Master or Bachelor Thesis

Carbon Nitride-based Materials for the Thermocatalytic Conversion of CO₂

Motivation
Within the scope of this research project, the use of active transition metal nanoparticles on graphitic carbon nitride (C₃N₄) as a support material is being investigated. In the literature, C₃N₄ is primarily used as a photocatalyst and in electrocatalysis. It has a large band gap and can activate various molecules, including carbon dioxide. These nitrides possess special physicochemical properties that make them also useful as support materials in thermocatalysis. They can activate reactants and exert synergistic effects on the nanoparticles. Preliminary results indicate that the reduction of cobalt oxide nanoparticles to metallic cobalt on C₃N₄ is inhibited compared to other support materials.

Scientific Proposal
The first step of the planned project involves the synthesis of metal oxide nanoparticles with different morphologies and sizes. The active metal oxides are generally deposited onto the nitride support material using classical methods for the preparation of heterogeneous catalysts, such as impregnation. The production of well-defined nanoparticles is important because potential effects of the nitrides on the nanoparticles are expected to be size-dependent. This means that smaller particles are more strongly influenced by the physicochemical and electronic properties of the support material than larger ones.

As mentioned earlier, preliminary results strongly suggest that the reduction of cobalt(II,III) oxide (Co₃O₄) nanoparticles on carbon nitride is inhibited, thereby stabilizing the oxide phase even under the H₂-rich conditions. On the other hand, the high potential for efficient CO₂ activation via carbon nitride may provide multiple additional conversion pathways for CO₂ valorization. Therefore, hydrogenation reactions of CO₂ to methane or short-chain hydrocarbons are of great interest.

What I can offer
- I foster a strong mentorship bond with my students, ensuring regular meetings upon their request.
- I am readily accessible to provide assistance with any challenges they may encounter.
- I encourage my students to actively participate in shaping the final project by allowing them the freedom to contribute their own ideas.
- I believe in maintaining a balance where the thesis remains a reflection of their work rather than my own, which is why I prefer to act as their advisor without excessive interference.

What should you bring to the job
- Enjoying the process of exploring and acquiring new knowledge.
- Effective communication skills.
- Working with a clear focus on achieving goals
- Familiarity with proper laboratory practices and a sensible approach to handling chemicals.

Your tasks
- Synthesis of various nanoparticles with regard to size and/or shape.
- Careful characterization of the synthesized materials and catalysts.
- Characterization of model catalysts during activation.
- Investigation of the catalytic performance of selected samples in laboratory reactors with thorough analysis of the spent catalysts after application.

Start time: now
Type of work: Experimental & Analytical
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