Additive Manufacturing Meets Reaction Engineering – Novel Raney® Copper Catalyst Structures for Methanol Synthesis

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Abstract

In the current work, we present a new, interdisciplinary approach between reaction engineering and additive manufacturing to produce a structured Raney copper catalyst. Currently, structured catalysts are being developed by coating a carrier structure with the catalytically active species. This procedure involves several process steps, like multiple coating, impregnation, calcination, and catalytic activation. With our new top-down approach, periodic open cellular structures (POCS) will be additively manufactured by selective electron beam melting from a commercial CuAl alloy. The catalyst structure is activated by the principal of Raney®, where part of the aluminum is leached out with sodium hydroxide. For maintaining high stability, just the external surface is activated by alkali leaching, whereas the unreacted CuAl core will improve the heat-transfer of the catalyst structure (s. Figure 1). Our new innovative catalyst structures are interesting for exothermic gas-phase reactions (e.g. methanol synthesis) due to their physical properties. The catalytically active nanoporous copper layer contacts the remaining CuAl core directly. Therefore the heat of reaction can be optimally dissipated. In our work, we will investigate the leaching of additive produced simple rods, which correspond to the dimensions of the strut size of typical POCS. We want to find out optimal leaching conditions for highly active and stable Raney-Cu rods. The leaching reaction is investigated by measuring the Al concentration in the solution. Moreover, we will measure the active copper surface area with N_2O decomposition. CT measurements will examine the thickness of the nanoporous layer. Catalytic tests for methanol synthesis of simple additive manufactured Raney Cu cylinders show promising results. Based on the knowledge gained in the leaching study, complex catalyst structures will also be activated and tested in the CO hydrogenation to methanol.

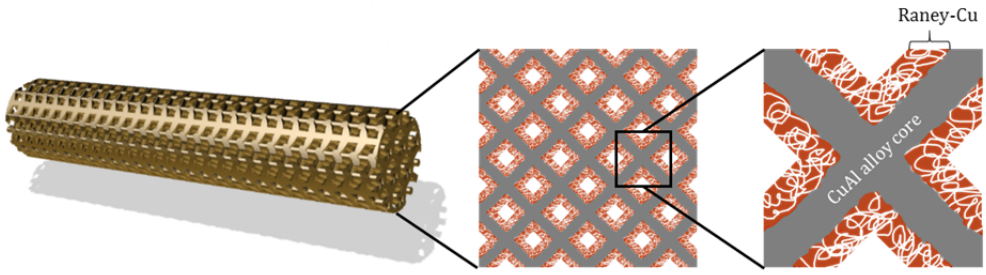

Figure 1:Schematic concept of additive manufactured Raney Copper catalyst structures