# Development of a Novel Catalyst for Conversion of Syngas to Liquid Hydrocarbons (Fischer–Tropsch products)

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The most common feedstock materials for syngas production are coal (so-called coal-to-liquids, or CTL) or natural gas (gas-to-liquids, or GTL) or biomass (biomass to liquid, or BTL), as shown in Figure 1. Fisher Tropsch (FTS) technology is used for the conversion of syngas to synthetic fuels. FTS technology is currently being employed in Qatar, Malaysia, South Africa, and China to produce ultraclean liquid hydrocarbons of ($C_5$ - $C_{25}$), which can be used as synthetic fuel such as kerosene, diesel and lubricant oil. Synthetic fuels have less impact on the environment because they are Sulphur free and have no contaminants such as heavy metals or aromatics in comparison with crude oil refined products.

The catalysts used is the heart of the FTS technology; that determines the quality of the products. Most of the current FTS catalysts operate at high pressure and temperature, which increases the cost. The catalyst developed in this patent uses lower temperature and pressure to produce high quality liquid hydrocarbons at a lower operating cost. In addition, the catalyst is made of copper and zinc supported on alumina and zeolite.

Only four transitional metals are currently thought to be active in FTS: cobalt, iron, ruthenium, and nickel. Only cobalt and iron have traditionally been considered for industrial application since nickel has been called a methanation catalyst, and simply because ruthenium is expensive. The active phase in FTS is often comprised of cobalt or iron, and its phase use depends on several parameters, including the goal product (fuels vs. chemicals) and cost.

The catalytic performance of the obtained catalysts is superior to all previously reported metal-based, and carbon-based catalysts under the same reaction conditions or parameters as well as the type of the products. The total cost of the catalyst is almost 3 or 12 times cheaper than commercial cobalt or ruthenium catalysts, respectively.

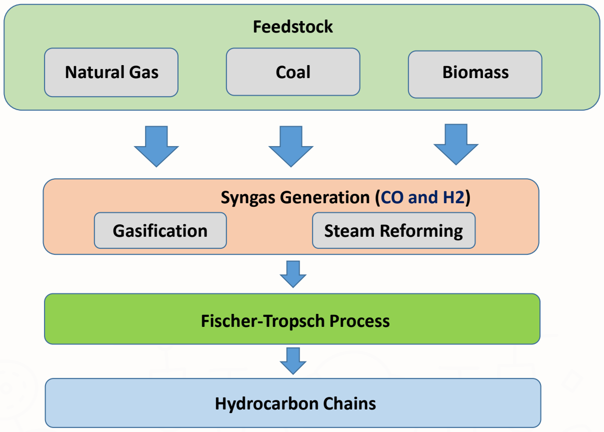


Figure 1. FTS process from Natural gas to hydrocarbon products.

The research goals were to (i) synthesize this catalyst using different syntheses procedures and (ii) optimize the synthesis procedure to obtain a catalyst active phase content with the highest selectivity and stability. The various synthesis techniques assisted changing the nanostructures while maintaining the same elemental composition facilitating the structure-activity/selectivity and stability studies. The promotional effect of basic oxides and noble metals on catalytic activity was also explored to optimize the activity, stability, and selectivity.

Here, the researcher synthesized and characterized a novel catalyst with different supports. This catalyst could be used in heavy alcohol conversion and Fisher-Tropsch products from Syngas ($CO/H_2$). The catalyst's efficiency is very high, and it can be prepared easily and used in mass production. The figures below show the wide range of products achieved using this novel catalyst at moderate pressures and temperatures.

The investigation led to the development of a novel catalyst by using the solution combustion synthesis (SCS) method and met the FTS application for hydrocarbon products. The catalyst gives the same stability and activity compared with those usually made of iron or cobalt. The catalyst was also characterized by a wide range of analytical techniques, e.g., X-ray diffraction analysis (XRD), X-ray photoelectron spectroscopy (XPS), scanning electron microscope (SEM), Brunauer–Emmett–Teller (BET), temperature-programmed reduction (TPR), and temperature-programmed oxidation (TPO). Also, The experiments were conducted in a high-pressure bench-scale reactor (fixed-bed) where the condensed liquid was collected and analyzed using the gas chromatography with mass spectrometer and FID (GC-MS), (GC-FID), and Karl fisher techniques in addition to the gas part by GC-TCD.

The novel catalyst has produced liquid hydrocarbons of the same quality as the commercial catalysts but at lower operating conditions and hence potential lower cost. Accordingly, the catalyst has been patented in the United States Patent and Trademark Office (USPTO) and granted the patent number US 11,045,793 B1 on 29-06-2021.

The research team that developed the catalyst comprises of Mr. Ahmed Soliman, Senior Chemist, Gas Processing Center; Dr. Kamel Eid, Research Associate, Gas Processing Center; Prof Ahmed El Zatahry, Dean of College of Arts and Sciences; and Prof. Aboubakr M. Abdullah, Innovation Acting Manager at Qatar University. The inventors examined and investigated different catalysis synthesis methods, activity, stability, hydrocarbons products, and FTS experiments as shown in Figures 2-3 as an example.

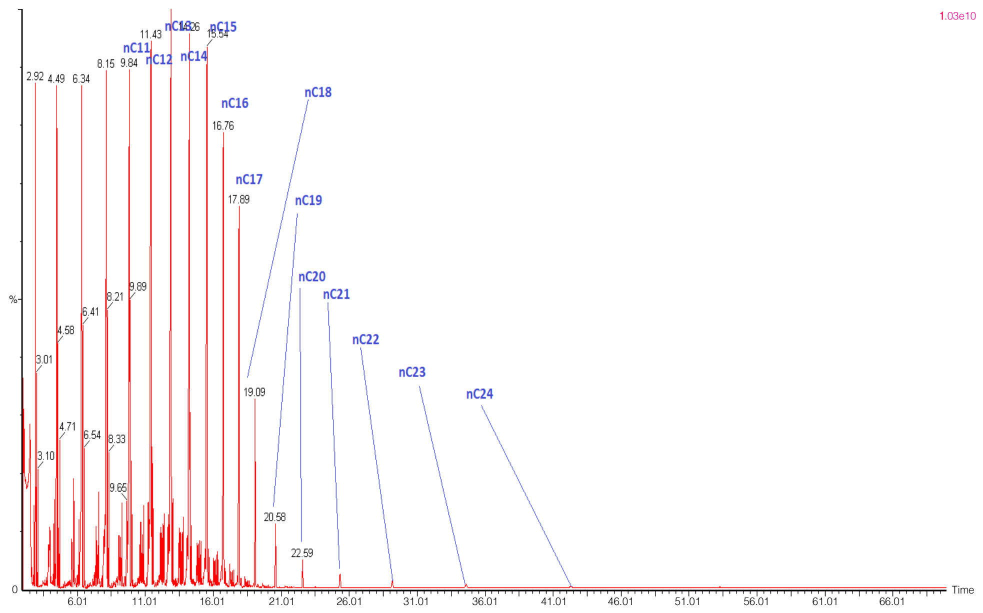


Figure 2. FTS products by GC-MS using the catalyst at 20 bar and 250 c°.

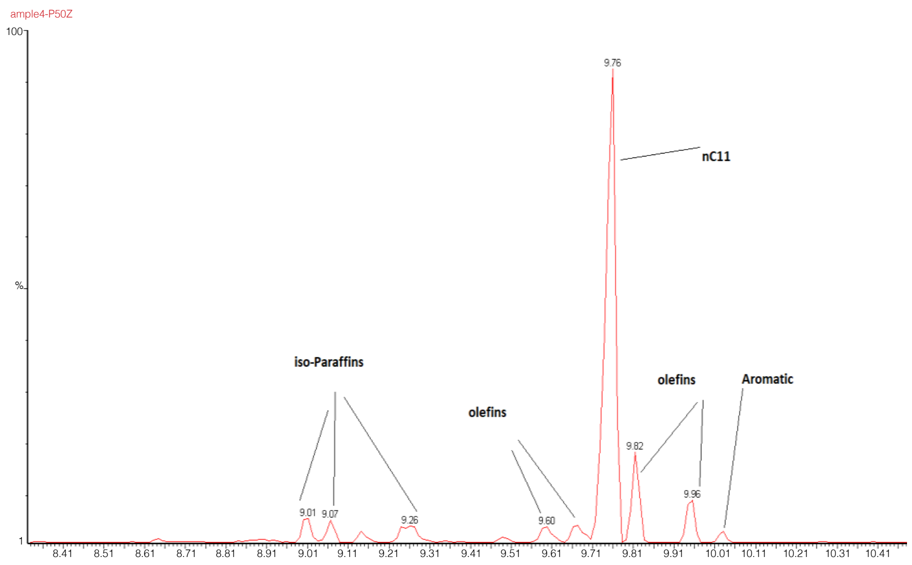


Figure 3. GC-MS showed the hydrocarbon identification of FTS products at 20 bar and 250 c°.