Fischer Tropsch Process (FTP)

Lecture (5)

Environmental Biotechnology Course (409 E)

New Technologies for Biofuel Production

Fourth year Environment Science, Environment Science & Chemistry students

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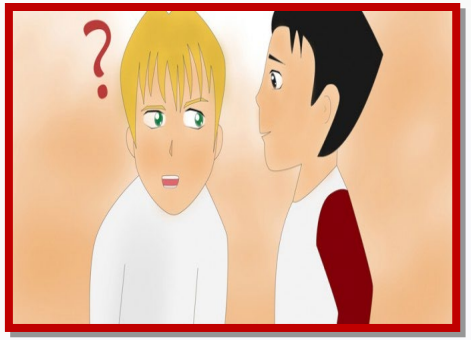
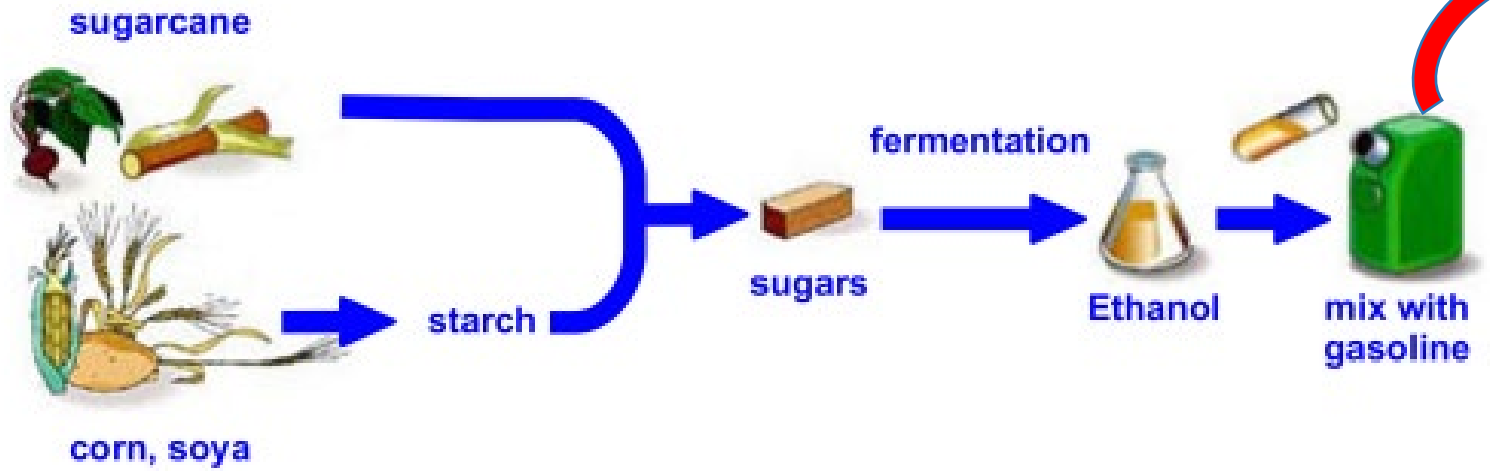
INSTRUCTIONS

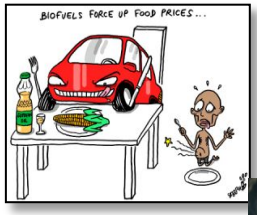


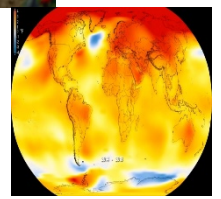
Biofuel Generations

First - Second - Third - Fourth

First Generation ------ Food







Second Generation ------ Biomass& wastes

1. Biochemical (sugar platform and fermentation).
2. Thermochemical pathways (syngas platform).

Biochemical
(sugar platform & fermentation)

Lignocellulosic biomass

↓

Pre-treatment

↓

Enzyme hydrolysis

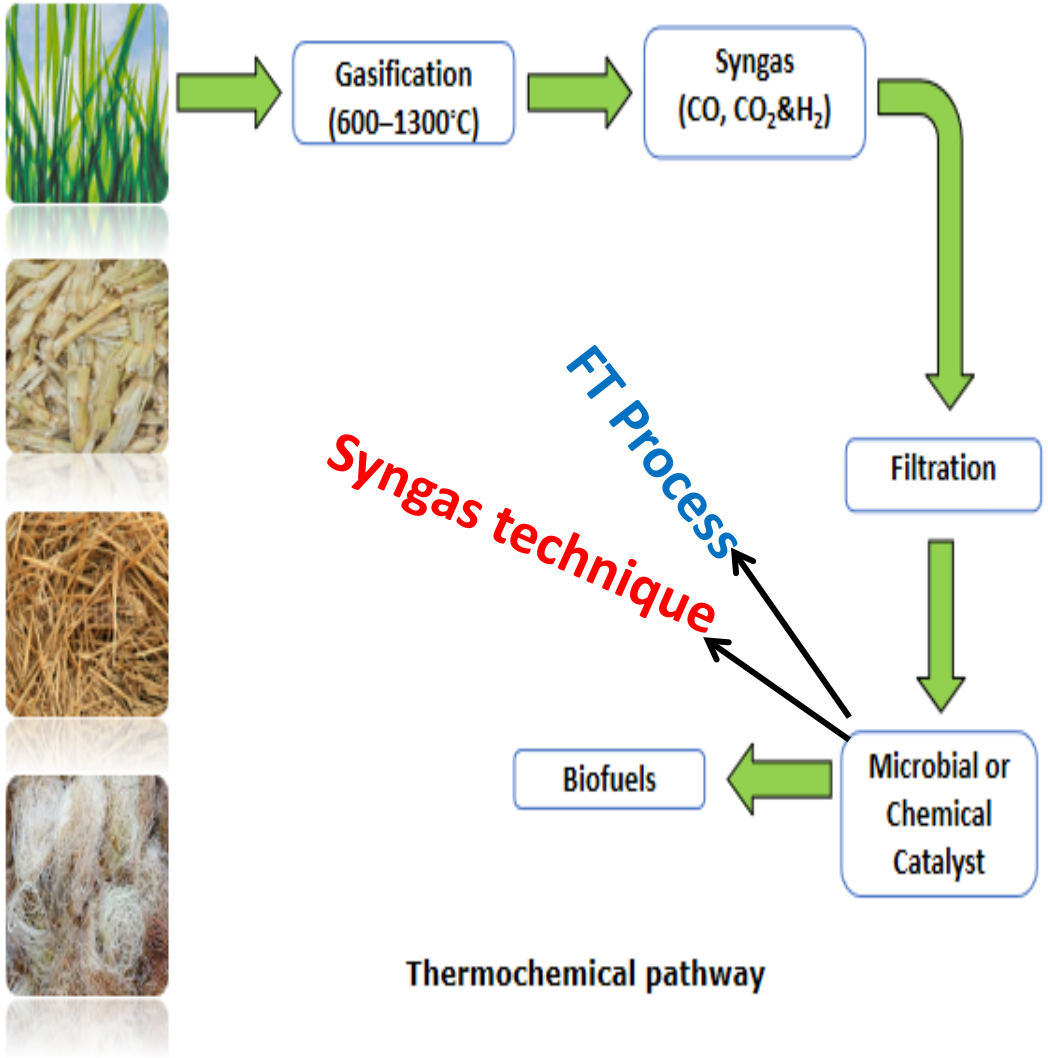
↓

Fermentable Sugars

↓

Biofuels

Thermochemical pathways
(syngas platform)



Thermochemical pathway

1. Fischer Tropsch (FT) Process

- FT process, originally developed by Franz Fischer and Hans Tropsch in early 1920s.
- The FT process involves a catalytic chemical reaction in which carbon monoxide (CO) and hydrogen (H_2) present in the synthetic gas are converted into hydrocarbons of different molecular weights based on the following equation:

$$(2n+1)\ H_2 + n\ CO \rightarrow Cn\ H(2n+2) + n\ H_2O,$$

and in the presence of metal catalyst such as iron or cobalt

Professor Franz Fischer (left) and Dr Hans Tropsch, the inventors of a process to create liquid hydrocarbons from carbon monoxide gas and hydrogen using metal catalysts.

Process conditions

❖Temperature

- Generally, the Fischer–Tropsch process is operated in the temperature range of 150–300 °C (302–572 °F).
- Higher temperatures lead to faster reactions and higher conversion rates but also tend to favor methane production. For this reason, the temperature is usually maintained at the low to middle part of the range.
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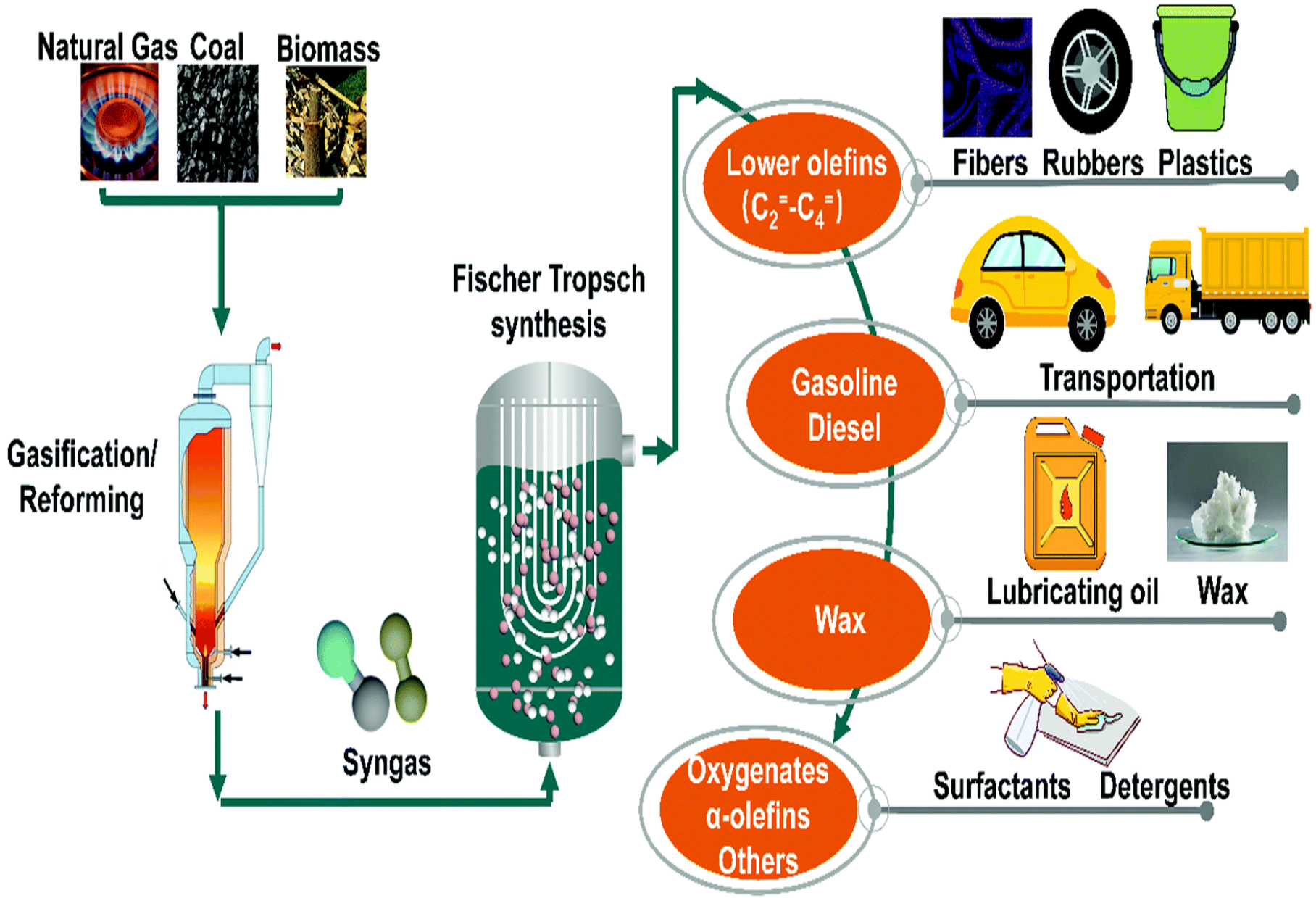
❖ Pressure

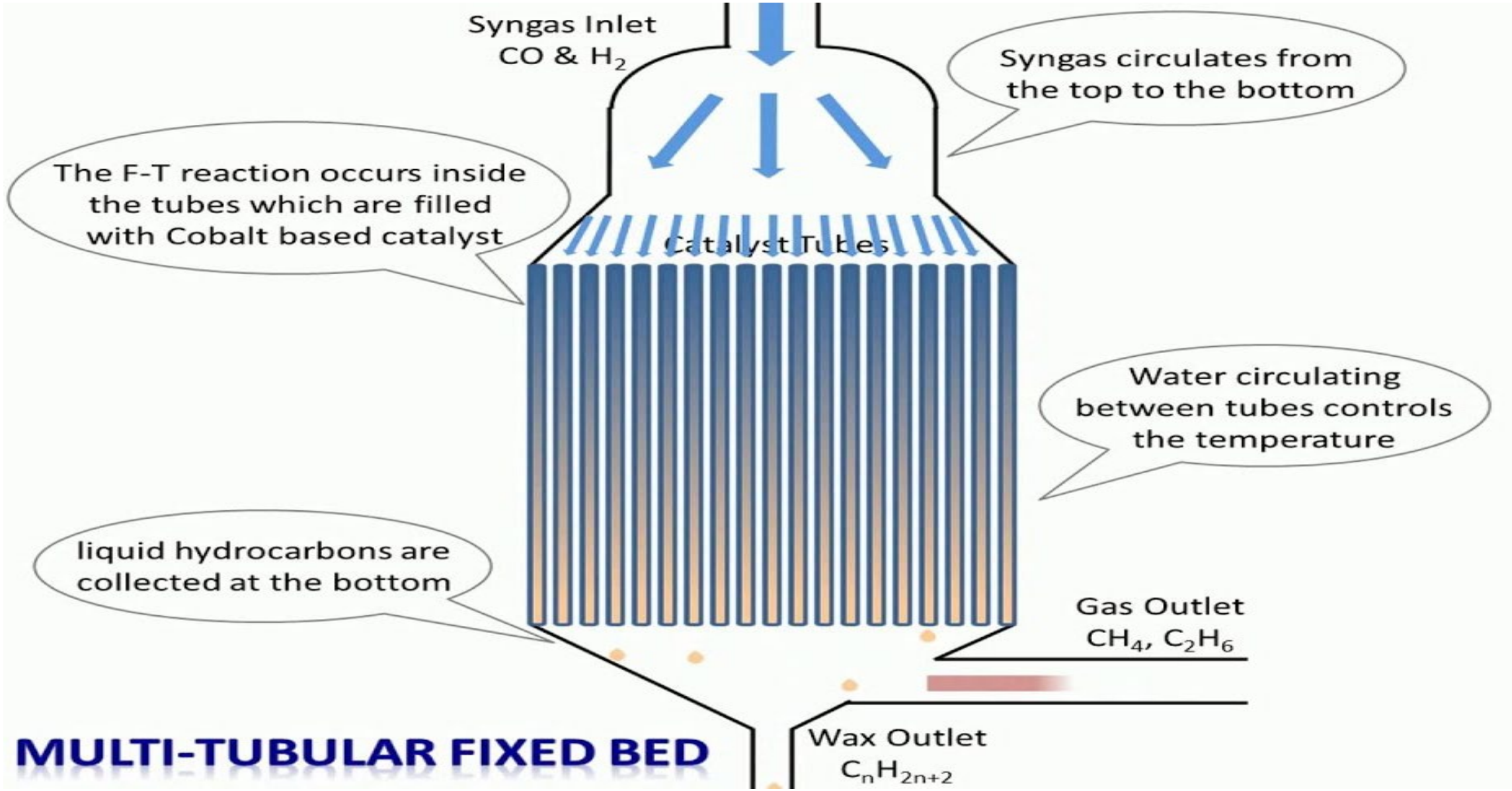
- Increasing the pressure leads to higher conversion rates and also favors formation of long-chained alkanes, both of which are desirable.
- Typical pressures range from one to several tens of atmospheres.
- Even higher pressures would be favorable, but the benefits may not justify the additional costs of high-pressure equipment, and higher pressures can lead to catalyst deactivation via coke formation.

- **Coke:** is a grey, hard, and porous coal-based fuel with a high carbon content and few impurities.

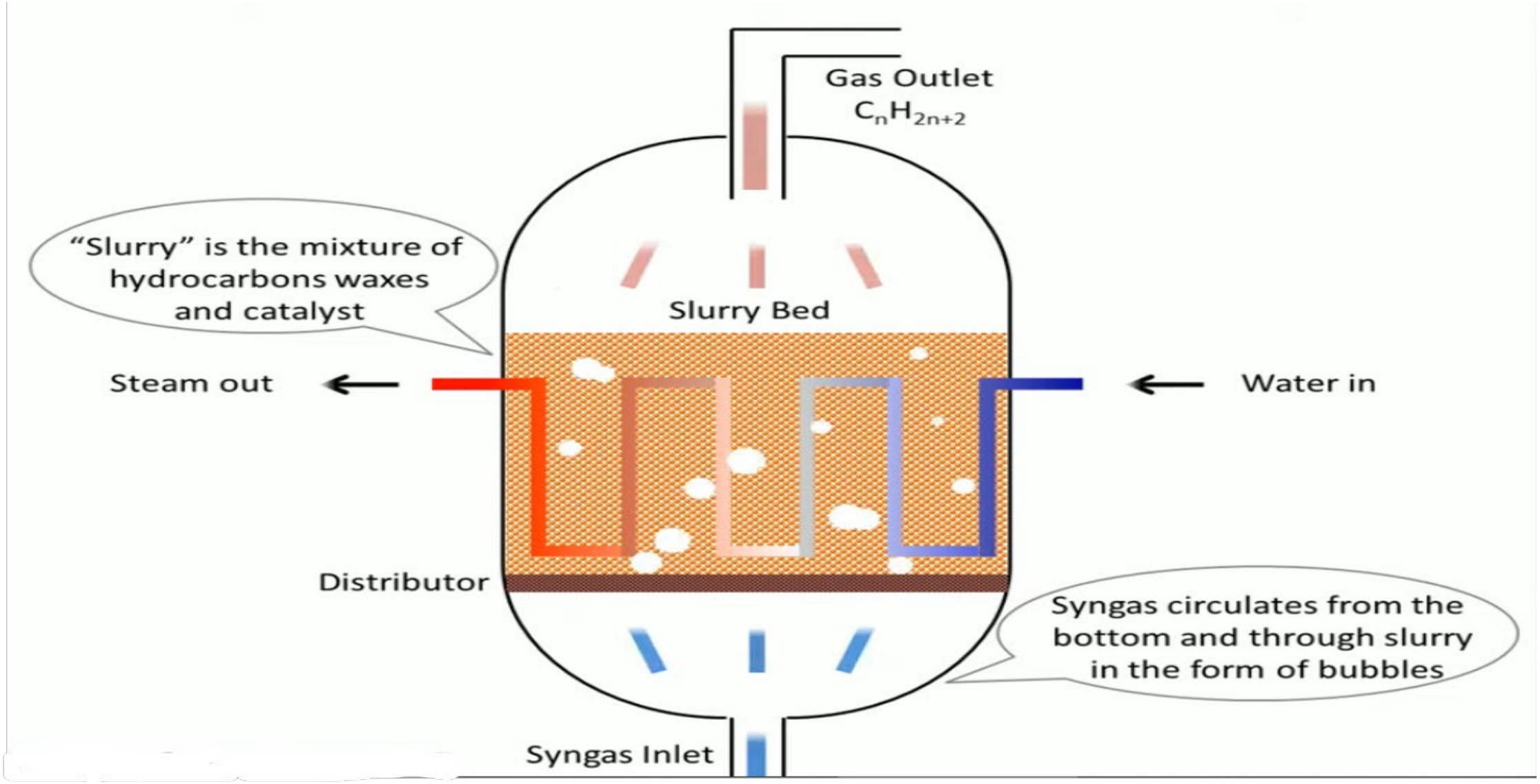
FT Process


Natural Gas
Coal
Biomass
Gasification/
Reforming
Syngas
Fischer Tropsch
synthesis
Lower olefins
($C_2^=$-$C_4^=$)
Gasoline
Diesel
Wax
Oxygenates
α-olefins
Others
Fibers
Rubbers
Plastics
Transportation
Lubricating oil
Wax
Surfactants
Detergents

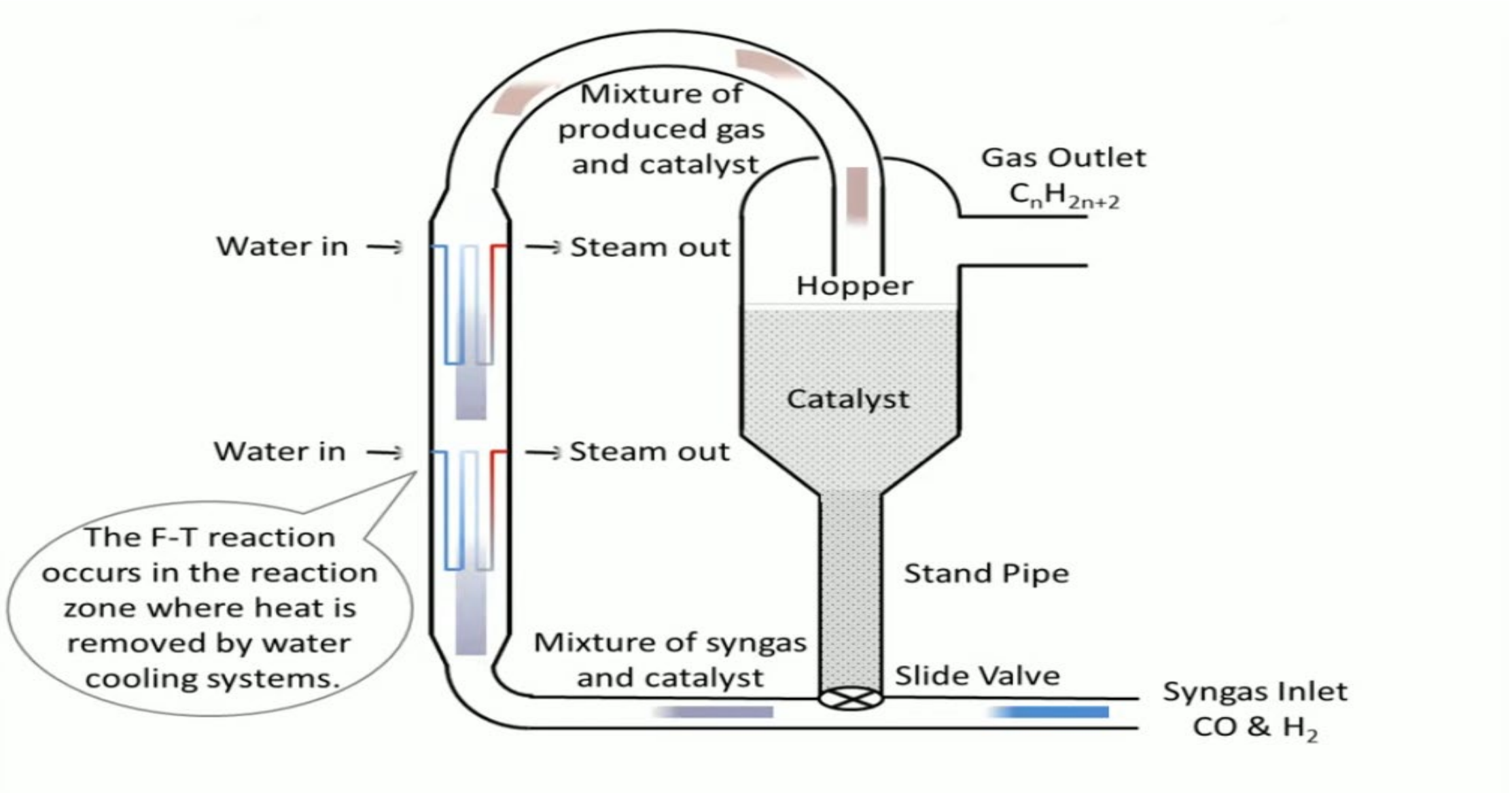
Multi tubular fixed-bed reactor



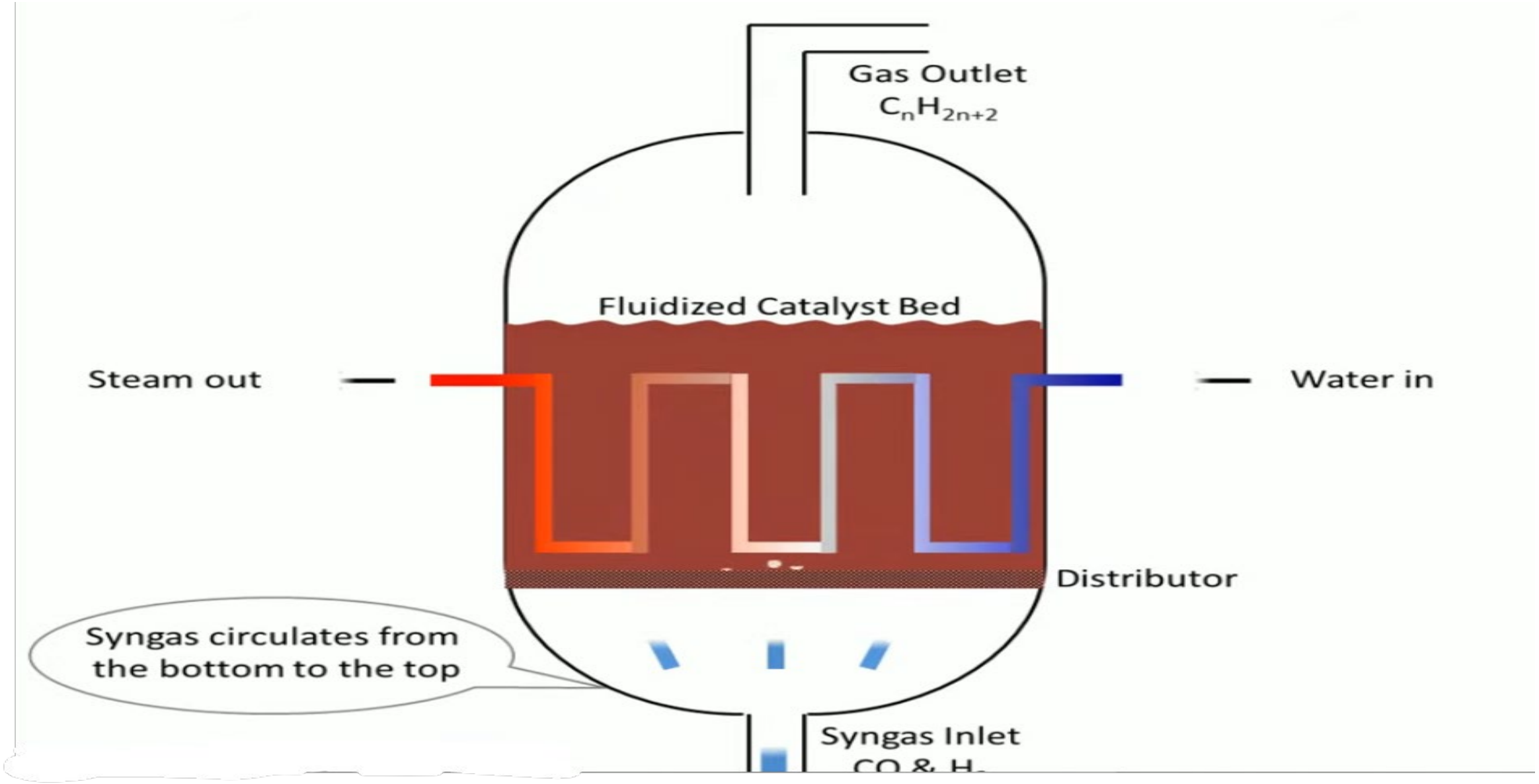
Fixed slurry bed



Circulating Fluidized Reactor



Fixed Fluidized Reactor



Catalysts

- Four metals are active as catalysts for the Fischer–Tropsch process: iron, cobalt, nickel, and ruthenium.
- Since FT process typically transforms inexpensive precursors into complex mixtures that require further refining, FT catalysts are based on inexpensive metals, especially iron and cobalt. Nickel generates too much methane, so it is not used.

However the catalytic process is a reliable technology, but it restricted by some barriers:

1. **Low catalyst selectivity,**
2. **Intensive operation cost due to the utilization of high temperature and pressurized reactors,**
3. **Wide distribution product,**
4. **Requiring a specific ratio of gas components to yield a desired product and the possibility of catalyst poisoning by the trace amount of sulfur gases presented in the syngas.**

Promoters and supports

- In addition to the active metal (usually Fe or Co), two other components comprise the catalyst: promoters and the catalyst support.
- **Promoters** are additives that enhance the behavior of the catalyst. For F-T catalysts, typical promoters including potassium and copper, which are usually added as salts. The choice of promoters depends on the primary metal, iron vs cobalt.
- Catalysts are supported on **high-surface-area binders/supports** such as silica, alumina, or zeolites.

References

Abubackar, H.N., Kennes, M.C.V., Christian, A., 2011. Biological conversion of carbon monoxide: rich syngas or waste gases to bioethanol Haris. Biofuels, Bioprod. Biorefining 6, 246–256. https://doi.org/10.1002/bbb

Abubackar, H.N., Veiga, M.C., Kennes, C., 2015. Ethanol and acetic acid production from carbon monoxide in a clostridium strain in batch and continuous gas-fed bioreactors. Int. J. Environ. Res. Public Health 12, 1029–1043. https://doi.org/10.3390/ijerph120101029

Acharya, B., Roy, P., Dutta, A., 2014. Review of syngas fermentation processes for bioethanol. Biofuels 5, 551–564. https://doi.org/10.1080/17597269.2014.1 002996

Mohammadi, M., Najafpour, G.D., Younesi, H., Lahijani, P., Hekarl, M., Rahman, A., 2011. Bioconversion of synthesis gas to second generation biofuels : A review 15, 4255–4273. https://doi.org/10.1016/j.rser.2011.07.124