How to Optimise Catalysis via Loading Control

Global energy consumption is tricky to forecast. Worldwide demand is expected to top 660 quadrillion Btu by 2050, an increase of around 15% from 2021–but how much of that will derive from fossil fuels versus renewable energy sources?

The World Energy Outlook estimates that as much as 66% of current energy demands are met by conventional fossil fuels (oil, gas and coal), but it is difficult to predict how that share will change as we move towards the middle of the century and the proposed target date for various net-zero commitments. Natural gas, nuclear, solar, and wind energy have made significant gains in the global energy mix as the world looks to decarbonise. But the future of renewable energy might well lie in green hydrogen.

What is Green Hydrogen?

Hydrogen is a highly reactive gas generated via electrolysis. It represents an extremely clean and efficient energy system that can be derived simply by passing a current through an active catalyst which separates hydrogen from water–yielding oxygen as a benign “waste” product. There is a full spectrum of different types of hydrogen, from grey to green. These colours primarily refer to the method of production; green hydrogen being the most sustainable. Even the electricity used in green hydrogen catalysis must come from a renewable source. Naturally, this represents an enormous opportunity for regions with significant existing renewable energy infrastructures, such as China, which claims a staggering 80% of the global solar market share.

Theoretically, an established network of renewable energy generators could be connected to a hydrogen power plant, creating a truly zero-carbon pathway to meeting future energy demands. Still, green hydrogen generation is not without challenges.

Challenges of Green Hydrogen Production

Cost is often touted as one of the main limiting factors of green hydrogen production. Electrolysing hydrogen from water requires an expensive and scarce ruthenium catalyst. Ruthenium has been the leading candidate material for active catalysts since the 1970s when it showed promising denitrification (de-NOx) results in automotive applications. It has been studied for various commercial reactions ever since. The drawback to ruthenium’s catalytic ubiquity is its scarcity. Present at just 10-7% of the Earth’s crust, ruthenium has already been highlighted by researchers at Yale University as an element facing considerable supply risk. How can green hydrogen be scaled-up if we begin to exhaust one of the most critical materials in its production? The obvious solution is to optimise catalysts through ruthenium loading control.

Understanding Loading Control

Loading control, in the context of catalytic substrates, is simply the process of optimising the consumption of critical materials. Organometallic catalysts are often generated via chemical vapour deposition (CVD), an instrumental technology in thin film deposition. Typical CVD practices involve the subsequent deposition of vaporised precursors onto a substrate to create a uniform coating that may be as thick as just a few nanometres. One method of ensuring loading control in catalyst generation would be to optimise the uptake of precursors during the deposition process–the level of wasted precursors for general CVD practices is gallingly high. But there is a more novel solution.

It is possible to reduce ruthenium loads by creating nanoparticles with a unique core-shell structure, composing an outer ruthenium shell with an inner core made from some less scarce material. These complex structures can even be optimised for catalytic activity.

If you are interested in learning more about how Nikalyte can help reduce valuable material loads through core-shell nanoparticle fabrication, contact a member of the team today.

References and further reading:

1. https://corporate.exxonmobil.com/energy-and-innovation/outlook-for-energy/energy-demand
2. https://www.saurenergy.com/solar-energy-blog/countering-chinas-solar-dominance-how-key-consumer-markets-are-adapting
3. https://www.bloomberg.com/news/articles/2023-01-10/is-green-hydrogen-the-fuel-of-the-future-china-us-europe-are-betting-on-it
4. https://www.sciencedirect.com/science/article/abs/pii/S0167299106809869
5. https://www.fastcompany.com/3044467/a-periodic-table-of-elements-that-the-world-is-running-out-of
6. https://avs.scitation.org/doi/10.1116/6.0001125