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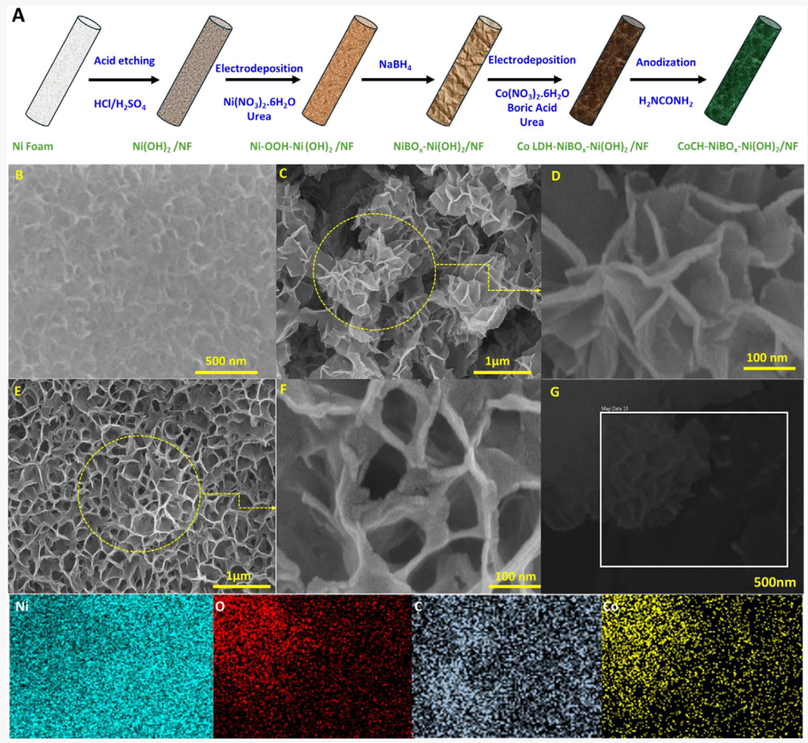
Scientists hail new ‘industrially viable technology’ that can squeeze hydrogen from seawater

Scientists say they have developed a new technology capable of extracting clean hydrogen fuel directly from seawater.

SHARJAH, EMIRATE OF SHARJAH, UNITED ARAB EMIRATES, May 12, 2025 /EINPresswire.com/ -- By Ifath Arwah, University of Sharjah

Researchers from the University of Sharjah claim to have developed a novel technology capable of producing clean hydrogen fuel directly from seawater, and at an industrial scale.

In a study published in the journal Small, the researchers report that they extracted hydrogen without the need to remove the mineral salts dissolved in seawater or add any chemicals. (Original Source URL: https://doi.org/10.1002/smll.202501376)

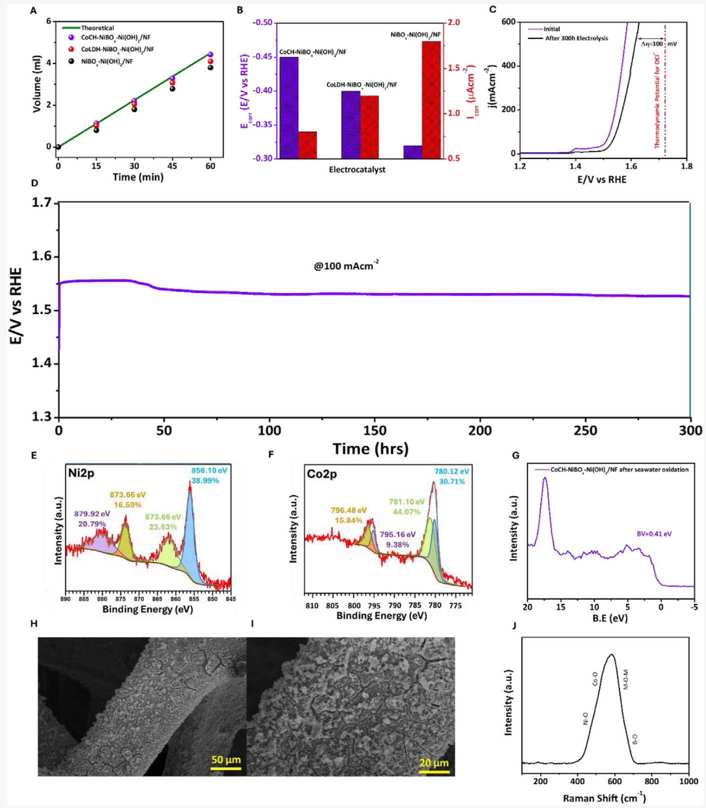


Systematic illustration of the formation process of how the new device extracts hydrogen from seawater. Credit: Small (2025). DOI: https://doi.org/10.1002/smll.202501376

According to the authors, the technology enables hydrogen extraction from seawater without relying on desalination plants, which require massive investments totaling hundreds of millions of dollars.

“We developed a novel, multi-layered electrode that can extract hydrogen directly from seawater efficiently and sustainably. Traditional methods face a host of problems, mainly corrosion and performance degradation caused by chloride ions in seawater,” said Dr. Tanveer Ul Haq, Assistant Professor in the Department of Chemistry, College of Sciences, University of Sharjah, and the study’s lead author.

The authors designed a specially engineered electrode which, in the words of Dr. Ul Haq, “overcomes these issues by creating a protective and reactive microenvironment that boosts performance while resisting damage.”



Faradic efficiency: corrosion potential and corrosion current density recorded before and after 300 h electrolysis, chronopotentiometry of valance band spectrum, and Raman spectrum after 300 h continuous electrolysis in alkaline seawater. Credit: Small (2

In a world where clean energy is no longer a luxury but a necessity, hydrogen stands out as one of the most promising solutions. Until now, scientists have primarily relied on pure water—a precious resource in many regions—to produce hydrogen.

This study addresses that challenge by introducing a new technology capable of generating hydrogen directly from seawater. “In short, we’ve demonstrated that direct seawater electrolysis is not only possible but scalable, delivering industrial-level efficiency while protecting the electrode over long-term use,” Dr. Ul Haq added.

In their study, the researchers describe their device as a “microenvironment-engineered, multilayered electrode design for sustainable seawater electrolysis.” When in operation, the apparatus delivers “a geometric current density of 1 A cm^{-2} in real seawater at an overpotential of 420 mV, with no hypochlorite formation and outstanding operational stability for 300 hours at room temperature.”

The electrode, the study notes, produces hydrogen at industrially relevant rates using untreated seawater. Nearly all the electrical input was converted into gas output, achieving a Faradaic efficiency of 98%.

“The advanced anode design achieves an industrially viable current density of 1.0 A cm^{-2} at 1.65 V under standard conditions, marking a significant step toward scalable, desalination-free hydrogen production directly from seawater.”

Faradaic efficiency measures the effectiveness with which electrons participate in a given electrochemical reaction.

“We created an advanced electrode that works in real seawater without needing any pretreatment or desalination," said the study's corresponding author, Yousef Haik, Professor of Mechanical and Nuclear Engineering at the University of Sharjah.

"Our system generates hydrogen at industrially relevant rates—1 ampere per square centimeter—with low energy input. This could revolutionize how we think about hydrogen production in coastal regions, especially in arid countries like the UAE, where freshwater is limited but sunlight and seawater are abundant."

The technology's strength lies in the electrode's advanced, multilayered structure, which not only withstands harsh seawater conditions but thrives in them. The device forms "a protective metaborate film, preventing metal dissolution and non-conductive oxide formation"—an approach that eliminates the need for energy-intensive water purification.

"This bypasses costly desalination and complex water purification, making green hydrogen production cheaper and more accessible," said co-author Mourad Smari, a research associate at Sharjah University's Institute of Science and Engineering.

One of the most impressive features of the system is its longevity. "It runs for over 300 hours without performance loss, resisting corrosion that usually destroys similar systems," said Dr. Ul Haq. The study explains that the carbonate layer "acts as an electrostatic shield," protecting the electrode's multiple layers from dissolution.

In performance tests, the electrode achieved a turnover frequency of 139.4 s^{-1} at 1.6 V, which the authors consider one of the highest reported for similar systems.

"In summary, the multilayered electrode architecture developed in this study provides an effective solution for efficient direct seawater electrolysis," the study concludes. "The ultrathin nanosheet morphology, with its high surface area, facilitates substantial catalyst exposure and activity, maximizing the surface sites available for direct seawater oxidation."

Dr. Ul Haq emphasized the technology's potential impact on clean and sustainable energy production.

"This technology can be applied in large-scale hydrogen plants that use seawater instead of precious freshwater. Imagine solar-powered hydrogen farms along the UAE coastline, using seawater and sunlight to produce clean fuel—with zero emissions and minimal resource strain."

Asked to explain in simple terms how the multilayered design works, Dr. Ul Haq said, "The electrode's layered design acts like a smart filter—allowing water in, blocking corrosion, and supercharging hydrogen production." He added that the system's performance is largely due to how it handles chloride ions in seawater.

The carbonate functionalization repels these ions and creates a local acidic microenvironment that accelerates the oxygen evolution reaction (OER), essential for hydrogen production. The paper notes that this mechanism “enhances OER kinetics and protects against chloride attack and precipitate formation.”

The technology has already attracted interest from “clean energy startups and regional innovation hubs,” Dr. Ul Haq noted. “Our innovation transforms seawater from a challenge into a solution… This is clean hydrogen made from the sea.”

The researchers are now looking forward to large-scale deployment of their technology. “We’re now moving from lab-scale to pilot-scale testing, looking to validate the technology under real-world outdoor conditions,” Dr. Ul Haq said. “Our next goal is to develop a modular hydrogen generator powered by solar energy, tailored for use in arid, coastal regions.”

LEON BARKHO
University Of Sharjah
+971 50 165 4376
lbarkho@sharjah.ac.ae
