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Integrated CO_2 capture and conversion to formic acid/methanol via methyl formate

Aim

The aim of this project is to evaluate an integrated route for CO_2 capture and formic acid/methanol production via methyl formate.

Justification

Carbon Capture and Utilization (CCU) has been recognized as one of the most promising technologies for mitigating climate change due to its capacity for large-scale CO_2 reduction. The main challenge of these technologies is that a large amount of thermal energy must be provided to supply high-purity CO_2 and purify the product[1]. An approach to eliminate the CO_2-desorption cost is to integrate CO_2 capture and conversion (ICCU).

ICCU strategies have been proposed for the production of formic acid (FA)/formates, methanol (MeOH), urea, methyl formate (MeF), carbonates, syngas, and materials suitable for construction[2]. FA, MeOH, and MeF are particularly interesting molecules for the research conducted in our group. FA and MeOH can be used directly as fuels, are important feedstocks for the chemical industry, and became recently attractive energy carriers. MeF can also be used to produce several industrially important chemicals, and by a simple hydrolysis reaction can generate simultaneously FA and MeOH[3].

Both FA and MeOH production from CO_2 have been thoroughly investigated. CO_2 hydrogenation to FA is thermodynamically unfavourable in the gas phase. Often, FA is stabilized in the form of formate adducts by reaction with a base. The isolation of pure FA from the stabilizing reaction media is consequently one of the major challenges in process schemes for CO_2-based FA production[4]. Regarding CO_2 hydrogenation to MeOH, the challenge relies on equilibrium limitations at high reaction temperatures and pressures, and the limited availability of catalysts capable of efficiently catalyzing the reaction under mild conditions[5]. A route for the production of FA and/or MeOH from CO_2 via MeF could be an alternative to sidestep these challenges.

In this project, an ICCU strategy for the integrated capture and conversion of CO_2 to MeF will be evaluated, as well as the potential for FA/MeOH production from the generated MeF (Figure 1). The CO_2 needed to produce MeF will be absorbed by MeOH. Then, the mixture of CO_2 and MeOH, together with H_2 will be used to synthesize MeF. The possibility to hydrolyse the purified MeF to FA or further hydrogenation to MeOH will be investigated.

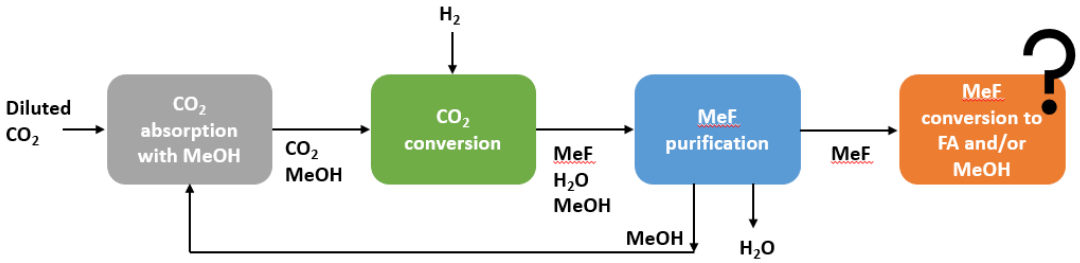

Figure 1. Integrated CO_2 capture and conversion to FA/MeOH via MeF process scheme.

Program

1. Literature study on the main steps of the process.
2. Selection of the unit operations and the models to use.
3. Process modeling using ASPEN.

References

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