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REVIEW

Polyaniline micro-/nanostructures: morphology control and formation mechanism exploration

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This article provides a brief overview of recent work by the authors' group as well as related researches reported by others on controlling the morphology and exploring the formation mechanism of typical micro-/nanostructures of polyaniline (PANI) and aniline oligomers through template-free aniline chemical oxidation process. The contents are organised as follows: (i) tuning the morphology of aniline polymerisation products by employing ultrasonic irradiation, mass transfer, and pH profiles; (ii) exploring the formation mechanism of micro-/nanostructures during aniline chemical oxidation through examining the precipitation behaviours of aniline oligomers and polymers in a post-synthetic system; (iii) tailoring PANI micro-/nanostuctures into pre-designed morphology by introducing certain heterogeneous nucleation centres; (iv) application potential of PANI nanofibres in the areas of transparent conductive film, electromagnetic interference-shielding coating and graphene-based electrode materials. This short review concludes with our perspectives on the challenges faced in gaining the exact formation mechanism of PANI micro-/nanostructures and the future research possibility for morphologically precisely controlled PANI micro-/nanostructures.

Keywords: polyaniline, micro-/nanostructure, oligomer, self-assembly, formation mechanism

Introduction

Polyaniline (PANI) is a typical intrinsically electrical conductive polymer which possesses a conjugated chain structure composed of alternating benzenoid and quinonoid units. PANI can be readily synthesised through the chemical oxidative polymerisation of aniline. In a traditional aniline chemical oxidative polymerisation process, the oxidant (e.g., ammonium peroxysulphate; APS) solution is gradually added to the strongly acidic solution of aniline under stirring and irregular micro-sized PANI particles are always produced. However, due to such disadvantages as its being insoluble in common solvents and infusible even at decomposition temperature, applications of the conventionally synthesised PANI are extremely limited. PANI micro-/nanostructures, which can exhibit a large specific surface area and better processability, are much more attractive than the conventionally synthesised bulk PANI as a novel kind of organic electronic materials (Huang et al., 2003; Mi et al., 2008).

Despite their unique chemical structures, the properties of PANI micro-/nanostructures are highly dependent on their morphologies (Li et al., 2009a). Researchers in this area have sought to develop novel chemical oxidation routes for a certain PANI micro-/nanostructure or to prepare PANI micro-/nanostructures with special morphologies (Chiou & Epstein, 2005a; Huang & Kaner, 2004; Huang et al., 2003; Huang & Lin, 2009; Li et al., 2008; Ma et al., 2009; Tran et al., 2011; Wang et al., 2005a; Zhou et al., 2008). Unfortunately, due to the complicated aniline chemical oxidation process which has disadvantages such as incompletely developed polymerisation mechanism (Ahmed, 2004; Gospodinova et al., 1993;

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