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Designing a pH-based Deposition Protocol for Colloidal Ni Nanoparticles on $MgAl_2O_4$

Aim

Develop a pH-assisted technique to enhance the deposition of colloidal Ni nanoparticles (NPs) on a $MgAl_2O_4$ support, and apply the Ni/$MgAl_2O_4$ materials in CO_2 utilization reactions.

Justification

Supported Ni NPs are viable catalysts for a variety of CO_2 utilization reaction, e.g. methane dry reforming and CO_2 methanation. While reaction studies of such Ni catalysts are abundant, fundamental knowledge on their structure-property relationships is still lacking. It is primordial to unambiguously establish relationships between the catalyst's structural parameters and its performance, as this forms the basis for a knowledge-driven catalyst design. At the fundaments of such an approach lie model catalysts prepared by synthesis strategies that allow independent control over the structural parameters.
The use of colloidal NPs is one such strategy that allows achieving the desired level of control. However, a bottleneck herein is the deposition of the NPs onto the support, as conventional impregnation of the colloid on the support usually yields very low metal loadings (~1 wt%), which proves troublesome for certain applications. This problem may be overcome through the use of electrostatic interactions between the NPs and the support, made possible by tuning the pH of the colloid-support mixture.

In this project, building on the LCT's in-house expertise of Ni/$MgAl_2O_4$ materials for CO_2 utilization, a pH-based deposition protocol will be developed for Ni colloids on $MgAl_2O_4$.

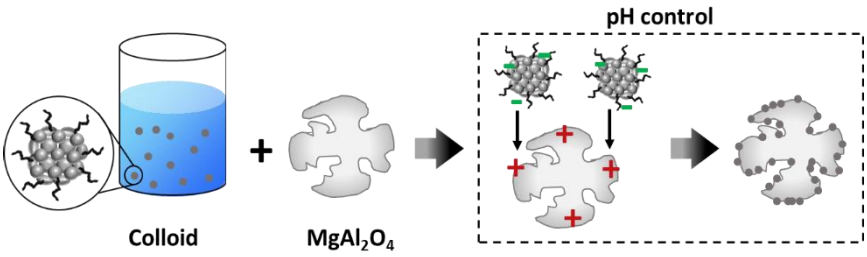

Figure 1. Schematic representation of the pH-induced deposition of colloidal Ni NPs on $MgAl_2O_4$.

Program

1. Literature survey on Ni materials for CO_2 utilization, colloidal (Ni) NP synthesis and pH-based colloidal deposition protocols.
2. Synthesis of Ni colloids and $MgAl_2O_4$; pH tests to assess electrostatic deposition conditions.
3. Material characterization: S(T)EM(-EDX), BET, TPR, TPO, XRD, TGA …
4. Performance testing for CO_2 utilization (methane dry reforming, water-gas shift reaction).