In Situ STM of the Fischer-Tropsch Synthesis Over Co(0001)

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Using high-pressure high-temperature STM we have studied the reaction of syngas, a mixture of carbon monoxide and hydrogen, over a Co(0001) single crystal. The experiment models the Fischer-Tropsch synthesis of paraffins that, in the modern version, is mostly performed with supported cobalt catalysts. The process is expected to become the key future method for the production of liquid fuels. Open questions are the chemical and structural state of the operating catalyst, and, related to this, the reaction mechanism. At 500 K, the temperature of the industrial process, and at pressures in the 10 mbar range, we could detect the formation of methane on the Co(0001) surface by mass-spectrometry. Under the same conditions atomic resolution by the STM was achieved. The data show that the surface remains metallic and does not transform into cobalt oxide or carbide. Surprisingly, a surface roughening, assumed in the usual models of the Fischer-Tropsch synthesis, was completely absent. Experiments without H_2, at the same partial pressures of CO, show that CO can dissociate on the Co(0001) surface under these conditions. Syngas experiments in which the hydrogen gas contained sulfur in the ppb range showed a strong surface restructuring, connected with a drop in catalytic activity. The STM data thus also provide insight into the poisoning of the catalyst.