Zwitterionic polymer containing hydrophobic group: rheological properties strengthen

Ling Liu [a], Shaohua Gou [a, b], Huichao Zhang [c], Lihua Zhou [a], Lan Tang [a] and Lang Liu [a]

[a.] Oil and Gas Field Applied Chemistry Key Laboratory of Sichuan Province, Southwest Petroleum University, Chengdu 610500, China.

[b.] Address here.State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Southwest Petroleum university, Chengdu 610500, China.

[c.] Henan Energy and Chemical Group Co., Ltd, China

1 The effect of reaction conditions on the polymer

As shown in Table S1, the effect of monomer molar ratio on the apparent viscosity of the copolymer was investigated under the conditions of a reaction temperature of 50 °C, a pH of 7, and Initiator $(NH_4)_2S_2O_8$ and $NaHSO_3$ accounted for 0.0642‰ of the total mole of monomer. Moreover, the apparent viscosity was measured at a temperature of 25 °C and a shear rate of 7.34 s^{-1}.

As can be seen from Table S1, the apparent viscosity of the copolymer increases as AA increased (No. 1-3). However, if the AA continues to be increased, the apparent viscosity shows a downward trend (No. 4-5). At the same time, the apparent viscosity of the copolymer reached a maximum value of 343.2 mPa·s (No. 3) when the molar ratio of the hydrophobic long-chain monomer NAE and the zwitterionic monomer MEPS was 1:1.5. Finally, the optimum monomer molar ratio was n(AM): n(AA): n(MEPS): n(NAE)=330:140:1.5:1.

Table S1 Effect of monomer molar ratio on apparent viscosity of the copolymer

Number	AM:AA:MEPS:NAE	Apparent Viscosity (mPa·s)
1	420:50:1.5：1	232.6
2	380:90:1.5：1	254.4
3	330:140:1.5：1	343.2
4	280:190:1.5：1	296.5
5	240:230:1.5：1	287.6
6	330:140:0.5：1	226.9
7	330:140:2：1	286.3
8	330:140:2.5：1	242.6
9	330:140:3：1	233.0
10	330:140:2：0.5	189.6
11	330:140:2：1	276.3
12	330:140:2：1.5	253.4
13	330:140:2：2	241.1
14	330:140:2：2.5	201.8

2 Effect of initiator addition, pH and temperature on the apparent viscosity of the copolymer

Under the conditions of monomer molar ratio was n(AM): n(AA): n(MEPS): n(NAE)=330:140:1.5:1, the molar ratio of initiator to monomer, pH and reaction temperature were investigated. The effect of the apparent viscosity of the object is shown in Table S2. It can be seen that as the amount of initiator increases, the apparent viscosity of the copolymer first increases and then decreases (No. 1-5). It is most preferred when the initiators added are 0.0642‰ of the total molar to of monomers. During the optimization of pH, it was found that the polymer had an excellent apparent viscosity when the polymerization pH of the solution was 7. On the other hand, the apparent viscosity of the copolymer showed a tendency to increase first and then decrease as the reaction temperature increased, and the optimum reaction temperature was 50 °C.

Table S2 Effect of initiator concentration, pH, and temperature on apparent viscosity of MANPS

Number	Initiators to monomers (‰, molar)	pH	T/°C	Apparent Viscosity (mPa·s)
1	0.0214	7	50	No polymerize
2	0.0428	7	50	135.6
3	0.0642	7	50	343.0
4	0.0856	7	50	286.7
5	0.1070	7	50	198.5
6	0.0642	5	50	303.2
7	0.0642	9	50	281.3
8	0.0642	7	40	298.9
9	0.0642	7	45	281.3
10	0.0642	7	55	266.5
11	0.0642	7	60	178.5

3 Determination of intrinsic viscosity

The molecular weight of the polymer was determined by viscosity method under optimum conditions. After weighing 8.775 g of NaCl, 150 mL of pure water and 0.1 g of MANPS, the sample solution with a concentration of 0.001 g/mL was prepared. Using the same method, 2.925 g NaCl and 47.075 g pure water were used to prepare sodium chloride solution with a concentration of 1.00 mol/L. Measure the outflow time t at the corresponding concentration. Then according to the formula $\eta_r=t/t_0$ (t_0 is the pure solvent outflow time, t is the solution outflow time) and $\eta_{sp}=\eta_r-1$, the following data (Table S3) can be obtained:

Table S3 Outflow time of solution

Solvent added amount/ml	Relative concentration/C	t_1	t_2	t_3	average time
0	1.00	186.15	186.13	186.14	186.13
5	0.66	134.10	134.23	134.18	134.17
5	0.50	106.82	106.81	106.74	106.79
10	0.33	86.09	86.23	86.22	86.18
10	0.25	77.33	77.35	77.31	77.33
Solution outflow time t_0		54.81	54.63	54.72	54.72

From this, the intercept of the two lines can be derived, and then the average of the intercepts is taken as H. The intrinsic viscosity number was calculated by the formula $[\eta] = H/C_0$.