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FIB-SIMS investigation of carbazole-based polymer and copolymers electrocoated onto carbon fibers, and an AFM morphological study

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Abstract

The work presented in this paper reports preliminary results obtained by focused ion beam-secondary ion mass spectroscopy (FIB-SIMS) analysis in the study of micro-sized carbon fiber electrocoated by conjugated-nonconjugated polymers such as poly(*N*-vinylcarbazole-co-methylthiophene), poly(*N*-vinylcarbazole-co-vinylbenzene sulfonic acid) and polycarbazole. The aim of this study was to investigate by FIB-SIMS analysis the presence and concentration gradient of certain elements via depth profiling of the coating on selected carbon fibers. The presence of dopant ions together with their gradient of concentration in the coating layer was elucidated as well as the thickness of the copolymer layer electrocoated onto the carbon surface. AFM analysis performed on the electrocoated fibers yielded information regarding the surface morphology and roughness.

Keywords: FIB-SIMS; Carbon fiber; Conductive polymers

1. Introduction

Electrocoating of conjugated and nonconjugated random copolymers as surface functionalising materials on carbon fiber produces a novel material with interesting properties. The application of these coatings onto the carbon fiber surface enhances the interaction of the carbon fibers as a reinforcement material in polymer matrix [1]. Further application of these novel materials involves the preparation of miniaturized chemical sensors capable of operating outside the laboratory environment. The use of carbon fiber homogeneously coated by conductive polymers with well-defined surface functionalities should be suitable for the miniaturization of electrodes for detection of particular molecules [2]. Several copolymer- and polymer-coated (anodic) electrodes have been shown to be an effective electrode system for the determination of *p*-aminophenol at low detection limits [2]. The nature of copolymeric films, their structure and compositions plays an important role in the final properties of modified carbon surface. The interest for the characterization of these functionalised thin films is increasing [3–8] and recently electropolymerization (anodic coating) techniques, and morphological studies of thiophene oligomers on carbon fiber have been reported [9–11]. Electrocoated poly(*N*-vinylcarbazole-co-methylthiophene) (P[NVCz-co-MeTh], poly[*N*-vinylcarbazole-co-*p*-vinylbenzene sulfonic acid] (P[NVCz-co-VBSA]), polycarbazole and poly[carbazole-co-methylthiophene] onto carbon fiber (CF) micron sized electrodes have previously characterized by atomic force microscopy (AFM), Raman, FTIR-ATR and XPS spectroscopy [12–15]. Results indicate that the coating properties depend mainly on the initial feed ratio and the reactivity of monomers.

Methods for the morphological and elemental characterization of the electrocoated carbon fibers are under development [12–15] and an investigation of these materials via focused ion beam-secondary ion mass spectroscopy (FIB-SIMS) is presented in this paper. The following samples of electrocoated carbon fibers were investigated by FIB-SIMS: carbazole (Cz#12), *N*-vinylcarbazole-vinylbenzenesulfonic acid (NVCz-VBSA#3) and *N*-vinylcarbazole-methylthiophene (NVCz-MeTh#4) (Fig. 1).

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