STUDY ON BIODEGRADATION OF PALM OIL-BASED UV-CURABLE FILMS IN SOIL

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Abstract

The palm oil-based ultraviolet (uv)-curable films were subjected to an outdoor soil burial test to investigate the biodegradation under natural environment. The films were burial in the soil experiment plot at the Nuclear Malaysia's Dengkil complex which is near the BTS building at block 42. Biodegradation tests are more specific to burial film in soil experiments for 12 months under natural conditions. The biodegradability of palm oil resin based uv-curable films were investigated and compared with the petrochemical resin based film. The films properties were compared with respect to properties of the film morphology and the film weight loss which are analyzed using the scanning electron microscope (SEM), an optical microscope and the weight loss of film calculation. These findings suggested that the palm oil-based uv-curable films show quite satisfactory biodegradation levels.

Objectives

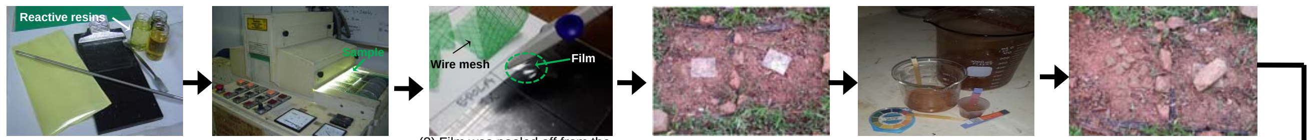
1. To study the environment characteristic such as the biodegradation of the palm oil-based coating films after the sample cultivate in a soil for 12 months.
2. To compare the biodegradation properties of the palm oil-based coating films and the petrochemical-based coating films in soil.

Introduction

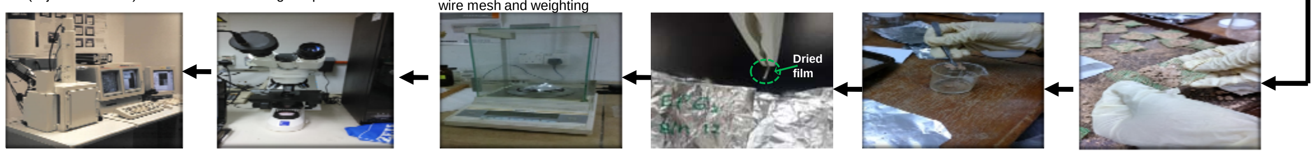
Nowadays, the ultraviolet/electron beam (UV/EB) line industries is still heavily dependent on the petrochemical-based raw chemicals imports, which are non-environment friendly materials. Hence, the development and the application of the palm oil-based radiation curing (radcure) products (i.e. coatings, adhesives and inks) could contribute to reduce the petrochemical-based chemicals imports and also in order to fulfill our own local industries demand that need cheaper, environmental friendly and natural product. More forward, the successful of these radcure products in our local UV/EB industries will directly beneficial in providing the jobs opportunity to local people as well as contribute increase the gross national income by year 2020 (MIDA 2014).

In this study, one of the good environment characteristic such as biodegradation of palm oil-based coating films in soil will be studied and compared to the petrochemical-based coating films. The palm oil-based films are known as epoxidized palm oil acrylated (EPOLA) and palm oil based urethane acrylated (POBUA) and the petrochemical based films are from the commercial grade oligomer type such as Ebecryl-264 (EB264) and Ebecryl-830 (EB830). The characterization of the sample for biodegradation is performing after the sample cultivate in a soil for one year. From this study, the biodegradation of palm oil-based films show the most easily to degrade because it has higher percentage of weight loss compared to the petrochemical-based films.

Methods and Materials



(1) Reactive resins preparation (Tajau et al. 2014) → (2) Uv-curing of the samples on the glass plate → (3) Film was peeled off from the glass plate and inserted into the wire mesh and weighting → (4) Samples were buried in the soil → (5) Soil pH study → (6) Samples were taken every 2 months



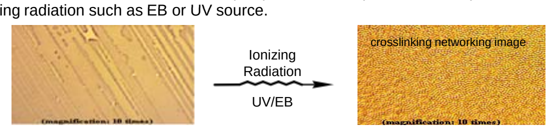
(a) SEM (b) Optical microscope (11) Film morphology characterization ← (10) Film weighting ← (9) Dried film ← (8) Cleaning the sample from soil using distilled water ← (7) Separating film from the wire mesh

Figure 1: Methodology of the study.

Results and Discussion

A. Radiation Curing (Radcure) Technology:

- Transformation of reactive resin from liquid phase to solid phase after subjected to the ionizing radiation such as EB or UV source.



(a) Liquid phase reactive resin (b) Solid phase film

Figure 2: Optical microscope images.

C. Biodegradation images:

1. The SEM images in Fig. 4 shows different features of the biodegradation images of the films.
2. From the study, the biodegradation process's features is based on the type of the oligomer used to formulate the uv-curable film.
3. After 12 months in soil, the EPOLA-based shows loose of the crosslinking networking, the POBUA-HMDI shows the pores appearances and the EB830 shows the biodegradation additives appearances, as shown in the Fig.4 below.

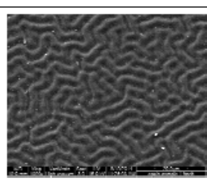
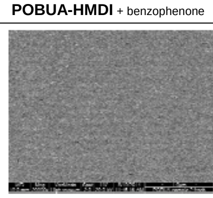
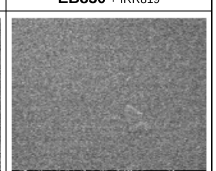
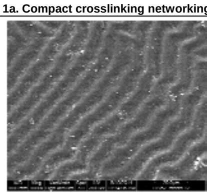
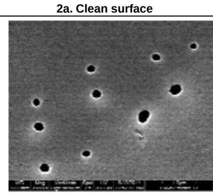
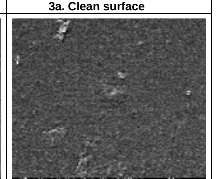
Type of sample	Palm oil-based uv-curable film		Petrochemical-based uv-curable film
	EPOLA + IRR819	**POBUA-HMDI** + benzophenone	**EB830** + IRR819
Before burial in soil (reddish brown & acidic soil, pH ranges 3.0-5.0)	 1a. Compact crosslinking networking	 2a. Clean surface	 3a. Clean surface
After burial in soil for 12 months	 1b. Loose crosslinking networking	 2b. Appearance of the pores	 3b. Appearance of the additives

Figure 4: Scanning electron microscope (SEM) images.

B. Biodegradation study: Weight loss of the films in soil after 12 months

1. Table 1 tabulated the percentage of weight loss of the uv-curable films in soil for 12 months. The films weight loss was increased after 12 months compared to the slightly weight loss at the second months on the last year September (Table 1) due to long period exposure of the films to the natural environment i.e. the soil microorganism and the rainfall factor throughout the year.
2. Figure 3 shows the palm oil-based films are easy to degrade compare to the petrochemical-based films. Besides that, films that formulated with acrylate type oligomers such as EPOLA and EB830 resulted a satisfactory weight loss amount compare to the films formulated with urethane type oligomers such as POBUA and EB264 (Fig. 3).
3. From the study, the biodegradation of EPOLA-based films show the most easily to degrade because it has higher percentage of weight loss.

Table 1: A biodegradation study based on weight loss of the palm oil-based films and the petrochemical-based films in soil for 12 months.

Type of oligomer	Percentage of weight loss, % (taken every 2 months)											
	Type of photoinitiator											
	Benzophenone						IRR819					
	Sep'13	Nov'13	Jan'14	Mar'14	May'14	Jul'14	Sep'13	Nov'13	Jan'14	Mar'14	May'14	Jul'14
EPOLA	67.07	-	30.32	90.51	77.08	89.57	17.47	36.56	26.90	22.64	-	93.33
POBUA-IPDI	34.68	15.48	85.81	-	34.96	40.37	-	58.71	38.46	39.88	39.88	19.35
POBUA-HMDI	33.33	46.31	43.30	-	61.86	83.76	67.51	24.23	39.25	19.02	-	-
EB264	31.82	-	19.84	43.10	-	66.85	54.60	-	-	29.94	23.78	59.10
EB830	31.58	75.23	74.77	-	37.65	71.60	80.83	40.33	-	-	-	75.97

Note: IPDI: isophorane di- isocyanate; HMDI: hexamethylene di-isocyanate; EB: Ebecryl; *IRR819: Irgacure 819*

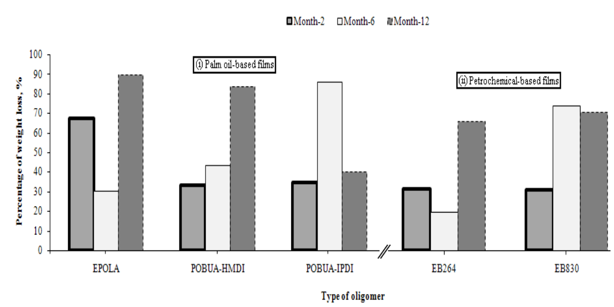


Figure 3: Weight loss for biodegradation process of the uv-curable films formulated with benzophenone photoinitiator within 12 months in soil.

Conclusion

The study concluded that the palm oil-based uv-curable films offers very interesting prospects as economically sustainable and environmental friendly products than petrochemical-based products. The biodegradation of palm oil-based films especially the EPOLA-based film show the most easily to degrade because it has higher percentage of weight loss compared to the POBUA-based films and the petrochemical-based films. An existing of this palm oil-based radiation curable product will benefit our local companies and people especially on the era of growing global demand for cheaper, nature, green and safe product.

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