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REVIEW

Carbonised polyaniline and polypyrrole: towards advanced nitrogen-containing carbon materials

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Polyaniline (PANI) and polypyrrole (PPY) undergo carbonisation in an inert/reduction atmosphere and vacuum, yielding different nitrogen-containing carbon materials. This contribution reviews various procedures for the carbonisation of PANI and PPY precursors, and the characteristics of obtained carbonised PANI (C-PANI) and carbonised PPY (C-PPY). Special attention is paid to the role of synthetic procedures in tailoring the formation of C-PANI and C-PPY nanostructures and nanocomposites. The review considers the importance of scanning and transmission electron microscopies, XPS, FTIR, Raman, NMR, and EPR spectroscopies, electrical conductivity and adsorption/desorption measurements, XRD, and elemental analyses in the characterisation of C-PANIs and C-PPYs. The application of C-PANI and C-PPY in various fields of modern technology is also reviewed.

Keywords: polyaniline, polypyrrole, carbonisation, N-containing carbon materials

Introduction

The last two decades have witnessed a tremendous development in carbon-based technologies, confronting the scientific community with a number of challenges regarding the development of new carbon-based advanced materials. Widespread applicability has been found for carbon materials such as carbon blacks, activated carbon materials, pyrolytic carbon materials, graphites, glass-like carbon materials, carbon fibres and filaments, etc., in modern technology. Carbon-based nanomaterials have presented an active field of research since the first discoveries of Buckminsterfullerene C60 by Kroto et al. (1985) and carbon nanotubes (CNTs) by Iijima (1991). Since that time, a large number of different carbon nanostructures have been reported, such as carbon nanospheres, nanofibres (CNFs), nanosheets, nanohorns, nanocages, etc. (Nxumalo & Coville, 2010). Graphene, representing a conceptually new class of two-dimensional carbon materials that are only a single atom thick, is a rapidly rising star in materials science; it exhibits exceptionally high crystal and electronic qualities and has already found numerous new potential applications (Geim & Novoselov, 2007).

In addition to the attractive properties of shaped nanocarbon materials, heteroatom doping, defined as the intentional introduction of foreign atoms such as boron, phosphorus and especially nitrogen, into the structure of the carbon nanomaterial, can further significantly affect their unique chemical, mechanical, and electronic properties. This kind of modification of carbon material by N and B was achieved for the first time by Stephan et al. (1994) using an arc discharge procedure. Although reported at the same time, N-doped carbon materials have received much more at-

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