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Technical paper

Calcium Carbonate from Clam Shell as a Thermal Conductor in Particulate Filled Polymer Matrix Composites

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Abstract

The thermal conductivity of the raw and stearic acid treated calcium carbonate ($CaCO_3$) from clam (Polymesoda bengalensis) shell powder infused in unsaturated polyester matrix has been measured. Eight different mean diameter sizes of clam shell filler were infused into unsaturated polyester (UPE) matrix. Thermal conductivity of neat UPE sample and when embedded with raw and stearic acid treated $CaCO_3$ filler with different mean diameter sizes and filler loadings were measured according to ASTM E1225-99. The result showed that UPE matrix composites with untreated clam shell produced higher thermal conductivity than treated clam shell. At constant filler content, the thermal conductivity of UPE/$CaCO_3$ composites was increased gradually as the filler size was decreased. The higher the filler content, the higher the thermal conductivity of the composites. Therefore, the inclusion of higher filler loading with finer filler size of seafood waste from clam shell can improve the performance of polymer matrix composites as a heat conductor.

Keywords: *Calcium Carbonate; Clam Shell; Particulate-Filled Composites; Stearic Acid; Thermal*

1. Introduction

Metallic fillers such as silver, copper and nickel are among the most common fillers embedded in the polymer matrix composites (PMCs) to increase the thermal conductivity. However, due to some drawbacks of metallic filler such as high density, low corrosion resistance, and high manufacturing cost lead to the replacement of other materials which could overcome those problems. Polymers are generally good insulators and light weight. Adding sufficient amount of filler may improve thermal conductivity of polymer matrix. Traditional fillers and common polymers with their thermal conductivities as collected by Ebadi-Dehaghani and Nazempour [1] are listed in Table 1.

Previous studies showed that the thermal conductivity of the composite materials can be increased by increasing filler content [2-4], decreasing filler size [4-6] and increasing filler interconnectivity [7]. Adding 30 vol% micron size graphite filler into Bakelite resin can improve thermal conductivity to 4.84 W/mK compared to 1.4 W/mK for neat Bakelite. Then, adding the same filler up to 55 vol% might improve the thermal conductivity to 12.28 W/mK [2]. Another example of effect of increasing filler content is nano calcium carbonate ($CaCO_3$) and zinc oxide (ZnO) in polyprolyplene (PP). Increasing filler content up to 15wt% of nano $CaCO_3$ and ZnO in PP increased to 0.36 W/mK and 0.4 W/mK respectively compared to 0.22 W/mK for neat PP [8, 9]. Decreasing filler size also might increase the thermal conductivity. For example nano size of expanded graphite filler at constant filler loading (7 vol%) in high density polyethylene (HDPE) improved the thermal conductivity to 1.59 W/mK compared to only 0.78 W/mK at micon size [10]. Interconnectivity also affects the performance of heat conduction. It is defined as a relative measure to an ideally interconnected network of the high thermally conducting phase. Weidenfeller et al [7] claimed that thermal conductivity of low conductive filler in PMCs can be improved by improving the interconnectivity of filler. Better interconnectivity of talc powder in PP matrix results in twice as high as Cu/PP composites at similar filler loading even though thermal conductivity of copper is approximately 40 times higher than talc [7].

PMCs with high thermal conductivity might be very useful in many applications. The thermal conductivity required in applications for heat sinks in electric or electronic systems for example, is approximately from 1 to 30 W/mK [19]. However, to achieve the appropriate thermal conductivity, higher filler contents which is normally higher than 30 vol% was infused in the polymer matrix [19]. This quantity unfortunately leads to processing challenge such as possibility to be extruded and injection molded [19] and alters the polymer behaviour density.

This research uses $CaCO_3$ extracted from the local clam shell as a filler or reinforcement in the polymer composite. The clam was locally known as *lokan bakau* or in scientific name as *Polymesoda bengalensis*. $CaCO_3$ is not new filler for polymeric composites. In 2007, Europe used about 4.8 million tons of filler and carbon black and calcium carbonate were reported as the most widely used fillers [20]. However, most of $CaCO_3$ is determined from limestone. The usage of waste materials such as clam shell in this study may reduce the amount of waste disposed in the landfill

Table 1: Thermal conductivities of some thermally conductive fillers [11-15] and polymers [16-18]

Fillers		Polymers	
Material	**Thermal conductivity at 25 °C (W/mK)**	**Material**	**Thermal conductivity at 25 °C (W/mK)**
Graphite	100~400 (on plane)	Low density polyethylene (LDPE)	0.30