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KOMPATIBILITAS DAN BIODEGRADASI PLASTIK POLIPROPILENA DENGAN PENGISI TURUNAN SELULOSA DAN PULP TANDAN KOSONG SAWIT

Basuki Wirjosentono, Purboyo Guritno, Darwin Yunus Nasution[1], dan Arnetty[2]

ABSTRAK

Kompatibilitas antara pengisi turunan selulosa dan pulp tandan kosong sawit di dalam matriks polipropilena serta sifat biodegradasinya tergantung pada sifat termoplastis dan hidrofilisitas dari bahan pengisi tersebut. Untuk itu diselidiki pengaruh struktur turunan selulosa yaitu: selulosa asetat dan selulosa diasetat, terhadap kompatibilitas dan biodegradabilitasnya dalam matriks polipropilena, yang dibandingkan dengan untuk pulp tandan kosong sawit. Campuran plastik dengan bahan pengisi yang disiapkan dengan cara refluks dalam pelarut xilena, dikarakterisasi kompatibilitasnya dengan teknik: uji sifat mekanis, mikroskop elektron payaran (SEM) dan uji sifat termal. Pengujian sifat biodegradasi bahan plastik dilakukan dengan cara: penguburan dalam tanah dan perendaman dalam medium bermikroba pseudomonas aerogenosa. *Dilaporkan bahwa tidak terlihat perubahan yang nyata dari kompatibilitas bahan pengisi dalam matriks polipropilena oleh perbedaan sifat termoplastis atau sifat hidrofilisitasnya. Secara mikroskopis terlihat bahwa setelah uji biodegradasi, spesimen uji menjadi lebih kasar permukaannya, membentuk retakan, dan berlubang-lubang. Penurunan berat spesimen uji pada penguburan dalam tanah sampah, terlihat lebih besar dibandingkan dengan bila dilakukan uji biodegradasi dalam media bakteri* pseudomonas aerogenosa. *Hal ini mungkin disebabkan oleh mikroba yang terdapat dalam tanah sampah telah beradaptasi dan mempunyai keaktifan yang lebih baik dibandingkan dengan biakan murninya. Dalam hal lain juga ada kemungkinan kerja sinergisme antara kegiatan berbagai mikroba yang terdapat dalam tanah uji penguburan.*

Kata kunci: tandan kosong sawit, pulp, turunan selulosa, pengisi plastik, polipropilena, kompatibilitas, biodegradasi

PENDAHULUAN

Plastik polipropilena (PP) banyak digunakan sebagai bahan kemasan berbentuk film dan kantong yang pada pasca pemakaian sukar terdegradasi dalam alam, sehingga menimbulkan masalah pencemaran. Telah diketahui bahwa penambahan pengisi pati jagung atau pati kentang ke dalam bahan polipropilena menghasilkan campuran plastik yang dapat terdegradasi dan telah diproduksi secara komersial (1, 7). Dalam hal lain, tandan kosong sawit dan limbah padat perkebunan lainnya merupakan sumber karbohidrat dan lignoselulosa yang potensial, karena tersedia dalam jumlah besar dan murah harganya. Limbah padat tersebut diharapkan dapat dimanfaatkan sebagai pengganti pati untuk bahan

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pengisi plastik yang dapat terdegradasi. Masalah yang dihadapi adalah rendahnya kompatibilitas bahan pengisi ini dengan matriks polipropilena, sehubungan dengan sifat kepolaran yang berbeda (3, 4, 5).

Dalam makalah ini diselidiki pengaruh adanya gugus asetat dari bahan pengisi: selulosa asetat (Tl: 240°C), selulosa diasetat (Tl: 235°C), dan pulp tandan kosong sawit terhadap kompatibilitas dan sumbangan sifat degradabilitasnya dalam matriks polipropilena. Substitusi gugus hidroksida dengan gugus asetat dapat meningkatkan sifat termoplastis atau menurunkan sifat hidrofilisitas dari turunan selulosa, yang diharapkan dapat berakibat pada kenaikan kompatibilitas, walaupun mungkin juga penurunan sifat degradabilitasnya. Derajat kompatibilitas campuran plastik yang dihasilkan diamati menggunakan teknik mikroskopi elektron payaran (SEM) dan pengujian sifat mekanis, seperti yang telah dilakukan oleh Zaini *et al.* (8,9). Sedangkan sifat biodegradasi bahan plastik ini diselidiki dengan cara yang telah dilaporkan oleh Nakashima dan Matsuo (2), serta Timmins dan Lenz (6), yaitu dengan metode penguburan dalam tanah dan perendaman dalam media bermikroba *pseudomonas aerogenosa*.

BAHAN DAN METODE

Bahan

Plastik polipropilena komersial (Philips), selulosa asetat dan selulosa diasetat (BDH Chemicals) digunakan langsung tanpa pemurnian. Pulp tandan kosong sawit disiapkan pada Balai Besar Selulosa, Bandung, sedangkan bakteri *pseudomanas aerogenosa* serta nutrient laktosa Broth diperoleh dari Laboratorium Mikrobiologi FMIPA USU, Medan.

Penyediaan campuran plastik dan spesimen uji

Bahan pengisi turunan selulosa dan pulp tandan kosong sawit (PTKS) dihaluskan sampai ukuran 53 μm. Plastik polipropilena komersial yang ditambahi berbagai jenis dan jumlah serbuk pengisi dilarutkan dengan cara refluks dalam xilena dan pengadukan intensif selama 3 jam. Pelarut xilena kemudian diuapkan pada suhu kamar dan dalam vakum pada suhu 40°C. Campuran plastik yang kering dicetak tekan (Paul Weber) membentuk film dengan tebal 0,2 mm pada suhu 180°C selama 3 menit tanpa tekanan dan dengan tekanan 100 kN selama 3 menit. Spesimen uji mekanis dibentuk menurut ASTM D 638-72 Type IV, (lebar 6 mm dan panjang 64mm) sebanyak 3 buah untuk setiap sampel. Sampel uji biodegradasi berukuran 10 mm x 30 mm.

Karakterisasi dan uji biodegradasi

Uji kuat tarik dan kemuluran dari 3 spesimen untuk setiap sampel campuran plastik dilakukan menggunakan Tokyo Testing Machine Type SC2DE. Homogenitas campuran plastik diamati menggunakan teknik mikroskopi elektron payaran (SEM). Uji biodegradasi dilakukan dengan perendaman 3 spesimen steril dari tiap sampel campuran plastik ke dalam media dan mengamati jalannya biodegradasi melalui penurunan berat setiap spesimen. Perubahan struktur kimia campuran plastik setelah biodegradasi dikonfirmasikan dengan metode spektroskopi inframerah FTIR.

HASIL DAN PEMBAHASAN

Kompatibilitas bahan pengisi turunan selulosa dan pulp tandan kosong sawit dengan matriks polipropilena

Kekuatan tarik (MPa) dan kemuluran (mm) dari spesimen campuran plastik pada berbagai komposisi dan jenis serbuk pengisi terlihat pada Tabel 1. Bila dibandingkan dengan bahan plastik polipropilena komersial, penambahan pengisi pulp tandan kosong sawit (PTKS), selulosa asetat (SA), maupun selulosa diasetat (SDA) akan menurunkan kekuatan tarik dan juga kemuluran campuran plastik. Homogenitas campuran juga menurun bila kadar serbuk pengisi dinaikkan sampai 40%. Tidak terlihat perbedaan yang nyata dari pengaruh jenis pengisi terhadap homogenitas maupun sifat mekanis campuran plastik untuk kadar pengisi yang setara. Ini berarti bahwa adanya gugus asetat yang meningkatkan sifat termoplastis pengisi turunan selulosa tidak berinteraksi efektif dengan matriks polipropilena. Serbuk pengisi tersebut masih membentuk fase tersendiri setelah pencampuran dengan plastik polipropilena dengan metode refluks dalam pelarut xilena. Hal ini mungkin disebabkan oleh rendahnya suhu refluks (135°C) dan kelarutan serbuk pengisi turunan selulosa (SA dan SDA) yang rendah dalam pelarut xilena. Untuk itu diperlukan pengolahan pada suhu tinggi, di atas titik leleh pengisi turunan selulosa (~250°C), agar diperoleh campuran yang homogen, walaupun perlu diperhatikan kemungkinan terjadinya dekomposisi bahan pengisi. Komposisi optimum campuran plastik polipropilena dengan serbuk pengisi turunan selulosa yang mempunyai kekuatan tarik dan kemuluran memadai dipilih dengan kadar pengisi 20%.

Tabel 1. Kekuatan tarik (MPa) dan kemuluran (mm) dari campuran plastik polipropilena dengan berbagai kandungan bahan pengisi: pulp tandan kosong sawit (PTKS), selulosa asetat (SA), dan selulosa diasetat (SDA)

Kadar Pengisi (%)	Kekuatan tarik (MPa)*			Kemuluran (mm)*		
	(PTKS)	(SA)	(SDA)	(PTKS)	(SA)	(SDA)
0	11	11,0	11,0	2,35	2,35	2,35
10	13,7	9,6	10,3	2,21	1,85	2,42
20	15,0	8,7	7,0	1,73	1,23	1,66
30	12,9	7,5	6,4	1,42	1,29	1,33
40	10,0	6,0	5,6	1,31	1,24	1,26

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

Uji biodegradasi sampel campuran plastik polipropilena

Sampel film campuran plstik polipropilena, (masing-masing 3 spesimen, tebal 0,2 mm, lebar 10 mm, panjang 30 mm), yang mengandung 20% serbuk pengisi PTKS, SA, dan SDA dibersihkan dan disterilkan dengan alkohol, lalu dikeringkan dan ditimbang. Kemudian dikuburkan dalam tanah sampah dari Tempat Pembuangan Akhir (TPA) Pancur Batu, Medan, dengan kelembaban dan suhu tetap (30°C). Perubahan berat rata-rata spesimen selama perlakuan biodegradasi ini, diperlihatkan pada Tabel 2.

Tabel 2. Perubahan berat spesimen campuran plastik polipropilena dengan 20% serbuk pengisi: PTKS, SA, dan SDA selama penguburan dalam tanah sampah

Waktu Penguburan (hari)	Berat spesimen (g) yang mengandung 20% pengisi		
	(PTKS)	(SA)	(SDA)
0	0,124	0,089	0,089
15	0,101	0,086	0,083
30	0,078	0,070	0,082
45	0,075	0,054	0,081
60	0,075	0,050	0,081

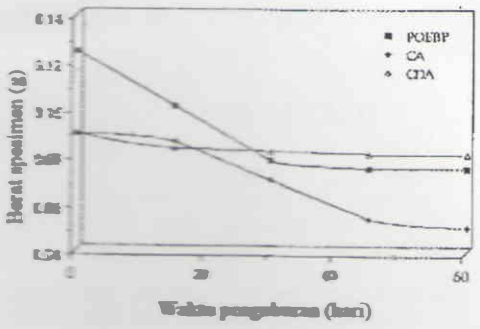
Keterangan: PTKS: pulp tandan kosong sawit, SA: selulosa asetat, SDA: selulosa diasetat

Dengan cara yang sama dilakukan uji biodegradasi dalam media laktosa Broth bermikroba *pseudomonas aerogenosa* menggunakan inkubator 30°C, untuk semua sampel campuran plastik. Diperoleh data perubahan berat rata-rata spesimen seperti pada Tabel 3. Plot perubahan berat spesimen selama penguburan dalam tanah terhadap waktu terlihat pada Gambar 1, sedangkan untuk perlakuan pada perendaman dalam media *pseudomonas aerogenosa* terlihat pada Gambar 2. Dari data perubahan berat spesimen selama perlakuan biodegradasi di atas (Tabel 2 & 3, serta Gambar 1 & 2), bahwa laju biodegradasi dengan penguburan dalam tanah sampah terlihat nyata, khususnya untuk campuran plastik yang mengandung serbuk pengisi PTKS dan SA. Spesimen dengan pengisi SDA terlihat tidak menunjukkan laju biodegradasi yang berarti. Hal ini mungkin disebabkan oleh rendahnya hidrofilisitas SDA yang mengandung dua gugus asetat per satuan ulangan bila dibandingkan dengan PTKS dan SA. Hal yang menarik bahwa laju biodegradasi pada penguburan dalam tanah sampah dari sampel campuran plastik tersebut lebih besar bila dibandingkan dengan pada perendaman dalam media bermikroba *pseudomonas aerogenosa* murni. Hal ini mungkin disebabkan bahwa mikroba yang terdapat dalam tanah sampah telah beradaptasi dan mempunyai keaktifan lebih baik dibandingkan dengan biakan murninya. Adanya kerja sinergisme antara beberapa jenis mikroba (bakteri atau jamur) di dalam tanah sampah mungkin juga menyebabkan laju biodegradasi campuran plastik yang lebih besar.

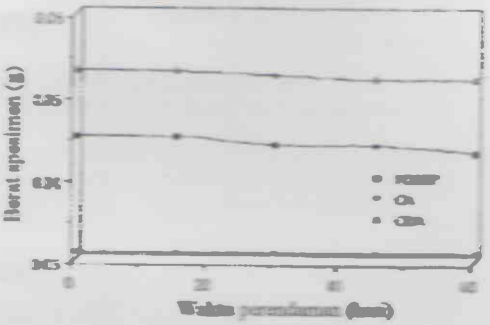
Tabel 3. Perubahan berat spesimen campuran plastik polipropilena dengan 20% serbuk pengisi: PTKS, SA, dan SDA selama perendaman dalam media lektosa Broth bermikroba *pseudomonas aerogenosa*

Waktu Perendaman (hari)	Berat spesimen (g) yang mengandung 20% pengisi		
	(PTKS)	(SA)	(SDA)
0	0,045	0,031	0,053
15	0,045	0,031	0,053
30	0,044	0,031	0,052
45	0,044	0,031	0,052
60	0,043	0,031	0,052

Keterangan: PTKS: pulp tandan kosong sawit, SA: selulosa asetat, SDA: selulosa diasetat

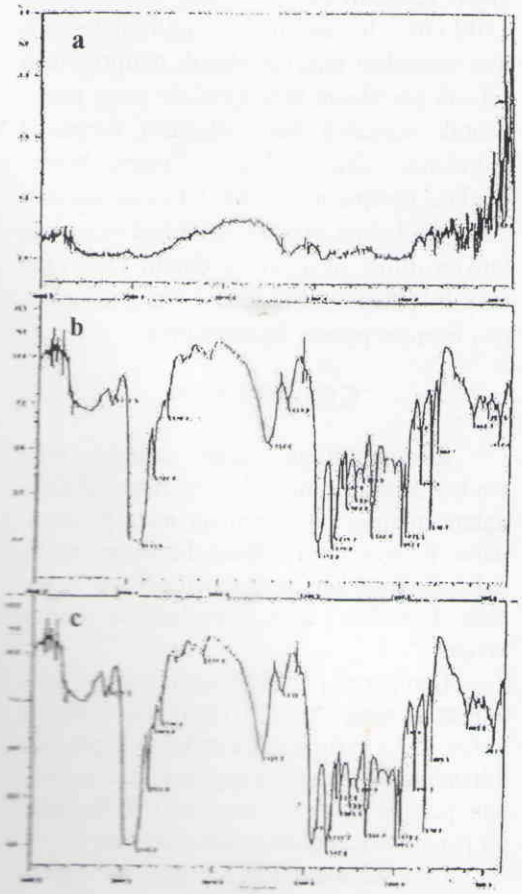


Gambar 1. Plot perubahan berat terhadap waktu dari spesimen film polipropilena yang mengandung 20% berbagai serbuk pengisi selama perlakuan penguburan dalam tanah sampah



Gambar 2. Plot perubahan berat terhadap waktu dari spesimen film polipropilena yang mengandung 20% serbuk pengisi selama perendaman dalam media lakinea Broth bermikrobs *pseudomonas aerogenosa*

Untuk menyelidiki pengaruh perlakuan biodegradasi terhadap struktur kimia molekul plastik, sampel film campuran plastik dianalisis menggunakan teknik spektroskopi inframerah. Spektra inframerah yang dihasilkan dari sampel film setelah mengalami biodegradasi dalam tanah sampah terlihat pada Gambar 3a – 3c.



Gambar 3. Spektra inframerah setelah biodegradasi dengan penguburan dalam tanah sampah selama 60 hari dari film spesimen campuran plastik polipropilena yang mengandung 20% serbuk pengisi: (a) PTKS, (b) SA, dan (c) SDA

Spektra FTIR pada Gambar 3a – 3c semuanya memperlihatkan serapan gugus hidroksida (-OH) pada bilangan gelombang 3400 cm^{-1}, yang melebar, dan serapan gugus karbonil (>C=O) yang intensif pada 1700 cm^{-1}. Ini merupakan indikasi terjadinya degradasi matriks plastik polipropilena selama perlakuan biodegradasi, yang membentuk senyawa hasil oksidasi bergugus hidroksida dan karbonil. Proses biodegradasi campuran plastik tersebut dimulai dari fase bahan pengisi, sehingga memungkinkan difusi oksigen ke dalam fase ruah matriks plastik polipropilena yang selanjutnya memicu proses degradasinya.

KESIMPULAN

Kompatibilitas bahan pengisi pulp tandan kosong sawit dan turunan selulosa dalam matriks polipropilena pada pencampuran dengan cara refluks dalam xilena tidak menunjukkan peningkatan yang nyata oleh kenaikan sifat termoplastis bahan pengisi.

Campuran plastik dengan pengisi pulp tandan kosong sawit (PTKS) dan selulosa asetat (SA) terbiodegradasi lebih cepat bila dibandingkan dengan yang mengandung bahan pengisi selulosa diasetat (SDA) pada uji penguburan dalam tanah sampah.

Bila dibandingkan dengan uji perendaman dalam media laktosa Broth bermikroba *pseudomonas aerogenosa*, biodegradasi spesimen campuran plastik tersebut pada perlakuan penguburan dalam tanah sampah memperlihatkan laju yang lebih besar.

Analisis spektroskopi inframerah memperlihatkan proses biodegradasi campuran plastik terjadi bukan hanya pada fase bahan pengisi, tetapi juga pada matriks polipropilena.

DAFTAR PUSTAKA

1. LOOMIS, G. L., M. JIZBICKI, and A. FLAMMINO. 1994. US Patent No. WO 9416020 A2 940721. Application Data WO 94-US221 940106.

2. NAKASHIMA, T., and M. MATSUO. 1996. Development of high strength and high modulus polyethylene-starch composite films and biodegradation of the composite films. J. Macromol. Sci. B. 35 (3 – 4) : 659 – 679.

3. PARK, B. D., and J. J. BALATINECZ. 1997. Mechanical properties of wood fibre/toughened isotactic polypropylene composites. Polym. Composites. 18 (1) : 79 – 89.

4. SAIN, M. M., and B. V. KOKTA. 1994. Polyolefin-wood filler composite I. Performance of m-phenylene bismaleimide-modified wood fibre in polypropylene composite. J. Appl. Polym. Sci. 54 (10) : 1545 – 59.

5. SCHUT, J. H. 1997. Wood-filled thermoplastics go commercial. Plast. World. 55 (10) : 12 – 15.

6. TIMMINS, M., and R. W. LENZ. 1994. Enzymatic biodegradation of polymers reviewed. Food, Cosmetics & Drug Pack. 9p.

7. VALDYA, U. R., and M. BHATTACHARYA. 1994. US Patent No. US 5446078 A 940829. Application Data US 94-207840 940308.

8. ZAINI, M. J., Z. ISMAIL, M. Y. A. FUAD, and J. MUSTAFAH. 1994. Application of oil palm wood flour as filler in PP. Polym. J. (Jap.). 26 (5) : 637 – 642.

9. ZAINI, M. J., M. Y. A. FUAD, Z. ISMAIL, M. S. MANSOR, and J. MUSTAFAH. 1996. Effect of filler content and size on mechanical properties of polypropylene/oil palm wood flour composites. Polym. Int. 40 (1) : 51 – 55.

Compatibility and biodegradability of polypropylene materials containing cellulose derivatives and oil palm empty bunches fillers

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Abstract

Compatibility of cellulose derivatives and oil palm empty bunches fillers in polypropylene matrix and their biodegradation behaviour depends on thermoplastic or hydrophilicity properties of the fillers. For these reasons, effects of chemical structure of the cellulose derivatives, i.e.: cellulose acetate, cellulose diacetate, on their compatibility and biodegradation behaviour in polypropylene matrix will be compared to that of oil palm empty bunches pulp. Plastic blends containing the above fillers prepared using reflux technique in xylene, were characterised for their compatibility using: mechanical strength tests. Biodegradation treatments of the plastic materials were carried out using: soil burial tests and immersion in lactose Broth medium containing pseudomonas aerogenosa *bacteria. It was reported that using the reflux technique, increase in thermoplastic property or decrease in hydrophilicity of the fillers did not show considerable effects on their compatibility in polypropylene matrix. However, during biodegradation tests, the presence of oil palm empty bunches pulp and cellulose acetate fillers increased biodegradability of the plastic blends. Biodegradation during burial treatment in waste disposal soil showed faster rate compared to that in lactose Broth medium containing* pseudomonas aerogenosa *bacteria. This may be due to that microorganisms in the waste disposal soil have adapted to their biodegradation condition, and posses higher activity than their pure innoculum. On the other hand, there was also possibility of synergistic biodegradation actions between various microorganisms in the waste disposal soil.*

Key words : oil palm empty bunches, pulp, cellulose derivatives, plastic filler, polypropylene, compatbility, biodegradation

Introduction

Polypropylene plastics (PP) have been widely used as packaging materials, which do not easily degrade in nature after use, and hence creating environmental concern. It was known that biodegradable polypropylene plastic blends have been produced commercially by adding corn or potato starch fillers in the polymer matrix (1, 7). On the other hand, oil palm empty bunches and various agricultural solid wastes have not been economically utilised as potential sources of carbohydrate and lignocellulose. One possible alternative of the utilisation is as wood-based starch-substitute fillers for biodegradable plastic due to their cheapness, low in weight, and large-scale availability. However, problems are still associated to the wood-based plastic fillers, such as their low compatibility in polypropylene matrix since the differences in thermoplastic and hydrophilicity properties (3, 4, and 5).

In this work, effects of acetate group(s) in the plastic fillers: cellulose acetate (Tm = 240° C), cellulose diacetate (Tm = 235°C), and oil palm empty bunches pulp on their compatibility and contribution to biodegradation behaviour of the polypropylene blends were studied. Substitution of hydroxyl to acetate

group(s) may improve thermoplastic property or decrease in hydrophilicity of the cellulose derivatives. This may inturn affect not only on increase in compatibility but also decrease in biodegradability of the blends. Degree of compatibility of the plastic blends was measured using mechanical strength tests, as has been reported by Zaini et. al. (8,9). Biodegradation property of the plastic materials was studied using similar technique reported by Nakashima and Matsuo (2), as well as by Timmins and Lenz (6), i.e: using soil burial tests and immersion in lactose Broth media containing *pseudomonas aerogenosa*.

Materials and Methods

Materials

Commercial polypropylene plastics (Philips), cellulose acetate, and cellulose diacetate (BDH Chemicals) were used directly without prior purification. Oil palm empty bunches pulp was prepared by Cellulose Research Centre in Bandung, whereas *pseudomanas aerogenosa* bacteria and lactose Broth nutrient were available from Microbiology Laboratory, Faculty of Sciences USU , Medan.

Preparation of plastic blends and test specimens

Cellulose derivative plastic fillers and oil palm empty bunches pulp (OPEBP) were milled and powdered to particle size: 53 μm. Commercial polypropylene plastic together with various fillers were dissolved using reflux technique in xylene followed by intensive mixing for 3 hours. The xylene solvent was then evaporated at room temperature and in vacuum at 40°C. The dried plastic blends were then compression moulded (Paul Weber) to produce plastic film of 0.2 mm in thickness at 180°C for 3 minutes without pressure and with 100 kN load for another 3 minutes. Test specimens for mechanical strength measurement were according to ASTM D 638-72 Type IV, (width: 6 mm and length: 64 mm). Samples for biodegradation tests were 10 mm x 30 mm in size.

Characterisation and biodegradation tests

Tensile strength and elongation tests of 3 specimens for every plastic blend samples were carried out using Tokyo Testing Machine Type SC2DE. Biodegradation tests were done by immersion burying of 3 sterile specimens of every plastic sample in lactose Broth nutrient/ waste disposal soil and following the degradation rate from weight decrease of every specimen. Possible chemical structural changes were confirmed using FTIR spectroscopy.

Results and Discussions

Compatibility of cellulose derivative and oil palm empty bunches pulp fillers in polypropylene matrix

Tensile strength (MPa) and elongation (mm) of the plastic blend specimens at various type and concentration of the plastic fillers were tabulated in Table 1. When compared to that of commercial polypropylene, addition of oil palm empty bunches pulp (OPEBP), cellulose acetate (CA), or cellulose diacetate (CDA), re-

sulted in elongation decrease as well as homogeneity of the plastic samples. Type of fillers did not show substantial effects of mechanical properties and homogeneity of the plastic blends at corresponding composition. This means that the presence of acetate group(s), which improved thermoplastic property of the fillers, did not effectively interact with the plastic matrix. The filler materials were still in their own phase even after intensive reflux mixing (135°C) with polypropylene in xylene. The reason for this may be due to the low solubility of the cellulose derivatives (CA and CDA) in xylene, which did not melt in the reflux temperature. Therefore, it is recommended that the blending should be carried out at high temperature above melting points of the fillers (~250°C), although attention should be made to possibility of decomposition of the fillers. Optimum composition of the polypropylene blends with considerable tensile strength and elongation was chosen at 20% filler contents.

Table 1. Tensile strength (MPa) and elongation (mm) of polypropylene blends containing various concentration of fillers: oil palm empty bunches pulp (OPEBP), cellulose acetate (CA), and cellulose diacetate (CDA)

Filler contents	Tensile strength (MPa)*			Elongation (mm)*		
	OPEBP	CA	CDA	OPEBP	CA	CDA
0	11	11,0	11,0	2,35	2,35	2,35
10	13,7	9,6	10,3	2,21	1,85	2,42
20	15,0	8,7	7,0	1,73	1,23	1,66
30	12,9	7,5	6,4	1,42	1,29	1,33
40	10,0	6,0	5,6	1,31	1,24	1,26

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

Biodegradation tests of polypropylene plastic blends

Samples of polypropylene blends (each represented by 3 specimens, thickness: 0.2 mm, width: 10 mm, and length: 30 mm) containing 20% of various fillers: OPEBP, CA, and CDA, were thoroughly cleaned with distilled water and sterilised with ethanol 96%, and then dried and weighted. These were then buried in waste disposal soil (from domestic waste disposal area, in Pancur Batu, Medan), at room temperature and humidity ranging from 25°-32°C and 70-80%, respectively. Average weight changes of the 3 specimens during the biodegradation are shown in Table 2.

Table 2. Weight changes of polypropylene blend specimens containing 20% of fillers: OPEBP, CA, and CDA during burial test using waste disposal soil

Burial time (days)	Weight of specimens (g) containing 20% of fillers		
	OPEBP	CA	CDA
0	0,124	0,089	0,089
15	0,101	0,086	0,083
30	0,078	0,070	0,082
45	0,075	0,054	0,081
60	0,075	0,050	0,081

Notes: OPEBP: oil palm empty bunches pulp, CA: cellulose acetate, CDA: cellulose diacetate

Using similar procedure, biodegradation tests were further carried out in lactose Broth media containing *pseudomonas aerogenosa* in an incubator at 30°C, for every plastic sample. The weight change results were shown in Table 3. The weight changes during soil burial treatment were also plotted against burial time in Figure 1, whereas the ones during immersion in media containing *pseudomonas aerogenosa* were also plotted in Figure 2.

Table 3. Weight changes of polypropylene blend specimens containing 20% of fillers: OPEBP, CA, and CDA during immersion in laktosa Broth media containing *pseudomonas aerogenosa*

Immersion time	Weight of specimens (g) containing 20% of fillers:		
(days)	OPEBP	CA	CDA
0	0,045	0,031	0,053
15	0,045	0,031	0,053
30	0,044	0,031	0,052
45	0,044	0,031	0,052
60	0,043	0,031	0,052

Notes: OPEBP: oil palm empty bunches pulp, CA: cellulose acetate, CDA: cellulose diacetate

From Tables 2 & 3, and Figures 1 & 2, it was indicated that the above weight changes data during biodegradation were revealing faster biodegradation rates, especially in the case of plastic blends containing OPEBP and CA fillers, whereas the ones containing CDA filler did not show substantial biodegradation rate. These may be due to lower hydrophilicity of the CDA, which contains two acetate groups per repeating unit, when compared to CA and OPEBP. Interestingly, it was shown that biodegradation rates during soil burial tests were always higher when compared to those of their corresponding samples during immersion tests in lactose Broth media containing pure *pseudomonas aerogenosa*. Microorganisms in the waste disposal soil were predicted to have been adapted in their plastic degrading environment and posses higher degrading activity compared to their pure innoculum. There were also possible synergistic actions between various microorganisms (bacteria and fungi) in the waste disposal soil to promote faster biodegradation process.

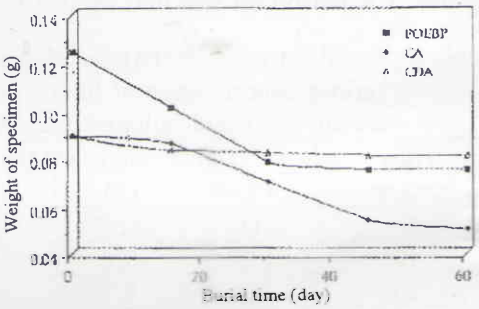

Figure 1. Plot of weight changes against burial time of polypropylene blend films containing 20% of various fillers during burial test using waste disposal soil

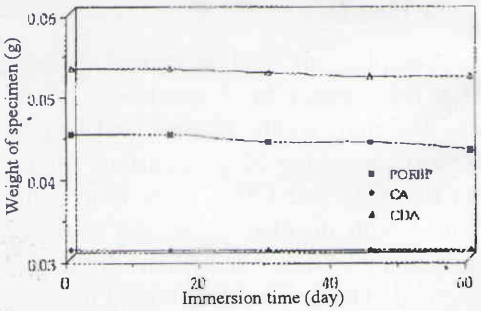

Figure 2. Plot of weight changes against burial time of polypropylene blend films containing 20% of various fillers during immersion in laktosa Broth media containing *pseudomonas aerogenosa*

To investigate the effects of biodegradation treatments upon possible structural changes on plastic molecules, the plastic samples were further analysed using FTIR spectroscopy. The FTIR spectra found for the plastic films after biodegradation in waste disposal soil were shown in Figures 3a - 3c. All of the spectra produced showed broad absorption of hidroxyl (-OH) group at wave number: 3400 cm^{-1}, and also intensive absorption of carbonyl (>C=O) at wave number: 1700 cm^{-1}. These data indicated the occurrence of degradation of the polypropylene plastic matrix during the biodegradation treatments, to form oxidation products containing hydroxyl and carbonyl groups. It seems that the biodegradation process was started from the filler phase, which then facilitating water and oxygen diffusion into the bulk phase of the plastic blend to promote environmental degradation of the plastic matrix.

Conclusions

Compatibility of cellulose derivative fillers in polypropylene matrix using blending process by reflux technique in xylene solvent did not show any substantial improvement by the increase of hermoplastic property of the fillers.

Plastic blends containing 20% of illers: oil palm empty bunches pulp OPEBP) and cellulose acetate (CA) were more faster biodegraded in soil burial treatment when compared to that containing cellulose diacetate (CDA).

When compared to those in lactose Broth media containing *pseudomonas aerogenosa*, biodegradation of the plastic blends by burial test in waste disposal soil showed faster rate.

Analysis using FTIR spectroscopy revealed that the biodegradation process of the plastic blends did not only occur in the filler phase but also extended into the plastic matrix.

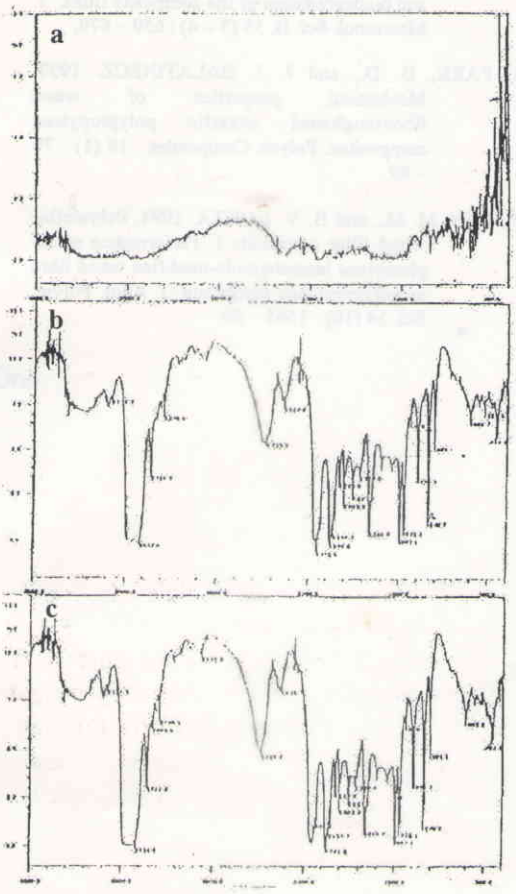

Figure 3. Infrared spectra after 60 days biodegradation using waste disposal soil burial treatment of polypropylene blend films containing 20% of fillers: (a) OPEBP, (b) CA, and (c) CDA

References

1. LOOMIS, G. L., M. JIZBICKI, and A. FLAMMINO. 1994. US Patent No. WO 9416020 A2 940721. Application Data WO 94-US221 940106.

2. NAKASHIMA, T., and M. MATSUO. 1996. Development of high strength and high modulus polyethylene-starch composite films and biodegradation of the composite films. J. Macromol. Sci. B. 35 (3 – 4) : 659 – 679.

3. PARK, B. D., and J. J. BALATINECZ. 1997. Mechanical properties of wood fibre/toughened isotactic polypropylene composites. Polym. Composites. 18 (1) : 79 – 89.

4. SAIN, M. M., and B. V. KOKTA. 1994. Polyolefin-wood filler composite I. Performance of m-phenylene bismaleimide-modified wood fibre in polypropylene composite. J. Appl. Polym. Sci. 54 (10) : 1545 – 59.

5. SCHUT, J. H. 1997. Wood-filled thermoplastics go commercial, Plast. World. 55 (10) : 12 – 15.

6. TIMMINS, M., and R. W. LENZ. 1994. Enzymatic biodegradation of polymers reviewed. Food, Cosmetics & Drug Pack. 9p.

7. VALDYA, U. R., and M. BHATTACHARYA. 1994. US Patent No. US 5446078 A 940829. Application Data US 94-207840 940308.

8. ZAINI, M. J., Z. ISMAIL, M. Y. A. FUAD, and J. MUSTAFAH. 1994. Application of oil palm wood flour as filler in PP. Polym. J. (Jap.). 26 (5) : 637 – 642.

9. ZAINI, M. J., M. Y. A. FUAD, Z. ISMAIL, M. S. MANSOR, and J. MUSTAFAH. 1996. Effect of filler content and size on mechanical properties of polypropylene/oil palm wood flour composites. Polym. Int. 40 (1) : 51 – 55.

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