



Cobalt based hybrid Fischer–Tropsch synthesis catalyst for improved selectivity of hydrocarbons in the JP-8 carbon number range from a synthesis gas obtained from the pyrolysis of the MixAlco process derived sludge

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ABSTRACT

The synthesis gas produced from the pyrolysis of the MixAlco process [5] (which converts wastes into fuels and chemicals) has the composition of ~45% H₂/35% CO together with up to about 20% CH₄. Recovery of the methane and application of steam reforming allows the adjustment of the H₂:CO ratio to about 1.9 optimum for cobalt performance in an enhanced Fischer–Tropsch synthesis (FTS) process. The performance of a new hybrid catalyst Co-SiO₂/Mo-Pd-Pt-HZSM-5 (with a metal–metal–acid functionality) was compared with that of a conventional Co-SiO₂ catalyst under the same thermodynamic condition of 10 atm and 250 °C. The specific surface areas of the two catalysts were characterized using the BET technique. The electron probe microanalyzer (with WDS and EDS capabilities) was then used to confirm the presence of the applied metals Co, Mo, Pd and Pt on the respective supports. The effect of pressure was then examined on the hybrid catalyst at the temperature of 250 °C and a higher pressure of 13.6 atm. At 10 atm and 250 °C, the conventional FTS catalyst produced fuels rich in hydrocarbons within the gasoline (C₄–C₁₂) carbon number range. Hydrocarbons with carbon numbers within the JP-8 (C₈–C₁₇) and to some extent diesel range (C₁₅–C₂₅) were also produced. At the same condition the Co-SiO₂-Mo-Pd-Pt/HZSM-5 catalyst increased the selectivity of JP-8 carbon number range hydrocarbons. When the hybrid catalyst Co-SiO₂/Mo-Pd-Pt-HZSM-5 was examined at 13.6 atm and 250 °C, a further increase in the selectivity of JP-8 carbon number range hydrocarbons and to some extent diesel was observed. The relative amounts of olefins and n-paraffins decreased with the distribution shifting towards the production of more isomers. A fixed bed continuous flow catalytic system was used.

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1. Introduction

With declining hydrocarbon petroleum deposits and increasing prices of petroleum fuels, there has been a renewed research interest in the search for alternative renewable sources of energy. One of the areas that has drawn interest is the catalytic conversion of syngas (H₂ and CO) to liquid transportation fuels. One of the key processes is the Fischer–Tropsch synthesis (FTS), which converts syngas into liquid hydrocarbons, primarily in the diesel range. The thermodynamic equilibrium conditions and the type of

catalyst are the key factors determining hydrocarbon products distribution. A generic predictive model for the product distribution is the Anderson–Schulz–Flory probability model [1,2]. According to this model, at lower probabilities for molecular propagation (chain growth), the selectivity of lower hydrocarbons (C₁–C₄) is highest. At higher probabilities, the selectivity of diesel (C₁₅–C₂₅) and complex waxes increases dramatically. At medium chain growth probabilities, the selectivity of gasoline (C₄–C₁₂) and JP-8 (C₈–C₁₇) are medium with a value of ~48% reported for gasoline selectivity.

Sources of feedstocks used to produce syngas in FTS are: natural gas in gas-to-liquid (GTL), coal in coal-to-liquid (CTL) and biomass in biomass-to-liquid (BTL) conversion technologies [3]. Each source has its own merits and demerits which sometimes dictate syngas production, processing and composition adjustment technologies and catalyst selection. For example when the feedstock is biomass, ultimate analysis of the biomass may dictate the use of either gasification or pyrolysis. Also the low hydrogen production potential of biomass versus natural gas will require the use of iron

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