Graphene (oxide) – Metal Composites for Electrochemical and Catalytic Applications

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Graphene, the honeycomb 2D network with sp² hybridized carbon, has been studied vastly due to its excellent thermal and electrical conductivity, high mechanical strength, and extremely high surface area. This wonder material has already expanded its applications by blending with noble metals, metal hydroxides and oxides. Herein, we report utilization of graphene-metal composites as electrode materials for electrochemical capacitors and catalysts for ammonia decomposition reaction. Graphene used in this study was obtained via reduction of graphene oxide synthesized with a modified Hummers method. Graphene oxide and different transition metal cations were combined via utilization of electrostatic interaction and reduced electrochemically. After reduction, almost 20-fold increase in capacitance was observed. From Cyclic voltammetry (CV) measurements, the highest capacitance was observed with addition of iron (II) cation: 135.4 mF cm⁻² after reduction. On the other hand, metal doped reduced graphene oxide aerogels were tested as catalysts for ammonia decomposition reaction. Prior to catalytic test, aerogels were reduced under H₂ atmosphere at 700 °C to grow metal nanoparticles and reduce graphene oxide, simultaneously. At 700 °C and 16.7 % ammonia conversion, 42.2 mmol H₂/g_cat/min was produced. The specific surface areas of aerogels were determined via Brunauer–Emmett–Teller (BET) analysis. To investigate the changes in structure during the catalytic test, composites were analyzed by Raman spectroscopy, Scanning transmission electron microscopy (STEM), and X-ray photoelectron spectroscopy (XPS).