MORPHOLOGY STUDIES OF TREATED AND UNTREATED SILICON CARBIDE FILLED POLYPROPYLENE COMPOSITES

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Abstract

Silicon carbide filled Polypropylene (PP) composites are fabricated, where the compounding is carried out by using Z-blade mixer with filler loadings of 0wt%, 10wt%, 20wt% and 30wt%. In order to improve compatibility between polypropylene matrix and silicon carbide particles, the particles surface was treated with titanate coupling agent (Lica-12). Composite sheets produced from hot press molding process are prepared for testing samples. The effect of filler loadings and incorporation of coupling agent on morphology of SiC filled PP composites are studied. The samples were sputter-coated with a fine layer of vanadium using a sputter coater and analyzed using JEOL JSM-646OLA scanning electron microscope. Comparison between morphology of treated and untreated PP-SiC composite is done. From morphology study, it can be seen that the filler distribution and SiC particle contact is improved by increasing the filler loading. Good filler distribution in the matrix improves the contact between filler and filler thus minimized the existing pores. As a result properties such as tensile strength and tensile modulus can be improved. The morphology also showed more pores exist in the 70%PP-30%SiC compared to 90%PP-10%SiC sample. From the result, a decrease of porosity can be observed for the composite treated with Lica-12 at 10% filler loading. However this treated SiC filled PP composites showed an increase in porosity as filler loading increased. To support the statement, SEM micrograph of 90%PP-10%SiC treated with 5%Lica-12 showed better dispersion of filler and improved wet-out between PP (matrix) and SiC (filler) compared to untreated 90%PP-10%SiC composites.

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INTRODUCTION

Thermally conducting but electrically insulating polymer-matrix composites is increasingly important for electronic packaging because the heat dissipation ability limits the reliability, performance and miniaturization of electronics [3]. Ceramic fillers such as aluminum nitride, silicon carbide and alumina are used. That explained why ceramic powder reinforced polymer materials have been used extensively as electronic packaging materials [1, 2]. This work is focused on SiC as filler in PP matrix due to its combination of high thermal conductivity and low cost. It is known that the transport of heat in nonmetals occurs by phonons or lattice vibration.

The thermal resistance is caused by various types of phonon scattering processes include pore scattering phenomenon [4]. Therefore, we investigate the existence of porosity in the composite system seems the phonon-pore scattering phenomenon can affect the thermal transport. The research also studied the effect of titanate coupling agent (Lica-12) addition on the porosity of PP-SiC composite since this type of coupling agent are believed can enhance the properties of composites combining a wide range of fillers and polymers [7].

METHODS AND MATERIALS

Polypropylene filled with silicon carbide (SiC-PP) composites are prepared with melt mix method by using Z-blade mixer with the rotation speed of 35 rpm at 190°C and then compressed by using hot press molding with the pressure of 165 kg/cm^2 at 190°C. Composites with different weight percentage of filler contents varying from 0% to 30% were prepared. In order to improve properties of composites consisting of PP filled with SiC particles, the particles surface was treated with a titanate coupling agent (Lica-12). The effect of titanate coupling agent on density and porosity of SiC-PP composite were measured as a function of filler loading and coupling agent content.

<u>Porosity Test</u>

Porosity is determined by using soaking process or water absorption test. The soaking process is done for 30-45 minutes. Absorption occurs when water liquid enter the pores existed in the sample solid. Porosity is the ratio between pores and total sample volume. While bulk density value is mass per total volume includes all the pores and filled portion of the pores. In this experiment, ethanol is used instead of water and the density value for ethanol is 0.7893 g/cm^3.

$$\% \text{ Porosity} = \frac{W3 - W1}{W3 - W2} \times 100\%$$

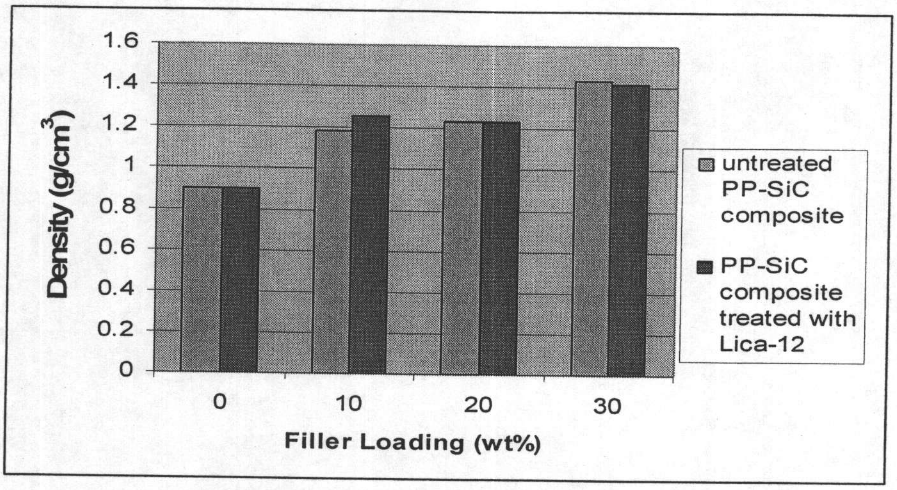
Where;

W1 = sample weight in air = solid weight + open pores weight

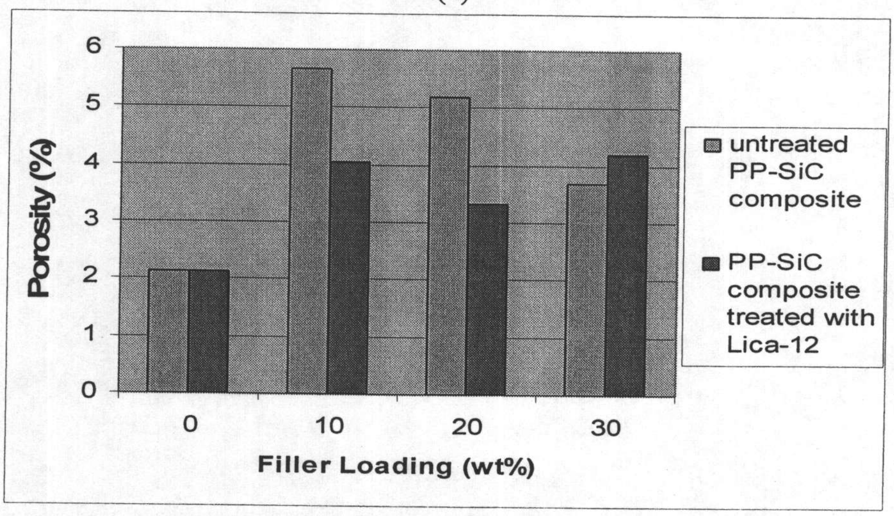
W2 = sample weight in water

W3 = sample weight in air after soaking = W1 + water weight with closed pores

RESULTS AND DISCUSSION



(a)



(b)

Fig. 1. **a) Bulk density and b) Porosity value of PP-SiC composite in different filler loadings.**

Figure 1a shows the bulk density of both treated and untreated composite with a function of filler loading. It can be seen that the density of untreated composite increased with increasing filler loading. However, the treated composite showed an increment in density at 10% filler content but exhibit a decrement in density at 30% filler content. Figure 1b shows the result for porosity test on the composite samples. According to the result, untreated 90%PP-10%AlN shows the highest porosity value at 5.7%. For overall untreated composite, porosity decreased as filler loading increased. But for the treated composite, the result is inconstant where 70%PP-30%AlN showed the highest porosity value. The result predicts that the addition of coupling agent caused a decrease of porosity for low filler loading composite (10% filler content) but promotes an increase in porosity for the higher filler loading composites. Previous research [8] stated that an increase in porosity is intrinsically related to the processes that take place during the mixing and compression molding procedures.

From morphology study (Figure 2-4), it can be seen that the filler distribution and SiC particle contact is improved by increasing the filler loading. Good filler distribution in the matrix improves the contact between filler and filler, thus minimized the existence of pores [10]. Figure 1b indicates that for untreated composite, the increase of filler loadings decreased the degree of porosity in the PP-SiC composite. Reduction of porosity increased the density of particle contacts. It is believed that this condition provides a better contact for the powder particles and therefore, facilitates thermal transport by improving contact in the powder chains [8].

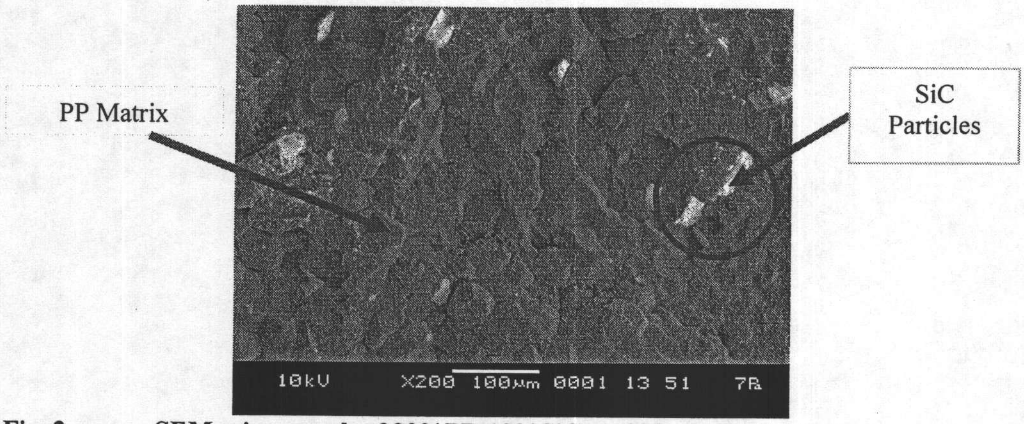


Fig. 2. **SEM micrograph of 90%PP-10%SiC at 200x magnification**

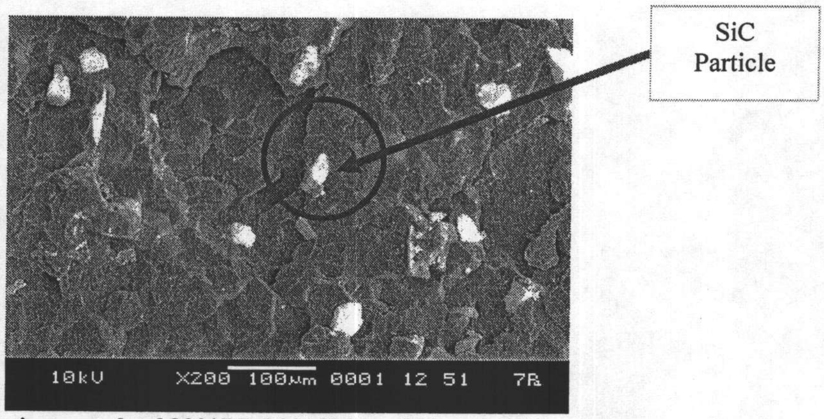


Fig. 3. **SEM micrograph of 80%PP-20%SiC at 200x magnification**

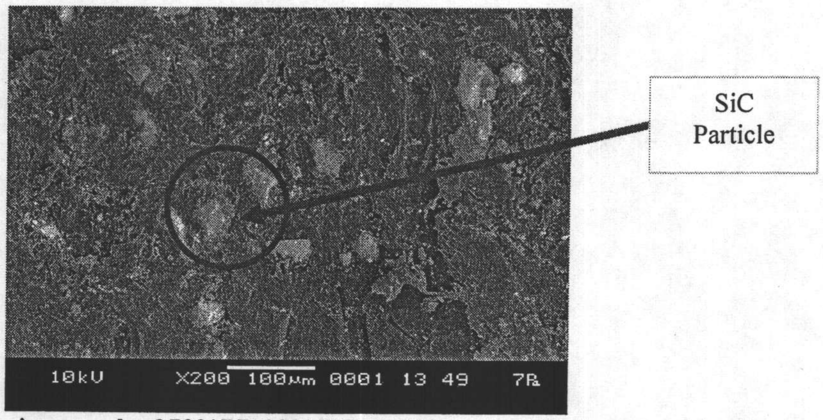


Fig. 4. **SEM micrograph of 70%PP-30%SiC at 200x magnification**

Coupling agent can enhance the compatibility between the resin and the filler thus enhance the dispersion of the fillers, improved wet-out between resin matrix and filler [9]. Comparison between morphology of treated and untreated PP-AlN composite is shown in Figure 5. Figure 5a shows the poor dispersion of filler due to weak filler-matrix interaction while Figure 5b shows better filler dispersion in matrix and better wetting by matrix caused by the addition of Lica-12. Good wetting by matrix can reduce porosity and these statement supported by the result obtained in Figure 1b. Figure 6a and 6b show the morphology of 90%PP-10%SiC and 70%PP-30%SiC respectively, where more pores exist in the 70%PP-30%SiC compared to 90%PP-10%SiC sample.

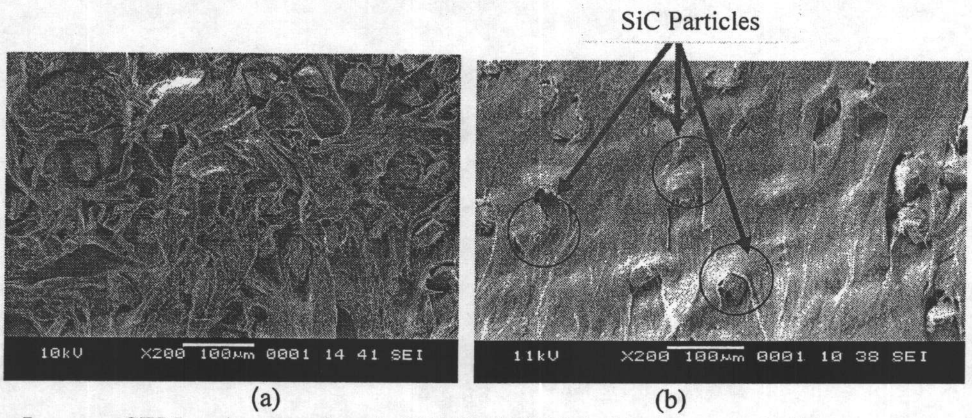


Fig.5. SEM micrograph of 90%PP-10%SiC (a) untreated (b) treated with 5%Lica-12 at 200x magnification showed better dispersion of filler and improved wet-out between PP (matrix) and SiC (filler)

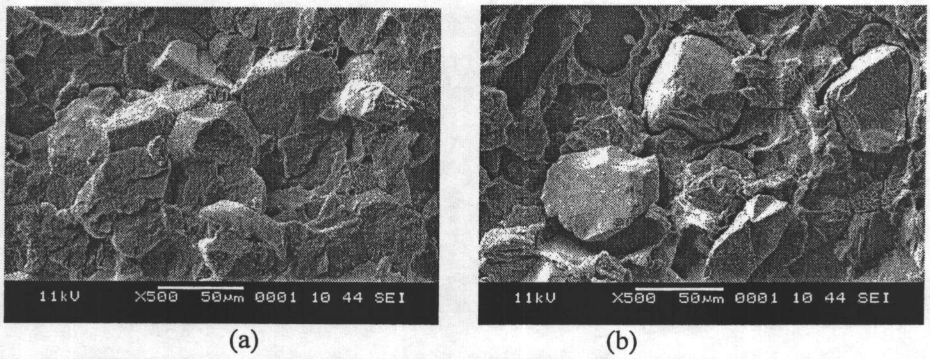


Fig. 6. SEM micrograph of (a) treated 90%PP-10% SiC with less pores existence (b) treated 70%PP-30%SiC with more pores caused by de-wetting of filler by matrix; at magnification 500x.

CONCLUSIONS

- For overall untreated composite, porosity decreased as filler loading increased.
- The addition of 5%Lica-12 decrease the porosity for PP-SiC composite with 10% filler content but promotes an increase in porosity for PP-SiC composite with 30% filler content.
- Good wetting by matrix can reduce porosity and these statement supported by the morphology studies on the composite system.

ACKNOWLEDGEMENTS

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