Research project and supervisory team

Supervisory Team	Xiaolei Fan Xiaoxia Ou
Short introduction & description of research project	*Hydrogen (H_2) energy is a clean energy for developing the sustainable society towards the Net Zero, yet the current H_2 production routes are not sustainable, viz. almost 50% H_2 production is based on steam reforming reactions employing natural gas and/or light hydrocarbons, and the use of fossil resources is unsustainable and associated with significant emissions of greenhouse gases. Ethanol is an established renewable platform since its production via biomass (such as corn grains and sugarcane) fermentation is the currently major route and economical. Hence, in steam reforming replacement of fossil resources with ethanol, i.e., steam reforming of ethanol (SRE) is one of the promising methods for producing sustainable H_2.* ***Project 1: CO_2 hydrogenation to methane and methanol*** *Methane (CH_4) and methanol (CH_3OH) are key fuels and platform chemicals for many important applications. They are conventionally obtained from fossil resources such as natural gas and coal. Hence, the use of the captured CO_2 as the carbon source can be a sustainable option to produce green CH_4 and CH_3OH for sustainable development of the society. Built on our previous research findings, this project will focus on the further development of economic catalysts based on transition metals such as Ni for methanation and Cu for hydrogenation to green methanol, which will be supported by relevant in situ and kinetic studies to gain mechanistic insights of the systems for pilot test and scaling up.* ***Project 2: Steam reforming of ethanol for bio-hydrogen production*** *Steam reforming reactions are normally performed in the temperature range from 200 to 650 °C, and hence catalyst deactivation at high temperatures is a challenging aspect to be addressed. Regarding the Ni-based reforming catalysts, the preparation of highly dispersed yet stable supported Ni phases could be achieved by (i) metal phase engineering such as second metal doping to disperse Ni, (ii) metal-support engineering such as confinement and (iii) process intensification (such as the use of structured supports)* *This project will seek rational design of novel reforming catalysts with significantly improved activity and stability and novel intensified processes for SRE. In addition, based on the experimental results, process simulation and techno economic assessment (TEA) which will be addressed by this project.*
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Short introduction & description of research project	*CO_2 as one of the main emissions which impose significant impact on human society such as climate change. To answer the call of China carbon neutrality in 2060, this project aims to convert the captured CO_2 from various sources (such as power plant and steel industry) to green platform chemicals such as syngas (via reforming reactions such as). This will be achieved by thermal and/or plasma catalysis, and will take the rational approach for catalyst design which involves the mechanistic study of the activity of different metallic catalysts such as Ni for dry reforming. Also, process intensification of reforming processes (via such as using fluidised bed and/or plasma activation) will be researched to alleviate the catalyst deactivation issues using fluidised bed.* ***Project: Dry reforming of methane with CO_2 for syngas production*** *Syngas (i.e., $CO+H_2$) is the essential feedstock to produce many value-added oxygenated chemicals and long-chain hydrocarbons via Fischer-Tropsch reactions. Again, the use of the captured CO_2 as the feedstock, together with CH_4, can help the shift the current reliance on fossil resources to more sustainable sources such as carbon waste and biogas, hence leading to the production of green chemicals via green syngas. However, the system involves significant carbon sources, which leads to substantial carbon deposition (coking), causing catalyst deactivation and pressure build-up. Also, the system requires high temperatures to activate the stable CO_2/CH_4, which lead to metal sintering and catalyst deactivation. Hence, rational design of novel reforming catalysts with significantly improved activity and stability and novel intensified processes are needed, which will be addressed by this project.*
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