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Synthesis and Characterization of Polyindole and CrO_2/Graphene Nanocomposites from Deep Eutectic Solvents Using Electro/Chemical Polymerization

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Abstract—Novel polyindole (Pin) and/or graphene (Gr)/chromium dioxide (CrO_2) nano-composites have successfully formed employing chemical and electrochemical (cyclic voltammetry technique) polymerization method in a deep eutectic solvent (DES), which was used as the polymerization medium. FTIR and UV-Vis spectroscopies, X-ray diffraction (XRD), thermogravimetric analysis (TGA) and voltammetric measurements were utilized to investigate electro/chemical properties of the Pin composites. Good conductivity was seen for the polyindole/graphene up to (5.56 S/cm) and polyindole/graphene/$CroO_2$ (9.85 S/cm) nanocomposites compared with pure polyindole (1.25 S/cm). The electrical stability of polymer films prepared in aqueous medium was studied. The results showed that the films possess remarkable electrical stability. The conductivity was also studied at different temperatures and the results showed that the conductivity increases with increasing temperature. The homogenous development of polyindole layers on electrode substrate were clearly observed by scanning electron microscopy technique and E-DAX. An increasing in surface area and porosity were accomplished in the polyindole composites compared to structure of polyindole surface. These findings give concept that the prepared composites would be valuable candidate for electrochemical applications.

Keywords: conducting polymers (polyindole), deep eutectic solvents, nanocomposites, graphene and chemical polymerization

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INTRODUCTION

Conducting polymers are conducting organo-materials due to the electron delocalization and conjugated systems [1, 2]. Thus, they have ability to change some of properties via doping processes. These features of electroactive polymers are distinctly various according to their chemical construction and morphologies [3, 4]. Over the last decades, electroactive polymers have been of growing interest and various applications because of their electrophysical features and implementations such as energy storage and mechanical strength in catalysts, moveable system, electric vehicles, supercapacitors, batteries, corrosion protection and electrochemical sensors [5, 6]. However, some electroactive polymers have some limitations, such as poor stability during redox process, degradation and low mechanical properties [7]. To overcome these limitations, some treatments during the preparation processes have been applied through incorporated the nano-particles within polymer chains [8].

Polyindole and its derivatives have attracted significant attention as a hopeful conducting material for many applications. This attention is due to diverse appealing merits, including a thermal stability, a good redox activity, powerful compatibility with components, and low degradation [9]. Recently, Polyindole composites including metal oxides, MXenes, and/or nano carbon materials have notably recognized as favorable electrodes for energy storage applications. In recent years, considerable efforts have been achieved to improve novel binary and ternary polyindole based nano-composites to employ the valuable electrochemical feature of the composite's components [10]. The study of polyindole/graphene/metal oxide composites becomes extremely important because of the synergistic influences that generation from combining the special properties of each component