PREPARATION AND CHARACTERIZATION OF POLYETHYLENE/POLYPYRROLE-COATED CALCIUM SILICATE COMPOSITES

Chu K. Ong, Sudip Ray, Peter Plimmer, Neil R. Edmonds, Allan J. Easteal
[Chu K. Ong]: ck.ong@auckland.ac.nz
Polymer Electronics Research Centre, Department of Chemistry,
The University of Auckland, Private Bag 92019, Auckland, New Zealand

Keywords*: polypyrrole, calcium silicate, wollastonite, polyethylene, compatibiliser*

1 Introduction

Intrinsically conducting polymers such as polypyrrole and polyaniline have been studied extensively in recent years for their electroactive characteristics and potential applications in electrical devices. However, they are often associated with problems related to their applications due to their brittleness, insolubility and infusibility. In order to facilitate utilisation of their unique properties, a variety of conducting polymer composites have been made [1-2]. Conventional thermal plastics processing techniques provide a practical and economical way to produce conducting polymer composites with the required mechanical performance [3]. In this work, we are investigating the effect of compatibiliser in the composite of polyethylene filled with either polypyrrole-coated calcium silicate or wollastonite. Four potential compatibilisers were used, namely poly(ethylene-co-methyl acrylate) (EMA), poly(ethylene-co-vinyl alcohol) (EVOH), maleated polyethylene (MAPE) and polyvinyl alcohol (PVOH), and the polyethylene used was linear medium density polyethylene (PE). Two forms of calcium silicate were used, one being a high surface area form (designated as CaSil) provided by Victoria University of Wellington (VUW), New Zealand; the other form was the naturally occurring mineral wollastonite. The compatibiliser is added to enhance the interaction between polypyrrole and PE with the rationale that the ethylene group favours the PE while the polar group favours the mildly polar polypyrrole.

2 Experimental

2.1 Preparation of polypyrrole-coated materials

Polypyrrole coated calcium silicate was provided by VUW. Deposition of polypyrrole on to wollastonite was based on the procedure described by Johnston et al [4]. 5 g of wollastonite was dispersed in about 200 mL of water, 30 mL of 0.01 M of aqueous ammonium persulfate was added and the suspension was stirred for 15 minutes. 0.4 mL of pyrrole dispersed in 5 mL of water was added dropwise to the suspension, and the reaction mixture stirred for about 2 hr. The polypyrrole-coated wollastonite produced was washed with water followed by methanol to remove unreacted pyrrole and dried in vacuum at 80^{o}C overnight.

2.2 Compounding polypyrrole-coated materials with polyethylene

Polypyrrole coated wollastonite (wollastonite-ppy) and polypyrrole coated CaSil (CaSil-ppy) were dried at 80^{o}C in vacuum for 12 hours prior to extrusion. PE +10 wt % compatibiliser mixtures with 5 parts per hundred (phr) CaSil-ppy or wollastonite-ppy were blended using a single screw extruder (Axon 16). The die temperature was 180^{o}C, and the screw speed was 65 rpm. The extruded chord was granulated and the composite pressed at 180^{o}C for 2 minutes to make a film about 150 μm thick.

2.3 Characterisation

The morphology of the composites was examined using scanning electron microscopy (Philips XL30 FEG). Raman spectra were recorded with a Renishaw 1000 spectrometer using laser excitations of 488 nm (blue-Argon+) and 785 nm (Infrared-diode). An Instron 5567 universal testing machine was used to study the effect of compatibilisers and polypyrrole-coated materials in PE on modulus and yield strength.

3 Results and discussion

Figure 1 shows SEM image of cross-section of cryoscopically fractured surface of composite made from PE/10 wt% EMA and wollastonite-ppy. It shows that there is a strong interaction between wollastonite-ppy and the polymer matrix: the matrix polymer appears to be adhering in strands to the surface of the fibrous particles.

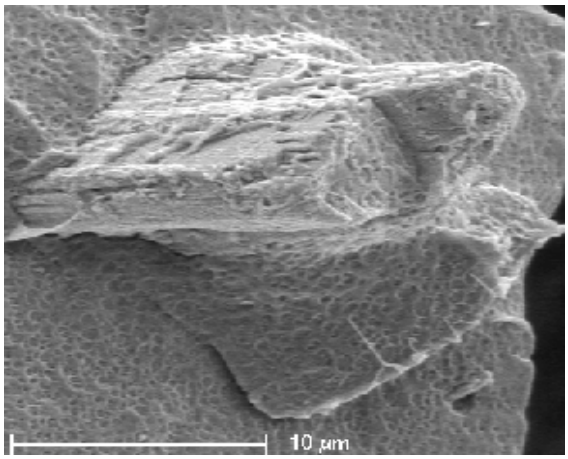

Fig. 1. Cross-section of polyethylene/polypyrrole coated wollastonite with poly(ethylene-*co*- methyl acrylate) as compatibiliser.

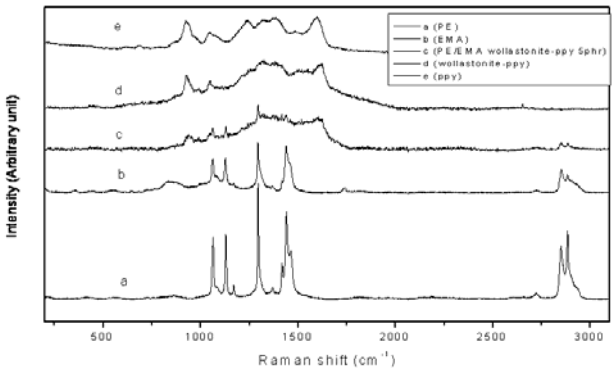

Fig. 2. Raman spectra under 785 nm laser excitation. (a) PE, (b) EMA, (c) PE/10 wt % EMA with wollastonite-ppy, (d) wollastonite-ppy, and (e) polypyrrole.

Fig. 2 shows Raman spectra of each component of the composite made from PE/10 wt% EMA and wollastonite-ppy. In the Raman spectrum of the composite (Fig 2c), the bands of polypyrrole [5] at 1595 cm^{-1} (C=C backbone stretching), 924 and 1047 cm^{-1} (C-H bending), and 1242 cm^{-1} (C-H or N-H bending) are present, indicating the stability of the polypyrrole coating to thermal processing at 180^{o}C.

Preliminary results of mechanical tests showed that the stiffness of the composite was slightly greater than that of neat PE.

Acknowledgment

The work was supported by the New Economy Research Fund under grant UOAX0408, from the Foundation for Research, Science and Technology, New Zealand.

References

[1] Han G., Yuan J., Shi G. and Wei F. "Electrodeposition of polypyrrole/multiwalled carbon nanotube composite films". *Thin Solid Films*, 474, pp 64-69, 2005.

[2] Yang J. P., Rannou P., Planes J., Pron A. and Nechtschein M. "Preparation of low density polyethylene-based polyaniline conducting polymer composites with low percolation threshold via extrusion". *Synthetic Metals*, Vol. 93, No. 3, pp 169-173, 1998.

[3] Paul R. K. and Pillai C. K. S. "Melt/solution processable conducting polyaniline: elastomeric blends with EVA". *Journal of Applied Polymer Science*, Vol. 84, No. 7, pp 1438-1447, 2002.

[4] Johnston J. H., Moraes J. and Borrmann T. "Conducting Polymers on Paper Fibres". *Synthetic Metals*, Vol. 153, No. 1-3, pp 65-68, 2005.

[5] Kilmartin P. A., Li K. C., Bowmaker G. A., Vigar N. A., Cooney R. P. and Travas-Sejdic J. "Spectroscopic studies of doping reactions in polypyrrole actuators". *Current Applied Physics*, 6, pp. 567-570, 2006.