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ABSTRACT:

Development of 3D Printed Catalytic Beds to Enhance Hydrogen-Based Technologies (Ammonia Synthesis and Decomposition)

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The Additive Manufacturing (AM) process involves successively depositing layers of material to create a 3D object. By utilizing AM, structured catalysts and reactors can be designed with locally tuned geometries and controlled porosity, which can be highly effective for chemical reactions. Flexibility in design and manufacturing is also a key advantage of AM. Due to these characteristics, several industrial and research fields consider AM an ideal alternative to traditional manufacturing techniques. One of the promising chemical compounds referred to as H2 carriers in the concept of "hydrogen economy" is ammonia; this fact has led to a great deal of interest in catalysts that facilitate the production of ammonia from N2 and H2 and the decomposition of ammonia into free-carbon H2. In particular, the present work deals with the design, manufacturing, characterization, catalytic activation (by dip/spin coating method) and performances evaluation (toward NH3 synthesis and decomposition) of Periodical Cellular Structures (POCS) and Triply Periodic Minimal Surface (TPMS) microarchitectures, 3D-printed in Ni-alloys with various structural parameters (porosity, Specific Surface Area, cell type and strut/sheet dimensions). The influence of different coating parameters (thermal pre-treatment of support, primer utilization, etc..), slurry components (catalytic powders, binders, dispersant) to deposit thin active layers onto 3D printed structured supports was experimentally assessed. Overall, a washcoat homogeneity was observed for all the samples prepared associated to the absence of uncoated areas and a high mechanical stability. Moreover, the structured catalysts, characterized by interconnected struts/sheet and high SSA demonstrated efficient gas diffusion pathway enhancing the catalytic activity toward ammonia synthesis and decomposition.

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