CATALYTIC PROPERTIES OF REDUCED GRAPHENE OXIDE SUPPORTED ON Al_2O_3 IN ETHANE DEHYDROGENATION

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Ethane dehydrogenation is an important industrial process for ethylene production, which is a key raw material for polymers and chemical synthesis [1]. Conventional methods such as steam cracking require high temperatures (800–900 °C) and are associated with high energy consumption and CO emissions [1–2]. Direct catalytic dehydrogenation is a promising alternative; however, its application is limited by thermodynamic constraints and catalyst deactivation due to carbon formation [2]. Carbon nanomaterials, particularly reduced graphene oxide (rGO), are of interest due to their high surface area, defect structure, and resistance to carbonization [3–4].

The catalytic properties of rGO supported on Al_2O_3, prepared via impregnation of the support with graphene oxide followed by reduction were investigated in ethane dehydrogenation [5]. The physicochemical properties of the samples were studied using SEM, FTIR, Raman spectroscopy, and nitrogen adsorption–desorption analysis. SEM revealed that rGO deposition and reaction do not significantly change morphology, while carbon formation is observed. FTIR confirmed transformation of oxygen-containing groups, Raman spectroscopy indicated increased defect density, and adsorption analysis showed a decrease in surface area due to pore blocking.

The rGO/Al_2O_3 catalyst exhibits higher activity compared to pure Al_2O_3. The onset of ethane conversion occurs at ~500 °C, while for Al_2O_3 it is observed at 550–600 °C. Conversion increases with temperature, reaching a maximum of ~28–29% at ~675 °C, followed by a decrease at higher temperatures due to catalyst carbonization. The catalyst demonstrates high selectivity toward ethylene, reaching 100% at temperatures below 650 °C, while at higher temperatures the selectivity decreases (to ~84% at 700 °C) due to side reactions, including methane formation.

Time-on-stream studies indicate initial activation of the catalyst, associated with structural rearrangement and formation of additional active sites, followed by gradual deactivation due to carbon deposition and loss of oxygen-containing functional groups. Despite this, relatively high selectivity toward ethylene (95–100%) is maintained during prolonged operation, indicating good stability of the catalytic system [4,6].

The reaction mechanism can be assumed to involve both heterogeneous and homogeneous pathways. On Al_2O_3, ethane activation is likely to occur on Lewis acid–base sites via dissociative adsorption and C–H bond cleavage [7–8]. On rGO, activation may be associated with defect sites and oxygen-containing functional groups [3,9–10]. At elevated temperatures, radical pathways are expected to become significant, involving homolytic C–H bond cleavage and formation of ethyl radicals, leading to ethylene and hydrogen [11–12]. Methane formation may indicate deeper transformation pathways. Carbonization is suggested to result in the formation of graphene-like structures, which may retain catalytic activity [3].

The rGO/Al_2O_3 catalyst demonstrates higher activity and selectivity in ethane dehydrogenation compared to pure Al_2O_3. The process is governed by the combined effect of oxide surface properties, graphene phase structure, and carbonization phenomena [3,7]. Despite partial deactivation due to carbon deposition, the formation of graphene-like structures preserves catalytic performance. These results confirm that graphene-based catalysts are promising for hydrocarbon dehydrogenation and that their performance can be tuned by controlling structure and surface chemistry [3–4].

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