Jurnal Penelitian Kelapa Sawit, 1998, 6(3) : 203 - 213
Indonesian Journal of Oil Palm Research, 1998, 6(3) : 203 - 213

PERANAN PEMEKACAHAYA $FeCl_3$ PADA FOTODEGRADASI PLASTIK POLIPROPILENA DENGAN PENGISI TURUNAN SELULOSA DAN PULP TANDAN KOSONG SAWIT

Purboyo Guritno, Basuki Wirjosentono, Zul Alfian[1], dan Ratu Evina Dibyantini[2]

ABSTRAK

Limbah bahan plastik dalam alam mungkin dapat terdegradasi bukan hanya secara biologis oleh pengaruh mikroba, tetapi juga disebabkan oleh sinar ultraviolet dalam cahaya matahari. Laju fotodegradasi bahan plastik dapat dipercepat dengan penambahan bahan pemekacahaya yang dapat terurai menjadi senyawa radikal pemicu degradasi bila terpapar radiasi ultraviolet. Dalam makalah ini diselidiki peranan pemekacahaya $FeCl_3$ terhadap sifat mekanis dan perilaku fotodegradasi campuran plastik polipropilena dengan pengisi: pulp tandan kosong sawit (PTKS), selulosa asetat (SA), dan selulosa diasetat (SDA). Sifat mekanis campuran plastik terlihat lebih dipengaruhi oleh kandungan serbuk pengisi, dengan kemuluran yang menurun bila kadar pengisi meningkat, sedangkan penambahan $FeCl_3$ dengan kadar 0 – 2 % tidak berdampak pada perubahan sifat mekanis campuran plastik. Kenaikan kadar pemekacahaya $FeCl_3$ secara linear mempercepat laju fotodegradasi, sedangkan jenis bahan pengisi tidak mempengaruhi jalannya fotodegradasi secara nyata. Pada tahap awal fotodegradasi pemekacahaya $FeCl_3$ diduga menyerap radiasi ultraviolet dan terurai menghasilkan radikal Cl. yang selanjutnya mampu memicu fotodegradasi campuran plastik. Hasil akhir fotodegradasi adalah pembentukan gugus hidroksida dan karbonil pada molekul plastik, yang akan meningkatkan sifat hidrofilisitas campuran plastik tersebut, yang berarti memperbesar kemudahan untuk terbiodegradasi dalam alam.

Kata kunci: tandan kosong sawit, pulp, turunan selulosa, pengisi plastik, polipropilena, pemekacahaya, fotodegradasi

PENDAHULUAN

Limbah padat hasil pertanian sebagai sumber selulosa, misalnya limbah padat kelapa sawit dapat digunakan sebagai bahan pengisi plastik hidrokarbon, seperti polipropilena, karena murah harganya, ringan, dan tersedia dalam jumlah yang besar. Narvang *et al.* (6) telah melaporkan pembuatan film plastik yang mudah terdegradasi menggunakan teknik ikatan silang antara pengisi tepung sagu dengan plastik polietilena linear rapatan rendah (Low density polypropylena, LLDPE). Akan tetapi kompatibilitas bahan pengisi turunan karbohidrat ini di dalam plastik polipropilena sangat rendah, sehubungan dengan sifat kepolarannya yang berbeda. Pada makalah terdahulu, senyawa turunan selulosa seperti: selulosa asetat (SA) dan selulosa diasetat (SDA) serta pulp tandan kosong sawit, telah berhasil digunakan sebagai pengisi plastik polipropilena (9). Telah pula dilaporkan oleh Day *et. al.* (1), dan Helmy (3), bahwa adanya bahan pengisi dalam matriks plastik dapat mempengaruhi perilaku fotodegradasi bahan tersebut.

Kemungkinan terjadinya degradasi bahan plastik dalam alam bukan hanya disebabkan oleh kerja biologis mikroba, tetapi juga oleh pengaruh sinar ultraviolet dalam cahaya matahari. Proses biodegradasi mungkin lebih dominan bilamana limbah

[1]Jurusan Kimia FMIPA, USU Medan
[2]FPMIPA UNIMED, Medan

plastik terkubur dalam tanah, sedangkan bilamana limbah plastik tersebut berada di atas permukaan maka proses fotodegradasi akan lebih mungkin terjadi. Radiasi ultraviolet (UV) dalam cahaya matahari yang dapat memicu fotodegradasi bahan plastik berada pada kisaran panjang gelombang 290 – 400 nm, yang intensitasnya sekitar 4 – 6 % dari total radiasi global. Radiasi UV ini mampu menginduksi proses fotokimia yang menghasilkan radikal bebas (R.) yang reaktif. Dengan adanya oksigen dalam udara, radikal bebas ini, selanjutnya berubah menjadi radikal peroksida yang dapat mengoksidasi molekul plastik membentuk gugus hidroksida dan karbonil (2,8). Fotodegradasi plastik polipropilena dapat dipercepat bila ditambahkan bahan pemekacahaya yang dapat membentuk radikal pemicu degradasi bila menyerap radiasi (7).

Pada makalah ini dilaporkan pengaruh pemekacahaya $FeCl_3$ terhadap sifat mekanis dan perilaku fotodegradasi campuran plastik polipropilena dengan pengisi: pulp tandan kosong sawit (PTKS), selulosa asetat (SA), dan selulosa diasetat (SDA). Selanjutnya, kemungkinan terjadinya perubahan struktur kimia campuran plastik juga diselidiki untuk meramalkan sifat biodegradasinya dalam alam.

BAHAN DAN METODE

Penelitian ini dilakukan pada laboratorium di Jurusan Kimia FMIPA USU, dan Pusat Penelitian Kelapa Sawit, Medan pada periode tahun 1997 – 1998.

Penyediaan campuran plastik polipropilena

Sampel campuran plastik polipropilena disiapkan menggunakan bahan pengisi: pulp tandan kosong sawit (PTKS), selulosa asetat (SA), dan selulosa diasetat (SDA), dengan konsentrasi optimum 20 % seperti yang telah dilaporkan terdahulu (9). Masing-masing campuran plastik ditambah pemekacahaya $FeCl_3$ pada berbagai konsentrasi 0 – 2 %. Campuran diaduk secara intensif dalam refluks dengan pelarut xilena selama 3 jam. Pelarut xilena kemudian diuapkan pada suhu kamar dan dalam vakum pada suhu 40 °C. Film sampel dengan tebal 0,2 mm disiapkan dengan cara cetak tekan (Paul Weber) pada suhu 180 °C selama masing-masing 3 menit tanpa dan dengan tekanan 100 kN. Spesimen untuk uji tarik disiapkan menurut ASTM D 638-72, dan untuk uji fotodegradasi berukuran 10 x 30 mm^2.

Uji fotodegradasi

Uji fotodegradasi film campuran plastik dilakukan menggunakan gabungan sumber radiasi ultraviolet dari 1 lampu UV Philips 20W, λ = 390 nm dan cahaya tampak dari 2 lampu TL Philips 20W, λ = 470 – 540 nm. Penyinaran dilakukan terusmenerus di dalam kabinet kayu ukuran 60 x 35 x 25 cm^3, yang dinding bagian dalamnya dilapisi foil aluminium. Sampel film diletakkan pada permukaan dinding dasar kabinet dengan jarak 30 cm dari sumber radiasi. Laju fotodegradasi diamati dengan mengukur waktu getas sampel film, yang selanjutnya dikonfirmasikan dengan pengamatan mikroskopi elektron payaran (SEM) dan spektroskopi FTIR.

HASIL DAN PEMBAHASAN

Sifat mekanis dan homogenitas campuran plastik

Sampel campuran plastik polipropilena yang mengandung pemekacahaya

$FeCl_3$ diuji sifat mekanisnya untuk dibandingkan dengan campuran plastik tanpa pemekacahaya. Data yang diperoleh (Tabel 1) memperlihatkan bahwa kandungan pemekacahaya sampai 2 % tidak mempengaruhi kekuatan tarik maupun kemuluran campuran plastik secara nyata.

Tabel 1. Kekuatan tarik (MPa) dan kemuluran (mm) dari spesimen campuran plastik polipropilena (ASTM D 638-72) yang mengandung 20 % pengisi dan pemekacahaya $FeCl_3$ (0 – 2 %)

No.	$FeCl_3$	Kekuatan Tarik (MPa)*			Kemuluran (mm)*		
		PTKS	SA	SDA	PTKS	SA	SDA
1	0	15,0	8,7	7,0	0,73	1,23	2,42
2	0,1	14,7	8,2	7,7	0,63	1,15	2,36
3	0,25	14,7	9,9	6,2	0,72	1,10	2,36
4	0,5	13,4	8,2	5,0	0,64	1,00	2,36
5	1,0	13,7	8,9	6,8	0,67	1,10	2,36
6	2,0	14,4	7,8	6,7	0,69	1,12	2,35

*Spesimen campuran plastik polipropilena mengandung 20 % pengisi: PTKS: pulp tandan kosong sawit, SA: selulosa asetat, SDA: selulosa diasetat

Kenyataan tersebut di atas mungkin disebabkan oleh tidak adanya interaksi kimia maupun fisika yang berarti yang menghubungkan antara pemekacahaya dengan bahan pengisi dan matriks polipropilena. $FeCl_3$ yang mula-mula dilarutkan dalam air dan selanjutnya dicampurkan dengan serbuk pengisi, setelah dikeringkan akan terdistribusi pada fase permukaan serbuk. Selanjutnya, tidak adanya gugus nonpolar pada molekul $FeCl_3$ menyebabkan interaksinya dengan matriks polipropilena tidak terjadi.

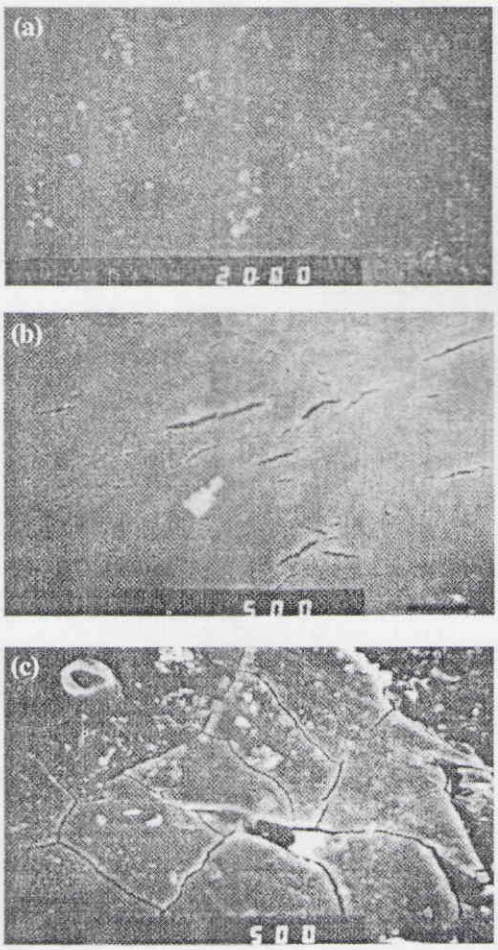
Peranan pemekacahaya $FeCl_3$ terhadap fotodegradasi campuran plastik

Laju fotodegradasi film campuran plastik polipropilena yang mengandung $FeCl_3$ (0 - 2 %) diamati dengan mengukur waktu getas sampel film, yaitu waktu penyinaran sampai sampel retak bila dilipat 180°. Tabel 2 memperlihatkan bahwa dengan uji penyinaran kenaikan kadar pemekacahaya $FeCl_3$ sebanding dengan percepatan laju fotodegradasi untuk semua sampel film. Hal ini mungkin disebabkan oleh pembentukan radikal Cl. Bila $FeCl_3$ menyerap radiasi ultraviolet menurut reaksi :

$$FeCl_3 + h\nu \rightarrow FeCl_2 + Cl.$$

Selanjutnya radikal Cl. tersebut akan bereaksi dengan molekul plastik dan membentuk radikal makro P. yang merupakan pemicu reaksi fotodegradasi. Dalam hal ini tidak terlihat indikasi interaksi antara $FeCl_3$ dengan molekul bahan pengisi selama proses fotodegradasi. Reaksi fotokimia di atas tidak dipengaruhi oleh adanya berbagai jenis bahan pengisi, sehingga pada Tabel 2 tidak terlihat pengaruh berbagai jenis pengisi terhadap laju fotodegradasi sampel plastik. Hasil akhir fotodegradasi adalah senyawa hidroksida dan karbonil, serta perubahan struktur molekul lainnya seperti: pemutusan rantai maupun pembentukan ikatan silang, yang menyebabkan sampel plastik menjadi getas dan retak. Foto SEM film campuran plastik

setelah fotodegradasi, Gambar 1a – 1c, memperlihatkan perubahan morfologis dan pembentukan retakan pada permukaan sampel sebagai akibat perubahan sifat mekanis tersebut.



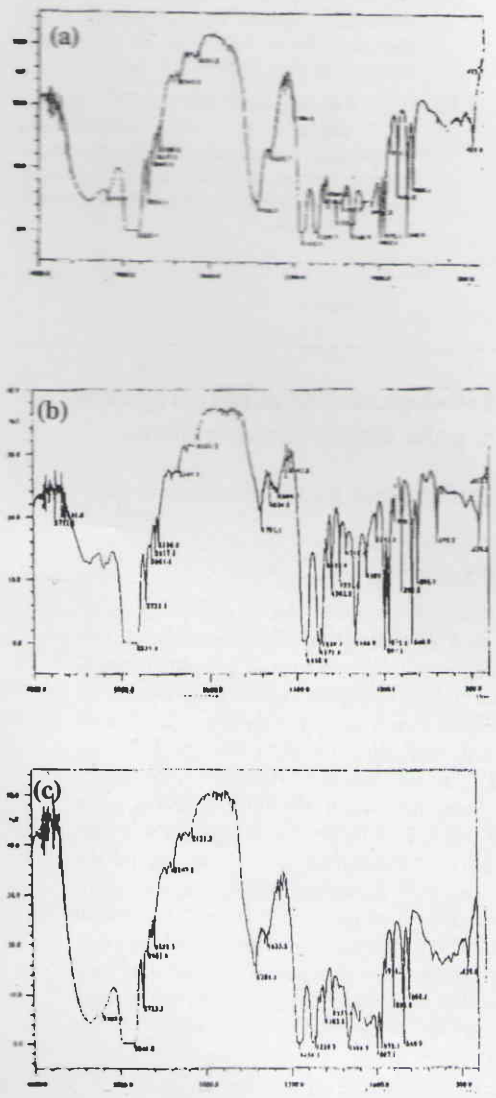
Gambar 1. Fotograf SEM setelah perlakuan fotodegradasi film campuran plastik polipropilena yang mengandung: (a) Tanpa aditif (Pembanding) (b) 20 % PTKS, (c) 20 % PTKS + 2 % $FeCl_3$

Tabel 2. Waktu getas selama perlakuan fotodegradasi film campuran plastik polipropilena yang mengandung 20 % bahan pengisi: PTKS, SA, dan SDA, serta berbagai kadar pemekacahaya $FeCl_3$

No.	$FeCl_3$ (%)	Waktu Getas (Jam)*		
		PTKS	SA	SDA
1	0	960	888	936
2	0,1	840	720	768
3	0,25	672	624	648
4	0,5	504	600	624
5	1,0	495	521	504
6	2,0	480	465	492

*Spesimen campuran plastik polipropilena mengandung 20 % pengisi: PTKS: pulp tandan kosong sawit, SA: selulosa asetat, SDA: selulosa diasetat

Dalam hal lain, selama pengolahan oleh pengaruh panas dan gesekan bahan plastik dapat mengalami degradasi termal yang diawali oleh pembentukan radikal bebas. Bila pengolahan dilakukan di bawah atmosfer udara, oksigen akan terlibat dalam proses degradasi menghasilkan senyawa teroksidasi (4). Dilaporkan bahwa senyawa teroksidasi yang mengandung gugus hidroksida atau karbonil mampu berperan sebagai pemekacahaya pada proses fotodegradasi selanjutnya (5). Perubahan struktur molekul plastik tersebut selama fotodegradasi dapat diamati dari spektra FTIR pada Gambar 2a-c. Ketiga spektra FTIR tersebut memperlihatkan munculnya puncak serapan gugus hidroksida pada bilangan gelombang 3400 cm^{-1} dan serapan gugus karbonil pada 1700 cm^{-1}. Terbentuknya gugus hidroksida dan karbonil pada rantai molekul plastik sebagai akibat fotodegradasi ini akan meningkatkan sifat hidrofilisitasnya. Karena itu dapat diharapkan bahwa campuran plastik polipropilena dengan pengisi turunan selulosa dan pulp tandan kosong sawit, yang telah terfotodegradasi oleh bantuan $FeCl_3$, akan lebih mudah terbiodegradasi dalam alam.



Gambar 2. Spektra FTIR setelah perlakuan fotodegradasi dari film campuran plastik polipropilena yang mengandung : (a) 20 % PTKS + 2 % $FeCl_3$, (b) 20 % SA + 2 % $FeCl_3$, (c) 20 % SDA + 2 % $FeCl_3$

KESIMPULAN

Campuran plastik polipropilena dengan bahan pengisi pulp tandan kosong sawit (PTKS), selulosa asetat (SA), dan selulosa diasetat (SDA) kompatibel pada kadar bahan pengisi mencapai 20 %.

Penambahan bahan pengisi menurun kemuluran, sedangkan kadar $FeCl_3$ tidak memperlihatkan pengaruh yang nyata terhadap sifat mekanis campuran plastik.

Kenaikan kadar pemekacahaya $FeCl_3$ secara linear mempercepat laju fotodegradasi, sedangkan jenis bahan pengisi tidak mempengaruhi jalannya fotodegradasi campuran plastik.

Munculnya gugus hidroksida dan karbonil selama fotodegradasi dapat meningkatkan sifat hidrofilisitas campuran plastik, sehingga diharapkan akan lebih mudah terbiodegradasi dalam alam.

DAFTAR PUSTAKA

1. DAY, M., J. D. COONEY and M. MACKINNEN, 1995. Degradation of contaminated plastics. polym. Deg. & Stability, 48, 341.

2. GIJSMAN, P. and J. SAMPERS. 1997. The influence of oxygen pressure and temperature on the uv-degradation of polyethylene. Polym. Deg. & Stability, 58, 55.

3. HELMY, S. A. 1993. The study on alkaline degradation of cellulose: part II. Effect of the supermolecular structure of pulp. Polym. Deg. & Stability. 39, 159.

4. KELLY, C. and J. R. WHITE. 1997. Photodegradation of polyethylene and polypropylene at slow strain rate. Polym. Deg. & Stability. 56. 367.

5. LEE, M., T. COSTAS and C. PARK. 1998. Extrusion of PE/PS blends with supercritical carbon dioxide. J. Polym. Eng. & Sci. 38. 1112.

6. NAWANG, R. F. D. DANJAJI, H. ISMAIL, U. S. ISHIAKU and Z. A. ISHAK. 1997. Degradable films made from crosslinked sago starch and linear low density polyethylene

(LLDPE): The mechanical properties, water sorption and degradation. Proc. of Lignocellulosic Conference. School of Industrial Chemistry, Universiti Sains Malaysia.

7. RANBY, B. 1998. Photochemical modification of polymers photocrosslinking, surface photografting and lamination. J. Polym. Eng. & Sci, 38, 1229.

8. ROBELLO, M. S and J. R. WHITE. 1997. The role of physical structure and morphology in the photodegradation behaviour of polypropylene. Polym. Deg. & Stability, 56, 55.

9. WIRJOSENTONO, B., P. GURITNO, D.Y. NASUTION, dan ARNETTY. 1998. Kompatibilitas dan biodegradasi plastik polipropilena dengan pengisi turunan selulosa dan pulp tandan kosong sawit. Jurnal Penelitian Kelapa Sawit. 6(2) : 153 – 164.

The role of $FeCl_3$ as photosensitiser on photodegradation of polypropylene containing cellulose derivative and oil palm empty bunches fillers

Purboyo Guritno, Basuki Wirjosentono, Zul Alfian[1], and Ratu Evina Dibyantini[2]

Abstract

Plastic wastes in nature may be degraded not only biologically due to micro-organism actions but also because of ultraviolet radiation in sunlight. Rate of the photodegradation can be accelerated by addition of a photosensitiser, which may decompose to produce degradation-initiating radical when exposed to the radiation. Therefore, the role of photosensitiser $FeCl_3$ on mechanical properties and photodegradation behaviour of polypropylene blends containing various fillers: oil palm empty bunches pulp (OPEBP), cellulose acetate (CA) and cellulose diacetate (CDA) had been investigated. The mechanical properties were more affected by the filler contents, with decrease in elongation when the filler contents were increased, whereas addition of photosensitiser $FeCl_3$ up to 2 % did not show any effects on the mechanical properties. Increase in the photosensitiser concentration linearly increased the rate of photodegradation, whereas type of fillers did not show considerable effect on the extent of photodegradation. In the initial step, the photosensitiser was assumed to absorb ultraviolet radiation and decomposed to produce Cl. radical, which then initiated photodegradation of the plastic blends. Final stages of the photodegradation were formation of hydroxyl and carbonyl groups onto the plastic molecules. This then may improve hydrophylicity of the plastic blends and hence increasing their ability to undergo biodegradation in nature.

Keywords: oil palm empty bunches, pulp, cellulose derivatives, plastic filler, polypropylene, photosensitiser, photodegradation

[1]Department of Chemistry, Faculty of Sciences USU, Medan
[2]Department of Chemistry, Faculty of Science Education UNIMED, Medan

Introduction

Agricultural solid wastes as raw material for cellulose, e.g. oil palm solid wastes, can be used as fillers for hydrocarbon plastics, like polypropylene, since their low weight, low price, and availability in large scale. Nawang *et. al.* (6) have reported production of degradable plastic films using crosslinking technique between sago starch and linear low density polyethylene (LLDPE). However, compatibility of the carbohydrate derivative fillers in polypropylene matrix is very low, because of differences in their polarity. In the previous paper, cellulose derivatives like: cellulose acetate (CA) and cellulose diacetate (CDA), and oil palm empty bunches pulp (OPEBP), have been used as fillers for polypropylene plastic (9). It has also been reported by Day *et. al.* (1), and Helmy (3), that the presence of fillers in plastic matrix may affect photodegradation behaviour of the materials. Possibility of degradation of plastic materials in nature is not only due to biodegradation action by microorganisms, but also because of ultraviolet radiation in sunlight. The biodegradation process may be more dominant when the plastic material is buried underground, whereas if the plastic wastes present on the surface photodegradation action is more possible to occur. Ultraviolet (UV) radiation in sunlight initiating photodegradation of plastic materials possesses wavelength range: 290 – 400 nm, with intensity around 4 – 6 % of total global radiation. The radiation is able to induce photochemical reaction to form free radicals (R.). In the presence of oxygen from the atmosphere, the free radical may produce reactive peroxy radical. Which then oxidising plastic molecules to produce hydroxyl and carbonyl groups (2,8). Photodegradation of the hydrocarbon plastics can be accelerated by addition of photosensitiser which function to form degradation-initiating radical when exposed to UV radiation (7).

In this work, the role of photosensitiser $FeCl_3$ on mechanical properties and photodegradation behaviour of polypropylene blends containing fillers: oil palm empty bunches pulp (OPEBP), cellulose acetate (CA), and cellulose diacetate (CDA) was investigated. Moreover, possibilities of occurrence of chemical structure changes of the blends were also studied to predict their biodegradation behaviour after experienced photodegradation.

Materials and Methods

This work was carried out in laboratories of the Department of Chemistry, Faculty of Sciences, University of North Sumatera, and of the Indonesian Oil Palm Research Institute in Medan, in the periods of 1997 – 1998.

Preparation of polypropylene plastic blends

Samples of polypropylene blends were prepared using fillers: oil palm empty bunches pulp (OPEBP), cellulose acetate (CA), and cellulose diacetate (CDA) at optimum concentration 20 % as has been reported in the previous paper (9). Each sample was added by various concentrations of 0 – 2 % $FeCl_3$ as photosensitiser. The mixtures were intensively mixed in reflux using xylene solvent for 3 hours. The solvent was then evaporated at room temperature and in vacuum at 40°C. Sample films 0.2 mm in thickness were prepared by compression moulded (Paul Weber) at 180°C for 3 minutes without and

another 3 minutes with 100 kN pressure. Test specimens for mechanical properties were according to ASTM D 638-72, and 10 x 30 mm^2 in size for photodegradation tests.

Photodegradation test

Photodegradation tests for the plastic blends were carried out using combination of one UV radiation (UV Philips 20W, λ = 390 nm) and two visible lights (TL Philips 20W, λ = 470 – 540 nm). Irradiation was done continuously in a wooden cabinet 60 x 35 x 25 cm^3 in size, whose interior was laminated with aluminium foil. The film samples were laid on the floor of the cabinet 30 cm normal to the lightsource installed on the ceiling. Rate of the photodegradation was followed by measurement of embritlement time, and confirmed by FTIR spectroscopy.

Results and discussions

Mechanical properties and homogenity of plastic blends

Samples of polypropylene blends containing various concentration of $FeCl_3$ as photosensitiser were tested for their mechanical properties and compared to that of without photosensitiser. The data found were tabulated in Table 1, indicating that photosensitiser concentration upto 2 % did not affect on the tensile strength or elongation of the blends. This may be due to that there was no considerable chemical or physical interactions between the photosensitiser and the polypropylene matrix. The $FeCl_3$ previously dissolved in water and then mixed with the filler powder, after drying will be distributed onto the filler surface. Furthermore, due to the absence of nonpolar group on the photosensitiser molecule resulted the lack of strong interaction with the polypropylene matrix.

The role of photosensitiser $FeCl_3$ on the photodegradation of plastic blends

Rate of photodegradation of the plastic films containing 0 – 2 % of $FeCl_3$ was measured from embritlement time of the films, i.e. time of irradiation until the films embritle when bended to 180°. Table 2 showed that during irradiation, increased in the concentration of $FeCl_3$ also linearly increased rate of the photodegradation for every sample. This may be due to formation of Cl. radicals when $FeCl_3$ molecules absorb UV radiation according to the following reaction:

$$FeCl_3 + h\nu \rightarrow FeCl_2 + Cl.$$

Table 1. Tensile strength (MPa) and elongation (mm) of polypropylene blend specimens (ASTM D 638-72) containing 20 % of fillers and photosensitiser $FeCl_3$ (0 – 2 %)

No.	$FeCl_3$	Tensile strength (MPa)*			Elongation (mm)*		
		OPEBP	CA	CDA	OPEBP	CA	CDA
1	0.00	15.0	8.7	7.0	0.73	1.23	2.42
2	0.10	14.7	8.2	7.7	0.63	1.15	2.36
3	0.25	14.7	9.9	6.2	0.72	1.10	2.36
4	0.50	13.4	8.2	5.0	0.64	1.00	2.36
5	1.00	13.7	8.9	6.8	0.67	1.10	2.36
6	2.00	14.4	7.8	6.7	0.69	1.12	2.35

*Polypropylene blend specimens containing 20 % of fillers: OPEBP: oil palm empty bunches pulp, CA: cellulose acetate, CDA: cellulose diacetate

Table 2. Embritlement time during photo-degradation of polypropylene plastic blend films containing 20 % of fillers: OPEBP, CA, and CDA, in the presence of various concentration of photosensitiser FeCl3

No	$FeCl_3$ (%)	Embritlement time (hours)*		
		OPEBP	CA	CDA
1	0.00	960	888	936
2	0.10	840	720	768
3	0.25	672	624	648
4	0.50	504	600	624
5	1.00	495	521	504
6	2.00	480	465	492

* = Polypropylene blend specimens containing 20 % of fillers: OPEBP: oil palm empty bunches pulp, CA: cellulose acetate, CDA: cellulose diacetate

Furthermore the Cl. radicals reacted with polypropylene plastic molecules to form photodegradation-initiating macro-radical R. On the other hand, there was no evidence of interaction between the $FeCl_3$ with the filler materials during photo-degradation process. In other words that the above photochemical reaction was not affected by the presence of various fillers, and hence Table 2 did not show any effect of type filler in the rate of photodegradation. Final products of the photodegradation were hydroxyl and carbonyl compounds, as well as other molecular structure changes such as: chain scission and crosslinking formation, which resulted in formation of embritlement and cracks on the plastic samples. SEM photograph of plastic blends films after photodegradation (Figures 1a – 1c), showed morphological changes and formation of cracks on the surface of the samples due to changes of mechanical properties.

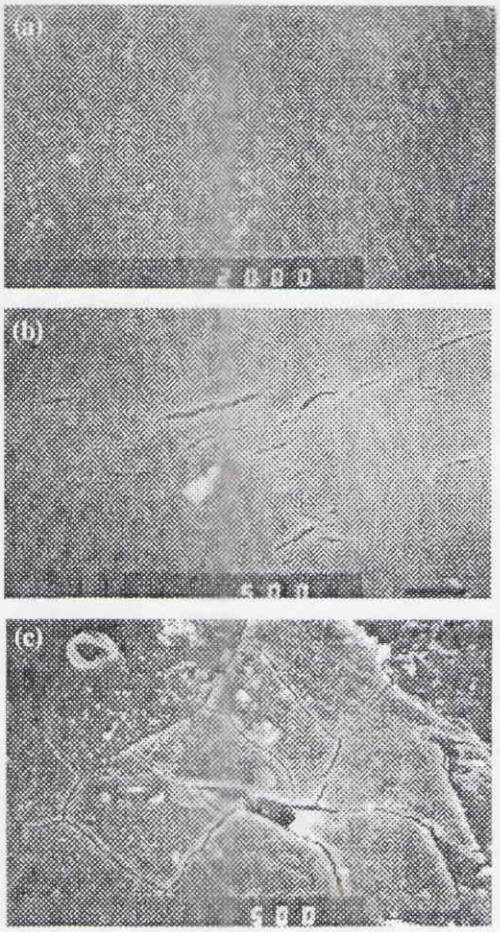


Figure 1. SEM photographs after photodegradation of polypropylene blend films containing: (a) Without additive (Control), (b) 20 % OPEBP, (c) 20 % OPEBP + 2 % $FeCl_3$

It has been reported that during processing due to the effects of heat and shear plastic materials may degrade thermally, initiated also by free radical formation. When the processing is carried out under air atmosphere, oxygen may involve in the degradation process producing oxygenated

(4). The last compounds containing hydroxyl and carbonyl groups may also function as photosensitiser for further photodegradation of the plastic materials (5). Molecular structure changes of the plastic blends during photodegradation can be observed from FTIR spectra in Figures 2a – 2c.The three FTIR spectra clearly showed absorption of hydroxyl group (-OH) at wave number: 3400 cm^{-1} and of carbonyl group (>C=O) at 1700 cm^{-1}. Formation of these polar groups on the plastic molecules during the photodegradation my improve their hydrophilicity. Therefore, it is expected that polypropylene plastic blends containing cellulose derivatives and oil palm empty bunches pulp fillers after photodegradation in the presence of $FeCl_3$ as photosensitiser, will be more biodegradable in nature.

Conclusions

Polypropylene plastic blends containing fillers: oil palm empty bunches pulp (OPEBP), cellulose acetate (CA), and cellulose diacetate (CDA) in the presence of $FeCl_3$ upto 2 % were compatible upto filler content: 20 %.

Addition of fillers decreased elongation of the plastic blends, whereas $FeCl_3$ content up to 2 % did not show substantial effect on the mechanical properties.

Increased in $FeCl_3$ concentration as photosensitiser, linearly accelerated the rate of photodegradation, whereas type of fillers did not affected the extent of the photodegradation.

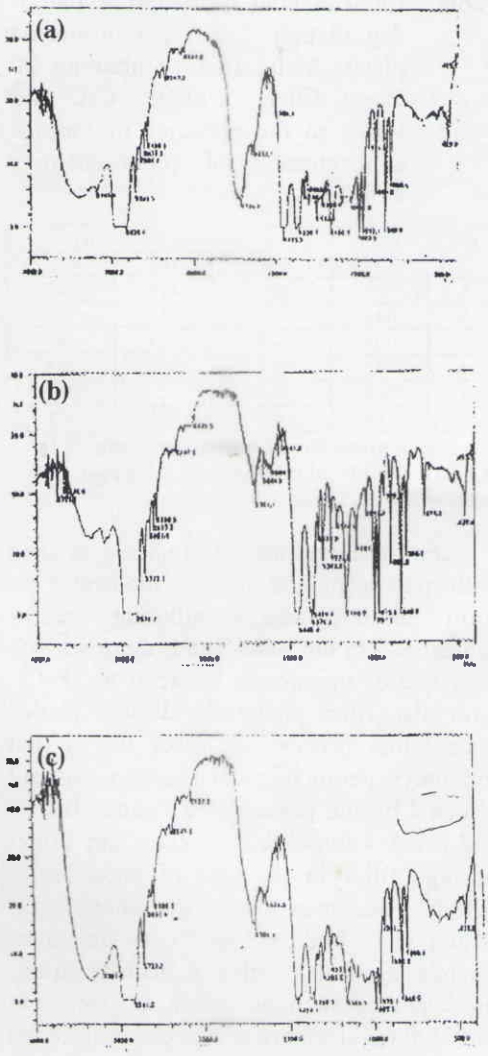


Figure 2. FTIR spectra after photodegradation of polypropylene blend films containing (a) 20 % OPEBP + 2 % $FeCl_3$, (b) 20 % CA + 2 % $FeCl_3$, (c) 20 % CDA + 2 % $FeCl_3$

References

1. DAY, M., J. D. COONEY and M. MACKINNEN, 1995. Degradation of contaminated plastics. polym. Deg. & Stability, 48, 341.
2. GUSMAN, P. and J. SAMPERS. 1997. The influence of oxygen pressure and temperature on the uv-degradation of polyethylene. Polym. Deg. & Stability, 58, 55.
3. HELMY, S. A. 1993. The study on alkaline degradation of cellulose: part II. Effect of the supermolecular structure of pulp. Polym. Deg. & Stability. 39, 159.
4. KELLY, C. and J. R. WHITE. 1997. Photodegradation of polyethylene and polypropylene at slow strain rate. Polym. Deg. & Stability. 56, 367.
5. LEE, M., T. COSTAS and C. PARK. 1998. Extrusion of PE/PS blends with supercritical carbon dioxide. J. Polym. Eng. & Sci, 38, 1112.
6. NAWANG, R. F. D. DANJAJI, H. ISMAIL, U. S. ISHIAKU and Z. A. ISHAK. 1997. Degradable films made from crosslinked sago starch and linear low density polyethylene (LLDPE): The mechanical properties, water sorption and degradation. Proc. of Lignocellulosic Conference. School of Industrial Chemistry, Universiti Sains Malaysia.
7. RANBY, B. 1998. Photochemical modification of polymers photocrosslinking, surface photografting and lamination. J. Polym. Eng. & Sci. 38, 1229.
8. ROBELLO, M. S and J. R. WHITE. 1997. The role of physical structure and morphology in the photodegradation behaviour of polypropylene. Polym. Deg. & Stability. 56, 55.
9. WIRJOSENTONO, B., P. GURITNO, D.Y. NASUTION, dan ARNETTY. 1998. Kompatibilitas dan biodegradasi plastik polipropilena dengan pengisi turunan selulosa dan pulp tandan kosong sawit. Jurnal Penelitian Kelapa Sawit. 6(2) : 153 - 164.

ooOoo