Magnetic Induction in Catalysis: Toward Adaptive Catalytic Systems for Challenging Hydrogenation and Hydrodeoxygenation Reactions

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Abstract

The decarbonization of the electricity sector defines challenges, but also major opportunities for the electrification of the chemical industry toward the defossilization of the chemical value chain. Various strategies are explored for the electrification of chemical processes (e.g. direct electrical heating, green hydrogen heating, electrochemistry, plasma activation, etc.), with requirements of high energy efficiency and compatibility with the intermittency of renewable electricity. Electrification is especially desired for the production of process heat, which so far relies mainly on fossil fuel.
In this context, magnetic induction heating is particularly attractive owing to its superior energy efficiency as compared to other direct heating methods. For catalytic processes, the contactless and selective heating provided by magnetic induction is of potential tremendous interest to heat catalysts directly in a localized and extremely rapid manner.[1]
Here, we present design strategies for the preparation of catalytic systems intended for magnetic induction catalysis. The prepared multifunctional catalysts are characterized and applied for synthetically relevant hydrogenation and hydrodeoxygenation reactions (e.g. of aldehydes, ketones, amides) using molecular hydrogen (H_2).[2-4] Iron carbide nanoparticles (ICNPs)[5] with excellent magnetic properties are used as heating agents to activate catalytic sites located at their surface or in their vicinity. The magnetically-induced very intense and localized energy transfer from ICNPs to catalytic sites enables excellent catalytic performances at strikingly mild conditions, and unlocks adaptivity to intermittent electricity supply. This work demonstrates the broad potential of the emerging field of magnetic induction catalysis, and highlights some of the key scientific questions on the way toward further development and widespread application of this technology.

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