CONVERSION OF SELECTED PLASTIC WASTE INTO CARBON NANOMATERIALS FOR APPLICATION IN THE ABSORPTION OF CARBON DIOXIDE AND ENERGY STORAGE

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Abstract

Plastic waste is a major environmental problem. It is non-biodegradable and can take hundreds of years to decompose. Plastic waste can also pollute waterways and oceans, harming wildlife and ecosystems. There are several ways to recycle plastic waste. One promising method is to convert it into carbon-based materials. Carbon-based materials have many potential applications, including energy storage, catalysis, and electronics. Hydrothermal/solvo thermal methods are a process used to break down plastic waste into constituent elements, including carbon, at lower temperatures. The carbon was then used to produce powdered carbon-based nanomaterials. The work was split into three projects that included using Poly(ethylene terephthalate (PET), polyethylene (PE) derived carbon for supercapacitors application and Polystyrene used for testing carbon dioxide capture testing. The Poly(ethylene terephthalate) (PET) study describes a sustainable, emissions-free process for converting PET plastics into carbon nanomaterials (CNMs) named PT-nano powder. The thermal-hydrothermal method has PT-nano powder above PET plastics' glass transition temperature (Tg). Under optimal conditions, PET plastics were efficiently converted into PT-nano powder with 86.6% crystallinity and an average particle size of 6.5 nm. The PT-nano powder was characterized for physical and chemical properties using different techniques, including UV-Vis, FTIR, Raman spectroscopy, XRD, FESEM, TEM, and proton NMR analysis. The characterization confirms the complete conversion of PET to solid fractions of carbon nanomaterial. The PT-nano powder was tested in supercapacitor performance application with electrochemical characterization. The symmetric fabrication showed a specific capacitance of 250.8 F/g, energy density of 34.83Wh/kg, and power density of 999.9W/kg with a current density of 0.5A/g. The device fabrication exhibited high cycle stability and high capacitance retention of 96.8% with a current density of 1.5A/g after 10000 cycles. The polyethylene (PE) plastic waste was converted into carbon-based nanomaterials for use in energy storage supercapacitors using solvothermal/hydrothermal synthetic methods. The electrochemical test revealed a specific capacitance of 155.5F/g with an energy density of 21.6Wh/kg and a current density of 0.25A/g. Furthermore, after 9000 cycles at a steady current density of 1.0A/g, the materials retained 98.5% of their capacitance. We show that the hydrothermal treatment of polystyrene (PS) in the presence of potassium hydroxide results in an efficient carbon sorbent with pores of 0.74 nm for CO_2 collection. The sorbent's CO_2 capacity at 25 °C is 17.0 ±1.1 wt% at 1 bar and 5.0 ± 0.6 wt% at 0.15 bar, and it regenerates when the temperature reaches 75 ± 5 °C. As a result, this PS-derived carbon compound could be useful in absorbing CO_2 from high-emissions sources. The conversion of plastic waste into carbon-based materials is a promising method for reducing plastic pollution and creating new value from waste. These methods have the potential to make a significant contribution to a more sustainable future.