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Application of Para Rubber Latex Mixed with Organic Dyes as Printing Ink for Biodegradable Plastic Film

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Abstract

The objective of this research was to evaluate the property of Para rubber latex applied as the binder in printing ink for biodegradable plastic film. The mixture of ink using natural or modified Para rubber latex was compared to the water-based ink using acrylic binder. Natural Para rubber latex in this study had solid content of 35.9%, 41.2%, 59.0% and 61.4%. The Para rubber latex was also modified by the addition of functional group called CNR at solid content of 16.5%, 19.2%, 26.8% and 28.2% respectively. Viscosity of samples was measured by Zahn cup #3 and drying time on plastic film was evaluated. The organic reactive dyes were used as colorant in printing ink. Two additive substances including dispersing agent and wax were added to help disperse the particles and to increase gloss, respectively. The printability of ink on biodegradable plastic film was tested using the bar coater. The optimal binder was natural Para rubber latex with solid content of 35.9% and 41.2%, which had the viscosity of 9.52 seconds and drying time of around 5 minutes. The viscosity of Para rubber latex with solid content of 59.0% and 61.4% was very high; thus, resulted in coagulation. Then modified rubber latex CNR with solid content of 16.5%, 19.2%, 26.8% and 28.2%, which had the viscosity around 8.30 seconds and drying time of around 5 minutes. Dye solution was prepared by adding 1 part of dye to 1 part of water (w/w). The formulation of ink that yielded the highest optical density of 1.43 was 8.4 g dye solution in 84 g Para rubber latex. The additive substances were added to the mixture to make up the weight of 100 g. The result showed that printing ink made from natural Para rubber latex with solid content of 35.9% and 41.2% and modified rubber latex CNR with solid content of 16.5%, 19.2%, 26.8% and 28.2% can be printed on the biodegradable film without surface treatment and ink layer color was brilliant. The modified rubber latex with solid content of 16.5%, 19.2%, 26.8% and 28.2% showed better print quality and smoother ink layer than the natural Para rubber latex. However, the adhesion resistance and rub resistance of this ink were inferior to traditional ink using acrylic binder.

Keywords : Biodegradable plastic, Modified Para rubber latex, Natural Para rubber latex, Organic dyes, Printing ink

Introduction

Environmental problems have been an issue that dramatically became a main problem in our world. One of the factors that caused a problem is non degradable waste, such as plastic, textile, etc.. Many people are trying to avoid this by using an alternative substances that is biodegradable. One of the main applications of biodegradable material is packaging, which was found in abundance in the municipal solid waste. Each package is required to have information that is usually printed with various kinds of inks. Some printing ink, including binder such as petroleum-based resin was difficult for biodegradation process[(1)] and caused pollution. Since the general ink is a environmental problem, the rubber latex[(2-3)] was then researched to be an alternative binder in printing ink. Therefore, the water-based ink using Para rubber latex as a binder was developed to print on biodegradable plastic film to have similar properties as the ink using acrylic resin. The Para rubber latex is not only cheaper than acrylic resin, that is a commercial binder, but also more environmental friendly.

Materials and Experimental Procedures

The natural Para rubber latex (NR) and Carboxylated natural Para rubber latex (CNR) were

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studied with various solid contents. The solid contents of NR were 35.9%, 41.2%, 59.0% and 61.4% while the solid contents of CNR were 16.5%, 19.2%, 26.8% and 28.2%. The samples were measured for viscosity with Zahn cup No. 3. The water-based ink was prepared by mixing 84% NR or CNR, 2% BYK-190 (dispersing agent), 4% E-842 N (wax), 0.2% VS-04 (shading agent), 0.14% solution of BYK-425 (viscous agent) and 8.4% solution of reactive dye. All ingredients were spin at 300 rpm for 15 minutes. The control water-based ink was also prepared by mixing 85.4% Acrylic resin (AR) and same other ingredients as the produced ink except the solution of BYK-425. The viscosity and pH of ink was analyzed before coating on biodegradable plastic film. The ink was coated on biodegradable plastic film by using bar coater No.6. The print qualities of ink with NR and CNR were analyzed and compared to those of the control ink with acrylic resin such as optical density, adhesion and rub resistance.

Results and Discussion

Viscosity of Binders and Printing Inks

To determine the viscosity of a liquid either binder or ink, the Zahn cup was dipped and completely filled with the substance. After lifting the cup out of the substance the time was measured until the liquid streaming out of it breaks up, this is the corresponding in seconds. The more viscosity was represented by the longer time.

Table 1. The viscosity of binder and printing ink

Sample of binder	Solid content of binder (%)	Viscosity of binder (seconds)	Viscosity of printing ink (seconds)
AR	48.0	46.00	29.50
NR	61.4	69.00	flocculation
	59.0	62.00	flocculation
	41.2	35.66	9.52
	35.9	15.43	9.10
CNR	28.2	8.87	9.05
	26.8	8.55	8.37
	19.2	8.42	8.33
	16.5	8.00	8.25

Table 1 shows that the viscosity of binder was reduced when the solid content was decreased. The inks with NR at a very high solid content of 59.0% and 61.4% were flocculated and unstable for printing. The other produced inks were stable and had enough viscosity around 8-10 seconds for application as liquid ink. The solid content and viscosity of CNR binder were greatly lower than those of NR binder but the ink with CNR had slightly less viscosity than the ink with NR.

The pH of Printing Ink

Table 2 indicated that pH of printing ink with NR was high with alkaline property while the ink with CNR had pH around 2. The CNR printing ink was acid because it was modified by the reaction with acid to add the carboxyl functional group. The ink with acrylic resin had a pH of neutral.

Table 2. The pH of printing ink

Sample of binder	Solid content of binder (%)	pH
AR	48	7.67
NR	41.2	9.52
	35.9	9.53
CNR	28.2	2.81
	26.8	2.85
	19.2	2.9
	16.5	2.96

Density Measurement of Printing Ink Film on Biodegradable Plastic

Table 3 shows that the printing ink with AR had more optical density than NR and CNR printing ink because AR had higher solid content than did NR and CNR. The color of AR binder was also darker than that of NR and CNR resulting in higher density of printing ink film. The density of ink film with CNR binder was also high enough although the solid content was too low, indicating that CNR had better property than NR did.

Table 3. The optical density of printing ink film on biodegradable plastic

Sample of binder	Solid content of binder (%)	Optical density
AR	48.0	1.85
NR	41.2	1.35
	35.9	1.10
CNR	28.2	1.23
	26.8	1.43
	19.2	1.37
	16.5	1.30

Adhesion

Adhesion measurement by a tape test according to standard of ASTM D3359 - 09e2 [4] showed that AR printing ink was a good binder which had adhesion of 100% on biodegradable plastic film. The ink with NR had slightly less adhesion than the ink with AR while the ink with CNR had greatly poorer adhesion. The CNR with less solid content had better adhesion on biodegradable plastic than the CNR with more solid content. However, the NR printing ink film was not bound on the substrate and peeled off the substrate after picking with the tape, but the CNR printing ink film was peeled with the tape as a layer. Therefore, the CNR ink had a more similar quality to the general ink than did the NR ink.

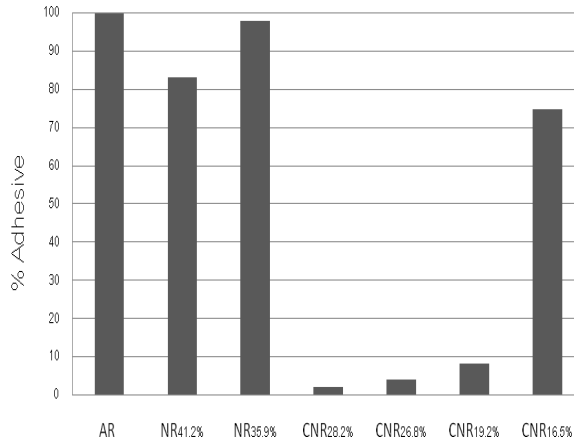

Figure 1. Adhesive (%) of ink film with different kinds of binder on biodegradable plastic

Rub Resistance

Rub resistance measurement according to standard of ASTM D 5264-98 [5] showed that acrylic resin printing ink had 100% Rub Resistance as no ink came off after rubbing. The NR and CNR printing ink had less rub resistance, and the lower solid content also resulted in higher Rub Resistance. In addition, the ink with CNR 16.5% had better rub resistance than the ink with NR 35.9%, indicating that the modified rubber latex with low solid content had a good trend to be applied as a binder in printing ink.

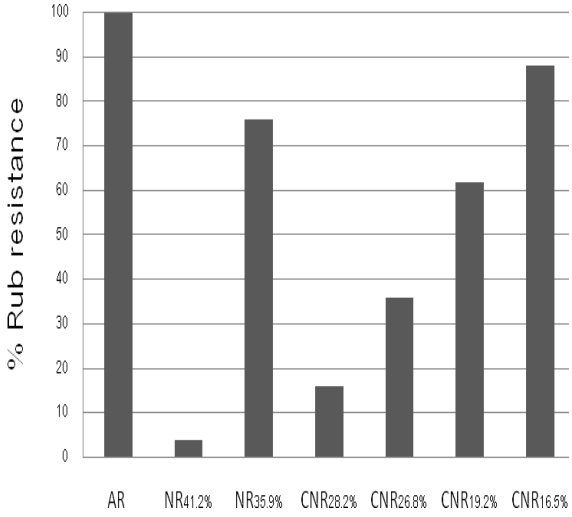

Figure 2. Rub resistance (%) of ink film with different kinds of binder on biodegradable plastic

Conclusion

The natural Para rubber latex (NR) and Carboxylated natural Para rubber latex (CNR) had a good printability on biodegradable plastic film without surface treatment. The ink with NR and CNR had slightly less density, adhesion and rub resistance than the ink with acrylic resin. In addition, lower solid content of NR or CNR had better adhesion and rub resistance. In this research, the ink film of CNR binder had closer properties to general ink film than the ink film of NR binder.

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