



Co–Ru/SiC impregnated with ethanol as an effective catalyst for the Fischer–Tropsch synthesis

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ABSTRACT

Silicon carbide containing cobalt (30 wt.%) doped with 0.1 wt.% of ruthenium catalysts prepared by incipient wetness impregnation of cobalt nitrate with either ethanol or water were tested in the Fischer–Tropsch synthesis (FTS) in a fixed-bed configuration. The catalyst prepared with ethanol exhibits a higher FTS performance compared to the one prepared with water and especially at high reaction temperature, i.e. 230 °C. The FTS performance of the cobalt-based catalyst impregnated with ethanol further increases, under high temperature and high space velocity, to reach a steady state reaction rate of 0.54 g_{CH₂} g_{catalyst}⁻¹ h⁻¹, and a relatively high C₅₊ selectivity of about 90%. In addition, the catalyst also exhibits a relatively high stability as a function of time on stream. ⁵⁹Co zero field NMR analysis has indicated that the proportion of cobalt atoms engaged in the small hcp cobalt particles (<8 nm) was higher for the ethanol impregnated catalyst and also to the more homogeneous dispersion of the ruthenium atoms within the cobalt network forming an alloy.

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1. Introduction

Due to the stagnation of proven reserves of crude oil it is expected that the utilization of natural gas will probably become of prime importance in the energy field in the near future. In the Gas-To-Liquid (GTL), Coal-To-Liquid (CTL) and Biomass-To-Liquid (BTL) processes, Fischer–Tropsch synthesis (FTS) is a key technology, which allows the transformation of synthesis gas issued from different sources into very long chain hydrocarbons followed by hydrocracking of the heavy fraction into useful compounds such as naphtha, diesel, lubricants and others. Among these processes which have received increasing scientific and industrial interest in the last decades [1–6] the GTL is the most developed one. Recent advances in catalyst development and reactor technology have significantly contributed to the fast growth of the GTL process during the last decade for supplying ultra-clean fuels (sulfur- and nitrogen-free and no aromatics) for transportation. Cobalt is one of the most active metals for the FTS reaction and is mostly employed as supported catalyst due to its reasonable

price, high stability, high activity, high selectivity to higher hydrocarbons and low water–gas shift activity [1]. Typically, the cobalt metal loading ranges from 10 to 30 g per 100 g support. In order to increase the active site density per volume it is generally supported on a high specific surface area carriers such as alumina, silica or titanium dioxide [7–9]. Since FTS is a highly exothermic reaction, the removal of reaction heat at high CO conversion is a major concern. However, the above-mentioned supports are insulating materials which are not able to prevent hot spot formation within the catalyst bed, leading to low liquid hydrocarbon selectivity. Indeed, on insulating supports such as alumina or silica the heat transfer within the catalyst bed could induce temperature gradients in different parts of the bed. In areas where high conversion of CO occur the catalyst temperature could be high whereas in other parts of the bed the temperature could be significantly lower. Depending to the pore size distribution of the support, a temperature gradient could also occur within the catalyst body, i.e. between the catalyst outer surface and the catalyst matrix, which could modify the liquid hydrocarbon selectivity of the reaction. New developments dealing with the use of conductive supports such as metallic foams or monoliths have recently been reported for improving the heat transfer for the FTS reaction [10–14].

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