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Supporting Information

Comb-Shaped Polyzwitterion with Surface-Activity via N-maleoyl Chitosan Modified HPAM for Displacement of Residual Oil

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1. Optimum Conditions

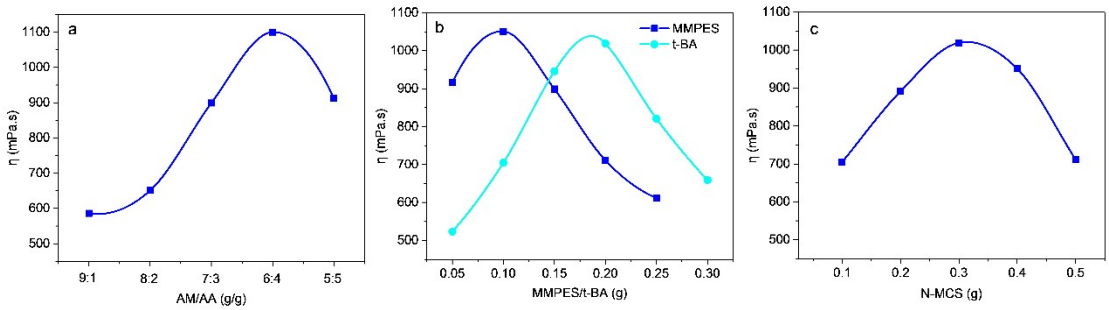

Fig. S1 The optimum mass of monomers.

Table S1. The effects of the ratio of AM, AA, MMPES, t-BA and N-MCS on PNMASt.

AM (g)	AA (g)	N-MCS (g)	MMPES (g)	t-BA (g)	η (mPa·s)[b]
9	1	0.3	0.1	0.2	594
8	2	0.3	0.1	0.2	651
7	3	0.3	0.1	0.2	907
5	5	0.3	0.1	0.2	924
6	4	0.3	0.1	0.2	1080
6	4	0.5	0.1	0.2	706
6	4	0.4	0.1	0.2	949
6	4	0.2	0.1	0.2	893
6	4	0.1	0.1	0.2	701
6	4	0.3	0.05	0.2	922
6	4	0.3	0.15	0.2	886
6	4	0.3	0.2	0.2	716
6	4	0.3	0.25	0.2	625
6	4	0.3	0.1	0.05	537
6	4	0.3	0.1	0.1	706
6	4	0.3	0.1	0.15	939
6	4	0.3	0.1	0.25	816
6	4	0.3	0.1	0.3	683

[a]Conditions: initiator loading= 0.03g, pH= 7, Temperature= 40 °C.

[b]Apparent viscosity: copolymer solution=2000 mg/L, HAAKE MARS III rheometer (HAAKE, Germany) at 30 °C.

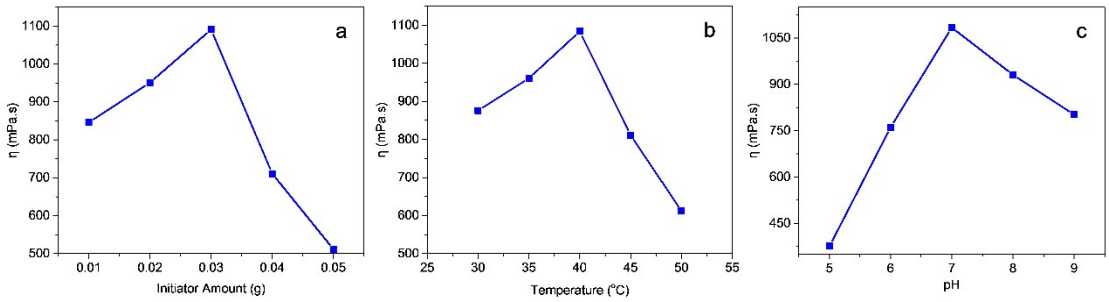

Fig. S2 Optimum amount of initiator, pH value and temperature.

Table S2. The effects of the initiator concentration, pH and temperature on PNMASt.

Initiator (g)	pH	Temperature (°C)	η (mPa·s)[b]
0.01	7	40	851
0.02	7	40	946
0.03	7	40	1080
0.04	7	40	697
0.05	7	40	508
0.03	5	40	386
0.03	6	40	757
0.03	8	40	970
0.03	9	40	770
0.03	11	40	—[c]
0.03	7	30	874
0.03	7	35	957
0.03	7	45	791
0.03	7	50	603

[a]Conditions: AA/AM/N-MCS/MMPES/t-BA = 6/4/0.3/0.1/0.2 (g).

[b]Apparent viscosity: copolymer solution=2000 mg/L, HAAKE MARS III rheometer (HAAKE, Germany) at 30 °C..

[c]situation: obvious copolymerization was not observed.

According to above, the optimum conditions is that, N-MCS: 0.3g, AM/AA: 6g/4g, MMPES: 0.1g, t-BA: 0.2g, initiator: 0.03g; pH=7; T=40 °C.

2. Measurement of the intrinsic viscosity for copolymer

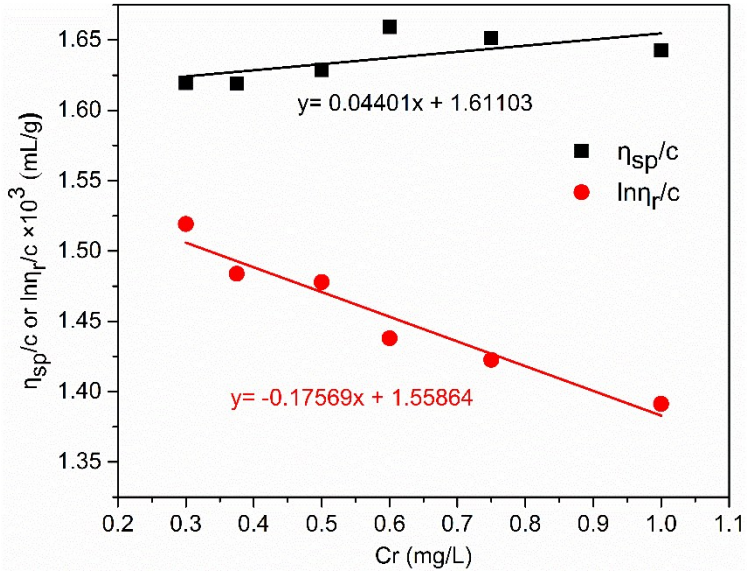

Fig. S3. The ηsp/c and lnηr/c relationship with the concentration of PNMASt.

As shown in Fig. S3, it was clear that the values of two fitting curve (η_{sp}/c and lnη_r/c) fitted to the ordinate was 1611.03, 1558.64 mL/g, respectively, and so, the intrinsic viscosity of PNMASt was about 1590 mL/g.

3. Measurement of monomer conversion for PNMASt

High-performance liquid chromatography (HPLC; Shimadzu Co., Japan) as an reliable method to get monomer conversion of PNMASt. H_2O (UP):CH_3OH (99%) as the mobile phase (1.0 mL/min) flowed through a C_{18} chromatographic column (40 °C) and a UV detector (wavelength: 210 nm). Following eq calculated the conversion of monomers from PNMASt with the content of unconverted monomers from ethanol that which was to purify PNMASt:

$$D\,(\%) = \frac{W - \frac{SC_0}{S_0} \times V}{W} \times 100\% \qquad (1)$$

Where D is conversion of monomer, W is total mass of monomer, S is the peak value of measured monomer in ethanol, C_0 and S_0 are concentration and peak of corresponding standard sample of measured monomer, V is the volume of ethanol for purified PNMASt.

The function of monomers' peak area (AA, AM, MMPES and t-BA) and concentration was shown as following:

S_{AM}=1641090+4.44112×10^7×C, S_{AA}=919876.33002+1.37002×10^7×C,

$S_{t\text{-}BA}$=239896.60023+3.10056×10^6×C, S_{MMPES}=501272.23518+3.96531×10^6×C,

On the basis of the results, the conversion for AM, AA, MMPES and t-BA are 99.24%, 93.78%, 79.49% and 82.03% separately. The purified copolymer is 10.1904 g.

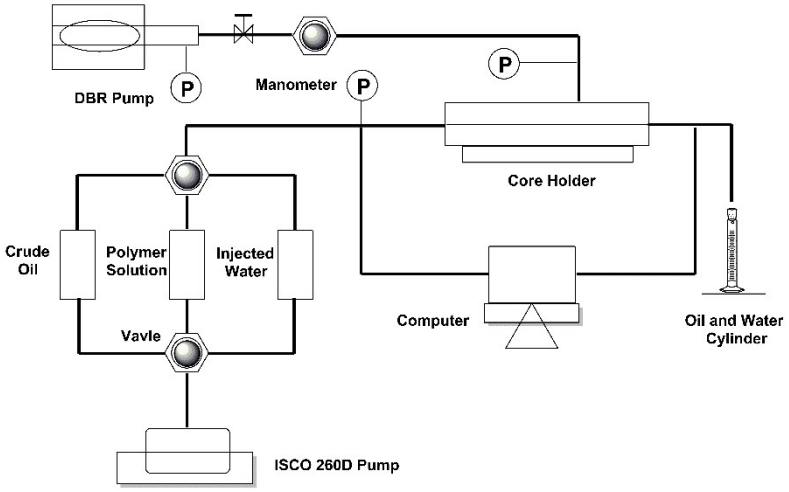

Fig. S4 The experimental apparatus of core displacement experiment.

Table S3 Basic Information for Artificial Core

Core No.	Permeability (D) [a]	PV (ml)	Porosity (%)	Oil saturation (%)
1#	1.79	45.8	37.58	89.24%
2#	1.85	44.9	36.69	89.15%

[a] Determined by Darcy's Law.

Table S4 Parameters of simulated formation water from shengli oilfield

Inorganic ions	K^+, Na^+	Ca^{2+}	Mg^{2+}	CO_3^{2-}	HCO_3^-	SO_4^{2-}	Cl^-	**Total**	**pH**
Concentration(mg/L)	3091.96	276.17	158.68	14.21	311.48	85.29	5436.34	9374.13	7.12

Table S5 Experimental results of EOR and mobility control ability

Polymer Item	P_0 (MPa)	P_1 (MPa)	P_2 (MPa)	Rf	RRf	E_1 (%)	E_2 (%)	EOR (%)
HPAM	0.011	0.093	0.021	8.45	1.91	57.32	50.11	7.21
PNMASt	0.013	0.24	0.086	18.23	6.62	66.94	53.62	13.32

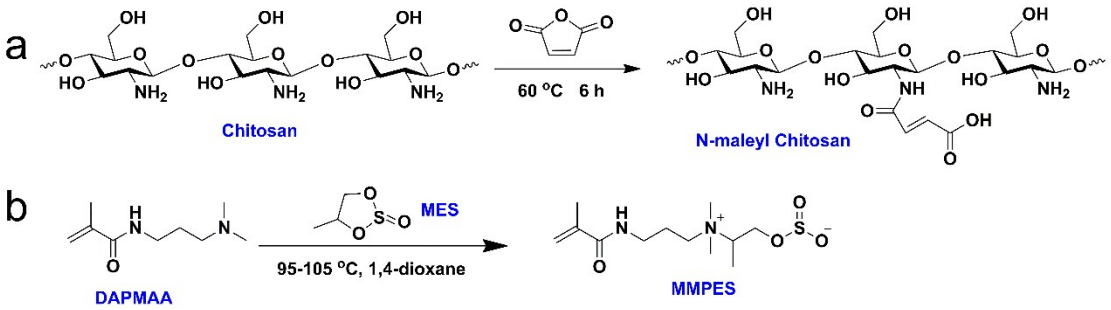

Fig. S5. Schematic diagram for synthesis, (a): N-MCS; (b): MMPES