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Chemists at FAU successfully demonstrate imine hydrogenation with inexpensive main group metal

In future, inexpensive and bio-compatible main group metals could replace expensive and toxic transition metals during catalytic processes. Chemists at Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) have now demonstrated that imine hydrogenation is possible using calcium instead of precious metals. Catalytic conversion of imines to amines is an important process in producing fine chemicals, especially in the pharmaceutical industry. The results have now been published in the journal 'Nature Catalysis' (DOI: 0.1038/s41929-017-0006-0).

Platinum has been used for over two hundred years as a catalyst for inert materials. It is an excellent catalyst, as it can split molecules of hydrogen, oxygen and other gases into single atoms. Today, for example, platinum is used as an oxidation catalyst in vehicles, for manufacturing nitric acid and for treating cancer. However, platinum has serious disadvantages. In terms of its molecular mass, this precious metal is almost twice as expensive as gold, there are only a few deposits on Earth, and platinum salts can be highly toxic as they can accumulate in DNA strands. Researchers all over the world are therefore looking for cost-effective and safe alternatives to catalytic converters made of so-called transition metals that include palladium, rhodium and iridium as well as platinum.

Promising: Catalysis with calcium

Chemists at FAU have now come significantly closer to achieving this. In their experiments, they demonstrated that imine hydrogenation is also possible with calcium instead of precious metals using comparably low technical outlay and surprisingly low pressures of up to one bar. Imines are organic carbon-nitrogen compounds that are converted to amines by catalytic adsorption of hydrogen atoms, a process that is important for the pharmaceutical industry in particular. 'We were really surprised at how well imine hydrogenation works with calcium,' says Prof. Dr. Sjoerd Harder, Chair of Inorganic and Organometallic Chemistry. 'Calcium is obviously a much better catalyst than we had previously thought'.

Cost-effective, bio-compatible and atom-efficient

Like magnesium, calcium is one of the so-called alkaline earth metals. As these early main group metals are available all over the world and are easy to extract, they are very inexpensive and their price stays stable. In terms of its molecular mass, calcium is 5000 times cheaper than platinum and even 11000 times cheaper than rhodium. And, in contrast to transition metals, calcium has a particularly high bio-compatibility. 'Calcium is completely harmless,' says Sjoerd Harder. 'It can be found in many organisms, in humans, for example, in bones and teeth.' In addition, the imine hydrogenation process with calcium catalysts that Harder describes is one hundred percent atom-efficient, as it does not generate any by-products.

Paradigm shift in organometallic chemistry

The researchers' findings could result in a paradigm shift in organometallic catalysis. Sjoerd Harder and his departmental staff have dedicated themselves to researching the full application potential of alkaline earth metals in complex catalysis processes and successively replacing established transition metals in these processes. The research findings have been published under the title 'Imine hydrogenation with simple alkaline earth metal catalysts' in the journal 'Nature Catalysis', which is part of the renowned 'Nature' group.

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