Polycarbonate polyols from biogenic CO_2 - Feasibility assessment

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Carbon dioxide has recently been used as feedstock to produce high-performance polymers, such as flexible polyurethane foams[1]. So far, only approximately 20 % of the carbon in the feedstock polyols, used as building blocks for polyurethanes, has been from CO_2 while the rest is fossil-based. Due to large market volumes of these polymers, millions of tons of CO_2 could be utilized annually on a global scale.

VTT is developing a concept where polycarbonate polyols are produced from biogenic CO_2 and clean hydrogen. CO_2 captured from biogenic processes (bioenergy production, biogas production, biomass gasification, pulp mill processes), hydrogen obtained from water electrolysis or as a by-product from the industry are converted into olefinic hydrocarbons in a two-step process. First carbon monoxide is produced by a combination of reverse water-gas shift (rWGS) reaction and catalytic partial oxidation (CPOX). Then carbon monoxide and hydrogen are converted to hydrocarbons by Fischer-Tropsch synthesis using a proprietary Fe-based catalyst leading to a high yield (> 45 %) of light olefins. The produced light olefins (C2-C4) are further oxidized into epoxides using hydrogen peroxide and the obtained mixture of epoxides is co-polymerized with CO_2 and a starter polyol into polycarbonate polyols to applied for polyurethanes.

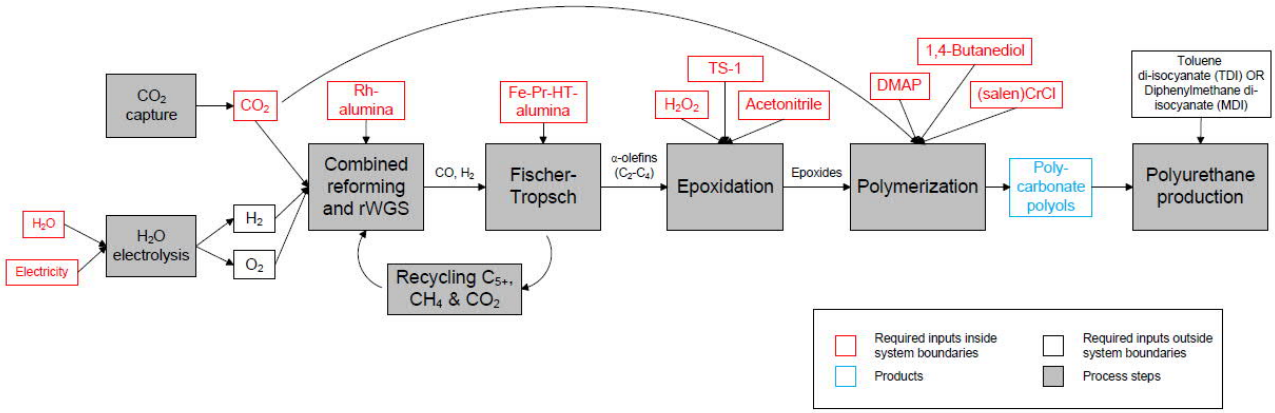

Figure 1. A simple flowchart of the BECCU process.

In the project, preliminary economic assessments for CO_2 capture and production of bio-CO_2 based polyols have been conducted. Carbon capture was experimented at small pilot-scale

with three absorption-based technologies by using various biogenic CO_2 sources. Based on the experimental data, techno-economic performance of the technologies were evaluated and compared to other promising carbon capture technologies reported in the litterature. Additionally, some CO_2 captured from the experiments was compressed, bottled and transported for further research in RWGS and Fischer-Tropsch synthesis experiments.

Our presentation will cover preliminary results from an on-going joint project BECCU with Finnish industry consortium. The BECCU (Figure 1) process has been simulated with Aspen Plus, and mass and energy balances are presented. Preliminary results for techno-economic evaluation including production costs of the main products are also presented. The economics of the concept was found to be very attractive with a short pay back time. Electricity needed for electrolysis and capital investment annuity were found to have the greatest effects on the production cost. Sensitivity analyses will be performed to assess the effect of the key variables. These variables include electricity price, CO_2 price, catalyst prices, product yield and capital investment.

[1] https://www.co2-dreams.covestro.com/en, accessed 30.01.2019