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IMPROVED IRON CATALYSTS FOR SLURRY PHASE FISCHER–TROPSCH SYNTHESIS

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Disclaimer

Abstract

This report describes research conducted to support the DOE program in development of improved (attrition resistant) catalysts for converting coal-derived synthesis gas to liquid fuels via slurry phase Fischer–Tropsch (F–T) synthesis. The primary objective of this research program is to develop highly active and selective attrition resistant iron F–T catalysts by spray drying.

Attrition strength of various types of iron F–T catalysts was studied under reaction conditions in a stirred tank slurry reactor (STSR). The attrition behavior was evaluated on the basis of observed changes in morphological properties (via SEM), and changes in particle size distribution after F–T synthesis in the STSR.

Three spray-dried catalysts (100 Fe/3 Cu/5 K/16 SiO_2 in parts by weight) prepared from wet precursors at Texas A&M University had excellent sphericity and smooth external surfaces. Their particle size distribution was rather broad ranging from 5 μm to 40 μm in diameter, regardless of the source of silica (colloidal silica, TEOS, or potassium silicate) employed in their preparation. The catalyst prepared from colloidal silica had the highest attrition strength among all catalysts studied during the course of this project. After 345 h of testing in the STSR its morphology remained practically unchanged, and it experienced small reductions in the volume mean diameter (5.4 %) and generation of particles smaller than 10 μm in diameter was very small (0.7 %). Catalytic performance of these catalysts was excellent. Syngas conversion was between 71 and 76 %, whereas methane selectivity was between 2.2 and 3.5 % and that of C_5^+ hydrocarbons was 78 % to 86 % (all selectivities are on C–atom basis).

Spray-dried catalysts, synthesized at Hampton University, with compositions 100 Fe/5 Cu/4.2 K/11 SiO_2 and 100 Fe/5 Cu/4.2 K/1.1 SiO_2 had excellent selectivity characteristics (methane selectivity of 2 %, and C_5^+ selectivity of about 85 %) but their activity and stability (deactivation rate) need to be improved. Spray-dried HU1112 catalyst (100 Fe/3 Cu/4 K/16 SiO_2 produced more methane (3.5 %) and less C_5^+ hydrocarbons (77 %) than the other two spray-dried catalysts. The attrition strength of catalysts containing 1.1 and 16 parts of silica per 100 parts of iron was found to be adequate for use in a slurry bubble column reactor (SBCR).

The primary objective of this project of synthesizing spray-dried iron F–T catalysts with adequate attrition strength and desirable F–T activity and selectivity for use in a SBCR for converting coal-derived synthesis into liquid fuels, has been achieved.

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