Comparison of Performance of an Iron Fischer-Tropsch Catalyst in a Fixed-Bed Reactor, CSTR, and SBCR

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Introduction

Fischer-Tropsch (FT) synthesis is a major route for converting synthesis gas made from coal or natural gas into hydrocarbons. The catalysts of choice for FT synthesis are iron (Fe) – and cobalt (Co) – based. Fe catalysts are significantly cheaper and are preferred for low H_2-CO ratio synthesis gas due to their excellent water gas shift (WGS) activity [1]. However, catalyst attrition and powdering, causing catalyst loss and wax contamination, has hindered the widespread application of Fe-FT synthesis in slurry bubble column reactors (SBCR), the preferred reactors for FT synthesis.

Spray drying is the method of choice for preparing Fe FT catalysts for SBCR [2,3]. Our previous efforts have concentrated on synthesizing spray-dried Fe FT catalysts with high attrition resistance [2,3] and high C_{5+} hydrocarbon yield [3]. One such catalyst prepared in a 2-kg quantity was tested in a fixed-bed micro-reactor, a CSTR and a 1.6-inch ID SBCR. In this paper we present the results of these tests.

Experimental

The tested iron FT catalyst had the composition 100/5/4.2 Fe/Cu/K with silica as structural promoter. The detailed catalyst preparation conditions and procedures have been described previously [2,3]. The catalyst was tested using a 0.305-inch ID fixed-bed micro-reactor, a 2-liter CSTR, and a 1.6-inch ID (26-feet tall) SBCR. The CSTR and SBCR tests are the courtesy of Rentech, Inc., a major developer of iron FT technology. The tests were conducted at 225-270°C and 300-375 psig (21-26 bar).

Results and Discussion

The CO productivity to total hydrocarbons (HC_{total}) and C_{10+} hydrocarbon yield at a H_2-CO ratio of 0.67 and 300 psig for various temperatures is shown in Figure 1. The CO productivity to HC_{total} increased with increasing temperature, as well as the molar selectivity to CO_2 (from 35% to 42%, data not shown). However, the C_{10+} yield was higher at lower temperatures. Thus, lower temperatures enhance carbon utilization into economically preferred C_{10+} products, instead of C_1-C_4 hydrocarbons and CO_2.

The effect of reactor type on CO productivity to HC_{total} and on the selectivity to C_{5+} hydrocarbons and to CO_2 at 255-260°C and $H_2/CO = 1.6$ is shown in Figure 2. The selectivity values of the SBCR are much closer to those of the fixed-bed reactor than the CSTR, despite their difference in CO productivity. The SBCR was run for 75 hours. The CO conversion was still gradually increasing when the run was stopped. During the run the catalyst did not undergo attrition. A sharp separation of catalyst from the wax was achieved after the run; the product wax was free of iron, as shown by a burnout in a thermogravimetric analysis (TGA) cell. Efforts are under way to further optimize this catalyst for long-term SBCR testing.

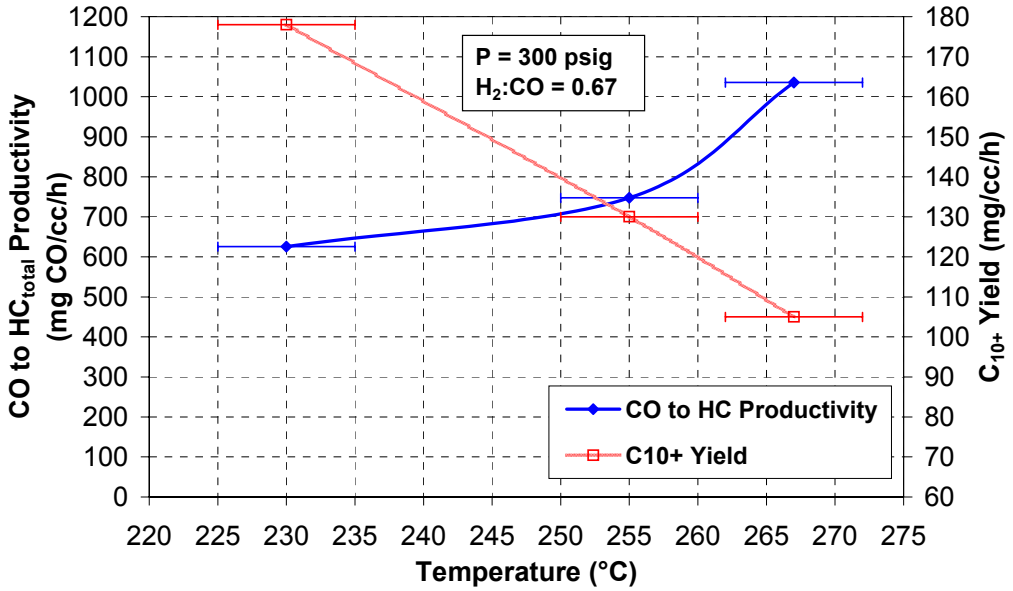

Figure 1. CO productivity to total hydrocarbons and C_{10+} yield for fixed-bed reactor

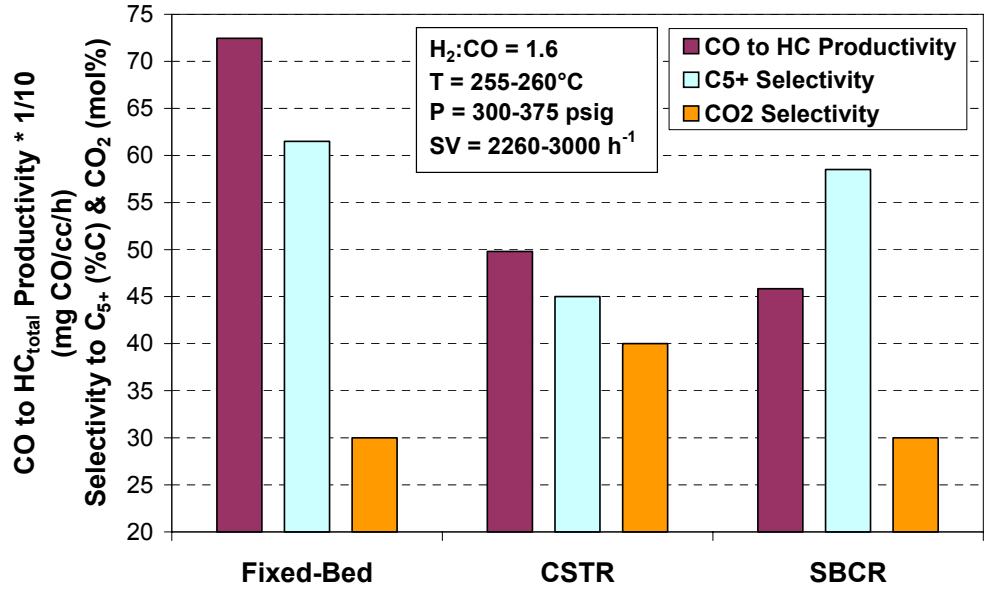

Figure 2. CO productivity to total hydrocarbons, C_{5+} selectivity, and CO_2 selectivity

References

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3. K. Jothimurugesan, J.G. Goodwin, Jr., S.K. Gangwal, and J.J. Spivey, *Catal. Today*, 58 (2000) 335.