ABSTRACT

Composites consisting of metallic nanoparticles (NPs) as reinforcement, carbon (C) allotropes, and biomaterials as matrix have great potential for applications in spintronics, magnetic data storage, optoelectronics, and energy storage devices. In spintronic applications, the composite must exhibit both magnetic and semiconducting properties. Consequently, it is necessary for the C-allotrope, often serving as the matrix, to exhibit semiconducting properties. Carbon nanotubes (CNTs) are a suitable option for this purpose. Another variant of carbon, called carbon nanofibers (CNFs), has similar outstanding qualities to CNTs, making them a fantastic choice for constructing high-performance photodetector systems. The exceptional electrical properties of C allotropes are attributed to the presence of delocalized pi-bond electrons. To improve C allotropes' magnetic, electronic, and optical properties, 3D transition metal or metal alloy nanoparticles (NPs) can be attached to their surface through charge transfer between the C structure and the adsorbed NPs. In addition, there has been a growing interest in energy storage devices to enhance nanocomposites' environmental friendliness and sustainability by integrating metal or metal alloy nanoparticles into the biopolymer matrix. Biopolymer materials have various functional groups in their structure that are produced from different amino acids. These functional groups facilitate diverse interactions with other substances, including metals, electroactive compounds, and conducting polymers. Consequently, the composite materials have undergone significant improvements in their electrochemical characteristics. This thesis aims to investigate two aspects: (i) the magnetic and photoresponse properties of $Cu_{1-x}Ni_x$/C allotrope nanocomposites, and (ii) the electrochemical properties of $Cu_{1-x}Ni_x$/biomaterial nanocomposites.

The study has been conducted in three segments. **Part 1** focuses on investigating how the transfer of charge enhances coercivity in nanocomposites made of $Cu_{1-x}Ni_x$/CNTs. X-ray photoelectron (XPS) and Raman spectra provide evidence of charge transfer between the CNTs and CuNi alloy NPs. Based on the magnetization investigations, the coercivity of $Cu_{1-x}Ni_x$/CNTs nanocomposite samples has exhibited a substantial increase in comparison to the bare NPs. **Part 2** examines the photoresponse characteristics of two materials: bare CNF and a nanocomposite made of $Cu_{1-x}Ni_x$/CNFs. In comparison to various CNT-based devices, the bare CNF device demonstrates a higher photoresponse. Furthermore, the nanocomposite-based photodetector significantly improves photoresponse compared to the CNF-based device. In **Part 3**, the electrochemical properties of the $Cu_{1-x}Ni_x$/biomaterials-based nanocomposite have been investigated. The Cu-elastin monomer nanocomposite-based electrode demonstrates exceptional electrochemical performance compared to other NP-protein combinations, as evidenced by cyclic voltammetry, electrochemical impedance spectroscopy, and galvanostatic charge-discharge experiments.

Keywords: C allotropes, Metal alloy nanoparticles, Charge transfer, Coercivity, Photodetector, Electrochemical properties.