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ORIGINAL PAPER

Preparation, characterisation, and dielectric properties of polypyrrole–clay composites

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In this study, polypyrrole–clay (PPy–clay) composites were prepared by the in situ chemical oxidative polymerisation of pyrrole in the presence of clay. The chemical structures of the composites were characterised by FTIR and XRD analysis. The thermal properties of these novel composites were analysed by TGA and DSC measurements. Glass-transition temperatures and char yields increased with the increase in clay content in the nanocomposites. The interactions between PPy and clay were mainly between polypyrrole and the layers of clay. It was observed that, as the amount of clay in the composites increased, the dielectric permittivity decreased while the dielectric conductivity of the composite materials increased.

Keywords: polypyrrole, clay, thermal properties, dielectric properties

Introduction

Since the discovery of conducting polyacetylene films by Shirakawa in 1977, intrinsic electrically conductive polymers (ICP), also known as synthetic metals, have become a very important class of materials because of the unique electrical, optical, and chemical properties leading to their wide range of applications (Shirakawa et al., 1977; Pant et al., 2006; Ku & Liepins, 1987; Stejskal & Gilbert, 2002).

Among other conducting polymers, polypyrrole (PPy) is a promising material for a variety of electronic applications such as sensors, light emitting diodes, organic field-effect transistors, electromagnetic interference shielding, batteries, capacitors, and corrosion protection due to its environmental stability as regards oxygen and water, high conductivity, and ease of its synthesis (do Nascimento & de Souza, 2010; Lin et al., 2008; Omastová & Mičušík, 2012). PPys are generally synthesised by chemical or electrochemical oxidation of pyrrole in various media. Furthermore, in recent years the photopolymerisation of pyrrole was also reported (Murphy et al., 1999). In general, PPys are brittle, insoluble, and infusible, hence not possible to process (do Nascimento & de Souza, 2010). Over the last decades, a great effort has been invested in both academic and industrial areas into enhancing their processing potential (Kasisomayajula et al., 2010). In order to improve their properties, a number of PPy nanocomposites have been prepared (do Nascimento & de Souza, 2010; Boukerma et al., 2006).

When organic and inorganic components are mixed at molecular level, the resulting composites may exhibit unique properties far superior to those of the individual components (Wang et al., 2004). The rationale underlying the use of clay as a filler in conductive composites is that, when the nanocomposite is exfoliated, it can create conductive paths within a polymeric matrix (Boukerma et al., 2006). Hence, clay materials are the fillers most frequently studied in the preparation of conductive polymer composites (Madakbas et al., 2010). When polypyrrole chains are intercalated in interlayers of clay, PPys with an ordered chain structure and better properties can be obtained (Lin et al., 2008). Moreover, clay–polymer composites exhibit improved thermal and mechanical

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