EFFECTS OF FIBRE LOADING AND ADDITIVES ON THE PROPERTIES OF RUBBERWOOD-POLYPROPYLENE COMPOSITES

By

NOR YUZIAH MOHD YUNUS

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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Specially dedicated to

Abah dan Emak

Liza

Along

Thank you for bearing with my eccentricity

Thank you for your support and love

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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The three parts study utilised rubberwood, polypropylene and additives in which rubberwood and polypropylene was melt blended, compressed and moulded prior to preparation of test samples. Samples were tested using ASTM standards, except for water absorption where British Standard was adopted. Spectroscopic analyses of Fourier Transform Infra-red spectroscopy (FTIR), Dynamic Mechanical Analysis (DMA) and Scanning Electron Microscopy (SEM) were carried out on the RWPC.

For Part A the appearance of RWPC with 0.5mm fibre size was darker than 1-2mm fibre size RWPC. When additives were added, the colours of all the RWPC generally became darker. The water absorption ($p \leq 0.01$), hardness and mechanical strength of the WPC were significantly affected using the addition of fibre. Without maleated polypropylene (MAP), the coupling agent, the fibres behave as standard fillers. With MAP the resultant RWPC gave significantly enhanced strength properties (tensile, flexural, Izod) for RWPC containing 40 to 60% fibre loading. The enhancement was significantly ($p \leq 0.05$) stronger for 1-2mm fibre size.

In Part B1 the higher molecular weight maleated polypropylene (PMAP) have higher mechanical strength ($p \leq 0.05$) than the lower molecular weight MAP. The reactive additive (RA) different functionality used in Part B2 for RWPC after the polypropylene had been irradiated gave proportional increase in mechanical strength as the functionality increase. For di-functionality EBYCYL 600 (OLI), the presence of acrylates and epoxy gave different reaction mechanism leading to significantly ($p \leq 0.01$) improved RWPC performance.

For irradiated RWPC, reduction of mechanical strength upon ageing in 2-ethylhexanol acrylate (EHA), hexanediol diacrylate (HDDA) and OLI were attributed to de-polymerisation of the PP polymer caused by trapped radicals. Non-irradiated RWPC did not exhibit any de-polymerisation over a period of 24 months.

The DMA data showed the presence of reactive material in irradiated RWPC. The presence of exothermic peak accounted through the increase of storage modulus (E'), was proportional to the molecular weight of the RA used. The FTIR spectra also clearly indicate the presence of interaction of different rigidity for PP, rubberwood, untreated and treated RWPC. SEM images gave clear indication of the interaction changes for untreated versus treated RWPC.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia bagi memenuhi syarat untuk memperolehi Ijazah Doktor Falsafah

KESAN KEMASUKAN SERPAI DAN BAHAN TAMBAHAN TERHADAP CIRI-CIRI KOMPOSIT KAYU GETAH -POLIPROPELINA

Oleh

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Kajian tiga bahagian ini mengunakan kayu getah, polypropelina dan bahan tambahan di mana, kayu getah dan polipropelina dicampurkan dan dibentuk sebelum sampel ujikaji disediakan. Sample diuji menggunakan piawaian ASTM, kecuali bagi serapan air di mana piawaian British digunakan. Kaedah spektroskopi Fourier Transform Infra-Red Spectroscopy (FTIR), Dynamic Mechanical Analysis (DMA) and Imbasan Electron Microscopy (SEM) juga digunakan mengkaji RWPC.

Dalam bahagian A warna komposit kayu getah-polipropelina (RWPC) yang berisi serabut 0.5mm adalah lebih gelap dari serabut 1-2mm. Dengan kemasukan bahan tambahan, RWPC secara am menjadi lebih gelap. Ciri-ciri RWPC menunjukkan perubahan ketara pada serapan air ($p \leq 0.01$), kekerasan dan kekuatan mekanikal apabila serabut bertambah. Tanpa agent 'coupling' maleated polipropelina MAP, serpai kayu bertindak menyerupai bahan pengisi am. Bila MAP dicampurkan, RWPC yang terhasil mempunyai perubahan kekuatan (tensil, lenturan dan Izod) yang ketara untuk RWPC dengan kandungan serpai 40 dan 60%. Peningkatan ketara dilihat pada tahap $p \leq 0.05$ bagi serpai berukuran 1-2mm.

Di bahagian B1 PMAP yang menpunyai berat molikul lebih tinggi mempunyai kekuatan mekanikal yang lebih ($p \leq 0.05$) dari MAP. Penggunaan bahan tambahan aktif (RA) dalam bahagian B2 dengan nombor fungsi yang berbeza setelah polipropelina melalui radiasi menunjukkan peningkatan kekuatan berkadar terus dengan penambahan fungsi. Bagi EBYCYL 600 (OLI) yang mempunyai dua ciri kimia, kehadiran akrilat dan epoksi memberikan tindakbalas yang berbeza dan menghasilkan peningkatan kekuatan RWPC ($p \leq 0.01$).

Bagi RWPC beradiasi, penurunan kekuatan mekanikal semasa ujian penuaan untuk 2-etilhezanol akrilat (EHA), hezandiol diakrilat (HDDA) dan OLI disebabkan oleh pepecahan polimer. RWPC yang tidak diradiasi tidak mengalami keadaan yang sama dalam tempoh 24 bulan.

Pengunaan kajian spektroskopi DMA dapat menunjukkan kehadiran spesis reaktif dalam RWPC berradiasi.. FTIR juga dapat menunjukkan interaksi berlainan ketegangan bagi PP, serpai kayu getah, RWPC tidak terawat dan RWPC terawat. Image SEM menunjukkan terdapat perubahan tindakbalas untuk RWPC tidak terawat dan RWPC terawat.

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I certify that the Examination Committee met on 3rd November 2004 to conduct the final examination of Nor Yuziah Mohd Yunus on her Doctor of Philosophy thesis entitled "Effects of Fibre Loading and Additives on the Properties of Rubberwood-Polypropylene Composites." in accordance with Universiti Pertanian Malaysia (Higher Degree Act 1980) and University Pertanian Malaysia (Higher Degree Regulation 1981). The Committee recommends that the candidate be awarded to relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that there has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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Date: 03 November 2004

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