

EFFECT OF OPERATING CONDITIONS ON FISCHER-TROPSCH LIQUID PRODUCTS

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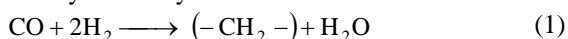
Abstract— Fischer-Tropsch synthesis is an important chemical process for the production of liquid fuels. In recent years, the abundant availability of natural gas and the increasing demand of gasoline, diesel and waxes have led to a high interest in further developing this process. The dependencies of liquid hydrocarbon product distribution of iron catalyzed Fischer-Tropsch synthesis on operating pressure and temperature have been studied. The study followed an experimental planning and the results were analyzed based on surface response methodology. The effects of different operating conditions on product distribution were compared based on number average carbon number and distribution dispersion. Results showed that high temperature (270°C) and pressure (27 atm) favor the production of heavy waxes that can be converted to liquid fuels through hydrocracking, while greater direct selectivity towards liquid fuels are favored by low temperature (240°C) and high pressure (30 atm).

Keywords— Fischer-Tropsch Synthesis, Liquid Fuels, Iron-based Catalyst

I. INTRODUCTION

In recent years, the Fischer-Tropsch synthesis (FTS) has become a subject of renewed interest particularly in converting natural gas (NG) into liquid transportation fuels. This can become a major advantage when dealing with natural gas because its storage is a big logistic problem, especially regarding exploration in off-shore exploitation platforms. A palliative transportation solution, which has been in relatively widespread use for years involves the conversion of NG into liquefied natural gas (LNG). However the LNG approach has a significant drawback since it is a relatively expensive process and the storage vessels requires rigorous thermal design and construction specs due to the required low temperatures. For that reason, if the FTS process is further developed and performed efficiently, it may become an economically viable alternative for delivering natural gas across large distances.

Natural gas can be converted to carbon monoxide and hydrogen (synthesis gas) via the existing processes, such as steam reforming, carbon dioxide reforming, partial oxidation and catalytic partial oxidation, followed by the FT synthesis reaction:



The study of the Fischer-Tropsch synthesis (FTS) with iron-based catalysts has been done by many investigators (Raje and Davis, 1997; van Steen and Schulz, 1999; Donnelly and Satterfield, 1989; Eliason and Bartholomew, 1999; Li *et al.*, 2002), and it has been shown that iron-based catalysts has satisfactory performance in the production of liquid fuels in the range of gasoline and diesel. Most researches have focused on the conversion of the FTS and on the overall rate of reaction (Raje and Davis, 1997; Eliason and Bartholomew, 1999) and many overall reaction rate equations of the FTS reaction have been proposed.

In recent years the focus on FTS researches have shifted towards a better understanding of the FT kinetic mechanism (Huff and Satterfield, 1984; Mandon and Taylor, 1981; Maitlis *et al.*, 1999) and product distribution (Patzlaff *et al.*, 1999; Donnelly and Satterfield, 1989; van der Laan and Beenackers, 1999; Fernandes, 2005, 2006; Fernandes and Sousa, 2006). Studies have shown that iron-based catalyst produces paraffins, especially low molecular weight paraffins (light gases, gasoline and diesel cuts), and a large quantity of olefins depending on the operating conditions that are employed.

van Berge (1997) has shown that in comparison to cobalt-based catalysts, iron-based catalysts present better performance and higher productivities than the Co-based catalyst at high pressures (over 10 atm, preferably above 20 atm) and space velocities, thus this evidence has to be further studied. In this study we have examined the number of carbon distribution of the liquid product of a FT reaction carried out under pressures between 20 and 30 atm, range of pressure which few papers are available in the literature.

II. EXPERIMENTAL

A. Catalyst Preparation

An iron catalyst with a 100Fe/5Cu/6K/139SiO₂ composition (molar basis) was prepared by successive impregnation with aqueous solution of Fe(NO₃)₃·9H₂O, Cu(NO₃)₂·3H₂O and K₂CO₃ to incipient wetness of SiO₂ (Grace-Davison Syloid 74) in a rotary evaporator (Tecnal model TE-211, Brazil) operated at 60°C under 500 mmHg (vacuum maintained with a vacuum pump Tecnal model TE-058).

After impregnation of each salt, the catalyst was dried in a drying oven (Fanem model AH-T, Brazil) at 60°C for 12 hours. After impregnation of the last salt, the catalyst was dried at 60°C for 24 hours and calcined