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The role of catalysis in Circular Economy is relevant, since, for instance, catalysis can solve the problem of waste (biogenic, fossil, municipal, industrial, etc.) by targeting either the recycling of high value building blocks or the degradation and rebuilding of molecules of interest.
Homogeneous catalysis largely contributes to the circular economy through two main aspects. Within homogeneous catalysts, the catalytic activity is due to a transition metal centre. This material can be recycled indefinitely, with limited loss. Regardless of whether the catalyst is palladium, rhodium, iridium, ruthenium or platinum-based, after it has undergone its reaction process, the used catalyst can be collected and sent to a recycling specialist. Generally, the catalyst manufacturer is able to recover the contained metal and produce a new catalyst; as is the case for Umicore.
The second aspect of homogeneous catalysis' contribution to the circular economy is its high selectivity and activity. Through these factors, homogeneous catalysts can contribute by reducing the generation of waste in chemical synthesis. A good example of this can be seen in olefin metathesis. These catalysts facilitate more efficient syntheses of large membered rings in pharmaceuticals processes. Additionally, they enable the valorisation of non-edible feedstock for the manufacture of key intermediates for applications such as high-performance polymers, speciality chemicals, cosmetics and more. The advantages of selectivity and activity are also seen in high-end cross-coupling catalysis, such as Buchwald or Hazari technologies, which enable C-C bond formation or amination of difficult substrates.
Last but not least, enantioselective hydrogenation is an elegant way to reduce waste by synthesising only the desired enantiomer, be it for pharmaceutical (such as in Januvia process by Merck Inc.) or agrochemical applications (Syngenta's Metolachlor).

Catalysis has always been a central technology in chemical manufacturing, and in energy conversion from and to various chemical forms. Despite its long and distinguished history, including many Nobel prize-winning discoveries, the future of catalysis is filled with new challenges. In particular, the impending and urgently needed transition from non-renewable to renewable sources of energy and chemical feedstocks will require the design of new catalysts and catalytic processes that are designed for sustainability.
Among the game-changing Nobel prizes that are transforming the chemical industry, let's concentrate on Noyori (2001), Grubbs, Chauvin and Schrock (2005) and Arnold (2018); and their contributions to sustainable chemistry.

Noyori's technology revolutionised the generation of chiral centres within the fragrance and life science industries. And, as all living bodies display chirality, there are numerous opportunities to further develop and industrialize enantioselective catalysis. For instance, in the agrochemicals industry, enantioselective catalysts could help to generate more selective crop treatments, making these processes more environmentally conscious.

The development, application and manufacturing of pheromones; a process made technically and economically viable due to the Nobel prize-winning technologies of 2005 and 2018, is another example of chemistry successfully contributing to the development of a more sustainable world. As previously mentioned, these advances in metathesis allow for the valorisation of non-edible feedstock for chemical processes. These applications show that renewable chemicals can be cost efficiently synthesized and bring additional properties compared to competing oil derivatives (1, 2).

Catalysis technologies will be essential for the decarbonisation of our energy generation infrastructure, which is necessary to reduce our energy CO_2 footprint. Catalysts can further support the application of H_2 as a means to store and generate energy with limited to no CO_2 emission. While renewable energy is necessary to power the production of H_2, and therefore store energy, catalysis is essential to restore this energy through an H_2 Proton-exchange membrane (PEM) fuel cell. However, developing the infrastructure to generate and provide green H_2 fuel remains a global challenge, even if the European Union and the German government have just decided to support it within their Green Recovery programs. As such, in the pursuit of a more sustainable future, chemistry must be at the forefront of key societal and political decisions.

References

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