New process breaks bulk metal into atoms for sustainable catalyst production

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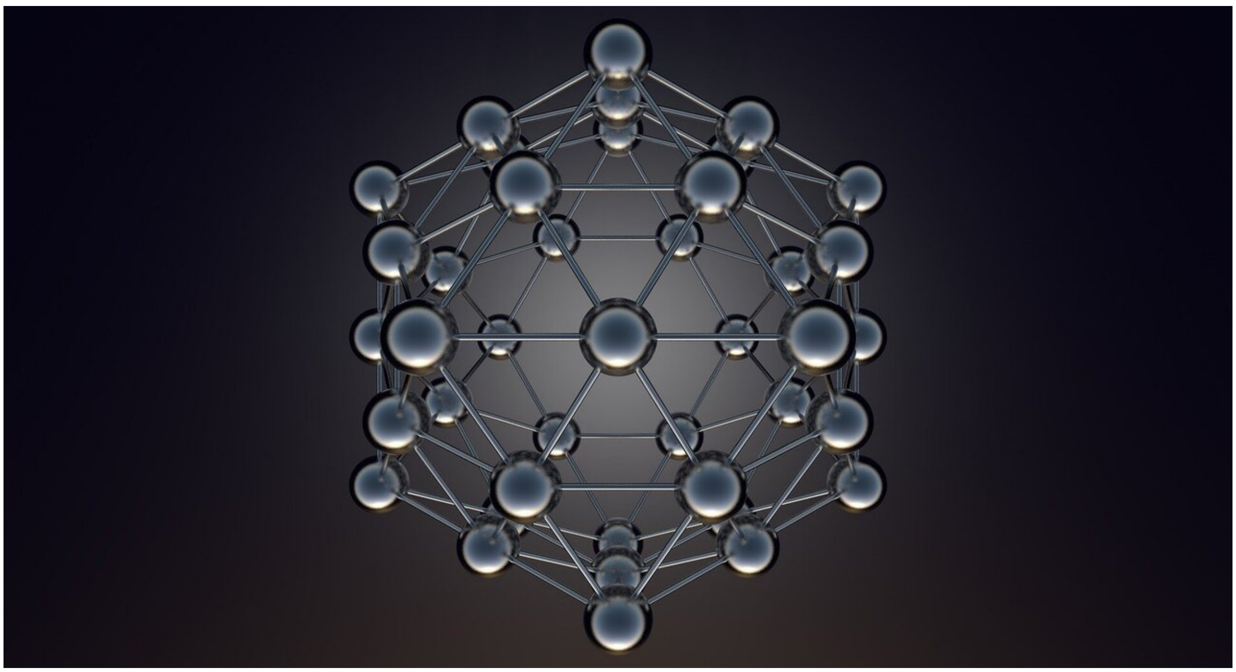

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Scientists have discovered a new process to break bulk metal into atoms to produce heterogeneous catalysts without any chemical waste, which will lead to new sustainable ways of making and using molecules in the most atom-efficient way.

Researchers from the University of Nottingham have demonstrated that "naked" Pt atoms can be dispersed onto powder supports directly by splitting bulk metal to atoms at the record-breaking rate of four and a half thousand trillion atoms per second (4.5×10^{15} atom/s) by magnetron sputtering. The method is scalable and solvent-free and opens the door for fabrication of valuable catalyst materials where Pt atoms are supported on powder particles. The study has been published in the Royal Society of Chemistry's peer-reviewed *Journal of Materials Chemistry A*.

Catalysts enable nearly 80% of industrial chemical processes that deliver the most vital ingredients of our economy, from materials (such as polymers) and pharmaceuticals to agrochemicals including fertilizers and crop protection. The high demand for catalysts means that global supplies of many useful metals, including gold, platinum and palladium, are becoming rapidly depleted.

To protect these metal supplies, it is vital to use each and every atom to its maximum potential. Atomic dispersion of metals in the support materials is one of the most powerful strategies for increasing the active surface area available for catalysis. The properties of the metal atoms can change drastically when compared with metal nanoparticles, leading to new phenomena otherwise inaccessible at the macroscale.

Traditionally methods for the preparation of atomically dispersed metal catalysts are based on either wet-chemistry (i.ereduction of metal salts) or atomic layer deposition (ALD). Industrial scale-up of these methods is difficult because they require multiple steps and/or high temperatures, generate large amounts of chemical waste, and are not readily generalisable across supports and metal catalysts.

This new research demonstrates how magnetron sputtering enables the production of atomically dispersed metals, including platinum, cobalt and nickel in the current publication, in any support material in a sustainable and scalable fashion. This method has been used in the glasscoating and semiconductors industry, and has now been adapted to make atomically dispersed metal catalysts.

The research team used analytical and imaging techniques to demonstrate the Pt atoms were atomically dispersed over the entire surface of the powder support and then applied this catalyst for photocatalytic hydrogen production.

"At the heart of our method individual metal atoms are knocked out of the bulk metal one by one by a fast beam of argon ions creating a shower of metal atoms raining onto the support material. The desired quantity of metal atoms can be generated on demand within seconds, but controlling their distribution on the powder support still remains a challenge. We are making good progress with designing innovative mixing systems for magnetron sputtering process and filed for a patent earlier this year," says Dr. Jesum Alves Fernandes, Assistant Professor in Chemistry at University of Nottingham who led the research.

More information: Emerson Cristofer Kohlrausch et al, A High-Throughput, Solvent Free Method for Dispersing Metal Atoms Directly onto Supports, *Journal of Materials Chemistry A* (2021). DOI: 10.1039/D1TA08372D

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