

properties and catalytic activity play important roles either independently or interactively in reactor behavior. It usually shows large complexity when a full 3D modeling is used. Therefore, a 2D model using dynamic time as the z-axis can be adopted to describe a 3D problem for our monolithic catalyst with regular shape so that the computation time can be greatly shortened. In the model assumptions, temperature is constant because of the highly conductive substrate in addition to the short heat transfer length in the microchannel reactor, and the heat release from the synthesis reaction is mitigated in such a way. The flow in the monolith channel is laminar and the axial diffusion of the reactants is negligible compared to the convection. We also assume identical conditions for each channel of the whole monolith whose behavior can be represented by one channel, and the catalyst sites are uniformly located in the washed coatings. The partial differential equations describing the mass balance in a monolith channel are written in two domains. In the flowing channel of the monolith, the reactant (CO) is transported by diffusion (in x, y directions) and convection (z-direction but represented by t that is solved as time dependent 2D problem).

In the washed coated catalyst porous phase, synthesis reactions occur and the material balance is characterized by kinetic rate and effective diffusion that reflects the pore properties. A Langmuir-Hinshelwood kinetics rate for the Co catalyst [11] was used in which parameters were regressed to fit small powder catalyst testing data in the microchannel reactors that provide isothermal solutions to the exothermic system.

$$(-r_{CO}) = D_{eff} \left(\frac{\partial^2 c}{\partial x^2} + \frac{\partial^2 c}{\partial y^2} \right)$$

The simulation results show the concentration distribution of the monomer precursor (CO) in a monolith channel. The CO concentration with a 60 μm catalyst coating yields larger gradient within the layer than the thinner coating with 15 μm thickness. It suggests that the efficiency of catalyst utilization is higher when having a thinner coating due to reduced mass transfer resistance.

Temperature Effect

CO conversion increased from 25% to 64% when the temperature was raised from 224° C. to 260° C. at 40 atm at a weight hourly space velocity of 3.73 g CO/g cat/hr, over a monolith catalyst with a 15 μm catalyst coating, with a H₂/CO of 2. See FIG. 7. The methane selectivity remained about 10%, which is a unique feature that is different from conventional FT reaction technology in which methane selectivity increases as temperature is increased. Pressure was measured at both upstream and downstream of the catalyst bed, since the monolith catalyst causes only slight pressure drop across the bed, the whole system pressure is 40 atm. According to the present invention, pressure should be measured upstream of the catalyst, if possible. The catalyst loading on the substrate varies with coating thickness, in this particular example with 15 μm coating, the total catalyst loading is 0.047 g. When we calculate weight hourly space velocity, substrate weight was not included, but alumina (Al₂O₃) coating as metal support is included as part of catalyst weight. That is: catalyst weight = Al₂O₃ coating + Co loading + Re loading.

Pressure Effect

Total pressure effect is shown in FIG. 8, at a certain temperature and space velocity, high pressure suppresses methane formation and increases syngas conversion. This occurs because high partial pressure of CO and hydrogen increases

the overall kinetic rate. In the meantime, the increased driving force of diffusion when the CO in the bulk phase is increased will mitigate the depletion of monomer on the catalyst sites, so that the chain growth probability is enhanced resulting in low methane selectivity.

As shown in FIG. 8, when tested at a 260° C. and a weight hourly space velocity (WHSV) of 3.73 g CO/g cat/hr, it was found that high pressure suppresses methane formation and increases syngas conversion.

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We claim:

1. A hydrocarbon composition made by a Fischer-Tropsch synthesis, comprising: C5 to C20 hydrocarbons wherein the amounts (by weight) of hydrocarbons decrease in the order C5>C6>C7>C8>C9>C10>C11>C12>C13>C14>C15>C16>C17>C18>C19>C20; wherein C5, C6, C7, and C8 are each present in at least 5 wt %; and wherein C20 is present in the range of 0.3 to 2.0 wt %; and further wherein the weight percents of C5 to C20 hydrocarbons are 8.5-9.5, 8.0-9.0, 7.0-8.0, 6.3-7.3, 5.4-6.4, 4.7-5.7, 3.9-4.9, 3.3-4.3, 2.7-3.7, 2.2-3.2, 1.7-2.7, 1.3-2.3, 1.0-2.0, 0.7-1.7, 0.5-1.5, and 0.3-1.3 weight percent respectively.

2. The hydrocarbon composition of claim 1 wherein C9 is present in at least 5 wt %; and C20 is present in the range of 0.4 to 1.5 wt %.

3. The hydrocarbon composition of claim 1 wherein C5, C6, and C7 are each present in a range of 6 to 10%.

4. The hydrocarbon composition of claim 1 wherein the weight percents of C5 to C20 hydrocarbons are about 9, 8.5,