Carbon Dioxide Valorization Using Liquid Phase Catalysis

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Excess greenhouse gases emissions are leading to climate change and global warming. Among them increasing atmospheric CO_2 level the main cause of concern. Therefore, there is an urgent need to find net zero carbon chemicals and fuels. Here we show our recent innovations in liquid phase catalytic approaches to produce bulk chemicals like formaldehyde and its derivatives. Liquid phase catalysis offers many advantages over gas phase conversion, such as lower temperatures, controlled selective conversion towards desired products and cascade reactions which shift the equilibrium of the reaction to achieve high conversion. In this context, Oxymethylene dimethyl ether (OME) or oligomeric oxymethylene dimethyl ethers (OME_n) production has become the hot research topic in these days due to its versatile fuel properties. It can be either used as direct fuel or fuel additive in diesel combustion engines because it shows high cetane number, excellent intermiscibility, less soot formation and NO_x reduction during combustion. Conventionally, OME_1 is produced from the partial oxidation of methanol in the presence of acidic catalysts. Literature also reported the OME_1 production from CO_2 hydrogenation in methanol over homogeneous catalysts and acid co-catalysts. However, OME_1 production from syngas is a viable green route but it remains challenging due to susceptibility of further aldehyde group transformation. In the light of this fact, OME_1 production from heterogeneous catalytic liquid phase CO hydrogenation is still suffering from the immaturity level.

In present study, BEA supported monometallic (Ni, Cu & Ru) and bimetallic (Ru-Ni & Ru-Cu) catalysts were synthesized and characterized for successful production of OME_1 from heterogeneous catalytic methanol mediated CO hydrogenation. For this purpose, OME_1 experiments were performed in 100 mL slurry batch reactors at various temperatures, H_2/CO molar ratio 2, 50 mL methanol and 100 RPM stirring speed under 75 barg. Experimentally, Ni-Ru and Cu-Ru provided the highest OME_1 Yield of 5.11 and 5.34 mmol/g_{cat}.L_{MeOH}, respectively.