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SURVACE COATING OF UNSA TURATED
POLYESTER RESIN ON KAMPER WOOD
DRY OBALAN OPS SPP) BY USIN CUP
RADIATION

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MATERIALS AND METHODS

Materials. Kamper wood panel samples as a substrate were used in the experiment. Unsaturated polyester resin containing of styrene monomer under the trade name of Yucalac type 157 was purchased from PT. Justus Sakti Raya Corporation, Jakarta. Styrene monomer and talc were purchased from PT. Harum Sari, Jakarta. Radical photoinitiator of 2-hydroxy-2-methyl-1-phenyl propanone under the trade name of Darocur 1173 were supplied by Merck. All chemicals were used as supplied without further purification.

Equipments. Coating of samples were performed by using a High Pressure Spray Gun GM 2600 of Wagner GmbH Germany. Irradiation was carried out using a one lamp of 80 Watt/cm UV-source of IST Strahlentechnik, Germany, equipped with a conveyor systems.

Experiments. Wood samples with the size of (20 x 15 x 0.5) cm were dried in a kiln drier to get a moisture content of 12-15 %, sanded using # 240 abrasive paper, coated with base coat and then irradiated by using UV-source at a conveyor speed of 3 m/min. Samples then were sanded with the same abrasive paper, coated with top coat and then irradiated again at variation of conveyor speed of 3 ; 4 ; 5 ; and 5.8 m/min. Composition of base coat and top coat were tabulated on Table 1. Base coating was conducted using brush whereas top coating was conducted using High Pressure Sprayer. The thickness of base coats and top coats were around 37 gram/ m^2 an 24 gram/m^2 respectively. Parameters observed were pendulum hardness, specular gloss and adhesion. Pendulum hardness was measured with a Koenig method using Pendulum Hardness Rocker according to the ISO 1522-1973 (E). The 60° geometry specular gloss was determined according to ASTM D 523-85. Adhesion was measured with a pull-off test as described on ISO 4624-1978 (E) using Elcometer Model 106 Adhesion Tester.

RESULTS AND DISCUSSIONS

Formulation. Appearance is very important for coated products, because someone just look the appearance for quick assessement of the product quality. Viscosity plays an important role for application of sprayer and appearance of the films obtained. Low viscosity gives a thin and good appearance of films. In general, radiation curable materials have high viscosity due to high solid content after curing. However, viscosity can be adjusted to a wide range by dilution with monomer. Commercial unsaturated polyester resin such as Yucalac type 157 was already mixed with styrene monomer. This resin still has high viscosity for coating applications. For appropriate spray application, resins should be added with more styrene. In UV-curing systems, low monomer concentration resulted in a high degree of cross link and better properties of cured films (6). On the other hand, a low monomer concentration causes a high viscosity and there will be a problem for spray application to get a good appearance. In order to get a good properties of films without sacrificing the appearance, the viscosity should be adjusted properly. Viscosity decreases from 262 cp. to 239 cp. as the photoinitiator concentration increases from 1.5 % to 3 % by weight. By considering the appearance and properties of cured films, the formulations which is selected in the experiment can be seen on Table 1. In the range of

photoinitiator concentration and conveyor speed used, the appearance of films obtained mostly are even and smooth.

Table I. Compositions of base coat and top coat.

Components	Weight ratio	
	Base coat	Top coat
Unsaturated polyester resin (Yucalac 157)	100	100
Styrene	-	7
Talc	10	-
2-Hydroxy-2-methyl-1-phenyl propanone (Darocur 1173)	2	1.5 ; 2 ; 2.5 ; 3

Hardness. Histogram on Figure 1 shows the pendulum hardness as a function of photoinitiator concentration and conveyor speed. The double bond of unsaturated polyester oligomer located on the back-bone sites, and this type of oligomers have low reactivity for radiation curing. For low photoinitiator concentration the UV-energy produces low number of radicals compared to the reactive sites and the rate of cure will be low. Number of radical produced increases with increasing photoinitiator concentration which in turn give higher cure speed and hardness. Hardness is influenced by number of cross link in the cured films. Photoinitiator molecules are increasingly excited by longer of UV-irradiation or lower conveyor speed and the polymerisation will run for a longer time. More cross link polymers are formed and resulted in higher hardness. At 1.5 % photoinitiator concentration, decreasing conveyor speed from 5.8 m/min. to 3 m/min. increases the hardness from 62 sec. to 102 sec. After a storage time of 3 days, hardness slightly increases as shown in Figure 2 compared with the data in Figure 1. Although the increase in hardness is small, in a level of 4 % to 8 %, it is observed at various photoinitiator concentration and conveyor speed. This was caused by slow termination of trapped radicals. The trapped radicals slowly in contact with styrene molecules, thus starting a cross linking reaction. Styrene radicals or chain can also migrate to a fumarate group and reaction occur with each other according reaction mechanism of cross linking polymerisation.

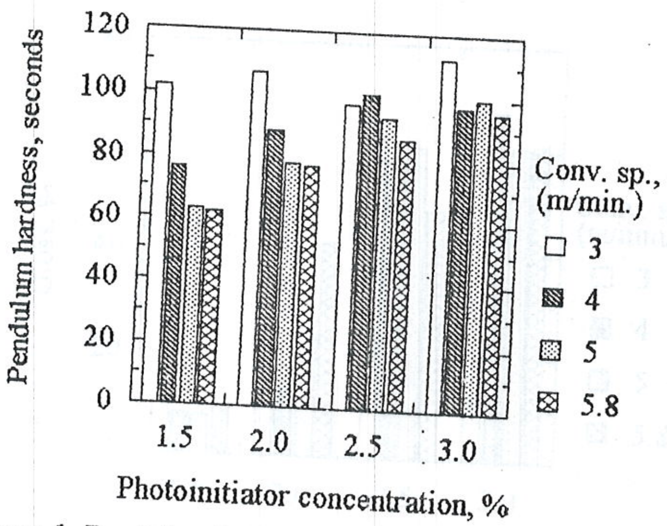

Figure 1. Pendulum hardness as a function of photoinitiator concentration.
Measurement : immediately after irradiation.

Adhesion. The adhesion test was conducted using pull-off test by measuring the tensile stress and failure pattern of films. Table II is one of the four similar results which do not expressed in this paper due to the fairly wide variation of the results. Effects of photoinitiator concentration and conveyor speed to either tensile stress or failure pattern of films do not clear. Its very difficult to draw a proper interpretation of the data obtained. The scaterred data have already appeared between data from test place 1 and 2 even in the same test sample (Table II). The most failure occur between substrate and base coat (A/B) and the rest of them are between base coat and top coat (B/C) or in the wood substrate itself (A). The adhesion is reduced with increasing thickness of films. Internal strain increases as a film thickness increases and at a particular thickness becomes sufficient to overcome the work of adhesion at the surface so that the film spontaneously peel off (8). The problem is the fluctuation of film thickness caused by the method of coating applications (brushing, spraying etc.), because differences in coating thickness can be one reason for the variation in test results. Cleanliness of the surface such as free of dust, particles, fat etc., is very important to get the best results. According to ASKIENAZY and ZWANENBURG (9), many factors play an important role for wide variation of data. Those are the surface defects and non uniformed test conditions. Both are tend to yield a lower value. The minimum and maximum values of the tensile stress are 6.3 Kg/cm^2 and 27.4 Kg/cm^2 respectively.

Table II. Tensile stress and failure pattern of films.

PC, %	CS, m/min.	Test place 1				Test place 2			
		T.S	A	A/B	B/C	T.S	A	A/B	B/C
1.5	3	10.5	10	90	-	14.06	5	95	-
	4	13.4	40	60	-	13.36	30	70	-
	5	7.7	10	90	-	8.44	-	100	-
	5.8	12.0	-	90	10	8.44	-	80	20
2.0	3	6.3	-	60	40	4.92	-	80	20
	4	14.8	10	90	-	11.25	30	70	-
	5	12.0	70	30	-	11.95	20	80	-
	5.8	7.7	-	100	-	10.55	-	100	-
2.5	3	27.4	-	100	-	14.76	-	95	5
	4	7.8	10	90	-	13.36	-	100	-
	5	12.7	-	100	-	11.25	-	100	-
	5.8	11.9	-	100	-	14.76	-	60	40
3.0	3	16.2	-	100	-	19.69	-	100	-
	4	9.1	-	100	-	7.03	-	100	-
	5	13.4	-	100	-	12.66	-	100	-
	5.8	10.5	-	90	10	14.06	-	90	10

PC = Photoinitiator concentration
CS = Conveyor speed
TS = Tensile stress

A = % failure in the substrate
A/B = % failure between wood and base coat.
B/C = % failure between base coat and top coat

CONCLUSION

1. Photoinitiator concentration was highly effect to the pendulum hardness and gloss of UV-cured films on kamper wood. Increasing conveyor speed decreases hardness especially at low photoinitiator concentration , but do not affect very much to the gloss. Storage time of 3 days slightly increasing the hardness of the cured films.

2. Measurement of adhesion using pull-off test do not give any information about the effect of photoinitiator concentration and conveyor speed but the failures are mostly occur between wood substrate and base coat.

3. In general, the appearance of unsaturated polyester films onto the kamper wood were even and smooth.

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