STATIC DISSIPATIVE BIOPOLYMER COMPOSITES FOR ELECTRONIC PACKAGING

W. Prissanaroon-Ouajai*, S. Ouajai and A. Reung-u-rai,
Department of Industrial Chemistry, Faculty of Applied Science,
King Mongkut's University of Technology North Bangkok,
1518 Piboonsongkarm Road, Bangsue, Bangkok, 10800 THAILAND
*Email Address: pwalaip@hotmail.com

SUMMARY

Static dissipative biopolymer composites have been prepared by adding conducting polypyrrole particles into poly(lactic acid) (PLA). Novel mixing method has been developed to improve the dispersion of polypyrrole particles in PLA matrix. Resistivity of the composites is in optimal electrostatic discharge (ESD) protection range, offering potential in electronic packaging applications where ESD is a major concern.

Keywords: Poly(lactic acid), Polypyrrole, Poly(ethylene glycol), Static dissipative, ESD

INTRODUCTION

Poly(lactic acid) (PLA) has received much attention in the research due to its biodegradability and biocompatibility. PLA has been considered as a major alternative to petroleum-based plastics for disposable items, such as packaging [1], as it is expected to reduce an impact on the environment caused by the production and utilization of petrochemical polymers.

The combination of insulating PLA with intrinsically conducting polymer such as polypyrrole (PPy) allows us to create new biopolymer composites with unique electrical properties, applying in electrostatic discharge (ESD) protection [2]. However, the polymer composites prepared as a mixture of PPy phase and PLA phase show a static dissipative property (Resistivity 10^6 to 10^9 Ω/Square) for ESD applications at a relatively high content of PPy due to aggregations of PPy particles.

In this research, PPy particles have been synthesized via micro-emulsion polymerization and then a master batch method has been performed to improve the distribution of PPy particles in PLA matrix. According to this method, a large quantity of PPy particles is dispersed in an aqueous solution of poly(ethylene glycol) (PEG) to give a master batch which is then blended with pure PLA resins before extrusion.

EXPERIMENTAL

PPy nanoparticles were synthesized via micro-emulsion polymerization in an aqueous solution containing purified pyrrole monomer (Fluka), sodium dedecylsulfate (Ajax Finechem) and ammonium peroxydisulfate (Sigma-Aldrich). After 24 h, large excessive

methanol was pour into the solution to terminate the reaction. The resulting PPy precipitate was centrifuged, washed with methanol an distilled water for several times and dried in a dessicator. To prepare PPy master batch, PPy particles was dispersed well in PEG solution under ultrasonication. The mixture was subsequently cast onto a glass container, dried at 80^{o}C for 24 hr and cut to small pieces. A certain amount of PPy master batch was then mixed with PLA resins before melt mixing in a twin screw extruder. Electrical conductivity of the compressed pellets of PPy and the PPy-PLA composites was examined by a four-point probe method following ASTM D257.

RESULTS

Characteristics of PPy particles

PPy particles were obtained at a high yield (>107%) due to incorporation of anionic surfactants into the PPy backbones. PPy particles had spherical morphology with 60-90 nm in average diameter and conductivity of 40 – 60 S/cm. FT-IR and UV-VIS spectra of the PPy particles indicated the typical characteristics of PPy in conducting state which were consistent with literatures [3].

Conductivity and morphology of PPy-PLA composites

The conductivity of the composites increased with an increasing content of PPy particles. It was found that the increase of PPy content from 1.0 wt % to 2.5 wt % in the PPy-PLA composites resulted in an enormous increase in conductivity by six orders in magnitude by changing from 3.5×10^{-15} S/cm to 1.4×10^{-9} S/cm. The PPy-PLA composite with the 5.0 wt % PPy content exhibited the conductivity of 8.8×10^{-7} S/cm indicating a static dissipative property which is optimal for ESD protection. The observed percolation threshold concentration of 2.5 wt % PPy content is appreciably lower than those of the PPy-PLA composites prepared by mixing PPy particles directly to the PLA matrix and other PPy composites reported elsewhere [4,5]. Scanning electron micrographs of the PPy-PLA composites showed good distribution of PPy particles. The conducting PPy was dispersed and interconnected homogeneously and continuously in the insulator PLA matrix without cutting of the connectivity. Effect of PPy content on mechanical properties of PPy-PLA composites is under investigation.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support of the Faculty of Applied Science, King Mongkut's University of Technology North Bangkok, Thailand.

References

1. G. Shi, *et.al.*, *Biomaterials*, **25**, 2477 (2004).
2. M. Angelopoulos, *IBM J. Res. & Dev.*, **45**, 57 (2001).
3. C. He, *et.al.*, *Synth. Met.*, **139**, 539 (2003).
4. M. Omastova, *et.al.*, *Synth. Met.*, **102**, 1251 (1999).
5. M. Omastova, *et.al.*, *Polymer Engineering and Science*, 1069 (2006).