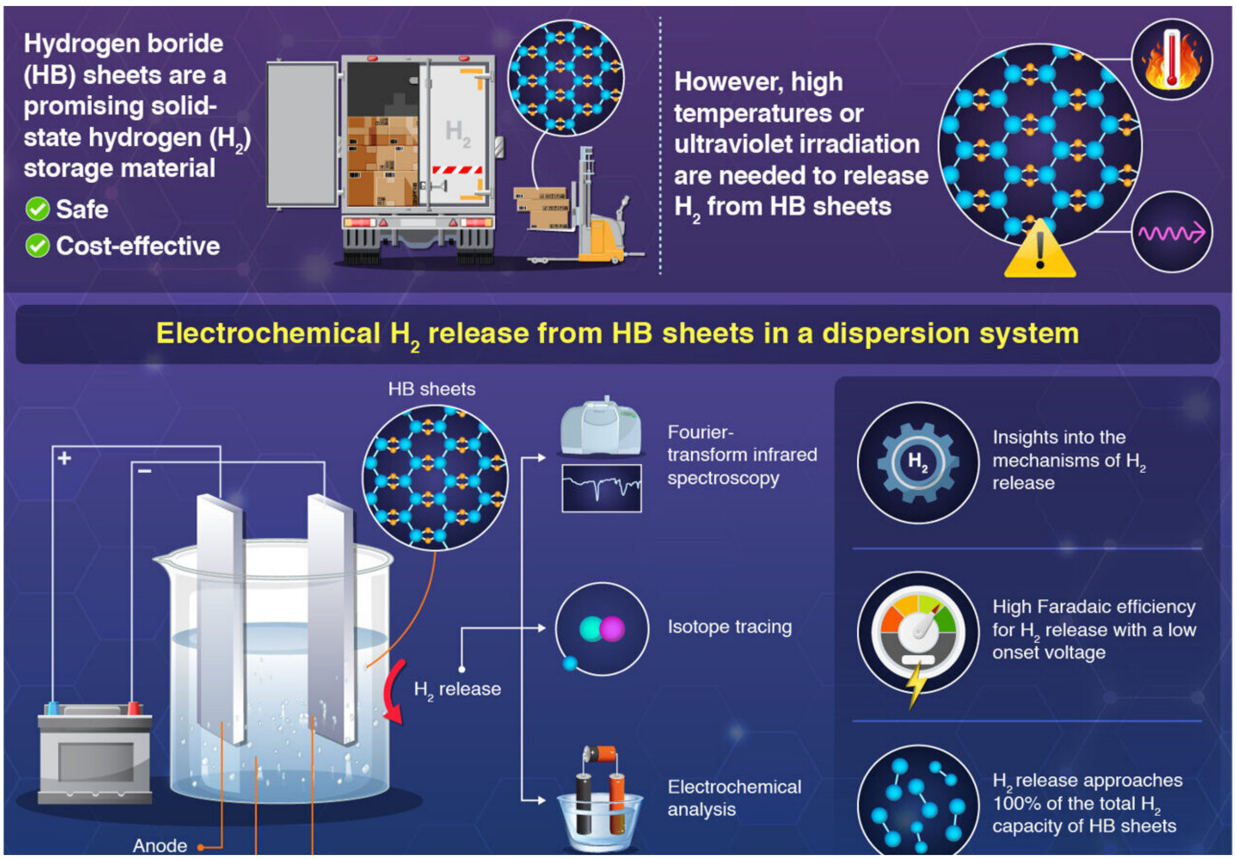
Scientists investigate a better way of releasing hydrogen stored in hydrogen boride sheets

February 9 2024



HB films may be applied as safe, economical, and lightweight carriers for H_2 transportation and storage. Credit: Tokyo Tech

The looming threat of climate change has motivated scientists worldwide to look for cleaner alternatives to fossil fuels, and many believe hydrogen is our best bet. As an environmentally friendly energy resource, hydrogen (H_2) can be used in vehicles and electric power plants without releasing carbon dioxide into the atmosphere.

However, storing and transporting H_2 safely and efficiently remains a challenge. Compressed gaseous hydrogen poses a significant risk of explosion and leakage, whereas liquid hydrogen must be maintained at extremely low temperatures, which is costly. But what if we could store hydrogen directly in the molecular composition of other liquid or solid materials?

This was the focus of a team of scientists from Japan, who, in a recent study published in the journal *Small*, investigated the potential of hydrogen boride (HB) sheets as practical hydrogen carriers. Storing hydrogen in HB sheets is not an entirely new concept, and many aspects of their potential applications as hydrogen carriers have already been studied. However, getting the hydrogen out of the sheets is the tricky part.

Heating at high temperatures or strong ultraviolet (UV) illumination is required to release hydrogen (H_2) from HB sheets. However, both approaches have inherent disadvantages, such as high energy consumption or incomplete H_2 release.

Thus, the team delved into a potential alternative: electrochemical release. Based on the mechanism of UV-induced H_2 release from HB sheets, the team speculated that electron injection from a cathode electrode into HB nanosheets by an electric power supply could be a superior way to release H_2 compared to UV irradiation or heating.

Based on this theory, the researchers dispersed HB sheets into acetonitrile—an organic solvent—and applied a controlled voltage to the dispersion. These experiments revealed that nearly all of the electrons injected into the electrochemical system were used to convert H^+ ions from the HB sheets into H_2 molecules. Notably, the Faradaic efficiency of this process, which measures how much electrical energy is converted into chemical energy, was over 90%.

The team also conducted isotope tracing experiments to confirm that the electrochemically released H_2 originated from the HB sheets and not through some other chemical reaction. Moreover, they also employed scanning electron microscopy and X-ray photoelectron spectroscopy to characterize the sheets before and after H_2 release, yielding further insights into the underlying mechanisms of the process.

These findings contribute to the development of safe and lightweight hydrogen carriers with low energy consumption. Although the team studied the dispersed form of the HB sheets in the published paper, the current findings are applicable to film or bulk-based HB sheet systems for H_2 release. Moreover, the team will investigate the rechargeability of HB sheets after dehydrogenation in a future study.

More information: Satoshi Kawamura et al, Electrolytic Hydrogen Release from Hydrogen Boride Sheets, *Small* (2024). DOI: 10.1002/smll.202310239

Provided by Tokyo Institute of Technology