

Fischer–Tropsch process

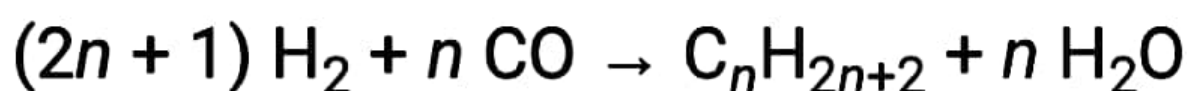
The **Fischer–Tropsch process** is a collection of chemical reactions that converts a mixture of carbon monoxide and hydrogen into liquid hydrocarbons. These reactions occur in the presence of certain metal catalysts, typically at temperatures of 150–300 °C (302–572 °F) and pressures of one to several tens of

It serves as an important reaction in both coal liquefaction and gas to liquids technology as well as many other chemical processes aimed at producing compounds based on hydrocarbon chains.^[1] It works by combining carbon monoxide and hydrogen that are produced from coal, natural gas, or biomass in a process known as gasification, and the Fischer–Tropsch process then turns these

gases into a synthetic lubrication oil and synthetic fuel.^[2] The Fischer–Tropsch process has received intermittent attention as a source of low-sulfur diesel fuel and to address the supply or cost of petroleum-derived hydrocarbons.

A Fischer–Tropsch-type process has also been suggested to have produced a few of the building blocks of DNA and RNA within asteroids.^[3] Similarly, naturally occurring FT processes have also been described as important for the formation of abiogenic petroleum.

The Fischer–Tropsch process involves a series of chemical reactions that produce a variety of hydrocarbons, ideally having the formula (C_nH_{2n+2}) . The more useful reactions produce alkanes as follows:



where n is typically 10–20. The formation of methane ($n = 1$) is unwanted. Most of the alkanes produced tend to be straight-chain, suitable as diesel fuel. In addition to alkane formation, competing reactions give small amounts of alkenes, as well as alcohols and other oxygenated hydrocarbons.^[4]

Fischer–Tropsch intermediates and elemental reactions

Converting a mixture of H_2 and CO into aliphatic products obviously should be a multi-step reaction with several sorts of intermediates. The growth of the hydrocarbon chain may be visualized as involving a repeated sequence in which hydrogen atoms are added to carbon and oxygen, the C-O bond is split and a new C-C bond is formed. For one $-\text{CH}_2-$ group produced by $\text{CO} + 2 \text{H}_2 \rightarrow (\text{CH}_2) + \text{H}_2\text{O}$, several reactions are necessary:

- Associative adsorption of CO
- Splitting of the C-O bond

- Dissociative adsorption of 2H_2
- Transfer of 2 H to the oxygen to yield H_2O
- Desorption of H_2O
- Transfer of 2 H to the carbon to yield CH_2

The conversion of CO to alkanes involves hydrogenation of CO, the hydrogenolysis (cleavage with H_2) of C–O bonds, and the formation of C–C bonds. Such reactions are assumed to proceed via initial formation of surface-bound metal carbonyls. The CO ligand is speculated to undergo dissociation, possibly into oxide and carbide ligands.^[5] Other potential

intermediates are various C₁ fragments including formyl (CHO), hydroxycarbene (HCOH), hydroxymethyl (CH₂OH), methyl (CH₃), methylene (CH₂), methylidyne (CH), and hydroxymethylidyne (COH).

Furthermore, and critical to the production of liquid fuels, are reactions that form C–C bonds, such as migratory insertion. Many related stoichiometric reactions have been simulated on discrete metal clusters, but homogeneous Fischer–Tropsch catalysts are poorly developed and of no commercial importance.

Addition of isotopically labelled alcohol to the feed stream results in incorporation of

alcohols into product. This observation establishes the facility of C–O bond scission. Using ^{14}C -labelled ethylene and propene over cobalt catalysts results in incorporation of these olefins into the growing chain. Chain growth reaction thus appears to involve both 'olefin insertion' as well as 'CO-insertion'.^[6]

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