Japan Organization for Metals and Energy Security (JOGMEC) Hydrogen & Fuel Cell Division 260706

Proposal:

Production of High-Purity Light Hydrogen Gas Using Light-Water-Rich Water and Cylindrical Membrane Electrodes

Proposer Information

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1. Purpose of the Proposal

Japan's hydrogen policy places strong emphasis on production efficiency, safety, and purity control. To advance decarbonization and the hydrogen-based society, it is essential to convert diverse forms of surplus electricity generated within each regional grid into chemical energy in the form of hydrogen, thereby contributing to climate change mitigation.

This proposal introduces a new hydrogen-production method that uses **Light-Water-Rich Water (99.99-99.999%)**, obtained through the previously reported *Centripetal Sedimentation Extraction Method*, as the electrolysis feedwater. By combining this high-purity light water with existing **cylindrical membrane electrodes**, the method enables high-purity, high-efficiency production of light hydrogen gas (H_2). Light-Water-Rich Water exhibits significantly lower ionic transport resistance during electrolysis, allowing higher efficiency than conventional water electrolysis and making it highly suitable for fuel-cell-grade hydrogen.

2. Characteristics of Light-Water-Rich Water

Light water (H_2O) is known to exhibit faster electrochemical reaction rates and lower interfacial resistance than heavy water (D_2O). Using the *Centripetal Sedimentation Extraction Method* together with **FFOF (Final Frontier Osmosis Filtration)**—which requires a controlled water head—natural water with a light-water content of 99.985% (3N) can be enriched to **99.99-99.999% (4N-5N)**.

Light-Water-Rich Water represents a new category of "high-purity industrial water" with broad applicability across multiple industries. In particular, its electrochemical advantages make it a valuable new feedstock for hydrogen production, improving efficiency and purity.

3. Overview of the Centripetal-Circulation Cylindrical Membrane Electrode System

Unlike parallel-plate electrode assemblies, this system consists of multiple cylindrical anodes arranged concentrically, each enclosed within its own membrane-separated cartridge. Electrolyte is injected from the lower part of each cylindrical electrode tube, forming an upward spiraling flow. The system has the following features:

1. **Uniform current distribution:** The cylindrical geometry equalizes current density and suppresses localized overpotential.
2. **Gas separation advantage (1):** Anode and cathode gases are isolated in separate membrane cartridges, ensuring reliable separation of H_2 and O_2 and enhancing safety.
3. **Gas separation advantage (2):** Upward spiraling flow removes generated gas from electrode surfaces, preventing bubble adhesion and resistance increase.
4. **Gas separation advantage (3):** The circulation tank is a centripetal-sedimentation device (PETACLONS type), enabling dissolved gases to be quantitatively separated as free gas.
5. **Gas separation advantage (4):** Electrolyte passing through UF/RO membranes with a controlled water head is fully degassed and temperature-conditioned, stabilizing electrode temperature and minimizing bubble formation.
6. **Stable electrolyte flow:** Centripetal vortex circulation ensures uniform flow and enhances the electrochemical conversion of water into light hydrogen gas.
7. **Scalable design:** Increasing the number of cylindrical electrode cartridges directly scales production capacity, making the system suitable for industrial deployment.

8. **Heavy-water and tritium-water enrichment:** Multi-stage cascade PETACLONS systems can reduce light-water concentration to extremely low levels, enabling enrichment (production) of heavy water and tritium water.
9. **Compatibility with existing equipment:** The system can be integrated into existing water-electrolysis installations with modest modifications and selection of appropriate cylindrical modules.

4. Alignment with JOGMEC Hydrogen Policy

This method aligns with JOGMEC's strategic objectives:

- Improving hydrogen production efficiency
- Enhancing operational safety
- Advancing domestic technological capability
- Strengthening the hydrogen supply chain

The use of Light-Water-Rich Water represents a uniquely Japanese technological advantage and contributes to international competitiveness.

5. Conclusion

The combination of Light-Water-Rich Water and cylindrical membrane electrodes offers a new hydrogen-production method with the potential to significantly improve conventional water electrolysis. It provides high purity, high efficiency, and high safety, while remaining compatible with existing industrial equipment. I would be grateful for an opportunity to discuss technical evaluation of this method.

Research on tritium water, heavy water, and light water separation has been submitted to Tokyo Electric Power Company and Mitsubishi Research Institute. Details are available at: http://www.fineclay.co.jp/

Public discussion meetings are held at the **Osaka Metropolitan University Cultural Exchange Center** (Osaka Station 2nd Building, 6th Floor), using the Small Seminar Room, Conversation Room, and other facilities for technical and business sessions.