DEVELOPMENT OF ATTRITION RESISTANT IRON-BASED FISCHER-TROPSCH CATALYST

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ABSTRACT

The Fischer-Tropsch (F-T) reaction provides a way of converting coal-derived synthesis gas ($CO+H_2$) to liquid fuels. Since the reaction is highly exothermic, one of the major problems in control of the reaction is heat removal. Recent work has shown that the use of slurry bubble column reactors (SBCRs) can largely solve this problem. The use of iron-based catalysts is attractive not only due to their low cost and ready availability, but also due to their high water-gas shift activity which makes it possible to use these catalysts with low H_2/CO ratios. However, a serious problem with use of Fe catalysts in a SBCR is their tendency to undergo attrition. This can cause fouling/plugging of downstream filters and equipment, makes the separation of catalyst from the oil/wax product very difficult if not impossible, and results in a steady loss of catalyst from the reactor.

Recently, fundamental understanding of physical attrition is being addressed by incorporating suitable binders into the catalyst recipe. This has resulted in the preparation of a spray dried Fe-based catalyst having aps of 70 μm with high attrition resistance. This Fe-based attrition resistant, active and selective catalyst gave 95% CO conversion through 125 hours of testing in a fixed-bed at 270°C, 1.48 MPa, $H_2/CO=0.67$ and 2.0 NL/g-cat/h with C_5^+ selectivity of >78% and methane selectivity of <5%. However, further development of the catalyst is needed to address the chemical attrition due to phase changes that any Fe-catalyst goes through potentially causing internal stresses within the particle and resulting in weakening, spalling or cracking.

The objective of this research is to develop robust iron-based Fischer-Tropsch catalysts that have suitable activity, selectivity and stability to be used in the slurry bubble column reactor. Specifically we aim to develop to: (i) improve the performance and preparation procedure of the high activity, high attrition resistant, high alpha iron-based catalysts synthesized at Hampton University, (ii) seek improvements in the catalyst performance through variations in process conditions, pretreatment

procedures and/or modifications in catalyst preparation steps and (iii) investigate the performance in a slurry reactor.

The effort during the reporting period has been devoted to attrition study of the iron-based catalysts. Precipitated silica appeared to decrease attrition resistance of spray-dried iron FT catalysts. It was found that the catalyst with precipitated silica content at around 12wt% showed the lowest attrition resistance. The results of net change in volume moment and catalyst morphology showed supporting evidences to the attrition results. Catalysts with low attrition resistance generated more fines loss, had higher net change in volume moment and showed more breakage of particles. BET surface area and pore volume of this catalyst series fluctuated; therefore no conclusion can be drawn from the data obtained. However, catalyst with no precipitated silica showed the lowest in BET surface area and pore volume, as expected. Addition of precipitated silica to the catalysts had no effect to the phase changes of iron that could have significant influence to catalyst attrition. The presence of presence of precipitated silica is needed for enhancing catalyst surface area; however, the amount of silica added should be compromising with attrition resistance of catalysts.

PUBLICATIONS AND PRESENTATIONS

Kandis Sudsakorn, James G. Goodwin, Jr., K. Jothimurugesan, and Adeyinka A. Adeyiga, "Preparation of Attrition Resistant Spray-Dried Fe Fischer-Tropsch Catalysts using Precipitated SiO_2". Industrial and Engineering Chemistry Research, 2001, 40, 4778.

Adeyinka A. Adeyiga, "Development of Attrition-Resistant Iron-Based Fischer-Tropsch Catalysts". UCR-HBCU Contractors Review Conference, Pittsburgh, PA, June 4-6, 2001.

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