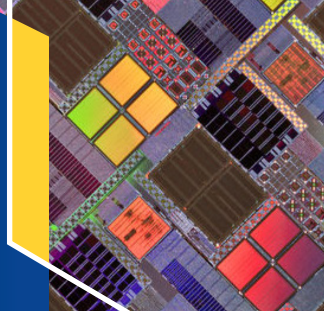

CAS INSIGHTS™

R&D TRENDS: NON-NOBLE CATALYSTS — A STEP TOWARDS SUSTAINABILITY

CAS
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Overview

By utilizing catalysts to support or enable renewable, energy-efficient, and greener processes, we can devise solutions that benefit society, business, and the environment. Evolving trends highlight the importance of non-noble metal based catalysts for a brighter, sustainable future.

Background: Noble metals such as platinum, palladium, and iridium have been widely utilized for their desired catalytic properties. However, their high cost and limited abundance hamper their applications.

Market potential: Driven by shifting demands for alternative energy and fuel, the global catalyst market size is expected to rise at 4.3% compound annual growth rate between 2021 and 2030.

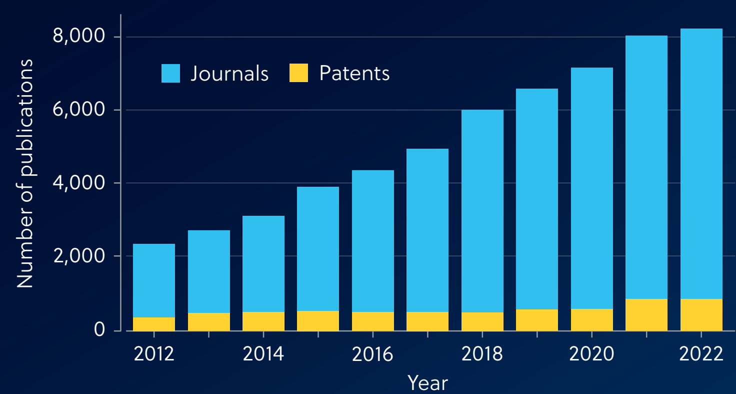
Key benefits: Global availability and favorable tolerability of transition metals such as titanium, vanadium, chromium, manganese, iron, cobalt, nickel, and copper make them ideal candidates to replace noble metal catalysts. Production of these sustainable alternatives generates less pollution and requires less energy consumption.

Key challenges: Sustainable catalysts with non-noble metals are more susceptible to degradation, may be less selective for the intended product, and can be challenging to characterize.

Emerging trends

The publication trend of using non-noble metals to develop sustainable catalysts and replace noble metals has advanced rapidly during the last decade. While journal publications dominate the publication volume, the number of patents is rising steadily.

General publication trends



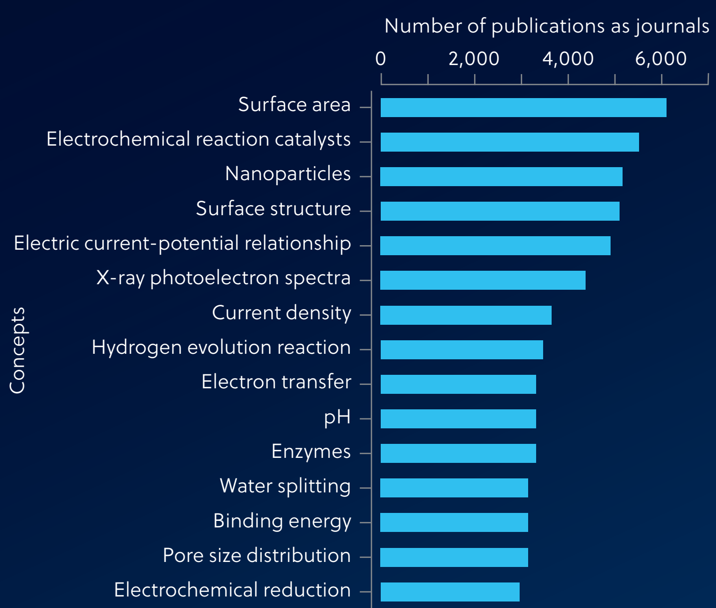
The need for sustainable catalysts

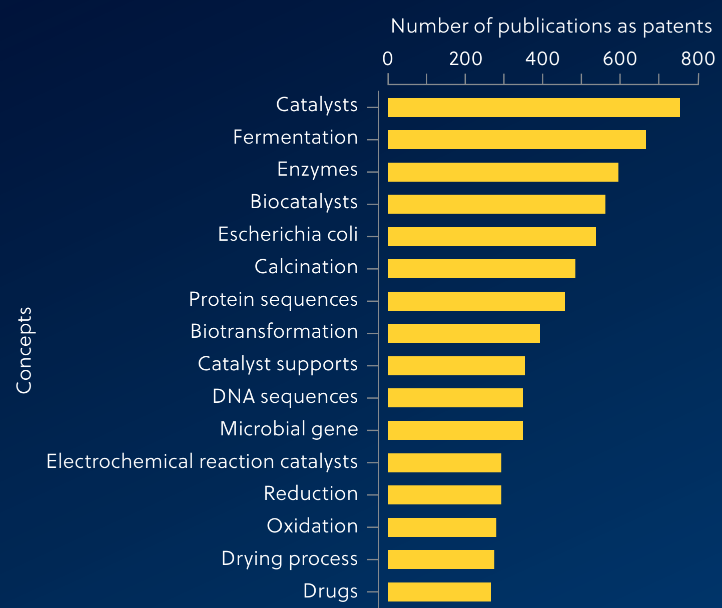
Noble metals are widely utilized for their desirable catalytic properties, yet their extensive use can occasionally negatively influence the environment. While transition metals offer an alternative, they carry certain limitations that must be overcome.

Property	Noble metal	Non-noble transition metal	Notes
Stability	High	Prone to corrosion	
Availability in earth's crust	Scarce	Very high	
Tolerance in the human body	Low	High	1300ppm of iron is permitted in pharma products vs. 10ppm in the case of noble metals
Mining process	Polluting and energy-intensive	Less pollution and energy consumption	
Ability to undergo 2-electron oxidation state changes	Yes	Prefer 1-electron oxidation state change	Most catalytic processes involve 2-electron transfer reactions
Selectivity of products	High	Low	
Easy of characterization	Easy due to stability	Difficult due to stability. Inert conditions may be needed	

Concepts in catalysis

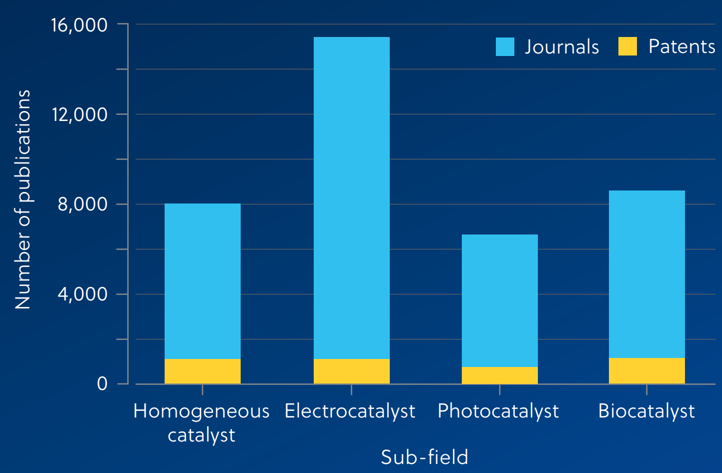
While journal articles typically feature concepts pertaining to electrocatalyst-related reactions/applications, the top 15 concepts in patents are mostly related to biocatalysts and enzymes. Biocatalysts, particularly hydrolases, are currently in great demand for industrial applications such as the food industry and detergent manufacturing. Based on the predominance of electrocatalysts in emerging research, we can anticipate a shift towards more innovative ideas in this topic being commercialized in the future for the purposes of sustainable catalysis. Photocatalysts (which have applications in wastewater treatment and air purification) and homogeneous catalysts are also important concepts featured in research on sustainable catalysts. As platinum group metals are predominant in homogeneous catalysis, there are ongoing research efforts to find alternatives for greater overall sustainability.





Trends in catalyst subfields

The key sustainable catalyst sub-fields explored within publications include electrocatalysts, photocatalysts, homogeneous catalysts, and biocatalysts. Electrocatalysts (catalysts involved in electrochemical reactions) are a particularly relevant sub-field in non-noble metal catalysis.



Looking ahead

The relatively low proportion of patents compared with journal publications indicates that research into sustainable catalysts has yet to reach the point of commercialization. However, the steady increase in research on non-noble metal-based catalysts signals a transition toward a sustainable future.

Learn more at cas.org/insights

More comprehensive information and references can be found at cas.org/sustainable-catalysts

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