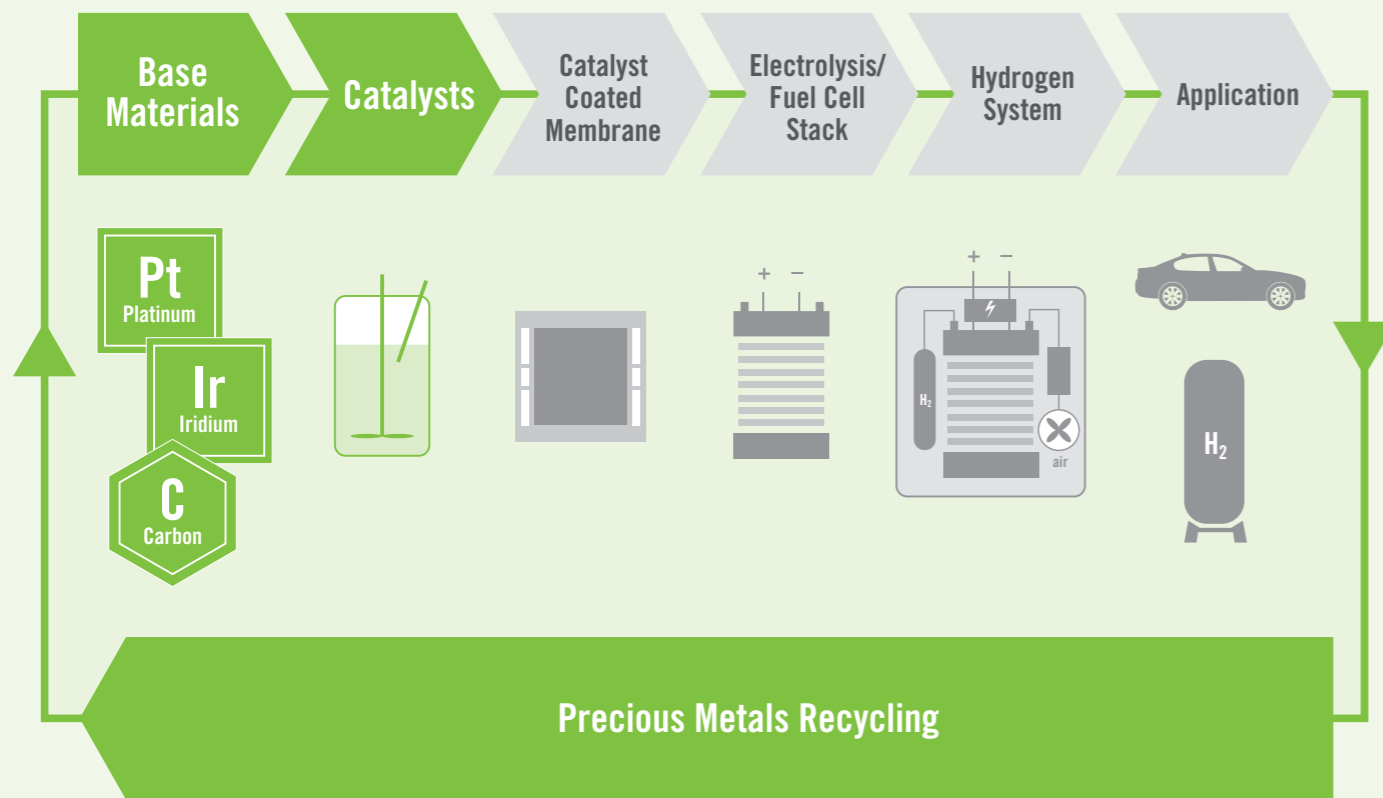


Electrocatalysts for **PEM Electrolyzers**

Explore our
new generation
of electrolyzer
anode catalysts and

**save up
to 90%
Iridium!**

Heraeus Hydrogen Systems



Heraeus – Catalyzing the Hydrogen Revolution

The implementation of a new energy regime is essential to achieve **worldwide decarbonization**. Renewable energies are the key solution as they do not rely on the combustion of fossil resources and do not form carbon dioxide. The generation of **renewable energy** however depends on sources, which availability fluctuates. To fully exploit their potential, the produced renewable energy has to be stored. The production of **Green Hydrogen** from renewable energy through PEM Electrolysis of water is a very suitable concept, becoming more and more prominent.

Green Hydrogen is therefore the energy carrier of the future. It will play a major role in the mobility sector and the world's daily energy needs. The cost-efficient production of **Green Hydrogen** on an industrial scale will be **the decisive component** on the way towards a **zero-emission society**.

Heraeus' new electrolyzer catalysts will contribute to achieve that goal.

PEM Electrolysis will play a pivotal role as the best-suited technology to produce Green Hydrogen. Heraeus is aware that the inevitable use of precious metal systems might create challenges for every operating company. That is why your best choice is to work with the **leading provider of precious metals as your partner** to master those challenges.

Heraeus has been **committed to precious metals** since more than 160 years. Utilizing profound expertise in precious metal catalysts, Heraeus is providing electrocatalysts for PEM Electrolysis and has an essential breakthrough in Hydrogen catalysts. The superior and innovative catalysts **save up to 90% of Iridium** compared to the industry benchmark while showing a **3 times higher performance**. The long-term stability of these novel solutions has been proven by long-term studies and thus backed up with data.

Besides the **superior catalyst range**, you benefit **from** an extensive portfolio of **precious metal services** which increases the planning reliability of your business. Achieve higher margins and focus on your core business by trusting the leading precious metal experts.

**Join us in catalyzing
the Hydrogen Revolution!**

Heraeus delivers value for your business

Heraeus electrolyzer catalysts address decreased Iridium content while increasing efficiency and performance. Our electrolyzer catalysts deliver the following benefits:



ACTIVITY

Efficient use of Iridium in different catalyst concepts allows to increase performance & reduce costs



STABILITY

With stability comes reliability, our catalysts will contribute to a high lifetime in your application



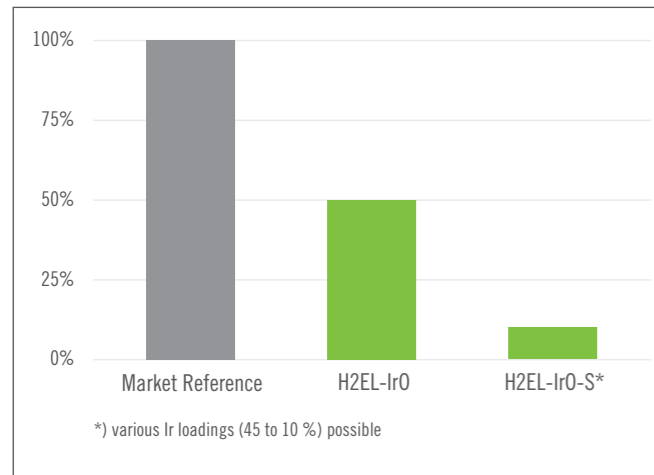
IRIDIUM SAVING

Ideal for large scale application due to significant savings in precious metal content

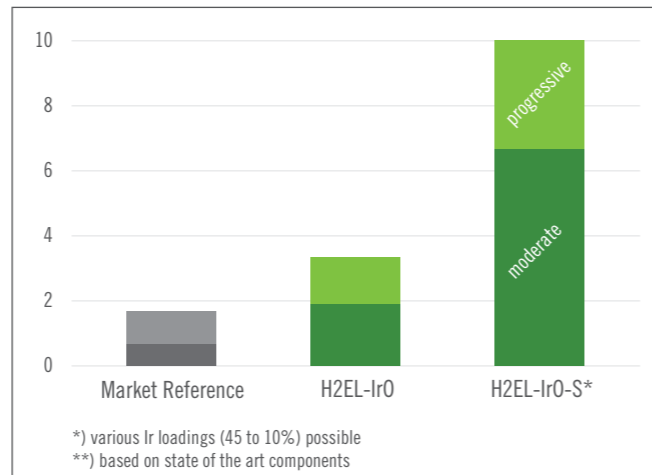


ELECTRODE AREA SAVING

Strong decrease in capital expenditure due to Iridium and catalyst material savings



Iridium use in PEM anode electrodes



Achievable newly installed capacity with one tonne Iridium per year in GW**

Heraeus catalysts save 50–90% on Iridium compared to the market's benchmark!

Low Iridium catalyst increases the possible outcome of one metric ton of Iridium from 1.7GW to up to 10GW.

Catalyst	Iridium savings in %	Theoretical PEM capacity with 1 t of Ir in GW/a
Market Reference	0	1 to 1.7
H2EL-IrO	up to 50%	1.4 to 3.3
H2EL-IrO-S	up to 90%	3.3 to 10.0

Based on single cell measurements at 80°C

We achieved breakthrough innovation by supplying electrolyzer catalysts with significantly reduced precious metal loading. Our product will provide you with an up to three times higher catalyst performance while reducing the precious metal loading by 50–90% in comparison to the competition.

These two proven benefits allow you to **save on precious and rare Iridium**. This favors the application of Heraeus catalysts on large scale processes and promotes the implementation of Hydrogen systems in our society.

Given their lower loadings of Iridium, Heraeus Catalysts H2EL-IrO-S (loading: 10 to 50%) prove to have a viable chance to win the race to become **the electrocatalyst of choice for PEM Electrolysis** as in 2030 Europe will target 40 GW of PEM electrolyzer.

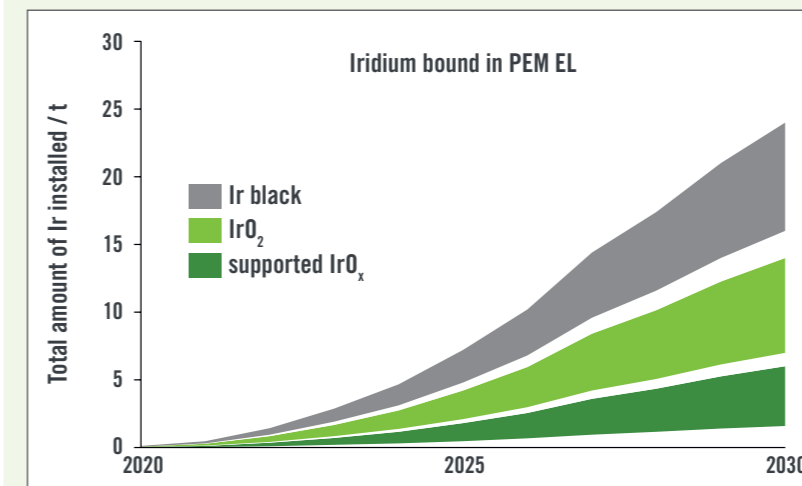
Our comprehensive product portfolio fits your needs

Catalyst	H2EL-Ir	H2EL-IrO	H2EL-xxIrO-S	H2EL-xxIrRu
Features	High metal purity	High surface area material	Reduced Ir content, supported material	Reduced Ir content
Performance focus	Highly active, stable	Highly active, highly stable	Excellent activity and material efficiency	Excellent activity and material efficiency
Ir crystallite size [nm] via XRD	3	2 – 4	2.5 – 3.5, partly amorphous	1.8 – 5.5
BET surface area [m ² /g]	21 – 25	>180	20 – 150	120 – 200
Mass activity @ 1.45 V _{cell} (iR-free)* [A/g]	~79	~86	~570 (30%)	~400 (Ir _{0.3} Ru _{0.7})

The Heraeus product portfolio includes electrolyzer catalysts with **different precious metal loadings**. These provide numerous benefits to your application. In order to find the perfect solution to your needs, materials can be tested in the **fully equipped on-site laboratories and test center**.

For more detailed **information about your possibilities in the broad product portfolio and for specific requests**, please contact our sales experts.

Material innovation to reduce Iridium volume requirements



40 GW goal

- 50% PEM in 2030
- Ir black 1.2 to 0.8 t/GW
- IrO₂ 0.7 to 0.35 t/GW
- NextGen 0.3 to 0.08 t/GW

Precious Metal Services

As a leading provider of precious metals, Heraeus offers you **professional management** of your precious metal assets via weight accounts, as well as recycling and refining of precious metals from a wide variety of starting materials, including logistics and waste management.

Heraeus has long-lasting experience and available capacities for recovering precious metals from a catalyst-coated membrane (CCM), which has been a challenge for the market in the past. Trust the expert for CCM **recycling that provides you with a complete loop of your precious metal needs.**

A LOCAL PARTNER ... AND A GLOBAL COMPANY

- Being part of the global Heraeus group, the local teams have access to a worldwide network of experts ensuring fast response to technical and commercial inquiries
- Production facilities and labs in Hanau, Germany and Nanjing, China offer on-site support as well as a large portfolio of related services

MORE THAN JUST RELIABLE PROCUREMENT

Dealing with precious metals can be challenging for you – for Heraeus, it is daily business. As **longstanding experts in precious metals**, Heraeus turns volatile markets into business opportunities. Whatever your need, you can rely on special expertise in **all aspects of physical and non-physical precious metals management.**



Hanau, Germany



Nanjing, China

PRECIOUS METALS TRADING

- Stable physical supply of all precious metals – including the rare PGM Iridium – due to global access to precious metals
- Four global Heraeus Trading offices across all relevant time zones enable seamless coordination across borders for your local requirements
- Financing and Risk Management/Price Hedging services optimize your precious metals procurement and secure your long-term profitability in the light of price volatility on the markets
- Digital One-Stop Solution myHeraeus.com: Comprehensive digital platform – including trading and recycling transactions myHeraeus.com offers full transparency of precious metals pool accounts and transaction history

Heraeus recycles your CCM and recovers your assets with the utmost transparency and maximum yield!

RECYCLING

Long lifetime is one of the key advantages of Hydrogen systems. But it is crucial to think about the future. Recovery of precious metals and the **treatment of spent CCMs** play an important role to implement Hydrogen systems in an economically viable and sustainable way. However, CCM recycling can be a challenge as fluorine-containing material imposes **specialized requirements in process, knowhow and equipment.**

As a leading provider with decades of experience in the recycling of precious metals, Heraeus has the technological competencies to **handle the full recycling process of CCMs.** All kinds of precious metals containing waste are processed, including the **recovery of Iridium** – a very complex process not many companies master. Heraeus experts ensure that your materials are handled in compliance with all applicable regulations. The recycling services are **fast, transparent** and provide you with the **maximum yield.**

Want to gain greater planning security while minimizing your price risks? Heraeus has a unique price hedging model that is right for your profitability!

About Heraeus

Heraeus Precious Metals is a leading provider of precious metals services and products. We combine all activities related to our comprehensive expertise in the precious metals loop – from trading to precious metals products to recycling.

With technical expertise, commitment to excellence, focus on innovation and entrepreneurial leadership, we are constantly striving to improve our performance. We create high-quality solutions for our clients and strengthen their long-term competitiveness by combining unique material expertise with leadership in technology.

HERAEUS PRECIOUS METALS

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