



**UNIVERSITI PUTRA MALAYSIA**

**DIELECTRIC AND MAGNETIC PROPERTIES OF  
NiZn-POLYPROPYLENE AND CoZn-POLYPROPYLENE  
FERRITE COMPOSITES**

**TAN FOO KHOON**

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OF NiZn-POLYPROPYLENE AND  
CoZn-POLYPROPYLENE FERRITE  
COMPOSITES**

**BY**

**TAN FOO KHOON**

Thesis Submitted to the School of Graduate Studies,  
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**Chair: Assoc. Professor Jumiah Hassan, PhD**

**Faculty: Faculty of Science**

Polymer-clay composites exhibit more interesting and improved mechanical, thermal, electrical, optical and pharmaceutical properties as compared to the pure polymer. Guided and motivated by this observation, the main objective of this project is to study the dielectric and magnetic properties of ferrite-polypropylene composites. The effects of different chemical composition of ferrite and different composition of ferrite added to the matrix were investigated.

The fillers,  $\text{Me}_x\text{Zn}_{1-x}\text{Fe}_2\text{O}_4$  (where  $\text{Me}=\text{Ni, Co}$ ;  $x=0.1, 0.2$  and  $0.3$ ) were prepared by the conventional solid state method. Different compositions of filler were doped into the polypropylene (PP) and blended to produce ferrite-PP composites.

For characterization, X-ray diffraction (XRD) was used to determine the crystalline structure while field emission scanning electron microscopy (FESEM) was used to analyze the microstructure of the ferrites. The dielectric properties were measured using an HP 4284A Precision LCR Meter from 20 Hz to 1 MHz at room temperature. An HP4291B RF Impedance Analyzer was used to measure the dielectric properties and magnetic properties of the samples from 1 MHz to 1.8 GHz at room temperature.

From the XRD analysis, it showed that the filler and PP underwent no unwanted reaction during blending process. According to the FESEM images, the average grain diameters of ferrites increased with increasing Zn content in ferrite. The composites with 30 wt% of ferrite added exhibit the highest relative dielectric constant,  $\epsilon'_r$ , which are 3.44 at 1 kHz and 2.78 at 100 MHz for  $\text{Ni}_{0.3}\text{Zn}_{0.7}\text{Fe}_2\text{O}_4$ -PP composite.

The existence of ferrite may take part in compensating the dipole moment of PP. Hence, the  $\epsilon'_r$  of 5 wt% - 10 wt% of ferrite composite is lower than pure PP due to the small amount of ferrite (moderate dielectric properties) added which do not give a significant contribution toward PP – based composite. Therefore, a significant improvement on the  $\epsilon'_r$  of the composites can be obtained with the addition of ferrite with more than 10 wt%.

The addition of ferrite shifted the dielectric loss peak to lower frequencies. A composite with high relative dielectric loss,  $\epsilon''_r$ , thus it can be utilized as electromagnetic wave absorbing material. By varying the weight ratio of ferrite, the composite can be tailored as an absorbing material at a desired frequency between 10 kHz to 300 kHz.

However, the composites do not have significantly improved relative real permeability,  $\mu'_r$ , due to the discontinuity of magnetic flux. 30 wt% of  $\text{Co}_{0.3}\text{Zn}_{0.7}\text{Fe}_2\text{O}_4$ – PP composite has the highest  $\mu'_r$ , which is 1.94 at 50 MHz.

As summary, the reinforcement of polymer with filler can enhance the dielectric and magnetic properties of the polymer composites. According to the effective medium theory, the high permittivity or high permeability of the polymer based composites can be obtained by putting the high permittivity or high permeability ceramic particles into the polymer matrices. Therefore, 30 wt% of ferrite-polypropylene

composites are given the highest  $\epsilon_r'$  and  $\mu_r'$ , among other composites at 20 Hz – 1 MHz and 1 MHz – 1.8 GHz.



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

**SIFAT DIELEKTRIK DAN MAGNET BAGI KOMPOSIT FERIT NiZn-  
POLIPROPILENA DAN CoZn-POLIPROPILENA**

Oleh

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Ogos 2011

**Pengerusi: Profesor Madya Jumiah Hassan, PhD**

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Komposit polimer-tanah liat mempunyai peningkatan dalam sifat mekanik, sifat terma, elektrik, optik dan farmasi berbanding dengan polimer tulen. Berpandukan dan dimotivasikan oleh pemerhatian ini, tujuan utama bagi projek ini adalah untuk mempelajari sifat dielektrik dan magnet komposit ferit-polipropilena. Kesan-kesan komposisi kimia yang berbeza dari ferit dan peratusan yang berbeza dari penambahan ferit ke matriks dikaji.

Pengisi,  $Me_xZn_{1-x}Fe_2O_4$  (di mana  $Me=Ni, Co$ ;  $x=0.1, 0.2$  and  $0.3$ ) disediakan melalui teknik pemrosesan seramik. Penambahan ferit dengan komposisi yang berbeza ke dalam polipropilena (PP) dan dicampur untuk menghasilkan komposit ferit-PP.

Bagi pencirian, pembelauan X-ray (XRD) digunakan untuk menentukan struktur hablur manakala pembebasan medan imbasan mikroskop elektron (FESEM) digunakan untuk menganalisis pertumbuhan butir dalam ferrites. Sifat dielektrik diukur menggunakan HP 4284A Precision LCR Meter dari 20 Hz sampai dengan 1 MHz dalam suhu bilik. HP4291B RF Impedance Analyzer digunakan untuk

mengukur sifat dielektrik dan sifat magnet sampel dalam 1 MHz sampai 1.8 GHz dalam suhu bilik.

Dari analisis XRD, ia menunjukkan bahawa pengisi dan PP tidak ada tindakbalas yang tidak diinginkan semasa proses pencampuran. Menurut gambar FESEM, purata diameter butiran ferrites meningkat dengan kandungan Zn dalam ferit. Komposit dengan penambahan 30 wt% ferit menunjukkan pemalar dielektrik relatif,  $\epsilon'_r$ , yang tertinggi iaitu 3.44 dalam 1 kHz dan 2.78 dalam 100 MHz untuk komposit  $\text{Ni}_{0.3}\text{Zn}_{0.7}\text{Fe}_2\text{O}_4\text{-PP}$ .

Kewujudan ferit boleh mengambil bahagian dalam memampas momen dwikutub PP. Jadi,  $\epsilon'_r$  bagi 5 wt % - 10 wt% komposit ferit lebih rendah daripada PP tulen kerana penambahan jumlah ferit yang kecil (sifat dielektrik sederhana) yang tidak memberikan sumbangan yang signifikan terhadap PP-ferit komposit. Oleh itu, peningkatan yang signifikan dalam komposit boleh diperolehi dengan penambahan ferit dengan lebih daripada 10 wt %.

Penambahan ferit menggerakkan puncak lesapan dielektrik ke frekuensi yang lebih rendah. Komposit dengan relatif lesapan dielektrik relatif,  $\epsilon''_r$ , yang tinggi, boleh digunakan untuk menyerap gelombang elektromagnet. Dengan mengubah nisbah berat ferit, komposit boleh disesuaikan sebagai bahan penyerap dalam frekuensi yang dikehendaki antara 10 kHz sampai 300 kHz.

Namun, komposit tidak memberi peningkatan yang signifikan terhadap ketelapan nyata,  $\mu'_r$ , disebabkan dengan ketakselajaran fluks magnet. 30 wt%  $\text{Co}_{0.3}\text{Zn}_{0.7}\text{Fe}_2\text{O}_4$  - PP komposit mempunyai nilai  $\mu'_r$ , yang tertinggi iaitu 1.94 dalam 50 MHz.

Kesimpulannya, penguatan polimer dengan pengisi dapat meningkatkan sifat dielektrik dan magnet komposit polimer. Menurut teori media berkesan, komposit berasaskan polimer yang berketelusan tinggi atau berketelapan tinggi boleh

diperolehi dengan meletakkan zarah seramik yang berketelusan tinggi atau berketelapan tinggi ke dalam matriks polimer. Maka, komposit 30 wt% ferit-polipropilena memberi  $\varepsilon'$ , dan  $\mu'$ , yang tertinggi di antara komposit yang lain dalam 20 Hz – 1 MHz and 1 MHz – 1.8 GHz.





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I certify that an Examination Committee has met on **date of viva voce** to conduct the final examination of Tan Foo Khoon on his degree thesis entitled “Synthesis and Characterization of Ferrite – Polypropylene composites” 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 Master of Science.

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## DECLARATION

I declare 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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**TAN FOO KHOON**

Date: 4 August 2011



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