DEPENDENCE OF THE CATALYTIC PROPERTIES OF rGO-Al_2O_3 NANOCOMPOSITES ON THE FRACTION SIZE OF ALUMINUM OXIDE CARRIER

Nosach V. V.[1,2], Buchko I. B.[2]
[1]National University "Kyiv-Mohyla Academy"
04655, Kyiv, str. Hryhoriya Skovorody, 2, Ukraine
[2]Institute of Physical Chemistry named after L. V. Pisarzhevsky National Academy of Sciences of Ukraine, 31 Nauky Ave., Kyiv, Ukraine
victorynosach@gmail.com

Carbon nanomaterials catalyze hydrogenation with molecular hydrogen, as demonstrated in hydrocarbon hydrogenation [1]. Their catalytic activity requires high crystallinity and low oxygen content [2]. Given its crystallinity and large surface area, reduced graphene oxide (rGO) is a promising hydrogenation catalyst. However, the effects of graphene plane size, layer count, defectiveness, and carrier structure on rGO's activity remain unclear. This study investigates the catalytic properties of rGO applied to aluminum oxide and the impact of different carrier size fractions on nanocomposite activity.

Nanocomposite samples with reduced graphene oxide (rGO) on aluminum oxide were prepared via impregnation, with an rGO content of 0.025 mg/g and varying aluminum oxide particle sizes. Graphene oxide (GO) was synthesized by exfoliating graphite oxide through ultrasonic treatment, following its oxidation via the Hummers method using sulfuric and phosphoric acids [3]. Each nanocomposite sample was labeled according to the carrier's particle size (mm) and the type/content of the applied graphene material, e.g., Al_2O_3(0.25-0.5)/rGO(0.025) and Al_2O_3(0.5-1)/GO(0.025).

The obtained samples were examined by the methods of Raman spectroscopy, scanning Electron microscopy (SEM) and nitrogen adsorption-desorption were used to analyze the samples. Their catalytic activity was assessed in ethene hydrogenation using a flow tube reactor with chromatographic monitoring of reaction products. The process was studied within a temperature range of 50–400 °C, with a reaction mixture consisting of 90 % H_2 and 10 % C_2H_4.

Raman spectroscopy analysis revealed D and G bands within 1200–1700 cm^{-1}, with the D/G intensity ratio (I_D/I_G) increasing after hydrogen reduction, indicating higher defectivity in GO compared to rGO. SEM analysis showed that graphene oxide forms layered sheets on the carrier surface without fully covering it. Adsorption-desorption isotherm analysis confirmed that the textural properties of aluminum oxide, as well as GO and rGO deposited on it, remain similar, suggesting that rGO is positioned on the outer surface without blocking the pores.

Catalytic activity tests showed that Al_2O_3(0.25-0.5)/rGO(0.025) had the highest activity (2.53×10^{-4} Mol·g(rGO)$^{-1}$·s^{-1}), while Al_2O_3(0.1-0.25)/rGO(0.025) exhibited the lowest (6.88×10^{-9} Mol·g(rGO)$^{-1}$·s^{-1}).

The obtained results suggest that the catalytic activity of rGO-Al_2O_3 nanocomposites is influenced by the carrier's particle size. However, no clear correlation between activity and fraction size was established, likely due to the complex interplay of factors such as textural characteristics and hydrogen spillover from rGO to the carrier, which plays a significant role in these systems.

[1] N. Syakir, T. Saragi, F. Fitrilawati Syakir N. Materials Science Forum, 2021 DOI:10.4028/www.scientific.net/MSF.1028.302

[2] J. Munuera, L. Britnell, S. Santoro. 2D Materials, 2021 DOI 10.1088/2053-1583/ac3f23

[3] Marcano, D. *ACS Nano*, 2010 doi.org/10.1021/nn1006368