



Effect of Support Chemistry on the Performance of Pt based Hydrotalcite Derived Mg(Al)O Shaped Catalysts in Propane Dehydrogenation Reaction

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Propane dehydrogenation (PDH) is an endothermic reaction that requires relatively high operating temperatures with a high-performance catalyst. In general, in the dehydrogenation process, bimetallic Pt-based catalysts supported on different metal oxides are widely employed. The catalyst also plays a significant role in the PDH reaction, such as pure and alkali-supported gamma alumina, MgO, mixed oxide with a spinel structure, or hydrotalcite-derived magnesium hydroxide. Among these, hydrotalcite-derived Mg(Al)O structure appears to be particularly promising owing to its basic nature, layered morphology, and having defect-rich Al³⁺ doped MgO surface. Additionally, its high thermal stability up to 800 °C further enhances its potential use in PDH. The main difficulty in the PDH reaction is the fast deactivation of the catalyst due to the coke formation and its rate. Hydrotalcite-based catalysts have emerged as a promising alternative because of their basic nature and distinctive structural properties. The catalyst utilized in the reactor must possess a specific structure, such as a pellet, tablet, or sphere, at both pilot and industrial plant operations. Consequently, the final catalyst comprised a shaped form with a reactively active metal phase deposited on it. In this study, two catalyst supports that had a different chemistry were selected for metal impregnation and reaction performance. The first was commercial MG70, which contains 100% of hydrotalcite and has a 5x5 mm diameter. The second is a home-made support produced by extrusion, which has a diameter of 1.3 mm and a length of 3-4 mm. The support developed by Tupras contained nearly 10% Al₂O₃ by wt as an inorganic binder, with the remaining part being hydrotalcite-derived Mg(Al)O. The final catalysts were produced by wet impregnation of active metal precursors sequentially (first Pt and then Sn salts) on two hydrotalcite-based shaped supports. Following drying at 120 °C and calcination at 600 °C, approximately 15 grams of catalyst were loaded into a fixed-bed reactor for testing its PDH performance. Prior testing, catalyst was reduced and activated in H₂/N₂ atmosphere at 600 °C. The PDH reaction was conducted under atmospheric pressure at a temperature of 550 °C and WHSV of 4 h⁻¹. The active metal composition was identified during the experimental studies and tests performed as follows: the total Pt content was found to be between 0.5 and 0.7% by wt, and the Sn/Pt ratio was in the range of 1.40 to 1.50 by wt/wt for the highest PDH reaction performance. When comparing the reaction performance of two different supports with constant metal loadings, initial propane conversion (~28%) was found to be close to thermodynamic equilibrium, propylene selectivity was approximately 95%, and the activity loss after 24 h time on stream was approximately 10% for the catalyst prepared on commercial 100% hydrotalcite support. The hydrotalcite support exhibited a higher propylene selectivity (~95%) than the home-made extruded support, which showed almost 92% selectivity and a higher amount of coke formation on the catalyst surface due to the Al₂O₃ content in the composition. In addition, the activity loss after 24 h was nearly 25% whereas the initial propane conversion was similar to the commercial supported catalyst. For the extruded catalyst, as the WHSV was tuned to 6 h⁻¹ and above, propylene selectivity reached 95%, while the propane conversion decreased slightly. This can be attributed to the reduction in contact time of gas stream on the catalyst surface and thus decreasing the coke formation rate. Consequently, two different catalyst composition with a high potential for use in the PDH reaction, operated at lower temperatures compared to the industrial processes, have been developed by investigation of support effect on the reaction conditions.