Einblicke in die Forschungsarbeit

MASTER THESIS

“Integration of greenhouse gases in chemical processes”

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Elite Graduate Program “Advanced Materials and Processes”

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Integration of greenhouse gases in chemical processes

Ana de Oliveira has studied in the Elite Master's Programme "Advanced Materials and Processes" (MAP) at Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU). She graduated in August 2020 after concluding her Master's Thesis at the Chair of Chemical Reaction Engineering (CRT) under the supervision of Dr. Moritz Wolf and Prof. Dr. Peter Wasserscheid. Her research focused on the process of dry reforming of methane (DRM), which incorporates two major greenhouse gases (GHGs), namely methane (CH4) and carbon dioxide (CO2), into the production of valuable synthesis gas.

A new catalyst concept

Numerous studies indicate that CH_4 and CO_2 concentrations in the atmosphere have extensively increased since pre-industrial times, mainly due to anthropogenic emissions. Thus, shifting from unsustainable exploitation of fossil fuels to renewable resources is inevitable. To mitigate the anthropologic carbon footprint on the earth, different strategies that favour sustainability are being used in the energy and chemical sectors. Synthesis gas (or syngas) comprises a mixture of carbon monoxide (CO) and hydrogen (H_2) that holds a great market value for the chemical industry, being essential base products for a multitude of fuels, fine chemicals and polymers. Syngas can be obtained from various carbon sources via reforming reactions using CH_4 with an oxidant. Within the scope of carbon capture and utilisation, DRM may employ CO_2 as the oxidising agent, being an attractive alternative to combine the valorisation of GHGs and the generation of syngas. Nevertheless, a breakthrough of DRM on an industrial scale has not yet been achieved. Strong catalyst deactivation by coke deposition due to the carbon-rich feed and particle sintering driven by the high operating temperatures of 700-1000 °C remain unsolved challenges. Thus, the recent advances in catalyst research for DRM mostly focus on concepts to boost stability and long-term performance. Supported liquid phase (SLP) catalysis merges advantages from classical heterogeneous and homogeneous catalysis, such as easy handling of the catalyst and well-defined active sites, respectively. Recently, a group of researchers at FAU introduced a new class of SLP catalysts, namely supported catalytically active liquid metal solutions (SCALMS), which comprises supported droplets of a liquid alloy consisting of a catalytically active metal dissolved in an excess of a low melting point metal, such as Ga. Previous research confirmed that the application of SCALMS materials in the dehydrogenation of propane suppressed carbon deposition and led to higher mass productivity in comparison to conventional heterogeneous catalysts.

In her work, Ana de Oliveira reported the first successful application of SCALMS in a high-temperature process. The catalytic performance of Ga-rich SCALMS using mesoporous SiC as carrier material during DRM at 900 °C were evaluated. Among the different active metals that were tested, Ga-Ni/SiC SCALMS displayed excellent stability and led to considerable suppression of coking.

German Catalysis Meeting

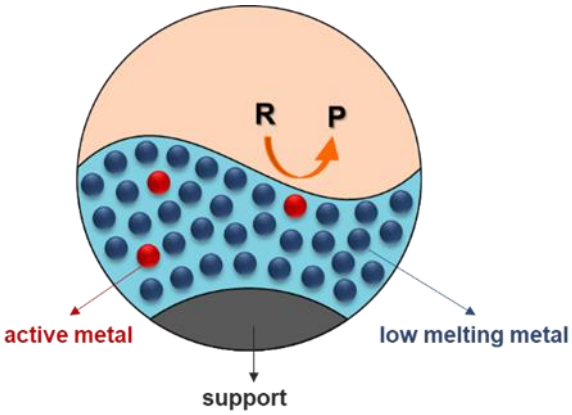
Ana de Oliveira presented her research through a poster entitled "Dry reforming of methane over Supported Catalytically Active Liquid Metal Solutions" during the annual German Catalysis Society Meeting (54. Jahrestreffen Deutscher Katalytiker) in March 2021. This four-day conference has been established as one of the most important catalysis events in Europe, covering topics ranging from fundamentals of catalysis to industrial applications. This year meeting was held online but still offered the chance for young scientists and research experts to discuss state-of-the-art catalysis and broaden their professional network during lectures and

discussions. All posters were uploaded into the event's online platform and were available during the whole event, allowing the attendees to skim through each of them and even get in touch with the author via Zoom.

The YounGeCatS, which is a German networking group of young scientists in the field of catalysis, organised five virtual poster sessions, where five attendees' posters were selected to be presented in each of them. Ana de Oliveira received the best poster prize in the category "Towards a circular economy: How catalysts can make a difference". The prize consisted of the book "Catalysis: Concepts and Green Applications" by Dr. Gadi Rothenberg.

Further Career Path

In October 2020, Ana de Oliveira started her PhD in the team Efficient Hydrogen Release of Dr. Moritz Wolf in the Chemical Hydrogen Storage research department from Prof. Dr. Peter Wasserscheid at the Helmholtz Institute Erlangen-Nürnberg for Renewable Energy (HI ERN). Her work focuses on catalyst development for low-temperature dehydrogenation of liquid organic hydrogen carriers (LOHC). LOHCs provide a safe and easily manageable method to store and transport H_2 to filling stations contributing to further develop the H_2 storage technology for sustainable and CO_2-neutral energy.



Schematic representation of a SCALMS system, showing the active metal dissolved in a matrix of a low melting point metal cast on a porous support. "R" represents the reactants and "P" the products of a reaction

© A. L. de Oliveira, "Dry Reforming of Methane over Supported Catalytically Active Liquid Metal Solutions (SCALMS) Effect of Carrier Material and Active Metal on the Catalytic Performance," University of Erlangen-Nuremberg (Friedrich-Alexander-Universität Erlangen-Nürnberg), 2020

More on the Elite Graduate Program:

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