CHAPTER 1

Introduction

This chapter deals with the background of the research, why carbon nanotube composites, and the objectives of this work.

1.1 Background

This thesis is a part of doctor of philosophy program in materials science, a doctoral degree type 1.1, proposed in the thesis title "Mechanical Properties and Thermal Conductivity of Multi-Walled Carbon Nanotubes/Polymer Composites Coated on Copper and Aluminium." It has three research objectives consisting of (1) to study microstructure, mechanical properties, and thermal conductivity of MWNTs/Polymer composites and composites coated on copper and aluminium, (2) to study the interfacial bonding between MWNTs/ Polymer composites coated on copper and aluminium, and (3) to study thermal absorption, heat transfer of MWNTs/Polymer composites coated on copper and aluminium.

In the past few decades, the use of composite materials in structural components has been increasing rapidly. The composite materials consist of at least two different components blended together in such a way that the properties of the material produced are greatly different from those of its compositions. One of the compositions forms a continuous phase called the matrix while the other, the discontinuous phase, is uniformly dispersed within the matrix called the reinforcement phase. The reinforcement phase well known as the filler material, can be in the form of fibers or particles. The filler material gives the composite with its specific physical properties while the function of the matrix is to hold the fillers together. Generally fibers are the most commonly used fillers and they can be either continuous or short fibers. Furthermore, fiber reinforced polymer composites still constitute the majority of composite materials produced due to their light weight and ease of fabrication. The most promising among fiber reinforced polymer composites are carbon nanotubes.

1.2 Why carbon nanotube composites

Carbon nanotubes (CNTs) have been proven to be an excellent thermal conductor in many applications [1]. Yields from theoretical predictions show an extremely high thermal conductivity for individual single-walled carbon nanotubes (SWNTs) and multi-walled carbon nanotubes (MWNTs) at 6000 W/mK and 3000 W/mK, respectively [2]. MWNTs have obvious advantages over SWNTs in aspects of low cost and ease of large-scale production. Although there is increasing interest in the dispersion of pristine SWNTs in common organic

solvents for the preparation route of the composites, the dispersion of pristine MWNTs was also widely reported [3-5]. In addition, MWNTs were readily available in our laboratory for the purpose of this project. Furthermore, the black color of MWNTs provides a good absorbing layer for the solar radiation, combined with their high specific surface area [6-7]. Therefore, MWNTs were usually chosen to improve the thermal properties of matrix materials [8-9].

1.3 Overview

Due to the need for pollution free energy, there is a keen interest in finding a solution for improving an efficiency of a solar heat collector [10]. Since the solar energy is an inexpensive source of renewable energy, many research studies in this topic focus on improving the efficiency of the collector [11-12]. The solar heat collector is utilized to absorb a solar radiation and transfers heat to a medium such as water or air. There are two types of the collector: non-concentrating and concentrating collector [13]. The non-concentrating one does not track the sun, while the concentrating collector tracks the sun and focuses the solar radiation onto absorber plates. The absorber plate plays an important role among various components of the solar collectors. To improve the heat absorption and heat transfer coefficients, the absorber plate needs to be maximized for surface roughness, thermal conductivity and density [14-19]. Moreover, the absorber is usually painted in black, because a dark surface absorbs the thermal radiation better than a light colored surface [20-23]. In other words, the black surface reflects a lower amount of the thermal radiation.

Since Iijima discovered carbon nanotubes (CNTs) in 1991 [24], and since then, CNTs have been shown to have excellent mechanical properties, with a tensile strength of approximately 20–150 GPa, and a Young's modulus of approximately 0.5–2 TPa [25-29]. CNTs also show high thermal conductivity (2000-6000W/mK) [25-29]. Many methods exist for the preparation of CNTs; for example, arc discharge, laser ablation, and chemical vapor deposition (CVD). However, the agglomeration of CNTs presents problems for their applications. Therefore, it is important to prepare CNTs to reduce the size of agglomerates and improve their dispersion before they are used [30].

Polymer/CNT composites are very interesting. Polymers are light, cheap, and tough, but have poor mechanical properties many scientists therefore use CNTs to fill polymers and improve their mechanical properties to provide a replacement material for wood or metal. Kundu et al. studied the effects of various methods for the preparation of linear low density polyethylene (LLDPE) films [31]. The film preparation procedures were varied, including variations in the cooling methods; quenching, forced cooling (by fan), and natural cooling were used. Naturally cooled samples showed the highest degree of crystallinity, and higher Young's modulus and yield stress, but lower elongation at break. In addition, the tensile strength was decreased when the degree of crystallinity increased. Mezghani et al. improved the mechanical properties of LLDPE/CNT fibers prepared using a twin-screw extruder [32]. They used CNT loadings of 0.08, 0.3, and 1 wt.% CNT in their study. The 1 wt.% CNT/LLDPE sample showed the highest tensile strength (increased by 38% compared to the pure LLDPE fibers). In ceramic processing, ceramic materials are consolidated using sintering process [33]. Green compact materials were heated at a high temperature below the melting point. The driving force for the sintering process is the reduction of the surface energy of the particles, which is caused by decreasing their vapor-solid interfaces. The sintering process therefore helps to decrease porosity in the compact materials.

1.4 Objectives of this work

The main objectives of this work are to study mechanical properties and thermal conductivity of Linear low density polyethylene/multi-walled carbon nanotube (LLDPE/MWNT) composites by using single-step and four-step heating in the melt mixing process in a furnace. The volume fraction of MWNTs in the composite materials was varied, with 1, 3, 5, and 10 vol.% used for four-step heating, and 1, 3, and 5 vol.% used in single-step heating. We will be investigated and discussed, as listed here,

1. To study microstructure, mechanical properties of MWNTs/Polymer composites and composites coated on copper and aluminium.

2. To study the interfacial bonding between MWNTs/Polymer composites coated on copper and aluminium.

3. To study thermal absorption, heat transfer of MWNTs/Polymer composites coated on copper and aluminium.

1.5 References

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