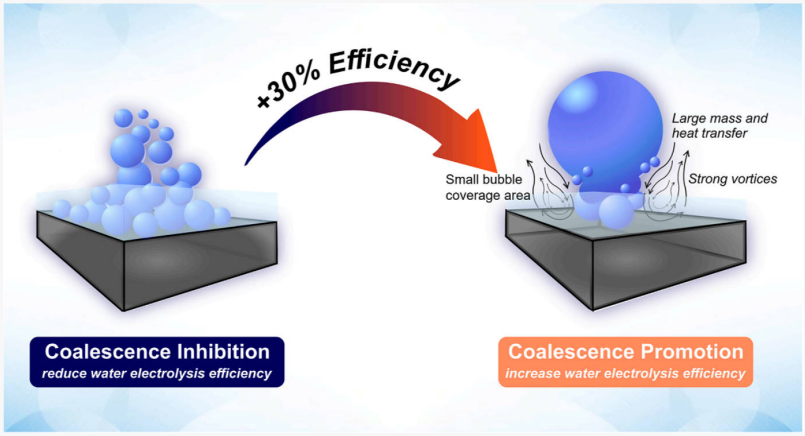
Larger bubbles could make water electrolysis more efficient

GA, UNITED STATES, July 31, 2026 /EINPresswire.com/ -- For decades, water electrolysis research has treated small, fast-departing bubbles as the ideal. A new study challenges that assumption. The researchers found that, under high-current operation, bubbles that merge and leave the electrode later can improve the hydrogen evolution reaction (HER). These larger departing bubbles are not helpful simply because they are large; they are useful because their coalescence clears tiny bubbles stuck to the electrode and stirs the nearby liquid. By tuning electrolyte composition, the team showed that coalescence-prone systems achieved up to 30% higher HER efficiency than coalescence-inhibited systems, offering a new way to rethink energy losses in hydrogen production.



Bubble coalescence boosts water electrolysis efficiency.

Green hydrogen is expected to help decarbonize chemical manufacturing, transportation, steelmaking, and other hard-to-electrify industries. Yet electrolysis efficiency remains limited by bubbles generated on electrode surfaces. These bubbles can cover catalytic sites, slow ion transport, and weaken heat and mass transfer near the electrode. Conventional strategies therefore focus on making bubbles detach earlier and at smaller sizes through surface design, wettability control, or external fields. But at high current densities, bubbles collide frequently, and bubble–bubble interactions begin to dominate the process. Based on these challenges, there is a need to investigate how bubble coalescence changes interfacial transport and electrolysis efficiency.

A research team from East China University of Science and Technology and Southern University of Science and Technology reported (DOI: 10.1016/j.esci.2025.100472) the findings in eScience, with the article available online on July 2026. The study examined how electrolyte composition controls bubble coalescence, bubble departure, and hydrogen evolution reaction (HER) performance in both acidic and alkaline water electrolysis. The results show that promoting, rather than suppressing, bubble coalescence can improve efficiency by reshaping how bubbles

leave the electrode surface.

The team used a three-electrode electrolytic cell with a platinum disk electrode, electrochemical measurements, high-speed imaging, and numerical simulations. In sulfuric acid, bubbles readily coalesced; when perchloric acid or sodium sulfate was added, coalescence was suppressed and bubble departure size became smaller. Surprisingly, the smaller bubbles did not improve performance. At −40 mA, adding perchloric acid reduced bubble size but caused about a 20% drop in HER efficiency. At −60 mA, the performance gap reached about 30%. Mechanistic analysis showed why: a just-detached bubble can linger above the electrode and continuously merge with surface-anchored microbubbles. This late departure pulls microbubbles away at sizes below 10 μm, freeing active sites before they become blocked. At the same time, coalescence generates local flows above 1 m/s, breaking up the normally stagnant interfacial layer and improving heat and mass transfer. In alkaline media, where coalescence is naturally suppressed, adding hydrophobic polystyrene (PS) microparticles promoted coalescence and improved efficiency by 2–6%.

The authors said the work shifts the key question in bubble management. Instead of asking only how to make bubbles smaller, they said future electrolysis design should ask how bubbles interact after they form. Bubble coalescence, they said, can act like a self-driven cleaning and mixing process at the electrode surface: it removes microbubbles early, reopens reaction sites, and brings fresh electrolyte into a region where transport is usually slow. This helps explain why larger departing bubbles can signal better, not worse, performance under high-current conditions.

These findings suggest a new design principle for gas-evolving electrochemical systems. In acidic systems, where bubbles already merge easily, electrodes or flow fields could be designed to increase useful bubble collisions. In alkaline water electrolysis, seawater electrolysis, and chlor-alkali processes, where bubble coalescence is often inhibited, electrolyte additives or particle-assisted strategies may help restore beneficial merging. The study also points to broader applications in industrial electrolysis, where surface bubble removal and interfacial transport remain major limits. By treating coalescence as a controllable tool, future devices may reduce energy loss without relying only on catalyst or electrode-surface improvements.

References

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