ATTRITION RESISTANT FISCHER - TROPSCH BASED ON FCC SUPPORTS

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ABSTRACT

The Fischer-Tropsch (F-T) synthesis is the reaction of CO and H_2 (syngas) to produce a wide variety of hydrocarbons, oxygenates, and olefins. Iron or cobalt-based catalysts are used when the desired products are hydrocarbons. Because the reaction is highly exothermic, a slurry bubble column reactor (SBCR) is the reactor of choice. For coal-derived syngas, which typically has a H_2/CO ratio of 0.5-0.7, iron-based catalysts are preferred over cobalt-based catalysts because (i) iron's high water-gas shift (WGS) activity eliminates the need for an external shift step, and (ii) iron is significantly cheaper than cobalt.

Although F-T synthesis provides the best means currently available for conversion of coal to synthetic transportation fuels, there are two major barriers to its widespread commercialization: (i) severe attrition of iron catalysts in SBCRs, and (ii) a wide, non-selective product slate consisting of (C_1 to C_{60+} hydrocarbons) that must be extensively processed further to make fuels. Although the most profitable F-T product slate varies with location and other factors, C_{10} to C_{20} hydrocarbons are believed to be the products of choice in many cases, and offer an opportunity for F-T products to be introduced in the market.

This project aims to develop an iron-based catalyst that addresses the two barriers that must be overcome for commercial success: (i) attrition resistance at the conditions found in a modern SBCR, and (ii) a selective product slate in the C_{10}-C_{20} range. This novel concept is achieved by chain-limiting and attrition-resistant F-T catalysts for SBCRs that maximize the production of C_{10}-C_{20} hydrocarbons. The iron catalysts will be designed with multifunctional capability to oligomerize and hydrogenate lower olefins and hydrocrack the C_{20+} hydrocarbons to produce the target C_{10}-C_{20} hydrocarbons. The research will employ, among other measurements, attrition testing and F-T synthesis at high pressure. Catalyst activity and selectivity will be evaluated using a small fixed-bed reactor and a continuous stirred tank reactor.

ACCOMPOLISHMENTS TO DATE

We have received samples of spent FCC catalysts from Engelhard and Albemarle (which has acquired Akzo). These catalysts have been characterized by carbon monoxide (CO), and Carbon Dioxide (CO_2) TPD has been carried out on both Engelhard and Albemarle catalyst. Results have been obtained from the BET surface area analysis, the ICP/MS studies, and TPR/TPD studies. These results will provide guidance on which materials to study first, as well as guidance on the impregnation procedures.

FUTURE TASKS

1. We need to carry out NH3 TPD to measure the surface acidity. The impregnation procedure will then be adjusted to ensure that this acidity is neutralized. The BET results will be used to estimate the pore volume, which will be used to determine the appropriate impregnation procedure.

2. Catalysts will be synthesized at Hampton and then tested at LSU at FT conditions. This will require modifications to the reactor tube in the Altamira AMI-200R-HP. An alternative approach is to create reaction conditions such that there are only gaseous products which will give qualitative information about the catalysts. This will allow tests to be carried out more quickly. Side-by-side tests with a baseline catalyst such as the Ruhrchemie iron catalyst will be used for comparison to known materials.

3. Hampton University has prepared a series of FCC-supported Fe catalysts for testing. LSU will test these materials for activity/selectivity. Initial tests will be carried out at conditions where the products are gas-phase. The purpose is to provide rapid screening of the materials, with the most promising materials selected for further testing. Reaction studies of the catalysts are on the catalysts in Table 2 are to be completed by August 2007.

FACULTY, STAFF, AND STUDENT SUPPORT FOR THE PROJECT

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