

PREPARATION AND CHARACTERIZATIONS  
OF PHENOLIC RESIN-SILICA  
NANOCOMPOSITES

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*To my mum and dad*

*Zainun Abd Kadir and Che Mohd Zin Hassim*

*Thank you for your enthusiastic support and encouragement*

*To my beloved siblings*

*Hudawaty, Zafirah, Hazim, Saiful, Nazili, Ariff, Fa'izun, Wa'ie and  
Ahmad*

*Hopefully all of you will success more than your sis*

*And*

*Special thanks for my grand mum and grand dad*

*Endon Awang and Abd Kadir Ismail*

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**PREPARATION AND CHARACTERIZATIONS OF PHENOLIC RESIN-  
SILICA NANOCOMPOSITES**

**NORUL AZLIN BINTI MOHD ZIN**

**November 2008**

**Chairperson : Prof Dr. Senin bin Hassan, Ph.D.**  
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Phenolic resin-silica nanocomposites samples in pellet shape have been successfully prepared by intercalation of polymer solution through the hot pressing method. The phenolic resin is modified with organic elastomers of silica nanoparticles, which is about 20 nanometer in diameter. The change of density and porosity was studied based on the addition of silica content in the phenolic resin composites. The densities of composites increased with the addition of the silica content from 10 wt.% to 40 wt.%. On the other hand, the porosity percentage was decreased with increasing of silica contents.

The mechanical properties (Young's modulus, energy to break and time to failure) of the nanocomposites samples were identified using the

Universal Testing Material Machine (UTM). The results of Young's modulus, energy to break and time to failure of the phenolic resin composites were found to be slightly increased with silica content from 10 wt.% to 30 wt.%. The thermal properties, such as transition temperature and enthalpy have been investigated using Differential Scanning Calorimeter (DSC). The phenolic resin composites results in an improvement of thermal properties with the addition of silica content as compared to the pure phenolic resin.

The X-Ray Microtomography (XRM) topographies have shown that the porosity exists on fracture structure for each nanocomposite. The nanocomposites surface structure has been analyzed using Scanning Electron Microscope (SEM). The observation shows that the fracture surface of the pure phenolic resin is relatively smooth and glassy, which is typical for a brittle material, but the phenolic resin- silica composites fracture surface is not smooth at all. The observations indicate the pure phenolic resin is brittle than phenolic resin-silica nanocomposites. Consequently, the physical properties of the phenolic resin-silica nanocomposites were improved with the addition of 10 wt.% to 30 wt.% silica contents, as compared to that of the pure phenolic resin.

**Keywords:** Phenolic resin, silica content physical properties mechanical properties, thermal properties, structure

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**PENYEDIAAN DAN PENCIRIAN NANOKOMPOSIT FENOLIK RESIN-  
SILIKA**

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Sampel nanokomposit fenolik resin-silika dalam bentuk pelet telah dihasilkan dengan larutan separa polimer menggunakan kaedah tekanan panas. Fenolik resin diubahsuaikan dengan penambahan elastomer organik iaitu nanopartikel silika berdiamater 20 nanometer. Ketumpatan dan peratusan keliangan sesuatu sample telah dikaji atas kesan percampuran fenolik resin dengan kandungan silika. Ketumpatan komposit fenolik resin telah meningkat berikutan penambahan kandungan silika dari 10 % per berat sehingga 40 % per berat. Sebaliknya, peratusan keliangan menurun dengan penambahan kandungan silika.

Sifat-sifat mekanik (modulus Young, tenaga untuk memecah dan masa untuk pecah) bagi setiap sampel nanokomposit telah dikaji dengan menggunakan Mesin Penguji Bahan. Keputusan-keputusan modulus

Young, tenaga untuk memecah dan masa untuk pecah bagi setiap sampel komposit fenolik resin didapati meningkat dengan kandungan silika (10% per berat - 30% per berat). Sifat terma seperti suhu peralihan dan entalpi dikaji dengan menggunakan Kalorimeter Pembeza Imbasan. Sifat terma untuk sampel komposit fenolik resin yang ditambah dengan kandungan silika menunjukkan peningkatan berbanding dengan fenolik resin tanpa silika.

Mikrotomografi Sinar X menunjukkan kewujudan keliangan di dalam dan pada permukaan setiap sampel nanokomposit. Keputusan keadaan struktur permukaan dianalisis dengan menggunakan Mikroskop Imbasan Elektron. Daripada pencerapan Mikroskop Imbasan Elektron, struktur permukaan fenolik resin tanpa kandungan silika kelihatan bersifat lebih kekacaan dan licin, yang turut menunjukkan ia bahan yang rapuh. Tetapi komposit fenolik resin dengan penambahan kandungan silika kelihatan tidak licin dan kasar. Hasil kajian menunjukkan fenolik resin tanpa silika adalah rapuh berbanding dengan nanokomposit fenolik resin-silika. Akhir sekali, keputusan untuk kesemua sifat-sifat fizikal komposit yang diubahsuaikan dengan penambahan kandungan silika (dari 10% per berat sehingga 30% per berat,) bertambah baik berbanding dengan fenolik resin tulen.



**Kata kunci:** Fenolik resin, kandungan silika, sifat fizikal, sifat mekanikal, sifat terma, struktur