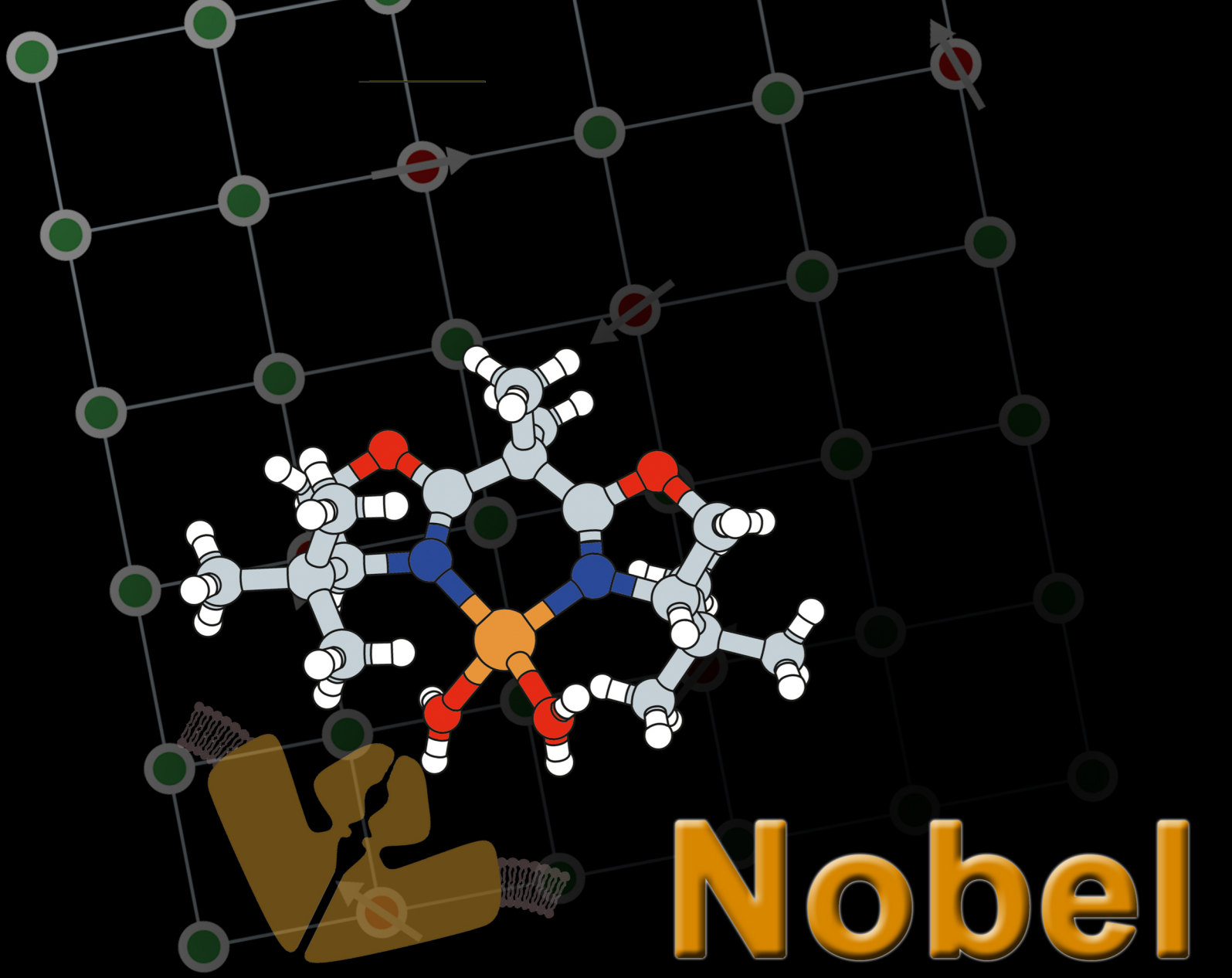


Towards making chemistry greener

Sk. Musharaf Ali

The ultimate dream of a chemist is to create a new molecule by linking together small chemical building blocks via chemical reaction through fewer steps with high yield and zero waste generation in faster and reasonably cheap route. To accomplish this, catalysts, which can breakdown molecule or join them together are often used. These substances that control and accelerate chemical reaction were earlier considered to be of two types: metal and enzymes. The metal to act as a catalyst should be free of oxygen and moisture, which is difficult to achieve in large scale. Moreover, metals are harmful to the environment. Enzyme, which build complicated molecules with amazing precision in living body usually can't be synthesized in the lab and needs to be isolated from biological sources. Since enzymes mostly get inactivated by heat and solvents, their in-vivo performance efficacy is much higher than in in-vitro condition.

These drawbacks lead to the discovery of third type catalysis, namely asymmetric organocatalysis. Benjamin List and David MacMillan are awarded the Nobel Prize in Chemistry 2021 for their development of a precise new tool for molecular construction: organocatalysis. This will have a great impact on pharmaceutical research, and will make chemistry greener.

In catalysis, there is an emphasis on not only making reactions faster, but also doing asymmetric or enantioselective reactions – those that produce only one mirror image (enantiomer) of handed molecules. As certain biological molecules – amino acids and sugars –only occur as single enantiomers, our bodies have an inherent ability to distinguish between enantiomers. This means the same molecule can smell of orange or lemon depending on its handedness.

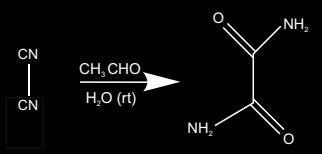
Prize 2021

S-limonene molecule has lemon scent, while its mirror image (R-limonene) smell like orange.

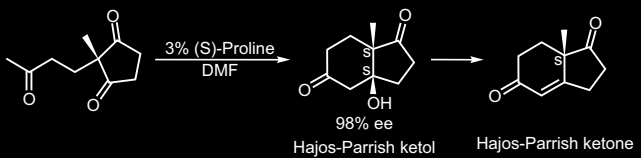
Liebig's synthesis of oxamide as the first organocatalysis reaction.

Asymmetric organocatalysts have been around for centuries, with an early example coming from Justus Liebig, who in 1860 reported that acetaldehyde catalyses cyanogen hydrolysis. Over the period of the 20th century, there were some reports of organic molecules acting as asymmetric catalysts (with varying success). But nobody thought of developing a comprehensive methodology or understanding how they work.

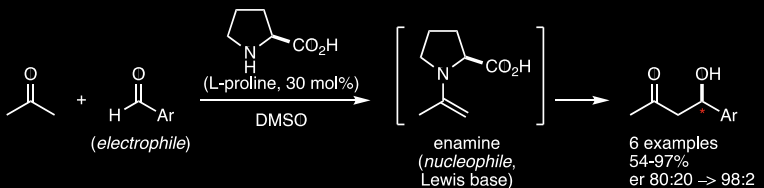
The Hajos–Parrish–Eder–Sauer–Wiechert reaction discovered in the 1970s was an example of asymmetric organocatalysis but didn't gain much attraction– possibly because the mechanism remained mysterious at the time.



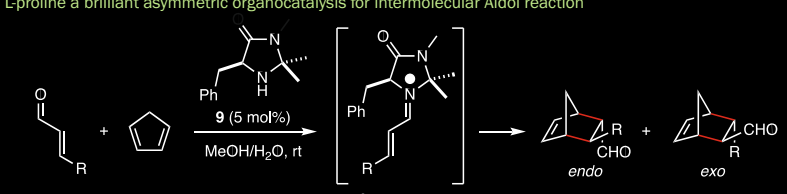
Liebig's synthesis of oxamide as the first organocatalysis reaction



The Hajos–Parrish–Eder–Sauer–Wiechert reaction



L-proline a brilliant asymmetric organocatalysis for intermolecular Aldol reaction



L-phenylalanine works as an asymmetric organocatalysis in Diels-Alder reaction