Synthesis of Polyacrylamide Microsphere and Its Salt and Temperature resistant Performance

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Abstract

A kind of polyacrylamide microsphere of P(AM-BA-AMPS) was synthesized using inverse suspension polymerization method and the synthesis conditions were optimized; Besides, the salt resistant performance of the polymer microsphere was studied. The average particle size of microsphere was under 140 um when the stirring speed was from 240 to 360 rpm. The dosage of the initiator was controlled at about 1.0 g. The average particle size decreased with the increasing of Span 60 dosage. And the dosage of Span 60 was controlled at about 0.4 g. The polymer microsphere had good water swelling performance in high salinity conditions and thus it has good plugging performance in high salinity reservoirs.

Keywords

Synthesis, polyacrylamide microsphere, salt resistant, swelling performance.

1. Introduction

Polyacrylamide microspheres are widely applied to reduce water production and enhance oil recovery in mature reservoirs with fractures or high permeability reservoirs [1-3]. However, there are several drawbacks of the polyacrylamide microspheres when used in-depth diversion treatments, such as the degradation of the microspheres and poor swelling performance in high salinity and high temperature reservoirs.

There are several synthesis methods to get polymer microspheres, such as emulsion polymerization, soap-free emulsion polymerization, dispersion polymerization, precipitation polymerization, inverse-miniemulsion polymerization, seeded polymerization, suspension polymerization,etc [4-7]. In this paper, inverse suspension polymerization was employed to synthesize the polyacrylamide microsphere to get micron's microspheres and its salt resistant performance was studied. Besides, 2-Acrylamido-2-methylpropane sulfonic acid (AMPS) was introduced into the microsphere molecule to obtain better salt resistant performance.

2. Experimental

2.1 Materials

Acrylamide (AM, AR) was twice recrystallized from acetone (AR) and then dried under vacuum.

Diesel (0#) which is used as the oil phase was commercially available products purchased in Sinopec gas station. Sodium carbonate (AR), N, N'- methylenebisacrylamide (MBAM, AR), Ammonium persulfate (APS), anhydrous ethanol, sodium carbonate, Span 60 and 2-Acrylamido-2-methylpropane sulfonic acid (AMPS) were obtained from Sinopharm Chemical Reagent Co., Ltd.

2.2 Synthesis of polymer microsphere

P(AM-MBAM-AMPS) was prepared by inverse suspension polymerization using diesel as the continuous phase and Span 60 as surfactant (Fig. 1). In this reaction, 0.07g MBAM monomer, 14 g AM monomer and sodium carbonate were dissolved in 40 mL water and stirred with nitrogen to remove dissolved oxygen. This solution was immediately poured into 60mL diesel with Span 60 and the mixture was mechanically stirred under nitrogen. After formation of aqueous droplets in continuous phase was confirmed, 5 mL ammonium persulfate (APS) was added to continuous phase to initiate polymerization for 4 h at 50 °C. After polymerization, the microsphere were separated from the oil phase and were washed several times with ethanol and water.

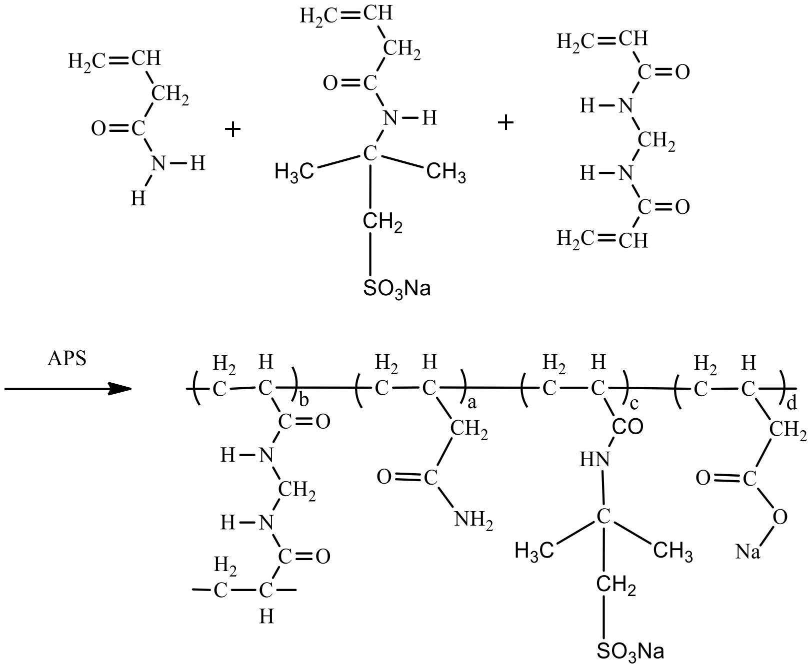

Fig. 1 Synthesis of P(AM-MBAM-AMPS)

2.3 Particle size measurements of microsphere

Particle size distribution was analyzed by Rise-2008 laser particle size analyzer (Jinan Rise Science & Technology Co., Ltd., China) at room temperature with the measurement range is 0.02~1200 μm.

2.4 Swelling Ratio measurements

The weighting method was employed to get the swelling ratio S_w of the microsphere. The swelling ratio of the microsphere is calsulated as follows:

$$S_w=(m_1-m_0)/m_0 \quad \text{(Eq. 1)}$$

Where m_0 is the initial weight of microsphere before swelling and m_1 is the weight of swollen microsphere.

3. Results and discussion

The synthesis condition was optimized firstly. Fig. 2 showed the influence of the mechanically stirring speed on the average particle size of microsphere. The average particle size of microsphere increased firstly and then decreased with the increasing stirring speed. The average particle size of microsphere was under 140 um when the stirring speed was from 240 to 360 rpm. The reason is mainly because at high stirring speed, it is inevitable that the chance of collisions between droplets will be increased and thus the average particle size of microsphere increased at high stirring speed.

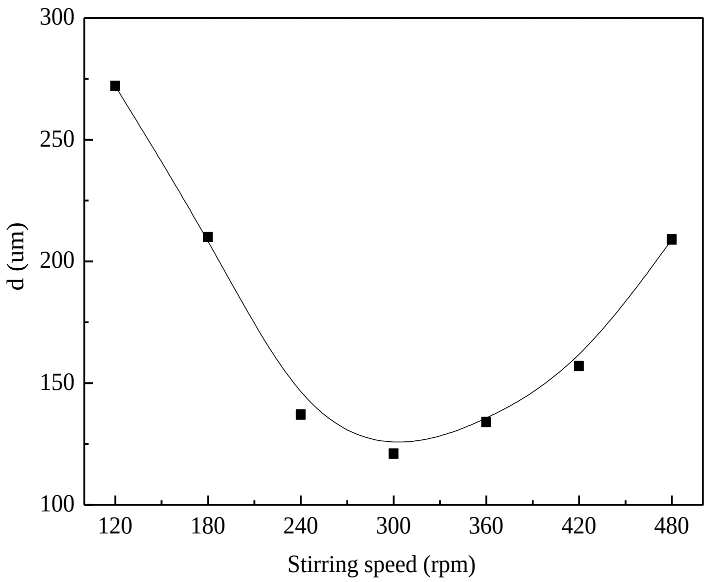

Fig. 2 Influence of stirring speed on the average particle size of microsphere

As in Fig. 3, with the increase of the the initiator dosage, the average particle size of microspheres increased but the increase rate slowed down gradually. In this paper, the dosage of the initiator was controlled at about 1.0 g.

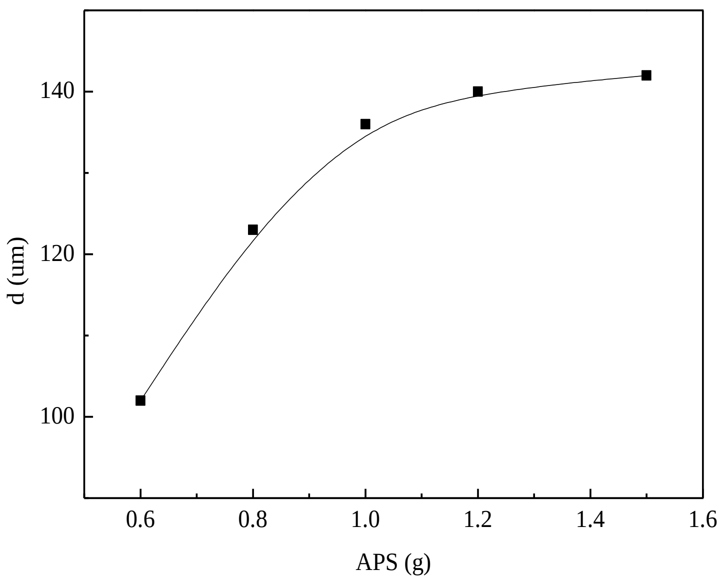

Fig. 3 Influence of initiator dosage on the average particle size of microsphere

As seen in Fig. 4, the average particle size decreased with the increasing of Span 60 dosage. This is because the surfactant can enhance the stability of the emulsion and obstruct the coherence between the droplets. In this paper, the dosage of Span 60 was controlled at about 0.4 g.

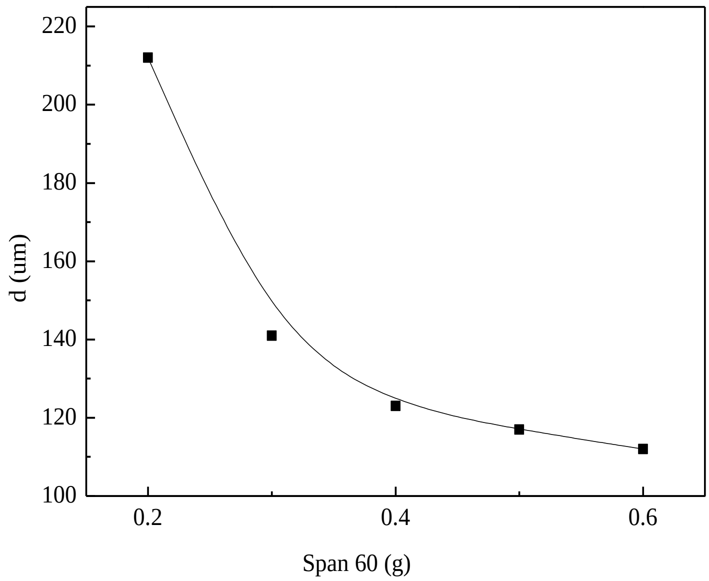

Fig. 4 Influence of Span 60 dosage of on the average particle size of microsphere

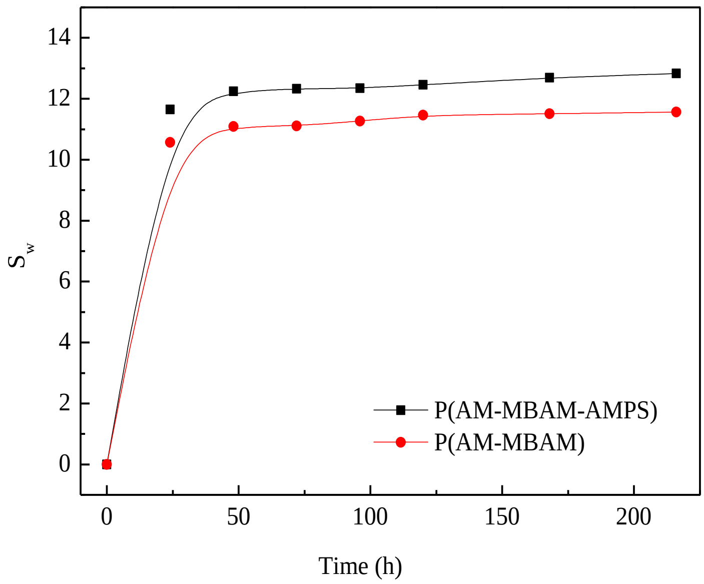

Fig. 5 The swelling properties of the polymer microsphere in 1.0 wt% NaCl solution at 50 °C

Fig. 5 showed the swelling property of P(AM-MBAM-AMPS) and P(AM-MBAM) without AMPS group. It can be seen that P(AM-MBAM-AMPS) had better swelling property in 1.0 wt% NaCl solution at 50 °C compared with P(AM-MBAM) which is mainly due to the introduction of the salt resistant AMPS group into the polymer structure.

4. Conclusion

A kind of polyacrylamide microsphere of P(AM-BA-AMPS) was synthesized using inverse suspension polymerization method and the synthesis conditions were optimized; Besides, the salt resistant performance of the polymer microsphere was studied. The average particle size of microsphere was under 140 um when the stirring speed was from 240 to 360 rpm. The dosage of the initiator was controlled at about 1.0 g. The average particle size decreased with the increasing of Span

60 dosage. P(AM-MBAM-AMPS) had better swelling property in 1.0 wt% NaCl solution at 50 °C compared with P(AM-MBAM).

Acknowledgements

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References

[1] C. Yao，G. Lei, L. Li, X. Gao. Selectivity of pore-scale elastic microspheres as a novel profile control and oil displacement agent. Energ. Fuel., Vol. 26 (2012) No. 8, p. 5092-5101.

[2] Z. Hua, M. Lin, J.Guo, F.Xu, Z.Li, M.Li. Study on plugging performance of cross-linked polymer microspheres with reservoir pores. J. Pet. Sci. Eng.,Vol.105 (2013), p. 70-75.

[3] J.Ji, C. Zeng, Y.Ke, et al. Preparation of poly(acrylamide-co-acrylic acid)/silica nanocomposite microspheres and their performance as a plugging material for deep profile control. J Appl Polym Sci., Vol.134 (2017) No.46, p. 45502.

[4] K. Nakabayashi, M. Kojima, S. Inagi, Y. Hirai, M. Atobe. Size-controlled synthesis of polymer nanoparticles with tandem acoustic emulsification eollowed by soap-Free emulsion polymerization. ACS Macro Lett., Vol. 2 (2013) No. 6, p. 482-484.

[5] Y. Chen, L. Tong, D. Zhang, W. Yang, J. Deng. Thermostable microspheres consisting of poly(N-phenylmaleimide-co-α-methyl styrene) prepared by precipitation polymerization. Ind. Eng. Chem. Res., Vol.51(2012) No.48, p.15610-15617.

[6] G.M. Hemingway, B.R. Gupta, J.D. Elton. Hydrogel nanopowder production by inverse-miniemulsion polymerization and supercritical drying. Ind. Eng. Chem. Res., Vol. 49 (2010) No.20, p. 10094-10099.

[7] B. Li, Y. Xu, M. Wang, X. Ge. Morphological control of multihollow polymer latex particles through a controlled phase separation in the seeded emulsion polymerization. Langmuir., Vol. 48 (2013) No.29, p. 14787-14794.