Effect of polypropylene type on G/CB/CNTs/PP composites properties as bipolar plate for PEM fuel cell

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ABSTRACT – Investigation of the conductive polymer composites (CPCs) have been carried out using Graphite (G), Carbon Black (CB), Carbon Nanotubes (CNTs) and Polypropylene (PP) as a binder. While, two types of PP which are medium density (MD-PP) and low density (LD-PP) were mixed with multi filler by using a ball mill. The comparison of PP with respect to the resulting electrical conductivity and mechanical properties were investigated. Results indicate that CNTs was dispersed better in MD-PP than LD-PP would cause better electrical conductivity and mechanical properties of G/CB/CNTs/PP composite bipolar plate which are exceeded of the U.S. Department of Energy (DOE) requirement.

1. INTRODUCTION

The development CPCs is a promising and growing field of research due to highly resistant to corrosion, low cost and have low densities that might result in the materials replacing metal bipolar plate in Proton Exchange Membrane Fuel Cell (PEMFC) [1]. The bipolar plate is a main component of PEMFCs stack, which takes a large portion of stack cost [2]. They can contribute 70-80% of the stack weight and up to 45% of the costs. Hence, the investigation on cost/performance materials of bipolar plates has become a critical research issue. In order to obtain the better electrical conductivity of the composite, the combinations of multi fillers have been used as bipolar plate materials [3]. The reinforced fillers used commonly including graphite, carbon nanotube, carbon fiber, and carbon black which has been incorporated into the composites to enhance overall performance of composite bipolar plates by conventional polymer processing technique [3]. There are two different types of polymeric resins including thermoplastics and thermosets in order to fabricate composite bipolar plate. Comparing with this two type material, PP have the advantages of low cost, good processability, well-balance physical and mechanical properties [4]. The aim of this study is to investigate the significant effects of Polypropylene (PP) types on electrical and mechanical properties G/CB/CNTs/PP composite as bipolar plate. The U.S. DOE has specified requirement (Table 1) regarding the conductivity, gas permeability and material strength which should satisfy for the fabrication of a bipolar plate.

Table 1 Requirement properties for the bipolar plate (DOE target) [2,4,5].

Property	Value
Electrical conductivity	> 100 [Scm^{-1}]
Thermal conductivity	> 10 [$W(mK)^{1}$]
Flexural strength	> 25 [MPa]
Shore hardness	> 50
Bulk Density	< 5 [g/cm^3]

2. METHODOLOGY

The multi filler materials are mixed used ball mill as pre-mixing process at a speed of 200 rpm for 1 and half hour. After that, the wt% compositions of G/CB/CNTs/PP are shown in Table 2 has been prepared. Then, a ball mill was used again to mix the materials from the previous stage with binder at a speed of 200 rpm for 1 hour. A hot press machine was used to shape the samples for properties measurements. The mixture of all material was then preheated for 20 min in a mould placed in the hot pressing machine before it pressed at a temperature of 185 ºC and a pressure of 85 kg/cm^2 for 15 min.

Table 2 The composition of composite G/CB/CNTs/PP (Based on weight %).

Filler			Binder
G %	CB%	CNTs%	PP%
52.0	25	3.0	20
51.0	25	4.0	20
50.0	25	5.0	20
49.0	25	6.0	20
48.0	25	7.0	20
47.0	25	8.0	20

3. RESULT AND DISCUSSION

3.1 Effect of CNTs/PP on electrical conductivity

As shown in Figure 1, the electrical conductivity was increased significantly in the order of CNTs/MD-PP>CNTs/LD-PP nanocomposite bipolar plates. At 6 wt% CNTs content, the electrical conductivities of CNTs/LD-PP and CNTs/MD-PP were measured at 125.4 S/cm and 158.32 S/cm respectively. This phenomenon may be attributed to the better dispersion of CNTs in MD-PP than LD-PP [4].

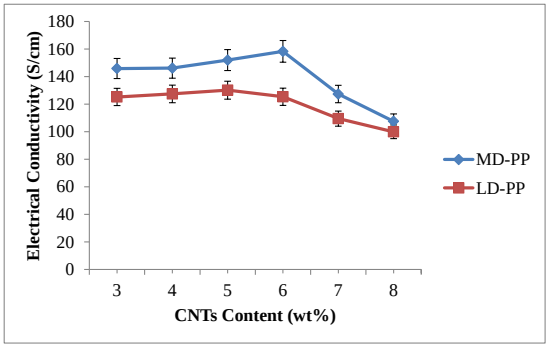

Figure 1 Electrical conductivity with various CNTs contents.

3.2 Effect of CNTs/PP on flexural strength

The flexural strengths of nanocomposite bipolar plates were increased with the increasing of CNTs content as shown in Figure 2. As CNTs content was at 5 wt%, the flexural strength of CNTs/LD-PP and CNTs/MD-PP were increased from 10.6 MPa and 22.95 MPa (3 wt%) to 13.64 MPa and 29.86 MPa (5 wt%), respectively. The CNTs/MD-PP nanocomposites bipolar plates with the better compatibility between fillers and polymer resin have the greater reinforcement of the flexural strength [5].

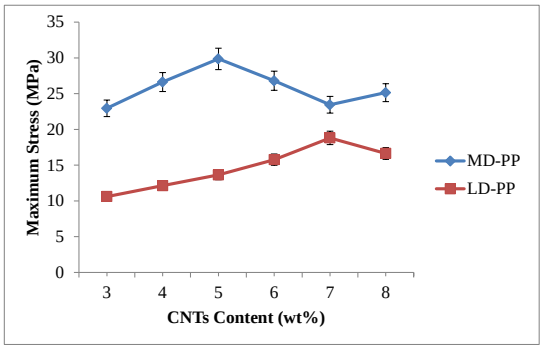

Figure 2 Flexural strength with various CNTs contents.

3.3 Effect of CNTs/PP on shore hardness and density

The value of shore hardness of CNTs/MD-PP nanocomposite bipolar plates were much higher than CNTs/LD-PP as shown in Figure 3. As 8 wt% of CNTs was incorporated into LD-PP and MD-PP nanocomposites bipolar plates, the hardness was increased to 72 (SH) and 81.3 (SH) respectively. These results postulated that better dispersion and good compatibility between CNTs and MD-PP will induce stronger adhesion [5]. However, the density of CNTs/LD-PP and CNTs/MD-PP nanocomposite bipolar plate showing no significant effects of increasing of the CNTs content. An average value of CNTs/LD-PP and CNTs/MD-PP density is 1.616 g/cm3 and 1.635 g/cm3, respectively. It achieves the requirements stated by the U.S. DOE for bipolar plate (<5 g/cm3).

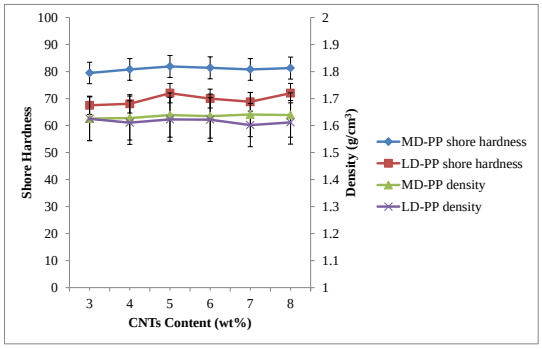

Figure 3 Shore hardness and density with various CNTs contents.

4. CONCLUSIONS

This observation indicates that the addition of CNTs (6 wt%) in MD-PP leads to a significant improvement with high electrical conductivity and mechanical properties which is can be used on the cell performance of the nanocomposite bipolar plate.

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