The thesis primarily encompasses the synthesis and characterization of various graphene based nanocomposites with a view to examine their potential applications in diverse fields. Designing and development of graphene based materials are motivated from its various promising chemical and physical properties. In the first chapter, an overview of recent progress on graphene or reduced graphene oxide (rGO) based research in terms of its synthesis, nanocomposites formation and their various interesting practical application in the advanced field has been portrayed. In the second chapter, synthesis of silver nanoparticles (Ag NPs) anchored rGO sheets and their strong surface enhanced Raman scattering (SERS) activity towards toxic uranyl ion (UO_2^{2+}) even at 10 nM concentration level have been depicted. Controlled aggregation of the coinage nanoparticles leads to form necessary 'hot-spots' to provide strong electromagnetic effect (EM), and the electrostatic interaction between UO_2^{2+} ion and remaining oxygen functionalities of rGO engender chemical effect (CE), which certify strong SERS signal intensity. Thus two mechanisms are co-jointly operated for Ag-rGO to offer such an observed enhancement of the Raman reporter. The third chapter describes a co-reduction pathway that offers Au_{core}-Pd_{shell} nanoparticles again on rGO nanosheets (GAP) which shows remarkable electrooxidation capability towards hydrazine (N_2H_4). Exploiting such electrochemical behavior of GAP, we have been able to develop an electrochemical sensing platform for N_2H_4 with high sensitivity and selectivity. In fourth chapter, well known electrocatalytic performance of Pt has been improved in association with Pd and Au. The as-obtained trimetallic nanoparticles decorated rGO sheets become morphologically attractive and technologically important. Growth management of three noble metal nanoparticles to prepare exclusive trimetallic nanoparticles and their homogenous allocation on rGO sheets are quite challenging. These problems have been easily resolved by adopting multistep pathway considering the electrostatic interaction between GO surface and positively charged surfactant coated Au NRs or Au-Pt bimetallic particles. The fabricated dog-bone shaped trimetallic particles decorated rGO sheets exhibit superior ethanol electrooxidation performance in contrast to commercial Pt/C by showing 6 times better mass utilization and ~40% higher tong-term durability. Apart from the metal nanoparticles, metal oxides or metal sulfides with diverse morphology and composition on rGO sheets have been investigated to reveal various interesting applications in the field of catalysis. Chapter five represents a new methodology for obtaining hierarchical CuS attached to rGO sheets through redox transformation reaction between Cu(I) and GO in GO-Cu(I)-Tu gel matrix (GO-gel) under mild heating condition. Synergistic effect of rGO and porous CuS in the

nanocomposite provides sufficient catalytically active sites towards peroxidase-like activity where Cu(II) centre mainly acts as Fenton's like reagent during the oxidation of 3, 3´, 5, 5´-tetramethylbenzidine (TMB) to blue colored product in presence of H_2O_2. In addition, new finding has been encountered in terms of diminishing oxidizing power of H_2O_2 in the catalytic reaction by successive addition of dopamine (DA). Thus a colorimetric sensing of DA down to 0.48 μM concentration level has been carried out utilizing high peroxidase-like activity of the designed CuS-rGO nanocomposite. Finally, in chapter six, rGO has been utilized as an electron transporter to develop an efficient visible-light driven photocatalyst. Although cadmium sulfide is a visible-light responsive material, but proximity of its valance band and conduction band leads to easy recombination of hole-electron pair, which is highly detrimental for effective dye degradation process. Gratifyingly, synthesized CdS-TiO_2 nanoparticles on rGO, tri-component nanocomposite, provides sufficient surface area for dye adsorption and new electron shuttle pathway by diminishing the possibility of charge recombination process to improve the dye degradation efficiency.

Keywords: Reduced graphene oxide, Nanocomposite, Surface Enhance Raman Scattering, Electrochemical sensor, Electrocatalysis, Peroxidase-like activity, Photocatalysis.