両性およびアニオン性ラテックスの混合率が塗工紙の印刷適性に及ぼす影響

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Effect of Blending Ratio of Amphoteric and Anionic Latex on Print Quality of Coated Paper

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Effectiveness of amphoteric latexes was studied to solve the problems of binder migration and uneven binder distribution in coating layers. The addition of amphoteric latex was effective in improving rheological properties of coating color in alkaline region through strong interaction with other coating components. As a result, coated papers made with amphoteric latex showed better printing qualities, such as paper gloss and surface smoothness.

Keywords : Amphoteric latex, Binder migration, Rheological property, Coated paper, Printing quality

分類 : W₉ 塗料調製薬品, S₉ 塗工印刷用紙 (微塗工印刷用紙含む), Y₈ 印刷

1. Introduction

Latexes are primarily used in paper coating formulation to provide greater coating strength, sheet gloss, ink gloss and printability. There are many types of latexes such as non-ionic, anionic or amphoteric latexes. Conventional anionic latexes provide good dispersion and rheology of coating color. Anionic latexes are compatible with the common coating components in water, and exhibit strong adhesion to cellulosic fibers and pigments. Anionic latex has many advantages for rheology of coating colors, and also improves printability of coated papers through their interaction with

other coating components.

In addition to the anionic latexes, use of amphoteric latexes was introduced in 1980 s to paper coating. The functional groups of amphoteric latex dissociates depending on the pH of coating color ; i. e., the amino groups are protonated to give positive ions under acidic conditions, while the carboxyl groups dissociates to give negative ions under alkaline conditions. This feature of amphoteric latex is highly useful in disrupting van der Waal's force between adjacent polymer chains causing aggregation or agglomeration of the color components.

In this study we examined the influence of blending

ratio of amphoteric latex and anionic latex on the rheology of coating color, interaction among coating components under various pHs, and printing qualities of the resulting papers.

2. Experiments

2.1 Materials

2.1.1 Base paper

An acidic base paper with grammage of 80 g/m² and

101 μm thick was used in this study. It had 75° sheet gloss of 7.09%, Parker PrintSurf Smoothness of 23.3 μm, opacity of 73.5%, and surface pH of 4.9.

2.1.2 Pigments

Two kinds of pigments were used : No.1 Clay and precipitated calcium carbonate (PCC). Their properties are shown in Table 1.

2.1.3 Latexes

Two kinds of latexes, amphoteric and anionic, were

Table 1 Properties of pigments

Pigments	pH	Viscosity (mPs)	Particle size (% under 2 μm)
Clay	6.31 (50% solid)	15.2* ¹	97
Calcium carbonate	8.64 (30% solid)	180* ²	95

*1.*2 : Brookfield viscometer-30 rpm, S-18)

Table 2 Characteristics of Latexes

Latexes	Solids content (%)	Viscosity (mPs)	Particle size (Å)	Tg (°C)
Amphoteric latex	50.0	47.9	1,820	19
Anionic latex	50.1	50.8	1,710	17

Table 3 Formulation of coating colors

Components		Colors			
		A	B	C	D
Pigments	Clay	70			
	Calcium carbonate	30			
Dispersant (Sodium polyacrylate)		0.3			
Latexes	Amphoteric	15	10	5	—
	Anionic	—	5	10	15
Thickener (carboxymethylcellulose (CMC))		0.2			
Insolubilizer (ammonium zirconium carbonate)		0.4			
Lubricant (calcium stearate)		1.0			
Total solids content (%)		55±0.3			

(Unit : parts)

used. Table 2 shows their properties.

2.1.4 Coating colors

Table 3 shows the formulation of four coating colors prepared for the study.

2.2. Methods

2.2.1 Particle size and zeta potential

The particle size and zeta potential of latex were measured by a light scattering particle analyzer, Zeta Plus (BIC, U.S.A.).

2.2.2 Viscosity of coating color

After pH adjustment with HCl or NaOH and stirring for 15 minutes, the viscosity of coating color was measured by a Brookfield Viscometer (spindle ; No.18) at 30 rpm.

2.2.3 Water retention of coating color

Water retention of coating color was determined by using AAGWR (Åbo-Academy, Finland). This test is based on pressure filtration and gravimetric determination of the dewatered coating color. The contact time and pressure in this measurement were 2 minutes and 2 bar, respectively.

2.2.4 Sediment weight ratio of pigment

A known weight of coating color was transferred to the cell and centrifuged at 11,000 rpm for 30 minutes. The sediment weight ratio was determined by dividing the sediment weight by the total weight of color.

2.2.5 Measurement of supernatant viscosity of coating color

After centrifuging the coating color at 11,000 rpm, the supernatant viscosity was measured by a Brookfield viscometer.

2.2.6 Properties of coated paper

Brightness and opacity of coated papers were measured by a spectrophotometer (Elrepho 3000, U.S.A) at 475 nm. Smoothness of coated paper was determined by a Bekk type apparatus (Toyoseiki, Japan), sheet gloss by a Glossmeter T 480 A (Techndyne Corp., U.S. A), and air permeability by a Denso-asperometer. Porosity was measured by a Gurley-type apparatus (Teledyne Gurley, USA).

2.2.7 Printability of coated paper

The printing test of coated paper was performed by a RI-II Printing Tester (Akira, Japan). Ink receptivity and ink set-off were determined by a Ink Densometer (Gretag, Switzerland). Visual quality was evaluated by five-point grading (human observation).

3. Results and Discussion

3.1 pH dependence of zeta potential

Fig. 1 shows the zeta potential of latexes as a function of pH. Above pH 5, the zeta potential ranged from -60 to -40 mV. On the other hand, the anionic charge density of the amphoteric latex decreased as pH lowers, and reached the isoelectric point at ca. pH 3.5. At pH lower than this, the latex became positive due to protonation of amino groups. This is in contrast with the case of anionic latex, which shows no charge reversal by pH changes.

3.2 Effect of blending ratio of latexes on coating color viscosity

Fig. 2 shows the effect of blending ratio of latexes on the viscosity of coating color at varied pH. All color samples showed no change in viscosity at above pH 9. This behavior is considered to result from the in-

Fig. 1 pH dependence of zeta potential of latex

Fig. 2 pH dependence of viscosity of coating colors

Fig. 3 pH dependence of dewatering of coating colors (2 bar and 2 min)

Fig. 4 Effect of pH on sediment weight ratio (Centrifuging : 11,000 rpm, 30 min)

crease in dissociation of carboxyl groups causing the decrease in viscosity. In contrast, the viscosity of coating colors prepared with amphoteric latex drastically increased by dissociation of amino groups causing flocculation of coating components in neutral and acidic regions, whereas that of anionic latex-based color showed no change with pH. The effect of amphoteric latex is remarkable even with a low level of addition, i. e., only 1/3 of the total amount of latex.

3.3 Influence of amphoteric latexes on dewatering and packing state of wet filter cake

Fig. 3 shows the pH dependence of dewatering of the coating colors containing anionic/amphoteric latexes in varied ratio. No difference in dewatering was observed for the four coating colors in alkaline region. A remarkable point here was that the dewatering of

Fig. 5 Low shear viscosity of supernatant viscosity as a function of pH for coating colors at 30 rpm

coating color with amphoteric latex abruptly increased at below pH 8. We assume that this behavior results from the interaction between cationic groups of amphoteric latex and anionic pigments, resulting in significant change in the structure of wet filter cake. As the blending ratio of amphoteric latex increases, dewatering of color also increased. Thus the filter cake of the amphoteric latex-containing color is more porous than the one with anionic latex.

3.4 Effect of latex composition on the interaction of color components

Fig. 4 shows that the sediment weight ratio of color increases as the pH decreases. Apparently the amphoteric latex particles bind to pigments as well as to anionic latex. As a result, the sediment weight ratio of the color containing 10 pph amphoteric and 5 pph anionic latexes was greater the color containing 15 pph anionic latex. This means that the amphoteric latex interacts with pigments, especially clay and makes anionic latex to combine pigments locally by bridging effect under acidic condition.

This phenomenon was also identified by measuring supernatant viscosity in water phase (Fig. 5) under lower pHs, where the amount of latex remaining in water phase decreased. As the proportion of amphoteric latex increased, the supernatant viscosity decreased gradually, whereas the sediment weight ratio increased in neutral and acidic region especially.

3.5 Influence of blending ratio of latexes on sheet gloss and smoothness

Fig. 6 shows that the coated papers made with high

Fig.6 Smoothness and sheet gloss of coated paper as a function of coating weight at a different blending ratio of latexes

blending ratio of amphoteric latex have better smoothness and sheet gloss. This effect is considered to result from the interaction between latex and acidic paper, causing less immobilization of color components and acceleration of coating layer formation. This effect was more remarkable for light-weight coated papers. Their smoothness and sheet gloss were the highest in the case of the blending ratio of amphoteric 10 pph and anionic 5 pph.

3.6 Influence on properties and printability of coating layer

Fig.7 shows air permeability and opacity of coated papers. The coated papers containing amphoteric latex were more porous and opaque than those with the anionic latex only. Figs. 8 and 9 illustrate the results of printability of coated paper such as wet ink receptivity, ink set-off, and print gloss. Coated papers prepared with amphoteric latex gave higher values for these characteristics. These results indicate the difference in the structure of coating layers. Thus the amphoteric latex-containing coatings are porous and bulky, having more spaces for ink to penetrate. This is especially advantageous for off-set printing, where quick absorption of wetting water improves print operation and print qualities.

4. Conclusion

In this study we investigated the influence of amphoteric latex addition on properties of coating colors printability of resulting papers. Our results indicated

Fig.7 Air permeability and opacity of coated paper as a function of coating weight by the mixing ratio of latexes

Fig.8 Wet ink-receptivity of coated papers as a function of coating weight (5 : good, 1 : poor)

Fig.9 Ink set-off and printing gloss of coated papers as a function of the mixing ratio of latexes (5 : good, 1 : poor)

its effectiveness in improving many of these properties, especially by optimizing the blending ration of two types latexes, amphoteric and anionic. This effect is considered to result from the ability of amphoteric latex particles to bind to clay and anionic latex after application of color to acidic base papers, where pH lowers and the amphoteric latex become positively charged by dissociation of amino groups.

Reference

- 1) Hau, X., Tanguy, P. A., Li, R., and Van Wangner, J. S. : Tappi J. 79 (5) 112 (1996).
- 2) Lee, Y. K., Onabe, F., and Usuda, M. : J. Tappi 46 (8) 75 (1992).
- 3) Lee, Y. K. : J. Korea Wood Sci. & Tech. 22 (1) series 82 (1994).
- 4) Bordman, D. and Feigenbaum, H. N. : Coating conference, 241 (1992).
- 5) Kogler, W., and Huggenberger, L., Coating conference : Tappi Proceeding, p 313.
- 6) Von Raven, A and Weigl, J. : Tappi J. 12 141 (1988).

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