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Coach	**Supervisor(s)**	**Funding**
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Designing highly selective Au-ZnO/Al$_2$O$_3$ methanol synthesis catalysts

Aim

Studying the effect of gold, its particle size and distribution, and Au-Zn interfacial sites on the catalytic performance of Au-ZnO/Al$_2$O$_3$ upon CO$_2$ hydrogenation to methanol.

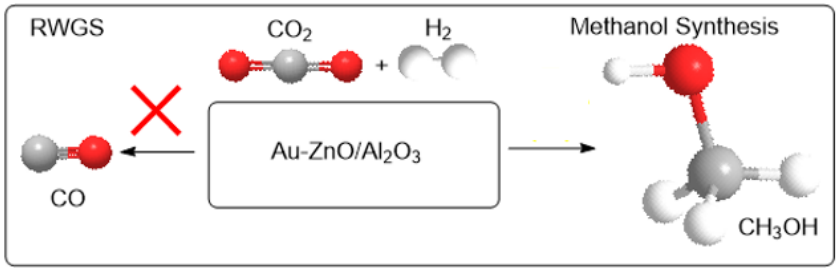
Justification

Catalytic reduction of CO$_2$ with H$_2$ to methanol serves multiple purposes including: (i) storing high energy density H$_2$ in chemical molecules, (ii) converting CO$_2$ to valuable chemicals in line with the proposed "methanol economy" and "liquid sunshine" technologies, and (iii) decarbonizing the chemical industry, where 50% of the industrial CO$_2$ emissions in Flanders come from. That is why North-C-Methanol is investing 140 million euros to reduce CO$_2$ emissions by 140,000 tonnes annually and to produce 44,000 tonnes of green methanol as feedstock for local industry and as fuel for ships and trains.

To date, significant efforts have been made on designing an efficient catalyst to convert CO$_2$ to methanol. One of the major drawbacks of the current commercial Cu/ZnO/Al$_2$O$_3$ catalyst is the formation of CO as a by-product due to the competing reverse water gas shift (RWGS) reaction. Cu is an active RWGS catalyst and substitution of Cu with another metal can be an effective approach to enhance methanol selectivity.

The gold nano-catalysts have shown capability in various chemo-selective hydrogenation reactions. Thus they would be able to do CO$_2$ transformation to formate (an intermediate species) by facilitating the activation of carbon dioxide and hydrogen.

The objective of this master thesis will be studying the effect of substituting Au with Cu in Cu-ZnO/Al$_2$O$_3$ during CO$_2$ hydrogenation to methanol. The crucial step will be optimizing the Au particle size and reduction condition to increase the Au-ZnO interfacial sites. Different synthesis approaches such as co/precipitation, impregnation, and grafting will be used to synthesize the Au-ZnO/Al$_2$O$_3$. Then, detailed kinetics of the CO$_2$ hydrogenation will be investigated to get insight into the effect of the Au, its particle size, and the Au-Zn interfacial sites. Characterization of the Au-ZnO/Al$_2$O$_3$ will be done to correlate the catalyst properties with its performance. The outcome of this study will be relevant for further research on the development of an industrially highly selective catalyst for CO$_2$ hydrogenation to methanol.



Program

1. Literature study: Studying catalytic methanol synthesis state-of-the-art.
2. Synthesis of supported Au catalyst.
3. Kinetic study of the catalytic CO$_2$ hydrogenation over synthesized catalysts.
4. Characterization of the developed catalysts.
5. Uncovering the effect of metal particle size and alloy formation on the selective methanol synthesis.

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