IN-SITU PRODUCTION OF ELECTRICALLY CONDUCTIVE POLYANILINE FIBRES FROM POLYMER BLENDS

A Thesis submitted for the Degree of
Doctor of Philosophy

by

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ABSTRACT

Polymers and polymer-based composite materials with electro-conductive properties, respectively, are materials with several potential applications. New materials are being offered in every area and novel products are constantly being introduced. Among these new materials, composites made of electro-conductive monofilaments and insulating polymers are nowadays being used as antistatic materials in the carpets and textiles industries. One promising approach for the manufacture of this kind of material is to generate the electrically conductive fibres in-situ, that is, during the actual forming process of the component.

The main objective of this project was to establish the feasibility of producing electrically conductive polyaniline (PANI) fibres within a suitable polymer matrix by means of the development of a suitable processing strategy, which allows the fabrication of an anisotropically conducting composite. It is remarkable, however, that layered structures of the conducting filler were also formed within the matrix material. The latter morphology, particularly observed in compression moulded specimens of a specific polymer system, was also in good agreement with that inferred by means of a mathematical model.

Experimentation was carried out with three different PANI conductive complexes (PANIPOL^{TM}). They were initially characterised, which assisted in the identification of the most suitable material to be deformed into fibres. Preliminary processing was carried out with the selected PANIPOL^{TM} complex, which was blended with polystyrene-polybutadiene-polystyrene (SBS), low density polyethylene (LDPE) and polypropylene (PP), respectively. The resultant blends were formed by ram extrusion, using a capillary die, to induce the deformation of the conducting phase into fibres. The morphological analysis performed on the extrudates suggested that the most suitable polymer matrix was SBS.

Further experimentation was carried out with the polymer system selected. The relationships between the content of conductive complex in the composites and their electrical conductivity and microstructure were established. The blends were compression moulded and they displayed a morphology of layered domains of the

conducting phase within the SBS matrix. The behaviour of the conductivity with respect to the PANIPOL^{TM} complex in the compression moulded blends was found to be characteristic of a percolating system with a threshold as low as 5 weight percent of the conducting filler in the blends. The morphological analysis performed on the extruded blends suggested that the conducting phase was deformed into elongated domains, aligned parallel to the extrusion direction, which in some cases displayed a considerable degree of continuity and uniformity. The level of electrical conductivity in the extrudates was considerably lower than that of their corresponding non-extruded blends. This was attributed to a lack of continuity in the conducting elongated domains produced in-situ within the SBS matrix.

Percolation theory and a generalisation of effective media theories were used to model the behaviour of the conductivity with respect to the content of PANIPOL^{TM} in the compression moulded blends. Both approaches yielded similar values for the critical parameters, which were also in good agreement with the percolation threshold experimentally observed. The results of the modelling suggested that, at the percolation threshold, the morphology of the composite may consists of aggregates of flattened polyaniline particles forming very long layered structures within the SBS matrix, which is in agreement with the results of the morphological analysis.

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"There is nothing I cannot do in the One who strengthens me".

Philippinians, 4.13.

To my parents, Mr. Fernel Cruz-Sobrino and Mrs. Teresa Estrada-Lizama

To my family

******

A mis padres, Don Fernel Cruz Sobrino y Doña Teresa Estrada Lizama

A my familia

"Todo lo puedo en Aquel que me fortalece".

Filipenses, 4.13.

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