



**UNIVERSITI PUTRA MALAYSIA**

**NANO ALUMINA AND RADIATION EFFECT ON  
THERMO-MECHANICAL PROPERTIES OF HIGH DENSITY  
POLYETHYLENE-HYDROXYAPATITE COMPOSITE**

**NURUL AKMIL BINTI MUSTAFFA**

**IPTPH 2011 1**

**NANO ALUMINA AND RADIATION EFFECT ON THERMO-MECHANICAL  
PROPERTIES OF HIGH DENSITY POLYETHYLENE-HYDROXYAPATITE  
COMPOSITE**

**By**

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**Thesis Submitted to the School of Graduate Studies, Universiti Putra  
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**August 2011**

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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**August 2011**

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**Faculty: Institute of Tropical and Forest Product**

This study aims to investigate the effect of nano alumina and radiation on the mechanical and thermal properties of high density polyethylene hydroxyl apatite (HDPE/HA) composite. Nano alumina was produced by using sol-gel method. Nano alumina was analyzed by using XRD, FTIR and TEM to confirm the spectroscopy of alumina and size. Percentage of HA was studied to get the optimum mechanical strength. The tensile strength was studied by varying the percentage of HA in the HDPE blend. Percentage of HA that has been used in this study were 10, 20, 30wt% with

respect to the weight of matrix. The 10 wt% and 20wt% of HA indicate the better tensile strength compare to 30wt% of HA. Before nano alumina can be used as filler in the polymer matrix, (3-methacryloxypropyl) trimethoxysilane (MPS) was used to functionalize the nanoparticles due to its bi-functional nature: hydrolysable group ( $-\text{Si}(\text{OCH}_3)_3$ ) and unsaturated carbon-carbon double bond. Percentage of silane used in this study is from 1 % to 5 % to the amount of matrix. At 4 % silane, tensile strength shows the best result compare to the other percentages. The effect percentage of nano alumina in the HDPE was studied by using 1 to 5 % of nano alumina to the amount of the HDPE. It is proved that the silane gives favorable effect to HDPE/nano alumina composite at 4% wt to the weight of matrix. The composite was irradiated to improve tensile properties. Subsequently, the composite was irradiated by using electron beam accelerator. Mechanical, thermal, and morphological properties were characterized. The mechanical properties result showed at 100KGy irradiation dose the tensile, flexural and impact strength increased as well as hardness value. The tensile fracture surfaces of the composites were characterized by using SEM and confirmed the tensile results. From the flexural analysis, the presence of nano alumina (with 4% MPS) in the composite (HDPE/HA) has insignificant increment on both flexural strength and flexural modulus. Impact strength for notched izod impact test was increased at the 4% percentage of nano alumina loading. The DMA result showed the  $T_g$  of the HDPE is shifted to the lower temperature after addition of HA, nano alumina and silane. The  $T_g$  of composite have n significant changes after irradiation. However, the irradiation has increased the storage and loss modulus. Lastly, DSC results showed the crystallinity of pure HDPE, composite 0 KGy, and composite 100 KGy was 47.08, 41.42, and 50.72 respectively.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**ALUMINA NANO DAN RADIASI MEMPENGARUHI THERMA-SIFAT  
MEKANIKAL KOMPOSIT POLIETILENA KEPADATAN TINGGI-HIDROKSI  
APATIT**

Oleh

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Kajian ini disediakan untuk mengkaji pengaruh alumina nano dan radiasi ke atas sifat-sifat mekanikal dan terma bagi komposit polietilinas berketumpatan tinggi hidroksapatit (HDPE/HA). Alumina nano dihasilkan mengguna kaedah sol-gel. Bagi memastikan saiz dan juga spektroskopi, alumina nano telah dianalisis menggunakan XRD, FTIR dan TEM. Peratusan HA juga dikaji bagi mendapatkan kekuatan mekanikal yang optimum. Kekuatan rengangan telah dikaji dengan mempelbagaikan peratusan HA di dalam campuran HDPE. Peratusan HA yang digunapakai di dalam kajian ini adalah

sebanyak 10, 20, 30 %wt berpandukan berat matrik yang digunakan. Setelah dikaji, berbanding peratusan Ha sebanyak 30 %wt, peratusan Ha 10 %wt dan 20%wt telah menunjukkan kekuatan regangan yang lebih baik. Sebelum alumina nano digunakan sebagai pengisi pengisi di dalam matrik polimer, (3-metakriloksipropil) trimetoksisilan (MPS) digunakan untuk mengfungsionalisasikan zarah nano kerana sifatnya yang dwi-fungsi: kumpulan terhidralisis ( $-\text{Si}(\text{OCH}_3)_3$ ) dan ikatan karbon ganda dua. Peratus silane yang digunakan di dalam kajian ini adalah dari 1 hingga 5 % berpandukan berat matix yang digunakan. Kekuatan regangan menunjukkan keputusan yang terbaik pada peratusan 4 % berbanding peratusan yang lain.pengaruh alumina nano di dallam HDPE telah dikaji dengan menggunakan 1 hingga 5 % alumina nano berpandukan berat matrik.adalah dibuktikan silane telah memberikan kesan yang baik kepada komposit HDPE/alumina nano. Pada peratusan 4 % berpandukan berat matrik.komposit juga telah diradiasikan untuk meningkatkan kekuatan regangan dengan menggunakan pancaran sinaran electron. Sifat mekanikal, terma dan morfologi komposit juga telah dikaji.sifat mekanikal komposit itu pada dos radiasi 100K Gy, kekuatan regangan, lenturan dan hentaman telah meningkat begitu juga dengan nilai kekerasan. Permukaan pecahan regangan komposit tersebut telah dianalisis dengan menggunakan SEM dan membuktikan keputusan regangan komposit tersebut. Berpandukan keputusan ujian lenturan, peratusan alumina nano (dengan 4 % silane) di dalam komposit (HDPE/HA) tidak memberikan sebarang kenaikan dalam keputusan kekuatan lenturan dan modulus lenturan. Kekuatan hentaman bagi ujian hentaman takikan izod melah meningkat pada peratusan alumina nano 4%. Keputusan DMA pula menunjukkan Tg HDPE telah beralih ke suhu yang lebih rendah selepas kehadiran HA alumina nano dan silane. Tg komposit

juga tidak mempunyai sebarang perubahan selepas komposit diradiasikan. Walau bagaimanapun, radiasi telah meningkatkan modulus simpanan dan modulus hilang. Akhir sekali, keputusan DSC menunjukkan penghabluran HDPE tulen, komposit 0KGy dan komposit 100KGy ialah 47.08, 41.42, dan juga sebanyak 50.72.



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I certify that an Examination Committee has met on **date of viva voce** to conduct the final examination of Nurul Akmil binti Mustaffa on her Master of Science thesis entitled " Nano Alumina and Radiation Effect Thermo-Mechanical Properties of High Density Polyethylene-Hydroxyapatite Composite" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student be awarded the (Name of relevant degree).

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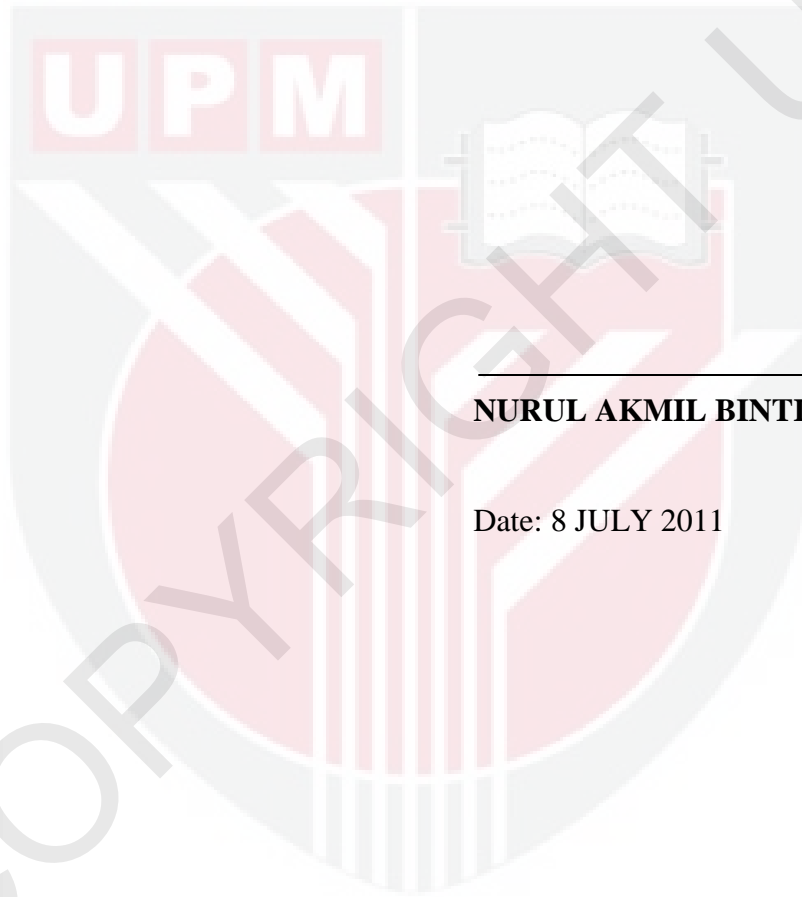
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## DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.



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