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Synthesis, characterization and cyclic voltammetry studies of helical carbon nanostructures produced by thermal decomposition of ethanol on Cu-foils

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ABSTRACT

Cu-foils have been used intensively to fabricate graphene and other carbon nanostructures. Several routes have been implemented to improve the synthesis of such carbonaceous nanomaterials. We investigated the growth of carbon materials on Cu-foils by mapping the reactor in a chemical vapor deposition method. Several Cu-foils were pretreated by sonication to modify their surface and were placed alongside the reactor and exposed to a flow of ethanol vapor. After carbon materials deposition, the Cu-foils were analyzed by scanning electron microscopy (SEM), high-resolution transmission electron microscopy (HRTEM), X-ray diffraction (XRD), Raman spectroscopy, and cyclic voltammetry (CV). It was demonstrated that the type of synthesized carbon nanostructure depends strongly on the position where the Cu-foils were placed. XRD characterizations revealed the presence of graphite materials, Cu, and CuO crystal structures. SEM characterizations revealed the presence of helical, herringbone and straight multiwalled carbon nanotubes with internal bamboo-shape morphology and formation of Cu nanoparticles. Important electrochemical properties of Cu-foils rich in helical carbon nanostructures were observed, suggesting this material can be used for redox reactions (RR) promotion. In addition, the hydrophobic properties were evaluated by contact angle measurements.

1. Introduction

In the last three decades, carbon nanotubes and graphene have attracted the attention due to their outstanding physical-chemical properties [1–5] and their potential application in electronics systems [6–8], sensors [9,10], energy devices [11–13], and biomaterials [14]. While for the production of carbon nanotubes has been led by different version of chemical vapor deposition (CVD) [15–20], the production of graphene has been performed using different techniques such as CVD [21–23], silicon carbide sublimation [24,25], molecular monomer coupling [26,27], liquid-phase exfoliation [28–30], and also mechanical exfoliation [31]. Nevertheless, the low cost, large mass production, good reproducibility and easily in the process control, make the CVD a viable method to produce and modify carbon nanostructures.

Three of the most used catalysts for the synthesis of carbon nanostructures are cobalt [32,33], nickel [34,35], and iron [36,37]. Cu is mostly used for the synthesis of graphene due to low carbon solubility values (<0.0001% at.), low cost and easy manipulation [38]. Li et al. [39] improved the synthesis of large-area graphene using copper foils (25 μm thickness) as a catalyst in a CVD system at 1000 °C. They found that the graphene growth is self-limited to the Cu surface foil and it grows mainly by a surface-catalyzed reaction rather than by a precipitation process. They also found that during the cooling process the precipitation of carbon atoms increases the number of graphene layers. Cu foils have been used as a substrate for the growth of another type of carbon nanostructures [40,41]. For instance, Atthipalli et al. [42] reported the use Ni and Inconel films

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