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Retention and Drainage Characteristics with Inverse Emulsion Type C-PAM

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ABSTRACT

This study was performed to characterize inverse emulsion type cationic polyacrylamide (PAM) and to compare with powder and salt dispersion type PAMs as a retention and drainage aid. Salt dispersion type PAM has defects of high amount of salt which increases conductivity of white water, low active polymer contents and relatively worse retention and drainage properties than others because of its low molecular weight. Powder type PAM has benefit of high active polymer contents and good retention and drainage properties, but defects of low dissolution speed and insoluble particle generation were observed. However, inverse emulsion type showed the best retention and drainage aids among them by controlling molecular weight and morphology easily and it had relatively higher active polymer contents and better solubility.

Keywords : polyacrylamide, retention, drainage, powder PAM, salt dispersion, inverse emulsion

1. Introduction

Polyacrylamide (PAM) has been applied for many purpose at the paper mills because of its convenience to modify molecular weight, morphology and ionicity.(1-2) Aqueous solution, powder, salt dispersion and inverse emulsion types were mainly applied. Aqueous solution type have been applied as a paper strengthening aids because its low molecular weight is advantageous to prevent agglomeration and give hydrogen bond between pulps. Medium to high molecular weight type of salt dispersion, powder and inverse emulsion have been applied as a retention and drainage aids because their high molecular weights were advantageous to give a flocculation between pulp and fillers. In this study, we characterized inverse emulsion type C-PAM by comparing physical and chemical characteristics with salt dispersion, powder types C-PAM and evaluated their application as retention and drainage aids for paper.

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2. Materials and Methods

2.1 Stocks

Stock consisted of LBKP and GCC (17% by dry pulp, wt). Beating of LBKP was adjusted to 400 ml CSF (±10 ml) using laboratory valley beater and final consistency of stock was adjusted to 0.18%. The pH of the stock was 7.0 and we controlled pH by $NaOH/H_2SO_4$ addition. We also changed conductivity to add ammonium chloride to observe tolerance of each chemicals in the high conductivity conditions.

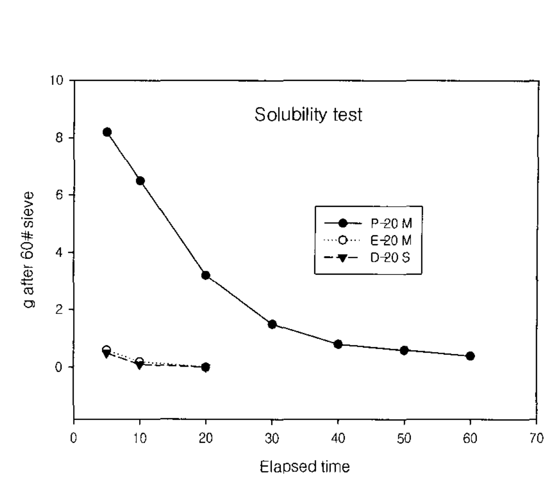

Fig. 1. Insolubles with dissolution time.

2.2 Cationic polyacrylamides

Cationic polyacrylamdes were applied after polymerization in the laboratory. Table 1 shows physical and chemical properties of applied C-PAMs. Salt dispersion type tends to increase solution conductivity. As you can also find Fig. 1 and Table 1, powder type tends to dissolve slowly. Inverse emulsion types were prepared various cationicity and molecular weight. Solid contents were determined by the evaporation residue method by using I.R desiccator at the condition of 1 g sample with 160℃ during 16 minutes. Molecular weight of the samples were determined to follow rotational viscometer method (4). In case of solubility, after dissolving C-PAM with distilled water at the consistency of 0.1%, we checked weight of insoluble particles using 60 mesh standard sieve at 5 to 10 minutes intervals. Analyses of pH and conductivity were determined by instruments of pH meter and conductivity meter after dissolving C-PAM with distilled water at the consistency of 0.1% at the room temperature. Ionicity was determined by the potassium polyvinylsulfonate titration method.

2.3 Retention and drainage

Retention test was performed by operation of RDA-HSF apparatus (Fig. 2). 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. The sequence of chemical contacted time of the stock was as followings. At first, stock was introduced

Table 1. Analysis of applied chemicals

Sample name		P-20M	D-20S	E-20S	E-20M	E-20H	E-10M	E-30M	E-40M
Types	unit	Powder	Salt dispersion	Inverse emulsion	Inverse emulsion	Inverse emulsion	Inverse emulsion	Inverse emulsion	Inverse emulsion
Solid Contents	%	90	40	45	45	45	45	45	45
M.W.	g/mol	6.0×10^6	5.2×10^6	5.1×10^6	6.5×10^6	7.8×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Dissol. Time	min.	60	10	10	10	10	10	10	10
pH	~	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Conductivity	μS/cm	187	2,520	161	157	156	149	158	165
Cationicity	meq/g	1.42	1.65	1.45	1.42	1.42	1.01	2.2	3.2

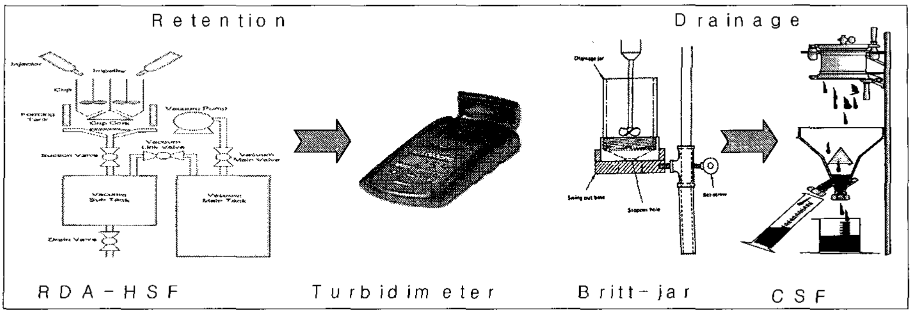

Fig. 2. Drawings of procedure of retention and drainage test.

to the jar and let it stirred at 1,000 rpm for 15 seconds. and then, C-PAM was added and let it stirred at 1,500 rpm for 15 seconds of 60 (±10) g/m^2 paper forming condition. Retentions were estimated to measure turbidity of white water using turbidimeter. Drainage was compared by final CSF drainage amount following TAPPI Standard T227 OM-99 using Britt jar at the same stock and sequence condition with RDA-HSF retention test.

3. Results and Discussion

3.1 Influence of the types of C-PAM

As you can see Fig. 3, retention and drainage of inverse emulsion were the best and followed by powder and salt dispersion type. This was the same with molecular weight orders. Therefore, molecular weight of the C-PAM was considered as an important quality factor of the retention and drainage aid. In case of salt dispersion type C-PAM, it was very difficult to increase molecular weight, because spherical form of the dispersed polymer tended to be broken when increasing molecular weight of the C-PAM. And only salt dispersion type affected conductivity of white water to increase slightly. It was assumed that abundant anionic salts must be added to improve dispersing ability. In the laboratory, it was difficult to find out the increase of conductivity of white water, but it will increase conductivity of the white water in the application to the closed white water system of the paper mill. In case of high conductivity stock condition of 5,100 μS/cm by the addition of ammonium chloride, salt dispersion type showed better resistance to the conductivity compared to powder and inverse emulsion types (Fig. 4). We assumed that this phenomenon was caused by

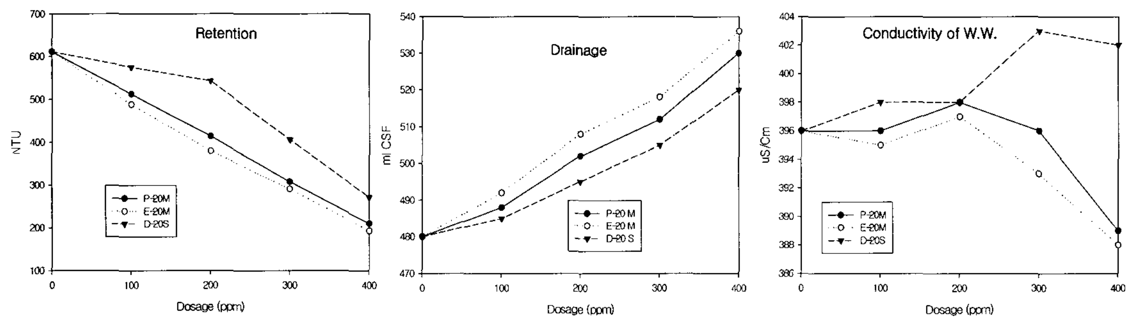

Fig. 3. Retention, drainage and conductivity of W.W. with different types of C-PAM at low conductivity (380 μS/cm) stock condition.

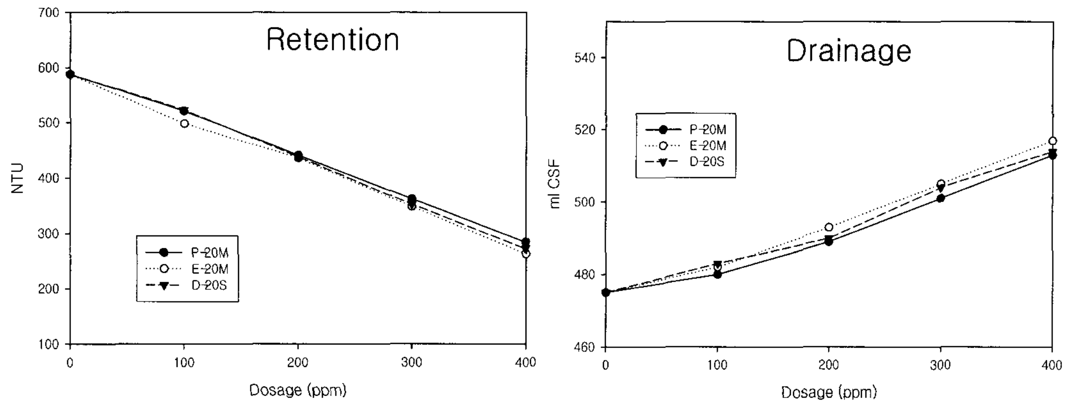

Fig. 4. Retention and drainage with different types of C-PAM at high conductivity (5,100 μS/cm) stock condition.

positive role of the stabilizing cationic polymers in the salt dispersion type C-PAM.

3.2 Influence of inverse emulsion type C-PAM

As you can see Fig. 5 of retention and drainage characteristics by the different molecular weight of inverse emulsion type C-PAMs, the higher molecular weight resulted in better performance of retention and drainage characteristics. This might be assumed that the higher molecular weight of the C-PAM induced the more chance to make bonding among pulp, filler and C-PAM. In case of retention and drainage characteristics depending on the ionicity of the C-PAM of Fig. 6, the ionicity around 1.4 meq/g showed the good performance of retention and drainage characteristics under the applied stock condition. However higher or lower ionicity resulted in worse retention and drainage characteristics. This might be considered that cationicity was not enough to bond properly between pulp and fillers in the lower ionic condition and repulsive power affected to prevent bonding between pulp and fillers in the higher ionic condition.

3.3 Influence of stock condition on the inverse emulsion type C-PAM

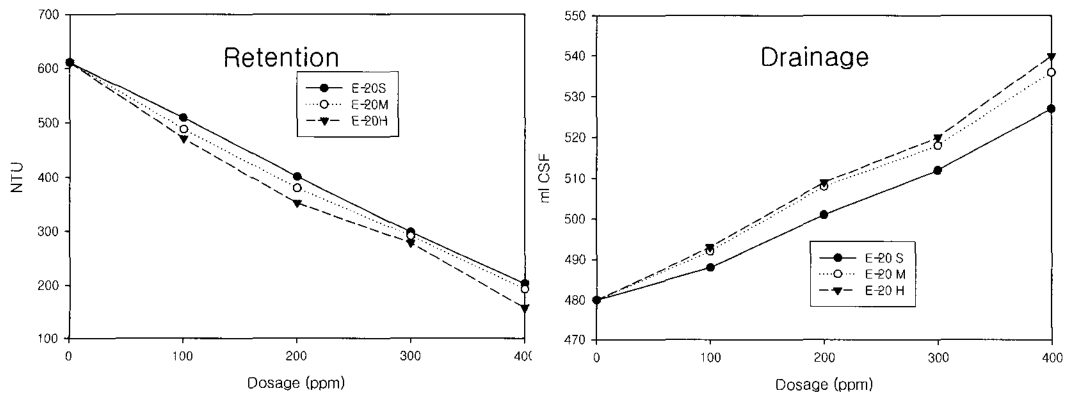

Fig. 5. Retention and drainage with different molecular weight of inverse emulsion type C-PAM (stock condition, pH 7.0, conductivity 380 μS/cm).

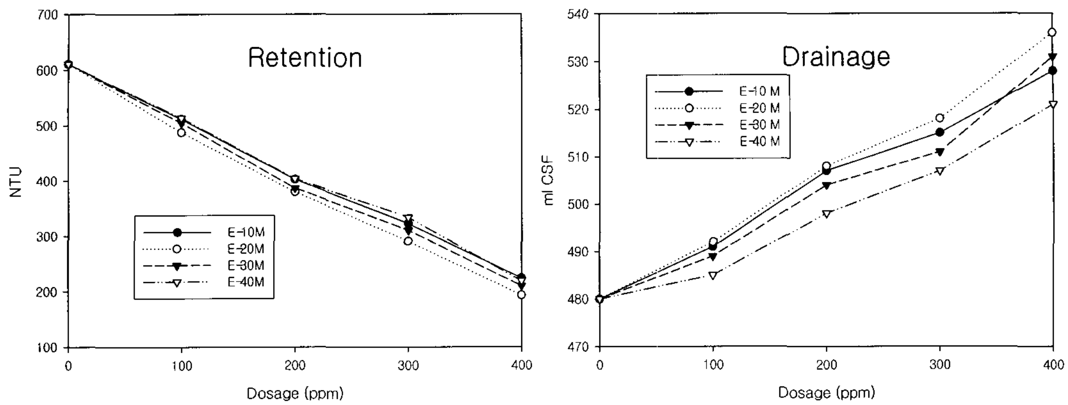

Fig. 6. Retention and drainage with different ionicity of inverse emulsion type C-PAM (stock condition, pH 7.0, conductivity 380 μS/cm).

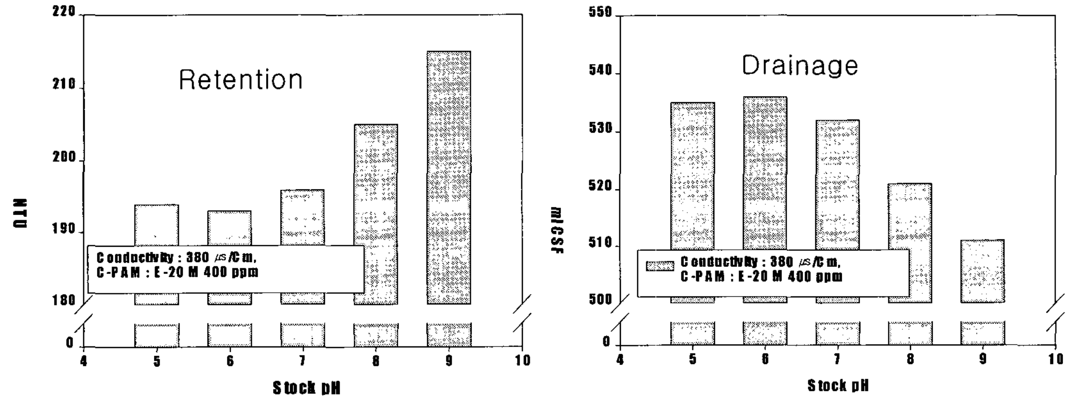

Fig. 7. Effect of stock pH on retention and drainage.

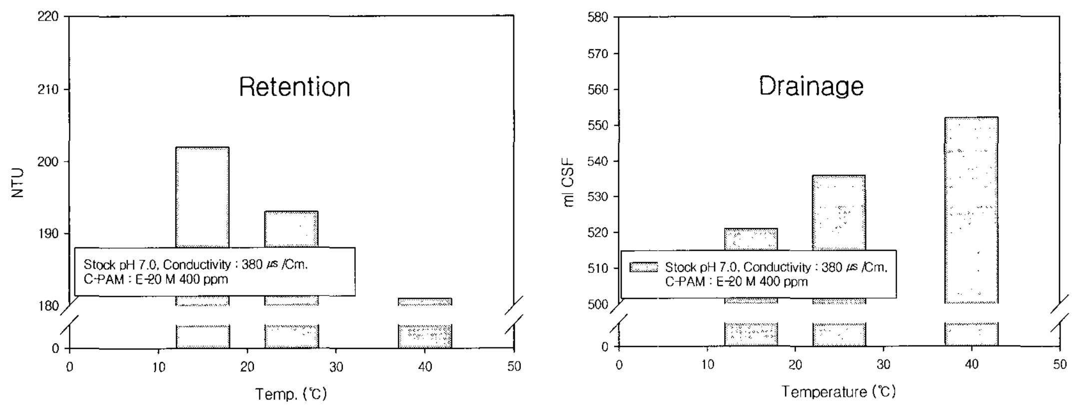

Fig. 8. Effect of stock temperature on retention and drainage (stock condition, pH 7.0, conductivity 380 μS/cm).

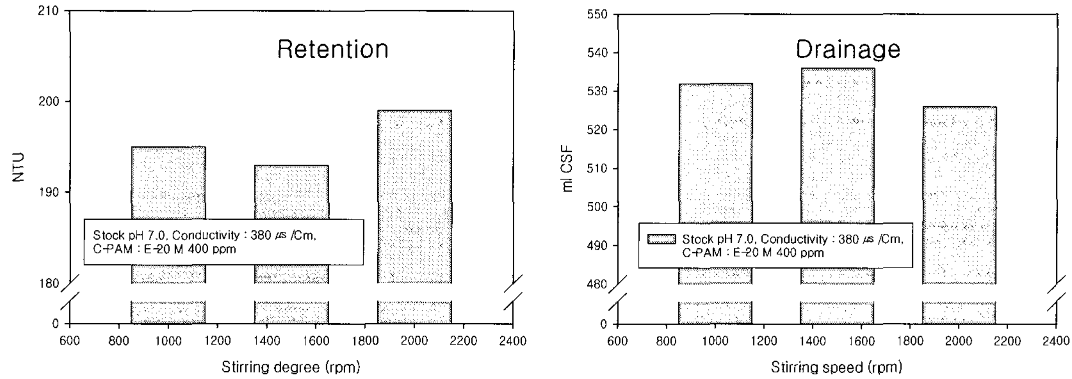

Fig. 9. Effect of stirring speed on retention and drainage (stock condition, pH 7.0, conductivity 380 µS/cm).

As you can see Fig. 7, retention and drainage were favorable at the stock pH 5 to 7 and retention and drainage were getting worse above the stock pH of 8, that is, in alkali condition. It was considered by the hydrolysis of cationic functionality of C-PAM by the attack of the hydroxide ion. We also found the higher stock temperature gave the better retention and drainage characteristics (Fig. 8). We thought high temperature gave positive effects on not only the reactivity among pulp, filler and C-PAM but also drainage by reducing viscosity of the water in the stock. Retention and drainage were improved by increase of stirring speed of 1000 to 1,500 rpm, but it changed worse by additional increase of stirring speed of 2,000 rpm (Fig. 9). It was considered that stirring rate was helpful in retention and drainage by improving reactivity among pulp, filler and C-PAM. Too much stirring rate, however, broke bonding among them.

4. Conclusions

1. In the low conductivity stock condition, retention and drainage by the inverse emulsion type PAM with high molecular weight was the best and salt dispersion type of the low molecular weight was the worst among them. However in case of the high conductivity stock condition, salt dispersion type showed better resistance than others to the conductivity. We might improve performance of inverse- emulsion C-PAM on the high conductivity stock condition to apply the same stabilizing cationic polymer as salt dispersion type in the future.

2. With regard to inverse emulsion type C-PAM, retention and drainage were improved by the increase of the molecular weight of C-PAM. And retention and drainage were better with the ionic condition around 1.4 meq/g under the applied stock condition. We found the molecular weight and ionicity were important factors to influence retention and drainage.

3. Retention and drainage were determined on different stock condition, Slightly acidic to neutral pH, higher stock temperature and proper shear conditions are most desirable.

To conclude research, inverse emulsion type had convenience of increasing molecular weight and controlling ionicity and molecular morphology. And it also has relatively higher active polymer contents than salt dispersion type because of its stable micelle condition. Therefore, the most suitable type of the paper retention and drainage among various types of C-PAM resulted from inverse emulsion type.

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