



**EFFECT OF FILLER LOADING AND CHEMICAL
MODIFICATIONS ON PROPERTIES OF
CHITOSAN/ POLYPROPYLENE COMPOSITES**

by

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LIST OF ABBREVIATIONS AND SYMBOLS

| | |
|----------------|----------------------------------------|
| PP | Polypropylene |
| AA | Acrylic acid |
| MMA | Methyl methacrylate |
| AAc | Acetic acid |
| 3-APE | 3-aminopropyltriethoxysilane |
| SDS | Sodium dodecyl sulfate |
| OSL | Organosolv lignin |
| SEM | Scanning electron microscopy |
| TGA | Thermogravimetry analysis |
| DSC | Differential scanning calorimetry |
| FTIR | Fourier transform infrared |
| T_m | Melting temperature |
| ΔH_f | Fusion enthalpy of composites |
| ΔH_f^0 | Fusion enthalpy of PP 100% crystalline |
| X_c | Degree of crystallinity |
| E_a | Activation energy |
| α | Degree of conversion |

Kesan Kandungan Pengisi dan Modifikasi – Modifikasi Kimia Ke atas Sifat – Sifat Komposit Kitosan/Polipropilena

ABSTRAK

Komposit polipropilena (PP) terisi kitosan telah disediakan menggunakan pencampur bilah – Z pada suhu 190°C dan kelajuan rotor 50 rpm. Kesan pembebanan kitosan dan jenis – jenis modifikasi kimia yang berbeza ke atas sifat – sifat mekanikal, morfologi and sifat – sifat terma komposit PP/Kitosan telah dikaji. Pelbagai jenis modifikasi kimia seperti akrilik asid (AA), metil metakrilat (MMA), asetik asid (AAc), 3-aminopropiltrioksisilana (3-APE) dan natrium dodekil sulfat (SDS) telah digunakan dikaji. Lignin terlarut organo (OSL) telah disari dari serbuk tempurung kelapa dan digunakan sebagai separa rawatan dengan AA and SDS. Keputusan menunjukkan bahawa penambahan kitosan ke dalam PP mengurangkan kekuatan tensil, pemanjangan pada takat putus, darjah penghabluran (X_c) dan tenaga pengaktifan (E_a), di mana kestabilan terma dan modulus Young komposit meningkat. Modifikasi kimia kitosan menghasilkan kesan positif ke atas sifat – sifat mekanikal dan terma komposit PP/Kitosan. Komposit PP/Kitosan terawat dengan AA, MMA, AAc, 3-APE, SDS mempunyai kekuatan tensil, modulus Young, kestabilan terma, X_c dan E_a yang lebih tinggi berbanding komposit tanpa rawatan. Interaksi antarmuka yang lebih baik di antara kitosan yang terawat dan matrik PP telah dibuktikan melalui kajian mikroskop elektron penskanan (SEM). Spektra FTIR kitosan yang terawat menunjukkan kumpulan berfungsi yang baru dari pembentukan ikatan kimia di antara kitosan dan bahan kimia pemodifikasi. Komposit PP/Kitosan yang terawat dengan AA and lignin yang terlarut organo (OSL) mempunyai kekuatan tensil dan pemanjangan pada takat putus yang lebih rendah tetapi modulus Young, kestabilan terma, X_c dan E_a lebih tinggi daripada komposit PP/Kitosan terawat dengan AA. Mikrograf SEM komposit PP/Kitosan terawat dengan AA dan OSL menunjukkan permukaan yang kasar. Kesan OSL kepada komposit PP/Kitosan terawat dengan SDS telah meningkatkan pemanjangan pada takat putus, kestabilan terma, penghabluran, tenaga pengaktifan, manakala kekuatan tensil dan modulus Young berkurang dibandingkan komposit PP/Kitosan yang terawat dengan SDS. Morfologi komposit PP/Kitosan dengan SDS dan OSL menunjukkan kelakuan mulur.

Effect of Filler loading and Chemical Modifications on Properties of Chitosan/Polypropylene Composites

ABSTRACT

Chitosan filled polypropylene (PP) composites had been prepared using Z-Blade Mixer at temperature 190°C and rotor speed 50 rpm. The effect of chitosan loading and different types of chemical modifications on mechanical properties, morphology and thermal properties of PP/Chitosan composites were studied. The various types of chemical modifications such as acrylic acid (AA), methyl methacrylate (MMA), acetic acid (AAc), 3-aminopropyltriethoxysilane (3-APE) and sodium dodecyl sulfate (SDS) were investigated. The organosolv lignin (OSL) was extracted from coconut shell powder and used as partial treatment with AA and SDS. The results showed that the addition of chitosan into PP matrix reduced the tensile strength, elongation at break, degree of crystallinity (X_c) and activation energy (E_a), whereas the thermal stability and Young's modulus of composites increased. The chemical modification of chitosan resulted positive effect on mechanical and thermal properties of PP/Chitosan composites. The treated PP/Chitosan composites with AA, MMA, AAc, 3-APE, SDS have higher tensile strength, Young's modulus, thermal stability, X_c and E_a compared to untreated PP/Chitosan composites. The better interfacial interaction between treated chitosan and PP matrix was proven by the scanning electron microscopy (SEM) study. The FTIR spectra of treated chitosan showed the new functional group from the formation of chemical bonding between chitosan and chemical modifying agent. The treated PP/Chitosan composites with AA and OSL had lower tensile strength and elongation at break, but higher Young's modulus, thermal stability, X_c and E_a than treated PP/Chitosan composites with AA. The SEM micrographs of treated PP/Chitosan composites with AA and OSL exhibited a rough surface. The effect of OSL to treated PP/Chitosan composites with SDS increased the elongation at break, thermal stability, crystallinity and activation energy, while the tensile strength and Young's modulus decreased compared to treated PP/Chitosan composites with SDS. The morphology of treated PP/Chitosan composites with SDS and OSL showed the ductile behavior.

CHAPTER 1

INTRODUCTION

1.1 Research Background

Polymer composites with enhanced properties and versatility have led to their application in many industries and applications, including automobile, aerospace, furniture and packaging (Demzen et al., 1998; Mathew et al., 2005; Terenzi et al., 2006). A composite is a multi – phase material consisting of two or more physically distinct components, a continuous (matrix) phase and a dispersed (filler or reinforcement) phase. The dispersed phase can be classified according to particle dimensions that include fibers, platelet, ellipsoids and spheres. These particles can be of organic and inorganic origin and possess flexible or rigid properties. Filler size has an impact on composite properties with high aspect ratio and display significant improvements in composite properties, including strength, thermal stability and gas barrier (Chang et al., 2005; Frounchi et al., 2006; Wang et al., 2006).

Fibers such as aramid, carbon and glass have been extensively used for reinforcement. While these composites exhibit favorable properties such as high strength and heat resistance, they are expensive to produce, difficult to recycle and do not biodegrade (Shank et al., 2004). A trend has been developed towards incorporating natural fibers or fillers into composites. This shift has been prompted mainly due to various environmental, economic and performance issues (Shank et al., 2006). Natural fillers offer a cost effective and renewable alternative to their synthetic counterparts