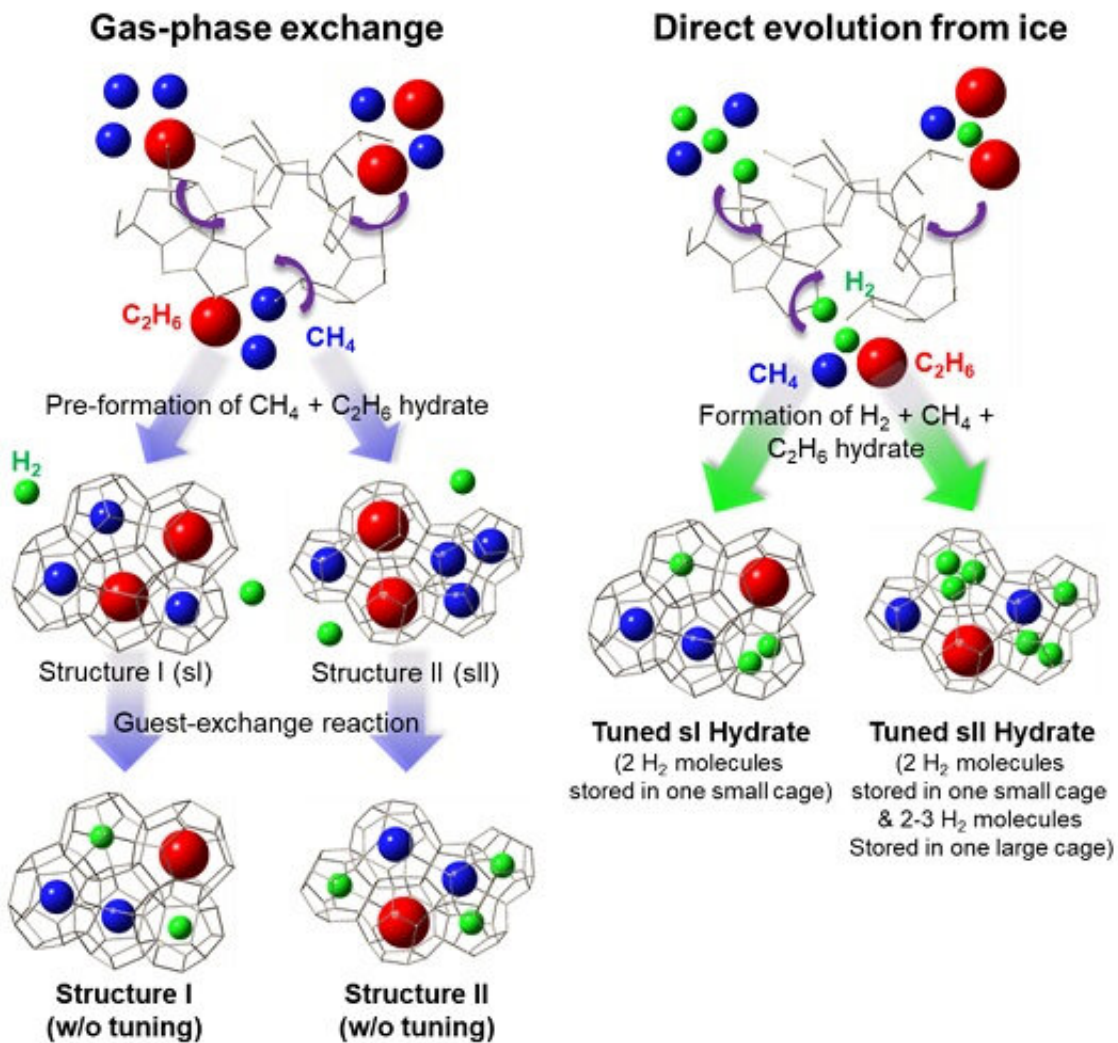


Hydrogen-natural gas hydrates harvested by natural gas

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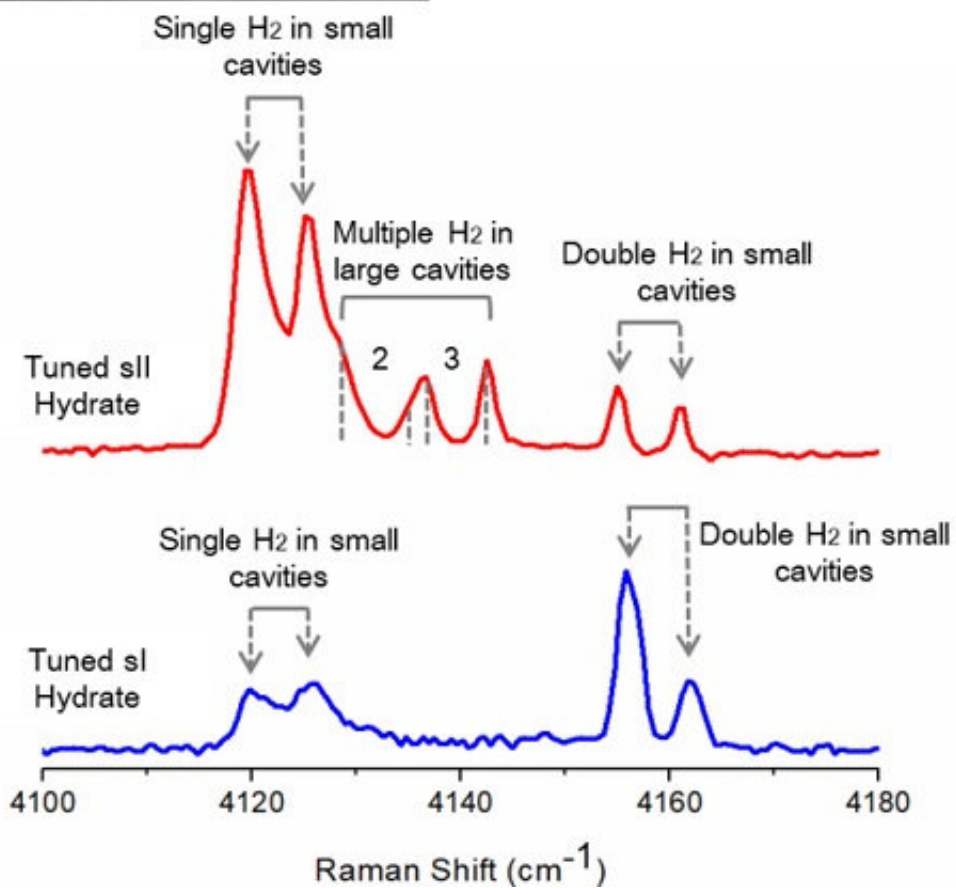
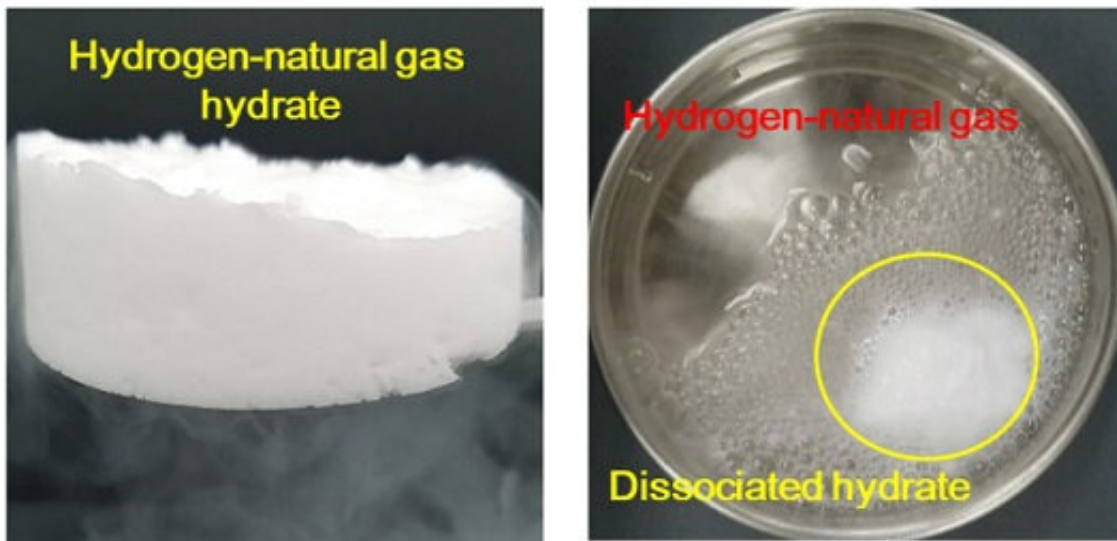
Schematics showing the storage method for hydrogen in a natural gas hydrate using a substitution method and storage method directly from ice to a hydrogen-natural gas hydrate. Credit: KAIST

A hydrogen-natural gas blend (HNGB) can be a game changer only if it can be stored safely and used as a sustainable clean energy resource. A recent study has suggested a new strategy for stably storing hydrogen, using natural gas as a stabilizer. The research proposed a practical gas phase modulator based synthesis of HNGB without generating chemical waste after dissociation for the immediate service.

The research team of Professor Jae Woo Lee from the Department of Chemical and Biomolecular Engineering in collaboration with the Gwangju Institute of Science and Technology (GIST) demonstrated that the [natural gas](#) modulator based synthesis leads to significantly reduced synthesis pressure simultaneously with the formation of hydrogen clusters in the confined nanoporous cages of clathrate hydrates. This approach minimizes the [environmental impact](#) and reduces operation costs since clathrate hydrates do not generate any chemical waste in both the synthesis and decomposition processes.

For the efficient storage and transportation of hydrogen, numerous materials have been investigated. Among others, clathrate hydrates offer distinct benefits. Clathrate hydrates are nanoporous inclusion compounds composed of a 3-D network of polyhedral cages made of hydrogen-bonded 'host' water molecules and captured 'guest' gas or liquid molecules.

In this study, the research team used two gases, methane and ethane, which have lower equilibrium conditions compared to hydrogen as thermodynamic stabilizers. As a result, they succeeded in stably storing the hydrogen-natural gas compound in hydrates. According to the composition ratio of methane and ethane, structure I or II hydrates can be formed, both of which can stably store hydrogen-natural gas in low-pressure conditions.



Artificially synthesized and dissociated hydrogen-natural gas hydrates. The Raman spectra of tuned sI and sII hydrate showing the hydrogen clusters in each cage. Credit: KAIST

The research team found that two hydrogen molecules are stored in small cages in tuned structure I hydrates, while up to three hydrogen molecules can be stored in both small and large cages in tuned structure II hydrates. Hydrates can store gas up to about 170-times its volume and the natural gas used as thermodynamic stabilizers in this study can also be used as an energy source.

The research team developed technology to produce hydrates from ice, produced hydrogen-natural gas hydrates by substitution, and successfully observed that the tuning phenomenon only occurs when hydrogen is involved in hydrate formation from the start for both structures of hydrates.

They expect that the findings can be applied to not only an energy-efficient gas storage material, but also a smart platform to utilize hydrogen natural gas blends, which can serve as a new alternative energy source with targeted hydrogen contents by designing synthetic pathways of mixed gas hydrates.

The research was published online in *Energy Storage Materials* on June 6, with the title "One-step formation of [hydrogen](#) clusters in clathrate hydrates stabilized via natural gas blending."

Professor Lee said, "HNGB will utilize the existing natural gas infrastructure for transportation, so it is very likely that we can commercialize this [hydrate](#) system. We are investigating the kinetic performance through a follow-up strategy to increase the volume of gas storage.

More information: Yun-Ho Ahn et al, One-step formation of hydrogen clusters in clathrate hydrates stabilized via natural gas blending, *Energy Storage Materials* (2019). [DOI: 10.1016/j.ensm.2019.06.007](#)

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