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Environmentally Benign Catalysts for Sustainable Chemistry: The Potential of Polyoxometalates

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Modern chemical production still depends heavily on fossil resources such as oil, gas, and coal. These raw materials have enabled the development of fuels, plastics, and countless everyday products. Yet, if we want to build a more sustainable future, we must replace fossil feedstocks with renewable alternatives such as biomass or carbon dioxide. This shift is not straightforward: renewable raw materials differ in composition and structure, which means that many established processes cannot be applied directly. To make use of these new resources, we must redesign chemical processes from the ground up —and this includes developing new catalyst materials.

Catalysts are the hidden drivers of chemistry. They make reactions faster, more efficient, and less energy demanding. My research focuses on a special class of catalysts called polyoxometalates (POMs). These are molecular clusters composed of metal and oxygen atoms. What makes them exciting is their flexibility: they can be built in many different shapes and modified by including a variety of different elements. Because of this, POMs can be adapted to perform a wide range of useful reactions that are relevant for sustainable chemistry.

In my work, I develop methods to synthesize and study new types of POMs for specific catalytic applications. By carefully changing their composition and structure, I investigate how these changes affect their ability to promote chemical reactions. I will present examples where POM-based catalysts show potential in processes that could one day help us use renewable raw materials more efficiently and with fewer unwanted by-products. This work is part of the broader efforts of the Albert research group, which is dedicated to designing chemical processes that are cleaner, more efficient, and better aligned with the principles of sustainability and green chemistry.

Looking ahead, our vision is to move beyond trial-and-error approaches towards rational design of catalysts —using insights from synthesis, advanced measurements, and theoretical modelling to predict and create the "right"catalyst for a given sustainable process. Through collaboration across chemistry and related fields, we aim to show how new material like POMs can help redefine chemical production in a more sustainable way.

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