Biomass to liquid fuels - BTL

Svatopluk Chytil[1], Anna Lind[1], Andreas H. Lillebø[2], Bjørn Christian Enger[2], Anders Holmen[2], Edd A. Blekkan[2]
[1]Department of Process Chemistry, Materials and Chemistry, SINTEF, N-7465 Trondheim, Norway
[2]Department of Chemical Engineering, The Norwegian University of Science and Technology (NTNU),N-7491 Trondheim, Norway

Introduction and objectives of the project

- **A promising way to produce 2nd generation biofuels** is through *biomass gasification* with subsequent production of liquid fuels via *Fischer-Tropsch synthesis (FTS)* (Fig. 1).
- The production of the biofuels is complicated by the composition of the gasification gas as the raw gas contains many impurities (H_2S, alkali metals, dust, tars) and undesirable/inert compounds (CH_4, CO_2) [1]. These components may cause failure of the process unit and/or negatively influence performance of catalysts used in the process [2]. Also, the H_2/CO ratio of the synthesis gas from biomass gasification is less suitable for FTS using conventional Co based catalysts.
- The main objectives of this fundamental research project are [3]:
  1. Conversion of undesirable components in the gasification gas followed by optimization of gas composition for FTS. (NTNU)
  2. Removal of synthesis gas impurities using high temperature sorbents. (SINTEF)
  3. Developing a modified FTS process, focusing on the differences between the existing (fossil fuel based) technologies and biomass based feed-stocks.

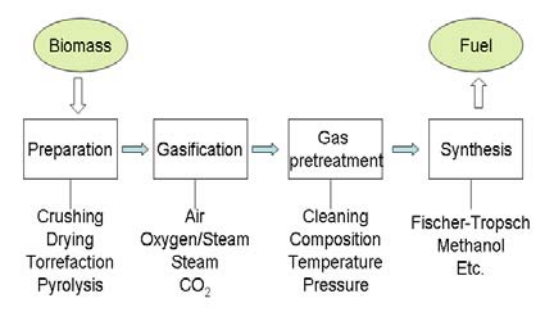

Fig. 1. A possible BTL concept (from [4]).

Experimental work

NTNU – Co based catalyst

- The main objective is to study FTS under conditions that are relevant for biomass derived syngas (CO/H_2), both in order to understand the effect of biomass impurities and to develop catalysts which are less affected by such.
- FTS catalyst testing is carried out by a careful modification of conventional Co based catalyst using alkali and alkali earth metals [5], transition metals or other impurity components such as sulphur.
- The prepared catalysts are characterised in order to better explain the catalytic behaviour. Properties such as surface area, pore volume, pore diameters, crystal structure, reducibility, degree of reduction and the number of H and CO sites, both *in situ* and *ex situ*, are particularly useful for this.

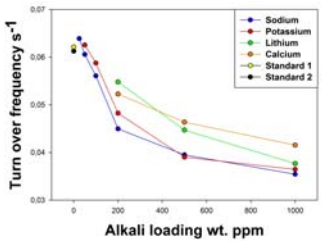

Fig. 2. Turn over frequency recorded at ~15 hour time on stream.
FTS Conditions: feed rate 250 NmL/min, 20 bar, 2,1 H_2/CO ratio, 210 °C.

- The lowering of catalytic activity upon addition of alkaline metals (Fig. 2) is proposed to be due to electronic effects, leading to decreased surface H concentrations and increased CO adsorption and dissociation.
  - Structural effects (site blocking) may also be assumed.

SINTEF – Removal of the impurities by sorption

- Initially, the main emphasis is placed on the adsorptive removal of H_2S from a model gasification gas.
- A series of Mn_xO_y-Al_2O_3 sorbents for H_2S removal have been prepared using:
  - Multiple wet impregnation
  - Spray drying
  - Two different Mn precursors
  - Impregnation on the agglomerated support
- The samples were thoroughly characterized by N_2 sorption, X-ray diffraction, Raman spectroscopy and temperature programmed reduction.
- The differences in terms of bulk, surface as well as textural properties were pointed out.
- It is expected that the variation in the sample properties will influence their sorption performance.
- Some of the samples have been tested as high temperature sorbents for H_2S removal from a dry gasification gas.
  - The samples have shown the ability to remove H_2S to a sufficient level.
  - Detailed testing of the samples to correlate the properties of the samples with the sorption performance is required.
  - The testing will be performed in a new set-up that is under construction.

Summary

- Impurities typically present in biomass derived synthesis gas lowering of catalytic activity, most likely through a combination of electronic and structural effects, which influences the concentrations of active surface intermediates during Fischer-Tropsch synthesis (FTS).
- This calls for sufficient cleaning of the synthesis gas prior its use in FTS, and/or for development of catalysts which can sustain good catalytic performance in the harsh environment that biomass derived synthesis gas represents.

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