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Hydrogenation of alkenes at low H_2 concentrations using photocatalytic sources

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ABSTRACT

Hydrogenations typically occur at high-pressures to increase the low solubility of hydrogen gas (H_2) in the organic solvent allowing H_2 to interact directly, in suitable quantities, with the metal catalyst surface in solution. This interaction occurs via the Horiuti−Polanyi mechanism[1] where the H_2 dissociates on to the surface, the alkene substrate binds to the metal, and the hydrogen atoms transfer to the substrate resulting in the alkane product. Given that the rate determining step in this mechanism is the final step, then from an experimental point of view, all you need to do is supply enough H_2 to replace any hydrogen atoms that have been used in the hydrogenation catalysis. This opens up the possibility of using low-concentration H_2 sources in hydrogenation catalysis. Photocatalytic water splitting using metal oxide semiconductors results in the generation of hydrogen and oxygen gases via water reduction and oxidation reactions.[2] If you use a suitable sacrifical agent such as methanol in such a system, then this stops the oxidation reaction and you end up with a low-concentration photocatalytic H_2 source which could be utilised further. Here, we introduce a novel dual-catalysis reactor design that integrates a photocatalytic hydrogen source with a hydrogenation reactor. This setup enables complete conversion of both activated and unactivated alkenes to their corresponding alkanes using exceptionally low hydrogen concentrations at atmospheric pressure.

1. Mattson, B.; Foster, W.; Greimann, J.; Hoette, T.; Le, N.; Mirich, A.; Wankum, S., J. Chem. Edu., 2013, 90, 613
2. Higashi, T.; Domen, K., ChemSusChem 2024, e202400663,

KEY WORDS

Photocatalysis, Hydrogenation, Reactor Design

BIOGRAPHY

I am currently working on a PETRONAS-funded project at the University of Adelaide, designing and building reactor systems to investigate bespoke photocatalytic materials for use in H_2 production and hydrogenation. Before that, I was a senior lecturer in inorganic chemistry at the University of Brighton from 2014 to 2023, a postdoctoral research fellow at Monash University from 2008 to 2013, and undertook my PhD in inorganic chemistry at the University of Edinburgh from 2005 to 2008.

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