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Effect of Poly (Ethylene Glycol) Diglycidyl Ether as Surface Modifier on Conductivity and Morphology of Carbon Black Filled Poly (Vinyl Chloride)/Poly (Ethylene Oxide) Conductive Polymer Films

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Abstract- *Blends of poly (vinyl chloride) and poly (ethylene oxide) with addition of carbon black as filler was prepared by solution casting technique to fabricate a conductive polymer film. Poly (ethylene glycol diglycidyl ether) (PEGDE) was added into the formulation in order to improve its properties. The surface morphology of the conductive polymer film was characterized by using scanning electron microscope (SEM). The result showed that the conductivity of the film was greatly enhanced by incorporating PEGDE as surface modifier in the PVC/PEO conductive polymer film.*

Keywords: Poly (Vinyl Chloride); Poly (Ethylene Oxide); Poly (Ethylene Glycol) Diglycidyl Ether; Electrical Conductivity

1.0 INTRODUCTION

Polymer blending is one of the most important methods for the development of new materials with a variety of properties and superior than the individual component polymer. It is one of the efficient ways to reduce the crystalline content and improve the amorphous content. Generally, polymer materials are insulators and blending with conductive filler to improve its conductivity properties. The conductivity of the composite materials depends on the size and shape of the filler particles in addition to their distribution within polymer matrix [1]. The conductivity of the polymer increases if the added filler forms a continuous conductive network in the matrix. The example of conductive filler in order to form conductive network are natural and synthetic graphite, copper, carbon black and carbon nanotubes [2].

Polyvinyl chloride is chosen as a polymer matrix because of its broad range of application, low cost, chemical stability, biocompatibility and sterilizability. It is broadly used in industrial fileds for many years. However, PVC has low thermal stability and brittleness which hinders certain applications. Therefore, it is important to blend PVC with other polymer materials to achieve good properties in order to yield high added values [3]. Polyethylene oxide (PEO) is semicrystalline polymer, owning both crystalline and amorphous phases at room temperature. It is the most interesting base material because of it is high thermal and chemical stability [1, 4]. PEO is a weak proton acceptor polymer and therefore it compatible with PVC because PVC can be considered as a proton donor which provides acidic hydrogen. In recent years, PVC is commonly used in polymer blending due to its miscibility with other polymer materials.

Carbon black (CB) which is commonly used in industry to achieve the conductive polymer composites due to its cost advantage over many other types of filler and abundant supply, exhibits the particle shape at relatively low concentration and supermolecular structures at relatively high concentration [5]. Carbon black widely used as conductive fillers in order to make the insulating nature polymers into electrically conductive due to its easy process ability and lighter than other metallic particles [6]. Poly (ethylene glycol diglycidyl ether) (PEGDE) was commonly used in the chemical industry for surface modifying and crosslinking. It is widely acted as an additive for crosslinking polymers bearing amine, hydroxyl and carboxyl groups and has a good solubility in water [7]. In polymer electrolyte application, PEGDE is usually incorporated as a plasticizer and stabilizer. It not only improves the conductivity but also the high chemical stability of the solid polymer electrolyte. Recently, Jing Fu et al. has been reported that the measured conductivity of the alkaline solid polymer electrolyte membrane from PVA ranged from 2.75 to 4.73×10^{-4} Scm^{-1} at room temperature was increase up to 1.5×10^{-3} Scm^{-1} by addition of PEGDE. This was due to high chemical stability of the membranes was achieved by high densely chemical crosslinking modification and the formed inter-penetrating network of the membrane [8].

The important objective of the research is to study the effect of PEGDE and loading of the conductive filler on the properties of PVC/PEO films. Therefore, this research reports an investigation on electrical conductivity properties and morphology of PVC/PEO filled carbon black conductive film by varying carbon black loading and addition of PEGDE in the conductive polymer film.

2.0 METHODOLOGY

2.1 Materials

Poly vinylchloride (PVC) with M.W ≈ 220 000 and poly ethylene oxide (PEO) with M.W ≈ 100 000 were used as a basic polymeric matrix. Carbon black (CB) with the mean particle size < 177 μm was used as conductive filler in the conductive polymer blend. Dioctylterepthalate (DOTP) with the M.W ≈ 390.56 was used as a plasticizer.

2.2 Sample Preparation

The PVC and PEO conductive film were prepared using solution cast technique. The required amount of PVC and PEO were dissolve in Tetrahydrofuran (THF) by using stirrer at speed 600 rpm. The solution was prepared at room temperature. After incorporating the required amount of Dioctylterepthalate (DOTP) as plasticizer, PEGDE as surface modifier and carbon black was suspended in the PVC/PEO blends. The mixture was stirred continuously for 4 hours until get a homogeneous mixture. Then, the mixture was cast onto a glass mould and allowed to evaporate slowly inside a fume cupboard at room temperature. The same methods were repeated to produce sample with different carbon black loading.

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3.0 DISCUSSION

Figure 1 shows the relationship of the electrical conductivity as a function of the conductive filler content for PVC/PEO/CB films and PVC/PEO/CB/PEGDE films. From the Fig. 1, the electrical conductivity of the PVC/PEO conductive film increased with increasing CB loading. The increment of electrical conductivity was due to the increasing of surface interaction between carbon black particles in PVC/PEO/CB films. However, the PVC/PEO/CB/PEGDE films showed higher electrical conductivity compared to PVC/PEO/CB film. This was due to the addition of PEGDE enhanced good distribution of CB on the surface of PVC/PEO/CB films. The presence of PEGDE also promotes the proton conduction and increase the conductivity value. Jin et al. have studied the effect of PEGDE content as plasticizers on the ionic conductivity of (PEO-PMA) based polymeric gel. The result show that the ionic conductivity increases with an increase in the content of PEGDE [9].

The percolation threshold value is about 20 wt% for both PVC/PEO/CB films and PVC/PEO/CB/PEGDE films. A percolation threshold in conductivity presents when the volume fraction of the filler enough to provide continuous electrical paths through the polymer matrix. The percolation threshold varies with the shape and agglomeration of the filler as well as type of polymer used [10].

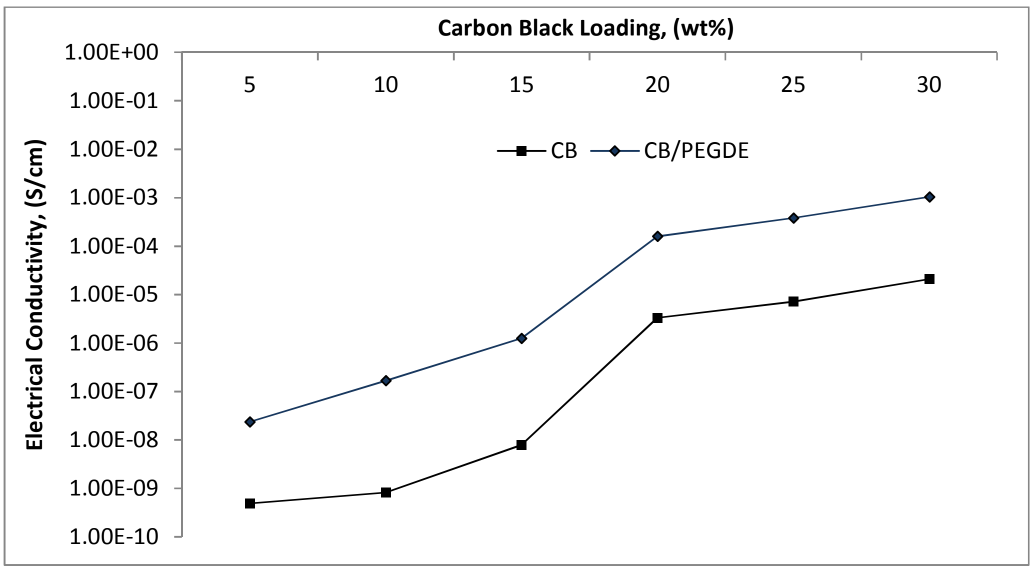
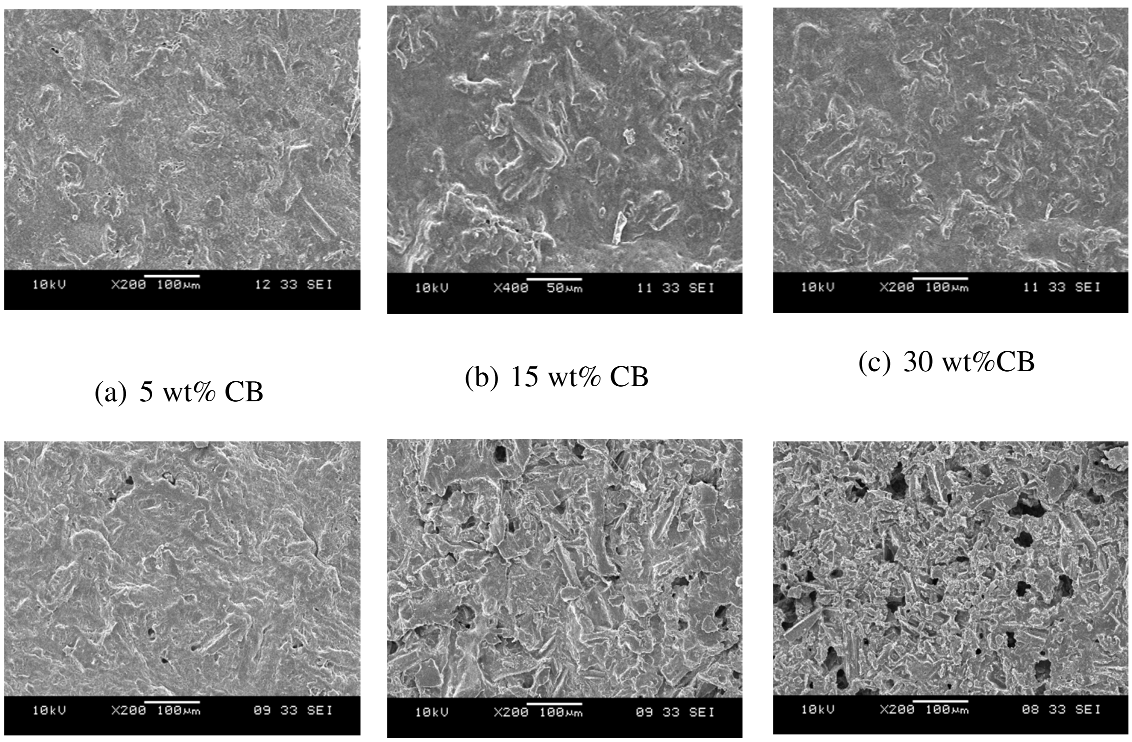


Figure 1: Electrical conductivity of PVC/PEO/CB films and PVC/PEO/CB/PEGDE films with different carbon black loading.

Figure 2 (a-c) shows SEM micrographs of extracted surface of PVC/PEO blends with carbon black loading. From the micrograph, at 5 wt% of CB loading there is good distribution of CB in the PVC/PEO blends indicated that a good interaction between carbon black and PVC/PEO phases. When the content of CB increased at 30 wt% (see Fig. 1(c)) shows the CB particles in the PVC/PEO blends formed an agglomeration on the surface of the film. The agglomerations of CB particles that formed on the surface will create the connection of the conductive path on PVC/PEO/CB conductive films that contribute to higher conductivity value compared to 5 wt% of CB loading.

Figure 2 (d-f) shows SEM micrographs of extracted surface of PVC/PEO blends with different CB loading and the addition of PEGDE as surface modifier in the conductive polymer films. However, the PVC/PEO/CB/PEGDE films show many holes on the extracted surface compared to PVC/PEO/CB film. Furthermore, the surface becomes rougher when the CB content increases by 5 wt% to 30 wt%. This was due to the extraction of PEGDE during the immersion of the films in toluene at 24 hours.



(a) 5 wt% CB (b) 15 wt% CB (c) 30 wt%CB

(d) 5 wt% CB/PEGDE (e) 15 wt% CB/PEGDE (f) 30 wt% CB/PEGDE

Figure 2: SEM micrographs of extracted surface of PVC/PEO/CB and PVC/PEO/CB/PEGDE conductive polymer film

4.0 CONCLUSION

The PVC/PEO/CB conductive polymer films were produced by using solution casting method. There are some improvement exist by incorporating PEGDE as surface modifier. The electrical conductivity of the PVC/PEO polymer film was increased with the addition of PEGDE as surface modifier into the PVC/PEO/CB films.

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