

On-Purpose Propylene Production via CO₂ Facilitated Propane Dehydrogenation

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ABSTRACT

Propylene demand has grown steadily since the mid 80s due to an increase in demand for propylene derivative production. Approximately 93% of propylene is produced as a byproduct of either ethylene production or petroleum refining, which has both grown over the years to ensure stable supply. While the overall demand for ethylene is greater than propylene, the growth rate of propylene demand is currently outpacing that of ethylene. This growth rate disparity will put stress on traditional sources, in particular the steam crackers used for ethylene production. As demand for propylene surpasses the supply generated from traditional sources, on-purpose propylene production has become more attractive. One such on-purpose propylene technology involves the catalytic dehydrogenation of propane. Propane dehydrogenation to propylene is a highly endothermic ($\Delta H_{r(25\text{ }^\circ\text{C})} = 29.70$ kcal/g-mol) and equilibrium limited reaction, which in combination with very small margin between propane and propylene prices has resulted to unfavorable economic conditions for the United States Gulf Coast (USGC) area.

One approach to improve the propylene production yield, hence reduce the capital and operating costs of propane dehydrogenation process, is to co-feed a suitable diluent such as CO₂. Co-feeding CO₂ with propane has the advantage of reducing the partial pressure of propane and propylene as well as consuming hydrogen produced from the dehydrogenation of propane via the reversed water-gas shift reaction hence shifting the dehydrogenation reaction equilibrium towards higher propylene yield per reactor pass. We have investigated the catalytic performance of commercial and in-house synthesized catalysts in the CO₂-facilitated propane dehydrogenation reaction and have shown improved propane conversion and propylene selectivity over the conventional direct propane dehydrogenation process. These ongoing experimental studies and economic evaluation of CO₂-facilitated propane dehydrogenation will be presented in this poster session. Critical issues such as CO₂/propane ratio, energy requirements, thermodynamics limitations, and key challenges of commercializing such a process will also be discussed. Other alternative processes that could benefit from this concept of co-feeding CO₂ will be briefly discussed.