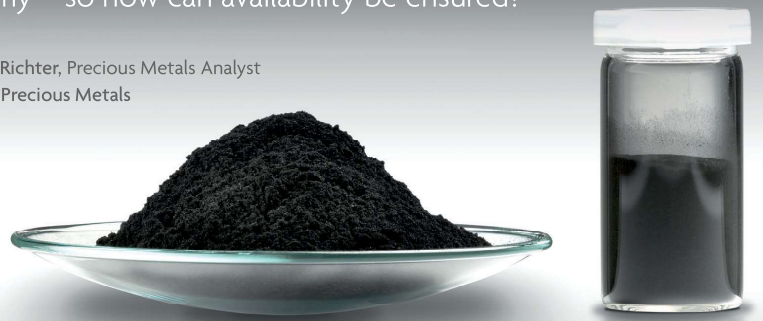
Iridium

An indispensable, scarce metal for the hydrogen economy – so how can availability be ensured?

By Dr. Julia Richter, Precious Metals Analyst at Heraeus Precious Metals



PEM electrolysis is pivotal for producing green hydrogen from renewable energy and is based on precious metals, namely platinum and iridium. The latter is especially scarce, as only around nine metric tons per year of primary metal are extracted by mines (and not likely to be significantly increased).

The required amount of iridium per gigawatt (GW) in PEM electrolysis currently averages 400kg/GW of electrolyser capacity; this is far too much to build the announced capacities for PEM electrolysis (more than 70GW by 2030) with the available amount of iridium.

Thrifting of iridium as well as the recycling of untapped streams is needed to safeguard the growth of PEM electrolysis. Here in this article, we'll explain why and how to do so.

Why iridium is a topic for the hydrogen economy...

Iridium is needed to produce the so-called 'green hydrogen' that is generated by means of water electrolysis using renewable energy sources. We all know that ambitious targets for hydrogen production in the coming decades have been set. For the production of green hydrogen, proton exchange membrane electrolysis (PEM-EL) is the best suited technology. And PEM-EL requires iridium.

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Why is PEM-EL superior for green hydrogen?

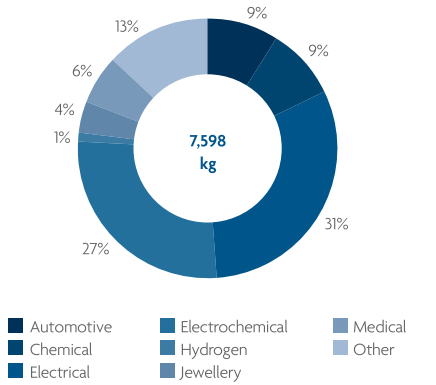
Renewable energy sources often fluctuate in their energy output. PEM can deal with these kind of circumstances relatively well. It can manage larger power fluctuations and works at high current densities; it shows a faster response time to fluctuating power generation; and it delivers hydrogen at high pressure and requires less space. According to expert estimates, 40% of the announced electrolyser capacity by 2030 will be based on PEM technology. Hence, out of an announced electrolyser capacity of 175GW by 2030, at least 70GW of PEM-EL can be assumed.

Why is iridium indispensable for PEM?

Electrolysers split water into hydrogen and oxygen. They have two electrodes: At PEM-EL, the cathode uses a platinum catalyst for the generation of hydrogen and the anode, where the oxygen evolution reaction takes place, an iridium catalyst. The oxygen evolution reaction is more demanding and needs to be efficient for a good overall performance.

The anode catalyst has to fulfill the following requirements: (a) good conductivity (b) good activity in forming oxygen, and (c) stability in an acidic environment. So far, iridium is the material of choice.

Figure 1. Iridium Demand in 2021 (in % terms)



Source: SFA (Oxford)

How much will be needed for 70GW?

It depends on the loading that is used: Currently, one GW of PEM-EL capacity requires between 300 and 500kg of iridium. With 70GW of PEM-EL, this results in an average cumulative iridium demand of about 32 metric tons (mt) by 2030. The Heraeus latest generation low loading iridium catalysts only requires 100kg iridium per Gigawatt, summing up to only eight mt by 2030.

Other applications for iridium are catalysts for the production of acetic acid and the chlorine-alkali electrolysis. It is also used in the electronics industry for single-crystal-growing and for spark plugs in the automotive industry and industrial plants. In general, where it is used it is often essential and not easy to replace. We say the applications are 'locked-in'.

Today, the production of green hydrogen currently accounts for only a small part of the total demand for iridium. However, PEM-EL is the fastest growing application for iridium and will drive the demand for iridium in the future.

So, what about mining – can't we just mine more?

Unfortunately, not that easily. Iridium belongs to the platinum group metals (PGMs) and is one of the rarest elements on Earth. With around 90%, the production is heavily concentrated in Southern Africa. It is exclusively mined as a by-product of PGM mining and the annual output is small, at about nine mt. For comparison, annual output of platinum is about 190 mt. For the mines, iridium turnover is comparatively low and even at currently high prices, cannot justify expanding platinum mining for the sake of more iridium. Thus, the primary supply of iridium depends heavily on platinum mining.

Can we increase the recycling rates?

Currently, on average only 20-30% of the iridium used in the various applications is recycled. And even those amounts are not freely available for PEM electrolysis as they are recycled on behalf of the owner of the originating application – and go back there.

Tapping the 70% 'potential' is also not easy. For many applications the end-of-life materials are difficult to collect, or the iridium concentration is quite low, which requires significant pre-treatment to reach a 'processable' concentration. However, Heraeus Precious Metals is taking up the challenge to access these so far untapped quantities of iridium by means of new technologies and partnerships.

With growing PEM-EL capacities, of course, end-of-life materials for PEM-EL will also grow. However, an electrolyser runs for about 10 years and consequently, the recycling of PEM-EL will not help much during the ramp-up phase.

Consequences on the market...

The market for iridium is illiquid mainly due to the limited supply and a small number of market participants. Thus, changes can trigger large price jumps. Currently, the market for iridium is almost balanced with the established applications. Remember, that these applications cannot replace iridium easily. Only in few applications is a substitution of iridium ongoing, or is use declining.

Our iridium experts at Heraeus Precious Metals estimate that about 1.5-2 mt of iridium can be released annually from existing applications through increased recycling, substitution or reduction. By 2030, a maximum of 12-16 mt of iridium could thus be available. However, current loadings for PEM-EL would need at least 16 mt more than that (in total 32 mt). This will most likely lead to higher price pressure and to temporary supply bottlenecks for the hydrogen economy, as well as for other applications. Considering the low iridium catalysts from Heraeus Precious Metals, only 7 mt of iridium is needed – cumulatively – for the same electrolyser capacity, which is within reach.

We have to act now

The hydrogen ramp-up is at risk. But not beyond hope. We just have to act now! The most important lever to solve the iridium gap is the soonest implementation of low-loading iridium catalyst solutions. These solutions are available, tested and backed up with data for the required activity and stability. Currently, these materials are in qualification in some projects, however speeding up the qualification is recommended.

Furthermore, additional recycling streams need to be evaluated, and it is essential to set up circularity for the hydrogen economy to feed future demand. Some governments have considered stockpiling iridium, but this will only lead to higher prices as well as longer-lasting availability challenges for the industry and hence, is not recommended. Heraeus Precious Metals will continue the development of technological solutions and is investing in expanding the infrastructure for the hydrogen economy.

About the Author

Dr. Julia Richter has a doctoral degree in Economics and worked for the German Council of Economic Experts before she joined Heraeus Precious Metals. She is now working as a Precious Metals Analyst.