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CONVERSION OF CELLULOSIC WASTES TO LIQUID HYDROCARBON FUELS: VOL. 2, A KINETIC STUDY OF THE MODIFIED FISCHER-TROPSCH SYNTHESIS OVER AN ALUMINA-SUPPORTED COBALT OXIDE CATALYST: FINAL REPORT

ARIZONA STATE UNIV., TEMPE. COLL. OF ENGINEERING SCIENCES

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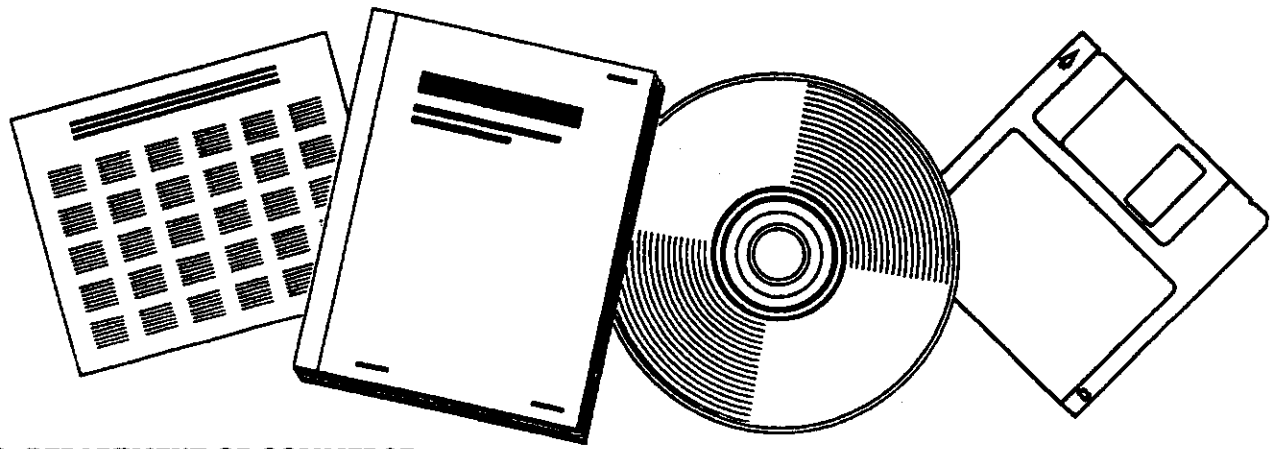

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Submitted

by

James L. Kuester
Principal Investigator

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College of Engineering and Applied Sciences
Arizona State University
Tempe, Arizona 85287

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ABSTRACT

A modified Fischer-Tropsch reaction with the incorporation of ethylene in the synthesis gas has been studied kinetically. The feed mixture was also comprised of methane and carbon dioxide in a proportion similar to a real pyrolysis gas composition. The feed gas was provided by a manifold of compressed gas cylinders. An alumina-supported cobalt oxide catalyst was prepared by an impregnation method and used in the experimentation.

A fixed-bed microreactor system was constructed and employed to carry out the experiments. The manipulated variables were the mass flow rates of hydrogen, carbon monoxide and ethylene, and the reaction temperature. Proper operating conditions for the kinetic experiments to minimize transport effects were determined through a justification phase of experiments and validated by the theoretical criteria checks. The results were as follows: (1) reaction temperature less than 498 °K, (2) weight hourly space velocity greater than 41.4 gm/hr of feed per gram of catalyst, and (3) catalyst particle size smaller than 60 mesh.

The gaseous product was analyzed by an on-line Carle analytical gas chromatograph equipped with a Spectra-

Physics digital integrator. The liquid product analyses were done by the Hewlett-Packard gas chromatographs. The liquid organic phase consisted mostly of straight chain alkanes (up to C_{35}). Some monomethyl paraffins and α-olefins were also present in small amounts. The aqueous phase was comprised mainly of water and 1-propanol.

Based on insignificant interparticle and intraparticle concentration gradients, a reaction mechanism was proposed with various alternative rate-determining steps. Corresponding intrinsic rate equations were derived to fit the experimental data, in terms of the rate, reaction temperature, and component partial pressures in the product, by the nonlinear Marquardt regression scheme. Experimental data were extracted from the qualified kinetic experiments, namely, less than 5% of conversion of the sum of three active reactants.

The study demonstrates that a model of the Eley-Rideal type, i.e., the reaction between the ethylene molecule and adsorbed hydrogen atom being the rate-determining step, may be the most probable course for the overall modified Fischer-Tropsch reaction to proceed.

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