Research of Wax Additives in the Water-Based Ink for Flexographic Printing

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Abstract Effect of three types of wax additives in the water-based ink is discussed, which are wax emulsion, micro-wax dispersions and wax dispersions. Softening point and particle size of wax are mainly studied on the ink's performances, such as gloss, friction resistance and rub resistance. The result shows that ink added WE3 which is micro-wax dispersions has good performance, and has best performance on the BOPP film while added 3 wt%.

Keywords Wax additives · Water-based ink for flexographic printing
Gloss · Friction resistance · Rub resistance

1 Introduction

In order to meet the requirements of high-speed printing of CI flexo press and rubbing requirements of soft packaging products, water-based ink should have excellent performances in resistance of friction, rubbing etc. Besides choosing the appropriate water-based resin, using rational wax additives is one of the key factors [1].

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This paper mainly studies how different kinds of wax additives used in water-based ink for flexographic printing effect the performance of print.

2 Experiments

2.1 *Raw Materials*

Pigment: cyan color paste C3.

Resin: acrylic film-forming resins R1 and R2, assisted resin R3 and R4.

Additives: wetting agent W1, defoamer F2, wax emulsions WE1, WE2, WE3, WE4, WE5 and WE6.

Printing substrate: BOPP film.

The reference formula is shown in Table 1.

2.2 *Test Methods*

2.2.1 Friction Resistance Test

According to the national standard GB/T17497-2012 Flexible printing packaging products (Plastic and metal foil), use MCJ-01A to test.

Friction resistance = $D/D_0 \times 100\%$

D_0—average density value before friction;

D—average density value after friction.

2.2.2 Rub Resistance Test

Clamp the test print using thumb and index finger, and knead 10 times to the opposite direction without stretching the print. The test is distinguished five levels. “5” is best that ink layer without any damage, and “1” is that layer is completely destroyed.

Table 1 The reference formula of table printing water-based ink

Raw materials	Manufacturers	Amount (wt%)
Water-based resin	Import	45.45–48.3
Color paste	Domestic	45.45–48.3
H_2O	Made in laboratory	2–5
Wetting agent	TEGO	0.1–0.3
pH modifier	Domestic	0.1–0.3
Defoamer	TEGO	0.2–0.5
Wax	Domestic/import	1–3

2.2.3 Water Resistance Test

Put the print in the water 40 h, and then test the decoloration, scratch resistance of the print. Assessment method is as rub resistance test.

3 Results and Discussion

3.1 Preliminary Test of Water-Based Wax Additives

According to different particle size, emulsified wax is classified wax emulsion, micro-wax dispersions and wax dispersions. Select six water-based wax additions which are all polyethylene wax to do experiments. It is mainly studied effects of different wax additives with the same content on the performances of ink, such as adhesion, friction resistance, rub resistance, water resistance and gloss. Basic performances index of the six wax additives are shown in Table 2, and their effect on the ink performances is shown in Table 3.

Integrated the data of Table 2, we can conclude as follows:

(1) Wax dispersions: inks adding WE1 and WE2 are improved the resistance of friction and rub of the coating, but they have a great influence on the gloss of the ink, which may be related to the large particle size of the waxes.
(2) Micro-wax dispersions: rub, friction and water resistance of the ink is improved significantly.
(3) Wax emulsion: WE5 and WE6 have high melting point, but their particle size is so small that their ability to resist the friction is relatively weak, that can't meet the requirements of printing.

Integrated above data, adding appropriate wax dispersion can improve friction resistance of the ink greatly. Because of its irregular particles and wide particle size distribution, wax particles form a heterogeneous and microscopically uneven surface on the ink film. The light waves produce a strong scattering effect, and reduces gloss of ink [2], which can be reduced that affects print quality. Due to particles of

Table 2 Basic performance index of water-based wax additives

Type	Company	No.	Particle size (μm)	Melting point (°C)	Solid content (%)
Wax dispersions	BASF	WE1	4	132	40
	Yijiu	WE2	6–8	120–125	40 ± 1
Micro-wax dispersions	Unkel	WE3	1.0–1.4	128	50 ± 1
	Yijiu	WE4	0.5–1	120–125	40 ± 1
Wax emulsion	Yijiu	WE5	≤ 0.1	137	42 ± 1
	Unkel	WE6	≤ 0.1	125	42 ± 1

Table 3 Wax additives (3 wt%) on performances of ink

No.	Adhesion	Friction resistance (%)	Rub resistance	Gloss (%)	Water resistance
No wax	5	0	2	76.47	1
WE1	5	97.6	5	71.77	5
WE2	4	97.9	5	65.8	5
WE3	5	97.7	5	82.2	5
WE4	3	90.58	5	79.0	3
WE5	5	42.3	2	82.3	2
WE6	4	65.23	2	80.8	2

Notes While adhesion/water resistance is 5, it indicates the best; while 1, it indicates the worst

micro-wax dispersion has spherical structure, they have little effect on the gloss of print, and it can improve friction and rub resistance of the ink if adding appropriate dosage. Particles of wax emulsion are sphere that they could not reduce the gloss of the ink, but because of their small size, it has little effect on improving friction resistance.

3.2 Effect of Wax Additives on Ink Performances

Because of speciality of plastic soft package such as food and hygiene products, besides high requirements of adhesion, leveling and gloss, there are high requirements for friction resistance and rubbing resistance. Adding appropriate wax additive into the ink can improve these performances. According to the influence of wax additives on the ink adhesion and gloss of Sect. 3.1, select WE1, WE3 and WE5 which have better performances in the ink to do gradient experiments. This chapter is mainly studied the influence of wax on friction resistance, rub resistance and gloss of the ink.

3.2.1 Effect of Different Wax Additives on the Friction and Rub Resistance

Integrated Table 4 and Fig. 1, after adding WE1, WE3 and WE5, friction and rub resistance are improved to different degree.

(1) While WE1 is added 1 wt%, the ink has significant improvement in friction resistance, and while added 2 wt%, the ink has the best performances of friction and rubbing resistance. It is chiefly because large particles in the WE1 play a vital role in the ability of exterior force resistance that can destroy the ink film. And these large wax particles can prevent further extension and deterioration of scratches which should protect the coating.

Table 4 Effect of wax additives on the friction and rub resistance

WAX	Performances/amount (wt%)	0	1	2	3	4	5
WE1	Friction resistance	30.1	80.2	97.4	97.6	97.2	97.3
	Rub resistance	2	4	5	5	5	5
WE3	Friction resistance	30.1	50.4	78.9	97.7	97	97.4
	Rub resistance	2	3	4	5	5	5
WE5	Friction resistance	30.1	35.1	39.4	42.3	50.7	67.5
	Rub resistance	2	2	2	2	2	3

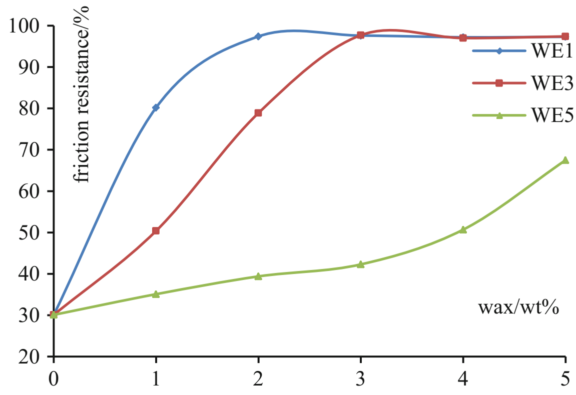

Fig. 1 Effect of wax additives on the friction resistance

(2) Due to the particle size of WE3 is less than WE1's, while WE3 is added 3 wt%, ink's performances could achieve optimal such as friction and rub resistance, and added its amount, performances of the ink can't improve. It may be that spherical wax particles that arranged on the surface of the ink layer have an effect on friction resistance. While added its amount, space between wax particles on the surface of the ink layer reduces, that is the surface area dominated by wax particles increased, which makes ink layer surface friction resistance decline. If WE3 is continued to increase, wax particles on the surface of the ink layer are arranged closely, and new particles are unable to enter so that they can only be arranged within the coating, which has little effect on friction coefficient of the layer [3]. Figure 2 is print's rub resistance while amount of WE3 is 0, 1, 2 and 3 wt% respectively.

(3) WE5 is nanoscale additive. Due to its particle size is too small, there is no obvious improvement on the ink's friction and rubbing resistance.

Fig. 2 Pictures of print's rub resistance while adding different amount of WE3

3.2.2 Effect of Different Wax Additives on Ink Gloss

While Wax additive added into the water-based ink, the wax particles approximate dispersed uniformly in the system. From Fig. 3, due to different particle size and distribution of the three types of wax additives which are wax emulsion, micro-wax dispersions and wax dispersions, the light will produce different degrees of diffuse reflection, and this will affect gloss of printing. From the data of Table 5 and Fig. 4, effect of different wax additives on ink gloss can be got. The influence of WE1 to the printing gloss is very great, that is mainly related to its large particle size and maldistribution. The gloss of ink film has certain improvement after adding WE3

Fig. 3 Distribution and reflection of different kinds of wax additives in ink

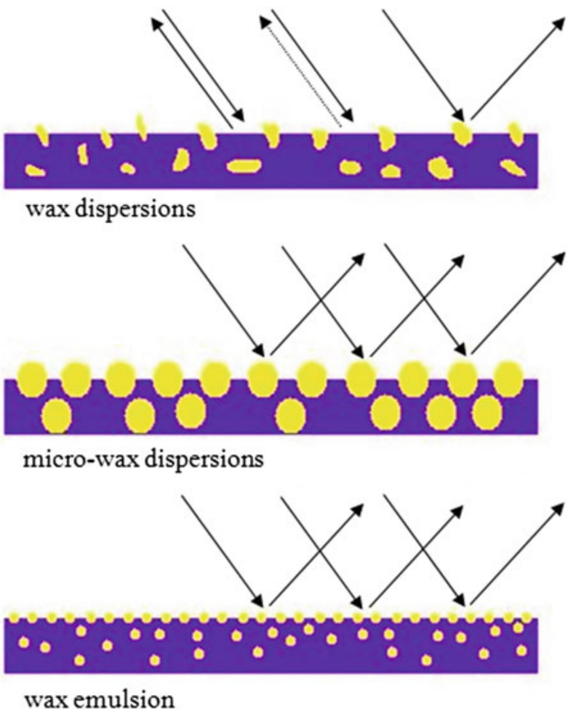

Table 5 Effect of different wax additives on ink gloss

Addition (%)	0	1	2	3	4	5
WE1	76.47	75.63	73.13	71.77	69.23	67.0
WE3	76.47	77.3	79.5	82.2	79.5	78.8
WE5	76.47	78.2	80.1	82.3	84.6	83.9

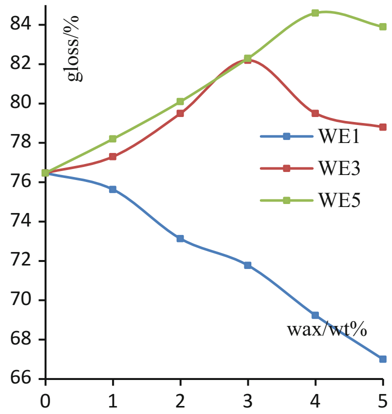

Fig. 4 Effect of different wax additives on ink gloss

and WE5, and amount of them is 3 and 4 wt% respectively, gloss of ink film is best. While increase their dosage could reduce the gloss. It may be because that some silicone additives float on the surface of ink layer which makes the coating uneven and decrease the gloss of the print [4]. Adding the two wax additives can make up these minor defects and increase the gloss. If dosage of them exceeds a certain amount, excess wax particles store inside the ink layer. At the same times, low content of large particle size of wax particles also affect the gloss of coating.

4 Conclusions

As an important table printing ink composition, wax additives can not only improve the resistance of friction and rub, but also affect the gloss of ink film. The results of experiments indicate that while addition of WE3 is 3 wt%, performances of the above mentioned are best. So select WE3 as anti-abrasion additives of water-based ink.

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