Investigation of Graphene-based materials for their application in waste water treatment and energy storage. (Index No- 103/16/Phys./24)

In recent years, one of the major environmental concerns in pollution control is the removal of hazardous materials from water resources. The pollution of water resources by industrial effluents containing toxic dyes like, Congo red, Methyl orange, Methyelene Blue etc. have been a serious problem to the human health and environment. On the other hand, climate change and gradual decrement of fossil fuels are also serious issues that our societies are presently facing. In this situation, supercapacitors are a type of energy storage technology that has been gaining a lot of interest in recent years due to their high-power density, long operational life, environmental friendliness, and product safety. Graphene-based materials have recently been characterized in multiple investigations as an incredibly effective material for wastewater treatment as well as electrode material for energy storage.

Therefore, we demonstrate, the photocatalytic degradation of methylene blue dye (MB) by manganese ferrite ($MnFe_2O_4$) nanoparticles and $MnFe_2O_4$ nanoparticles-decorated reduced graphene oxide heterostructures ($MnFe_2O_4$/rGO). MB degraded by 84% in the presence of $MnFe_2O_4$ after UV irradiation of 290 minutes, while 97% of it degraded in merely 60 minutes in the case of $MnFe_2O_4$/rGO heterostructures. Then, dimethylformamide (DMF) assisted nitrogen-doped reduced graphene oxide (N-rGO) was prepared in a single-step solvothermal method as a novel electrode material which showed highest specific capacitance 516 Fg^{-1} at a scan rate of 2 mVs^{-1} along with good cyclic stability and stable coulombic efficiency. After that, a single-step solvothermal method had been employed to synthesize $MnFe_2O_4$ and $MnFe_2O_4$/rGO composite which were used as an electrochemical electrode. The $MnFe_2O_4$/rGO composite nanoparticles showed an enhanced specific capacitance of 253 Fg^{-1} compared to 133 Fg^{-1} corresponding to the bare nanoparticles, at a current density of 10 Ag^{-1} within the potential range of -0.3 to 1.2V with excellent cyclic stability of 96% (after 5000 cycles), providing a good strategy for improving future supercapacitor electrode materials. Lastly, the solvothermal method was employed to prepare spinel cobalt ferrite nanoparticles (CF) and composite with graphene adsorbents (CF-rGO). The high saturation magnetization value of the samples may be used by the external magnetic field, which is advantageous for the recycling procedure in the adsorption application. The analyses show that CF-rGO with adsorption capacity of 15.5 $mg.g^{-1}$ has successfully removed 93% of MB from water.

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