Asian Journal of Chemistry; *Vol. 26, No. 5 (2014), 1349-1351*

ASIAN JOURNAL OF CHEMISTRY

http://dx.doi.org/10.14233/ajchem.2014.17228

Fabrication of New Cationic Polyacrylamide Flocculant Used for Treating Slime Water†

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Published online: 1 March 2014; AJC-14769

Along with the population explosion and the economic development, water treatment technology has recently received increasing attention. Herein, we introduce a facile visible-light-initiated polymerization method for the fabrication of cationic polyacrylamide flocculants with high molecular weight. The different experimental parameters affecting the property of polymer were investigated and the optimal synthesis conditions were established. In addition, the flocculating ability of cationic polyacrylamide for slime water was also studied.

Keywords: Polyacrylamide, Flocculant, Initiated polymerization, Slime water.

INTRODUCTION

As a linear high-molecular polymer, cationic polyacrylamide (CPAM) is extensively used to all kinds of wastewater treatment applications, due to its unique side-chain structure, high positive charge density, good water-solubility and so on. Especially in the settlement process of slime water, cationic polyacrylamide has been one of the most extensive flocculants. It can react and aggregate with negatively charged particles by neutralization and adsorption and regulate the stability and flocculation properties of the disperse system, which will be beneficial to settlement and dewatering performance of micro-fine coal slurry remarkably[1-3].

So far, many methods have been used to prepare cationic polyacrylamide, such as homopolymerization method, the modified method, heating-solution method and reversed-phase microemulsion method[4-6]. However, most of the existing composite flocculants involve high cost or complicated process. In this research, we report a visible-light-initiated polymerized method for a new cationic polyacrylamide flocculant combined of acrylamide and methacryloyloxyethyl trimethyl ammonium chloride. The different experimental parameters and flocculation performance in the slime water flotation were examined.

EXPERIMENTAL

Firstly, acrylamide (AM) and methacryloyloxyethyl trimethyl ammonium chloride (DMC) with a certain proportion were dissolved in deionized water and vigorously stirred at room temperature, regulated pH value to form a serials of 25 g polymer solution with same mass. Then, the photoinitiator was added gradually into the mixture to initiate action. After being aerated nitrogen and deoxidized for 4 min, the resulting colloidal solution was sealed and exposed to sunlight. After the reaction finished, the obtained cationic polyacrylamide samples were aged for 24 h and drying. The investigation of optimum synthesis conditions was carried out by altering certain experimental parameters, such as monomer mass concentration, photoinitiator dosage, pH value and illumination time.

The slime water used in the experiment came from Qianyingzi coal preparation plant. The intrinsic viscosity was measured by one point method according to GB 12005.1-89. The measurement was conducted under ambient conditions with a non-diluted Ubbelohde viscometer (d = 0.54 mm). The transmittance was recorded on JH·721-100 spectrophotometer.

RESULTS AND DISCUSSION

In general, an increase in intrinsic viscosity results in increased molecular weight and flocculating ability for linear polymer. Therefore, intrinsic viscosity was used to describe the flocculating ability of cationic polyacrylamide. The effects of the experimental parameters (monomer mass concentration, photo-initiator dosage, pH value, illumination time) on the intrinsic viscosity of cationic polyacrylamide were investigated,

†Presented at The 7th International Conference on Multi-functional Materials and Applications, held on 22-24 November 2013, Anhui University of Science & Technology, Huainan, Anhui Province, P.R. China

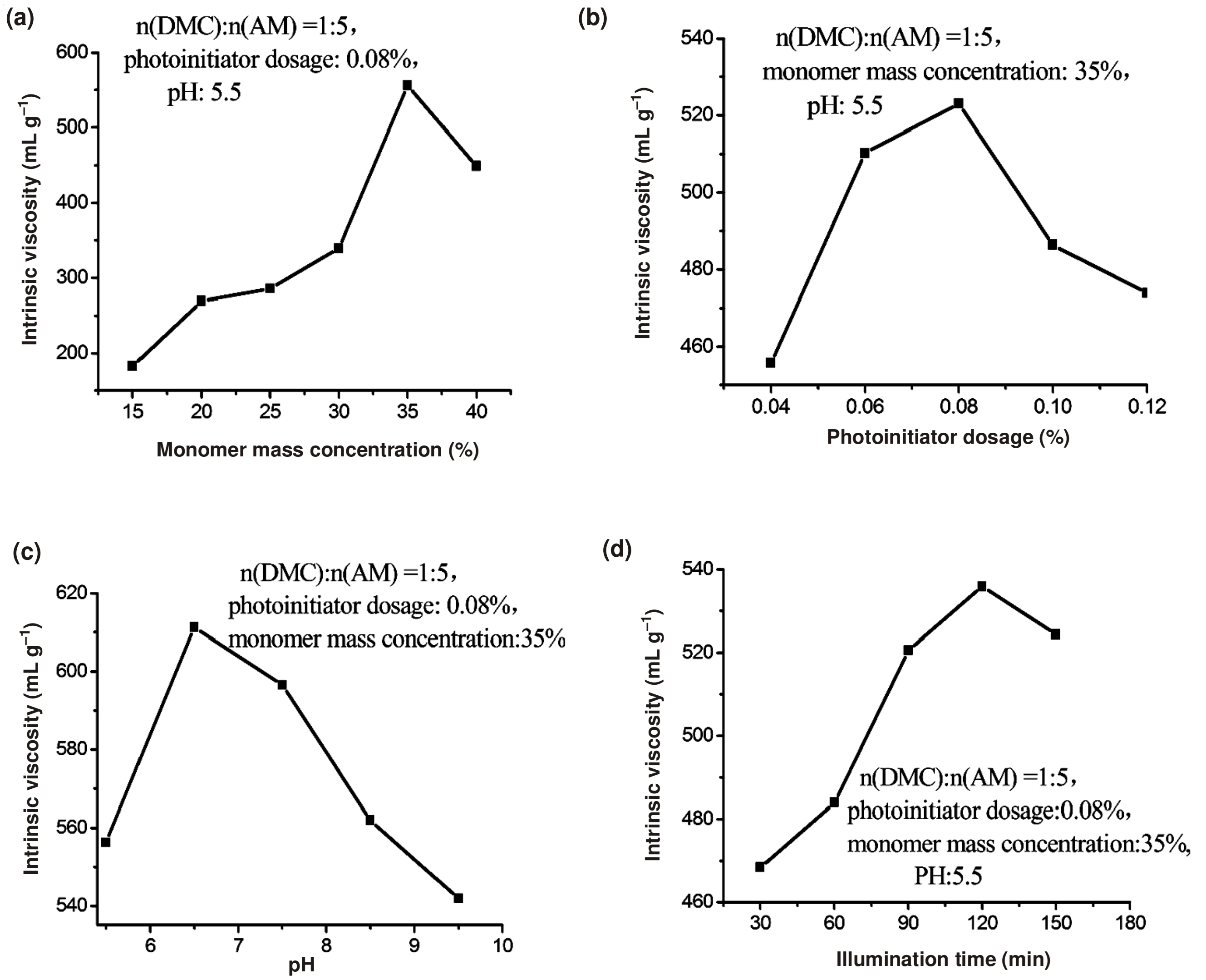

Fig. 1. Effects of experimental parameters on the intrinsic viscosity of cationic polyacrylamide

as shown in Fig. 1(a-d). As these experimental factors increased, the intrinsic viscosity of cationic polyacrylamide first increased and then decreased. It indicates that these factors have a significant effect on intrinsic viscosity of cationic polyacrylamide samples and there was an optimal range.

In order to further optimize the preparation condition, we design the orthogonal test of $L_9(3^4)$ based on the above single factor experimental results. Table-1 lists the results of the orthogonal test. The results indicate that when the experimental conditions are 35 % monomer mass concentration, 0.08 % photoinitiator dosage, pH of 6.5 and illumination time of 90 min, the intrinsic viscosity of cationic polyacrylamide is best. It indicates that it is possible to obtain better flotation results using these preliminary results and the optimization program.

TABLE-1
RESULT AND ANALYSIS OF THE ORTHOGONAL TEST

Run No.	Monomer mass concentration (%) (A)	pH value (B)	Illumination time (min) (C)	Photoinitiator dosage (%) (D)	Intrinsic viscosity (η)
1	1 (30)	1 (5.5)	1 (30)	1 (0.06)	322.29
2	1 (30)	2 (6.5)	2 (60)	2 (0.08)	354.46
3	1 (30)	3 (7.5)	3 (90)	3 (0.10)	317.16
4	2 (35)	1 (5.5)	2 (60)	3 (0.10)	525.36
5	2 (35)	2 (6.5)	3 (90)	1 (0.06)	512.88
6	2 (35)	3 (7.5)	1 (30)	2 (0.08)	542.26
7	3 (40)	1 (5.5)	3 (90)	2 (0.08)	464.65
8	3 (40)	2 (6.5)	1 (30)	3 (0.10)	474.73
9	3 (40)	3 (7.5)	2 (60)	1 (0.06)	421.72
K_1	993.91	1312.30	1294.69	1256.89	–
K_2	1580.50	1331.99	1301.54	1361.37	–
K_3	1361.10	1281.14	1339.28	1317.25	–
R	586.59	50.85	44.59	60.36	–

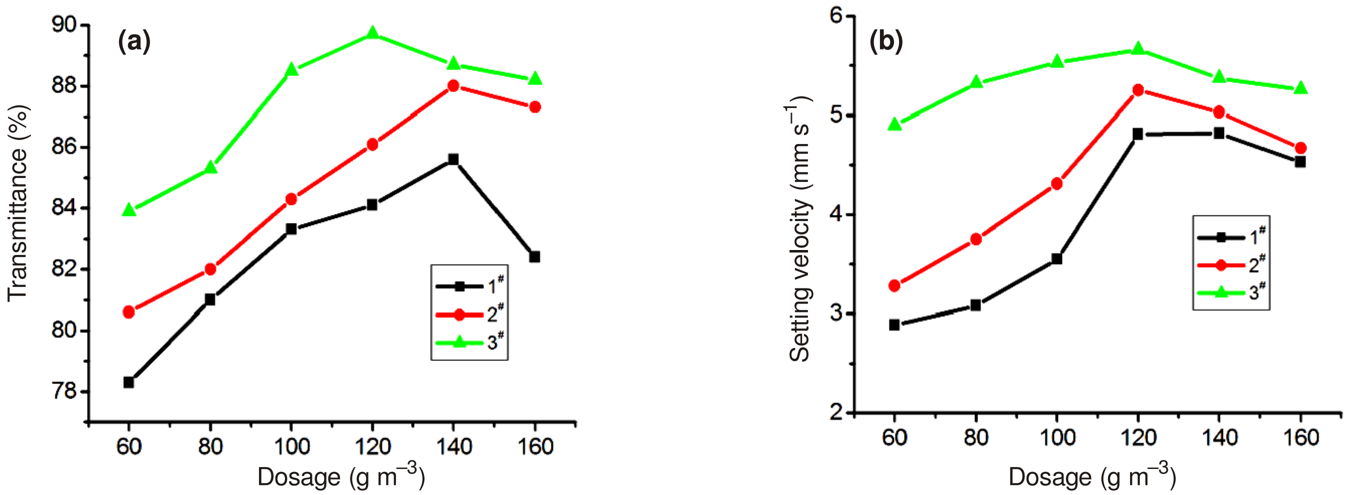

Fig. 2. Effects of different cationic polyacrylamide flocculants on settling velocity (a) and transmittance (b) for slime water

The application of cationic polyacrylamide to slime water flotation was examined as a case study. In the current work, the concentration of slime water is 80 g/L. The molecular weight of cationic polyacrylamide flocculants is 421 million, 503 million and 611 million, respectively, which is expressed as $1^{\#}$, $2^{\#}$ and $3^{\#}$, respectively. We measured the settling velocity and transmittance to describe the flocculating ability of cationic polyacrylamide. Fig. 2 shows the effects of different cationic polyacrylamide flocculants on flocculating sedimentation for slime water. Generally speaking, the larger the relative molecular weight, the better the flocculating effects. So compared with $1^{\#}$ and $2^{\#}$, $3^{\#}$ cationic polyacrylamide exhibits an enhanced settling velocity and transmittance, indicating that it has much more excellent flocculating sedimentation performance.

In addition, the dosage of the flocculants is mainly related to the content of suspended solids in the slime water and the flocculating effect generally tends to be better with increasing usage of flocculant. However, the flocculating effect reaches a maximum and then decreases with further increases in the usage of the flocculant. As shown in Fig. 2, the settling velocity and transmittance first increased and then decreased with the increasing of cationic polyacrylamide dosage. When the cationic polyacrylamide dosage was 6-7 mL, the settling velocity was fastest and transmittance could reach up to maximum with 89.7 %. If the cationic polyacrylamide dosage was excessive, the surface of colloid particles could adsorb a large number of macromolecular substances, resulting in the formation of the space layer and the failure of bridging between in solid particles. As a result, the flocculating effect was decreased.

Conclusion

A new cationic polyacrylamide flocculant with enhanced flocculating ability was successfully obtained by a visible-light-initiated polymerized route based on acrylamide (AM) and methacryloyloxyethyl trimethyl ammonium chloride (DMC). Using intrinsic viscosity as performance index, the optimal experimental conditions were confirmed: 35 % monomer mass concentration, 0.08 % photo-initiator dosage, pH of 6.5 and illumination time of 90 min. Moreover, it displays a very good flocculating effect for slime water.

ACKNOWLEDGEMENTS

This work was supported by the National Natural Science Foundation of China (21001003).

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