

Amphoteric-PAM이 재생펄프의 보류도 개선에 미치는 영향

Effects of Amphoteric-PAM for a Improvement of Retention Characteristics of Recycled-pulp

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Keywords : polyacrylamide, retention, drainage, amphoteric-PAM, inverse emulsion, recycled-pulp

1. Introduction

CPAM (cationic polyacrylamide) has been applied paper industry widely, because adjusting molecular weight and charge density are relatively easier than other polymers. Normally, CPAM is co-polymer of nonionic monomer of acrylamide and cationic monomer of methylchloride salt of dimethylaminoethylacrylate, however cationic charge can be lost by hydrolysis of carbonyl group of cationic functionality. As increase dissolving water pH and conductivity, hydrolysis rate is increased to lose its viscosity and charge density. To prevent hydrolysis of cationic functionality of CPAM, decreasing pH by adding acid is effective however, adding acid to the polymer is much difficult because acid affects polymer degradation. As water condition of paper mill tends to severe, consumption of CPAM is increasing gradually. We tried to solve problems to add 1 more anionic monomer of acrylic acid to the normal CPAM composition to make ter-polymer. This polymer reduce pH itself because it has acid functional group in the polymer chain to prevent hydrolysis of cationic charge. We found that this new type amphoteric high molecular weighted polymer improve not only dissolving water stability, but also retention characteristics because it induce more dense flocculation than normal CPAM.

2. Materials and methods

2.1. Materials

Acrylamide, methylchloride salt of dimethylaminoethylacrylate (DMAEA-MC), acrylic acid, hydrocarbon oil, and surfactants of chemical grades were used. ONP thick stock and white water were provided by B paper.

2.2. Methods

2.2.1 Amphoteric-PAM emulsion preparation

Amphoteric-PAM emulsion was polymerized by typical inverse emulsion manufacturing process following Son's method.(1~3) Normal CPAM is co-polymer of acrylamide and the methylchloride salt of dimethylaminoethylacrylate (DMAEA-MC). However, amphoteric-PAM is ter-polymer of acrylamide, DMAEA-MC and acrylic acid.

2.2.2 Analysis of Polymers

Solid content was measured by IR dessicator with condition of 160 °C and 16 minutes. Viscosity and molecular weight were measured by Brookfield viscometer (LV-2 type) preparing 0.5% polymer solution.(1) And charge density was measured by PVSX titration method. pH was measured by pH meter preparing 0.5% polymer solution.

2.2.3 Polymer stability test

2.2.3.1 Emulsion stability test

45 ml of emulsions were equipped to a centrifugal machine and set 4,000 rpm speed during 20 minutes. We compared thickness of separated oil per total volume. If stability of emulsion is improved, thickness of separated oil per total volume is decreased.

2.2.3.2 Solution stability test

Amphoteric-PAM and traditional CPAM emulsion were dissolved to 0.5% solution with waters to mixing tap water and dirty water to adjust conductivity. And viscosity and charge density were checked every 3 hours. we adjusted pH with HCl at need.

2.2.4. Paper application test

2.2.4.1 Stock

We adjusted final consistency of stock to adjust consistency diluting thick stock to white water. And the cationic demand of stock was 1.5 ml of 0.001N polyDADMAC titration and pH of the stock was 7.0.

2.2.4.2 Retention, drainage and formation test

Retention and drainage test were performed by operation of retention and drainage analyzer (RDA). The consistency of the stock was 0.18% and the volume of the stock was 1,000 ml. Vacuum condition of the drainage part was 200 mmHg at the main and sub tank. Retention was determined by measuring of FPR by filtering white water using filter paper and let it dry during 8 hours 105°C. Drainage was compared by drainage curves during RDA test. And formation was determined by using techpap 2D-F sensor with paper formed after RDA test. The sequence of chemical contacted time of the stock of RDA were the same as followings. At first, stock was introduced to the jar and let it stirred at 800 rpm for 5 seconds. And then, CPAM was added and let it stirred at 1,000 rpm for 10 seconds with the dosage of 500 ppm per total dried pulp.

3. Results and Discussion

3.1. Analysis of polymers

Solid content of normal CPAM showed a little higher than amphoteric-PAM

because of CPAM needs more surfactants to make W/O micelles. And charge density and pH of CPAM showed a little higher than amphoteric-PAM because anionic charge of acrylic acid functional group of amphoteric-PAM reduce cationicity and pH automatically. And viscosity and molecular weight of amphoteric-PAM showed slightly lower than traditional CPAM because reactivity of ter-polymer of amphoteric-PAM is lower than co-polymer of CPAM.

Table-1 Analysis of applied CPAM

Items	unit	CPAM	Amphoteric-PAM
Solid contents	%	41.2	39.2
Charge density	meq/g	2.22	2.01
pH at 0.5% solution	~	5.1	3.1
Viscosity at 0.5% solution	cPs	1,448	1,106
Molecular weight	g/mol	13,000,000	10,000,000

3.2. Polymer stability test

As you see figure 1, amphoteric-PAM is much stable than traditional CPAM. This can be explained that CPAM consist of only cationic charge in the polymer and these cationic charges give repulsive power among polymers to make bigger W/O micelle however amphoteric-PAM consist of cationic charge and anionic charge in the polymer and these cationic and anionic charges attract each other to reduce size of W/O micelle a little bit. Normally smaller micelle found better stability than bigger micelle. Figure 2 shows us solution stability under the dirty dissolving water condition of 500 uS/cm conductivity. CPAM lose viscosity more than 60% just 1 day stationing in the 30 °C water bath. And we can increase CPAM viscosity to add hydrochloric acid because of hydrochloric acid reduce solution pH and reduce the rate of hydrolysis of cationic functional group. However, adding acid to the W/O emulsion is very difficult because acid break W/O micelles. However stability

of keeping viscosity of amphoteric-PAM increased dramatically and this acid functional group in the polymer chain is stable in the W/O micelle and prevent hydrolysis of cationic charge effectively.

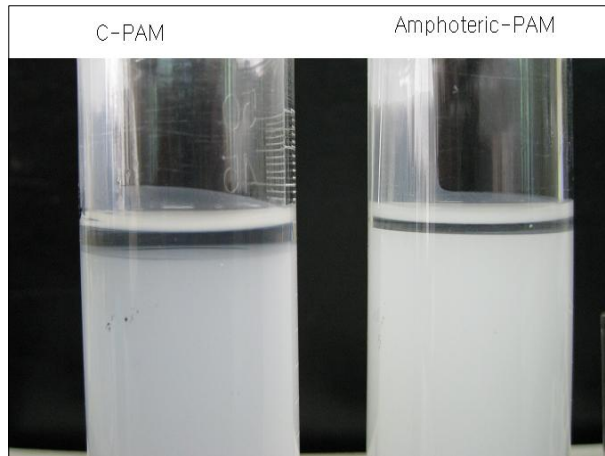


Fig.-1 Comparison of layer separation of oil per total emulsion after centrifugal machine at 3,700 rpm speed during 20 minutes

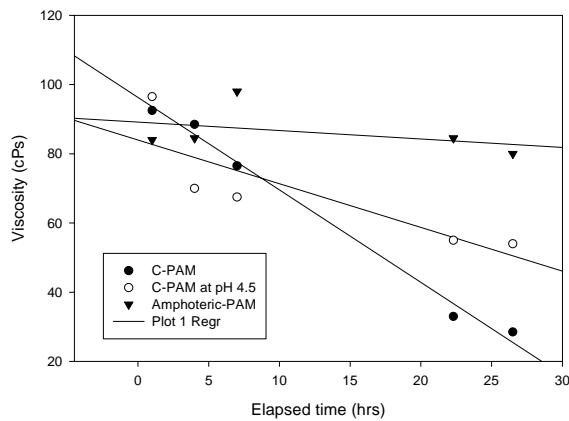


Fig.-2 0.5% Solution viscosity profile with 500 uS/cm conductivity dissolving water condition by elapsed time

3.3 Paper retention test

As you see figure 3~4, traditional CPAM affects retention and ash retention by different dissolving water conditions. As increase dissolving water conductivity to 500 uS /cm, retention and ash retention increased and retention and ash retention decrease again by increase conductivity to 1,000 uS /cm. It can be explained that conductivity of dissolving water increase reactivity of CPAM but too much conductivity affects negatively to the retention characteristics on the contrary. And we found the improvement of retention and ash retention to decrease pH of dissolving water of CPAM to reduce hydrolysis. Amphoteric-PAM resulted stable retention characteristics regardless of conductivity of dissolving water. It can be explained that reactivity of amphoteric-PAM is affected less than CPAM by conductivity. Especially ash retention of amphoteric-PAM shows a lot higher than traditional CPAM because anionic functional group in the amphoteric-PAM can attach inorganic ions of Ca^{2+} , Mg^{2+} by charge neutralization. As you see figure 5, drainage of amphoteric-PAM shows much better than traditional CPAMs because amphoteric-PAM makes more dense flocs by the flocculation of cationic charge and anionic charge in the polymer chain. Figure 6 shows formation profile of CPAMs and amphoteric-PAM. Adding acid to CPAM increased formation a little bit to compare CPAM. And amphoteric-PAM shows better formation regardless of dissolving water conductivity. It is the same with retention result and amphoteric-PAM is less affected by the change of dissolving water conductivity.

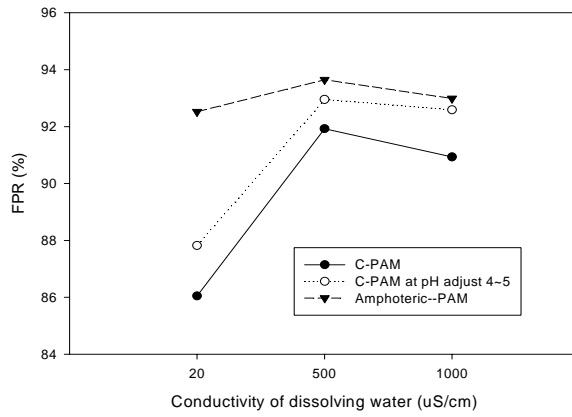


Fig.-3 First pass retention profile using polymer with various dissolving water condition

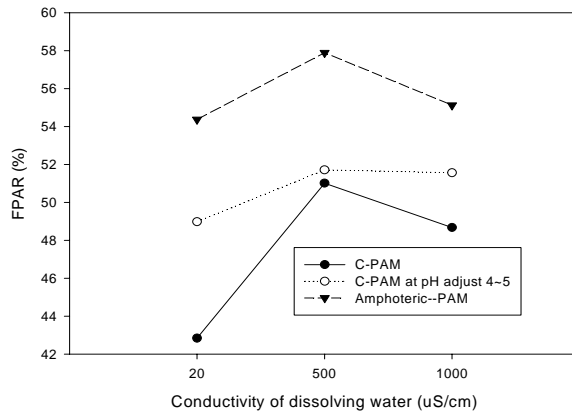


Fig.-4 First pass ash retention profile using polymer with various dissolving water condition

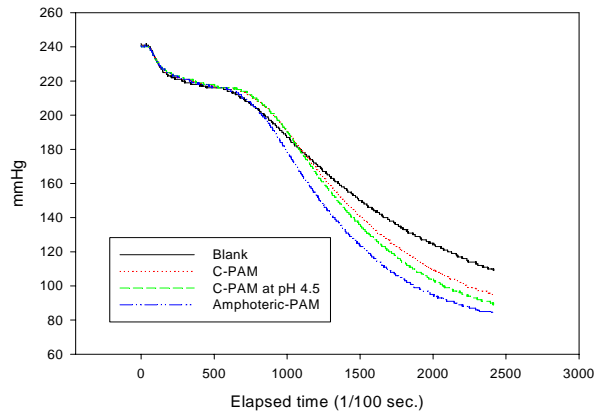


Fig.-5 Drainage profile using polymer with 500 uS/cm conductivity dissolving water condition

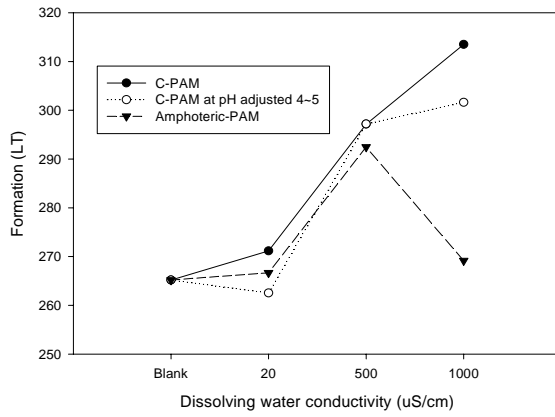


Fig.-6 Formation profile using polymer with dissolving water conditions

4. Conclusions

1. Amphoteric-PAM increases emulsion stability to reduce oil separation because attractive force between cationic charge and anionic charge shrink polymer and reduce W/O micelle size.

2. Amphoteric-PAM gives more acidity to dissolving water than CPAM and prevent hydrolysis of cationic charge and increase dissolving water stability.
3. Reactivity of amphoteric-PAM is less affected by dissolving water conductivity than traditional CPAM.
4. Retention, ash retention and drainage are better than traditional CPAM and especially ash retention value is a lot higher than CPAM because anionic functional group attach inorganic metal ion like Ca^{2+} , Mg^{2+} by charge neutralization.
5. Even though retention and drainage characteristics of amphoteric-PAM are good, formation characteristics are also good because of its dense flocculation.

Literature Cited

1. Dong-jin Son, Bong-yong Kim, Retention and drainage characteristics with inverse emulsion type CPAM, J. of KTappi, 38 (5) (2006).
2. Dong-jin Son, Bong-yong Kim, New retention system using branched polymer, KTAPPI Panpacific conference (2006).
3. Dong-jin Son, Bong-yong Kim, Effects of Branch Degree of CPAM for Retention and Drainage, KTAPPI fall proceeding (2007).