polymer surfactant firstly increased to a certain maximum concentration and then began to decline The polymer surfactant had the advantage of being salt resistant under conditions of high salinity, which illustrated that the high salinity sewage prepared polymer surfactant solution was suitable for the actual application.

(2) Viscosity Property

Figure 2 showed that under the same concentration conditions, the viscosity of type I polymer surfactant solution was obviously higher than the conventional polymer solution. The polymer surfactant, whose increment of viscosity value was higher than that of the polymer solution as the concentration increased, showed a better viscosification power.

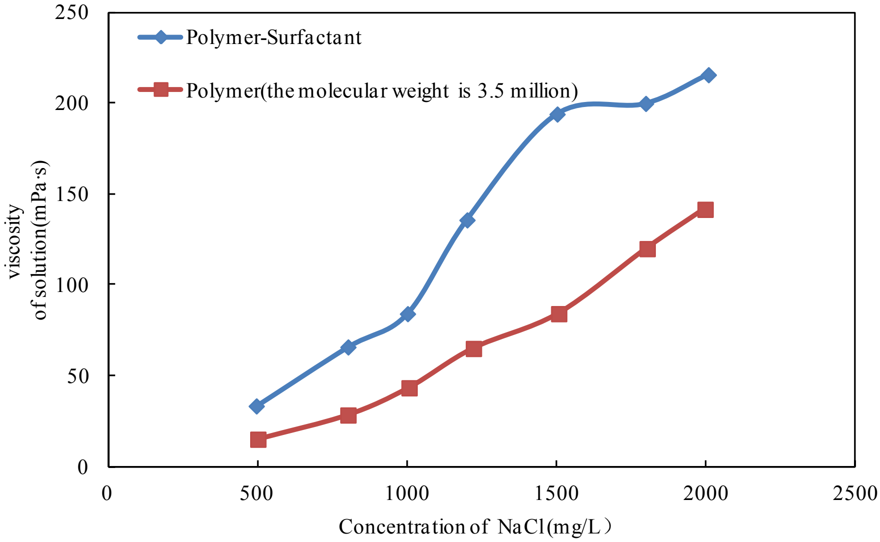

Fig. 2 The concentration and viscosity relation curves of polymer surfactant and polymer

(3) Viscosity Stability

Table 2 shows that while the placing time was prolonged, the viscosity of polymer surfactant first increased and then decreased. The overall observation however, was that the viscosity of the polymer surfactant solution obviously increased and the higher the concentration, the larger the increment.

Table 2 Sewage prepared polymer surfactant viscosity stability testing data table

Time (days) / concentration	0	3	7	15	30	60	90
1500（mg/L）	251.7	201.7	>1000	599	596	517	477
2000（mg/L）	297.6	>1000	>1000	>1000	>1000	>1000	>1000

(4) Emulsification Property
Different concentrations of polymer surfactant solution were prepared using on-site sewage mixed with crude oil on a 1:1 ratio and then placed in a 45℃ incubator for observation of the emulsification behavior. After inspection it was observed that the type I polymer surfactant showed an emulsification phenomenon when the concentration reached 800 mg/L. The emulsion was primarily a reverse emulsion type which could not be separated after having been vibrated for 16 days.

2 Analysis of Core Displacement Effect

Table 3 The core displacement experiment results

Chemical agent types	Preparation water	Viscosity (mPa.s)	Core physical property			Displacement effect		
			Kg (mD)	Φ (%)	So (%)	Water flooding (%)	Enhanced recovery (%)	Final enhanced rate (%)
polymer surfactant	sewage	104.5	554	26.2	68.9	41.94	19.89	61.83
polymer	sewage	29.2	546	26.8	73	44.03	14.0	58.03

Table 3 shows the core displacement experiment results with a polymer surfactant concentration of 1000mg/L). The polymer solution with a molecular weight of 15 million was produced by Daqing Refining and Chemical Company. It was observed from table 3 that the displacement effect of the polymer surfactant solution was obviously better than that of the conventional polymer solution. A water flooding scheme was implemented using a polymer surfactant displacement, during which an enhanced oil recovery of 19.89% was achieved. After water flooding further polymer displacement enhanced recovery by a further 14%. Table 4 shows that with an increase in polymer surfactant concentration, the displacement effect was also improved.

Table 4 The artificial homogeneous core displacement experiment results for different concentrations of polymer surfactant

Scheme	Permeability (mD)	Porosity (%)	Oil saturation (%)	Water displacement recovery (%)	Improved value of Polymer surfactant flooding (%)	Total recovery (%)
300mg/L 0.6PV	1154	23.5	74.8	47.6	8.8	56.4
	1158	24.8	73.9	47.5	9.2	56.7
500mg/L 0.6PV	1186	25	74.9	47.7	10	57.7
	1184	24.6	74.3	47.5	9.8	57.3
800mg/L 0.6PV	1066	21.6	74	47.5	11.7	59.2
	1056	22.8	75.6	47.6	12	59.6
1000mg/L 0.6PV	1107	21.6	71.9	47	15.9	62.9
	1123	22.6	73.5	47.3	16.2	63.5

3 Conclusions

Polymer surfactants have the advantage of a higher viscosifying property and better viscosity stability. While the placing time was prolonged, the viscosity of polymer surfactant increased. With increasing salinity, the viscosity of conventional polymer solution declined. The viscosity of the polymer surfactant first increased reaching a certain maximum concentration, and then began to decline, but the solution viscosity remained at a high value. Upon reaching a certain concentration, polymer surfactant concentration exhibited the emulsification phenomenon. The emulsion was primarily of the reverse emulsion type.

(2) The displacement effect of polymer surfactant solution was obviously better than the middle-to-high molecular weight polymer solution in the same concentration and as the polymer surfactant concentration increased, the displacement effect was also better. Further studies on the performance and displacement effect of polymer surfactant will have a great significance for industrialized application in future oil displacement.

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