Tuning the Properties of Electrochemically Reduced Graphene Oxide Films for Their Use as Anticorrosive Coatings for Steel Protection

Javier A. Quezada-Renteria[a], Conchi O. Ania[b], Luis F. Chazaro-Ruiz[a], José R. Rangel-Mendez[a]

[a] Environmental Science Division, Instituto Potosino de Investigación Científica y Tecnológica A.C. (IPICYT), Camino a la Presa San José 2055, Col. Lomas 4ª Sección, C.P. 78216, San Luis Potosí, SLP, México.

[b] POR2E Group, CEMHTI, CNRS (UPR 3079), Univ. Orleans, Orléans, 4571, France

Abstract

Films of graphene oxide (GO) were assembled on carbon steel (CS) by drop-coating and then electrochemically reduced to obtain reduced graphene oxide (rGO). The effect of the electrolyte composition, such as H^+ concentration, used for the reduction procedure was studied. The films were intensively characterized in order to identify the reduction mechanism and the defects introduced to the sheets during the reduction process. This showed that the electrochemical reduction method has clear advantages over other reduction procedures in delivering a rGO-film with the right physicochemical properties and defects, in order to perform as an anticorrosive coating. The defects consisted mainly in sp^3 domains caused by hydrogenation reactions taking place at the edges and other reactive zones, such as dangling bonds originated during the removal of the oxygenated groups. Because of this, the electrical conductivity of the rGO films was considerably low in comparison to the conductivity achieved by other reduction methodologies. Nowadays, it is well known that the main drawback of graphene-based materials for their use as anticorrosive coatings is the occurrence of a galvanic effect. The low conductivity of our rGO film is proposed as an alternative to avoid this effect. Additionally, a modified-rGO film with even lower conductivity and an increased hydrophobicity was produced through electrochemical methods. The anticorrosive properties of both rGO films were evaluated, paying special attention to identify the galvanic effect of these films over CS. Our results showed that neither of the films showed an important galvanic effect on the metal.