Researchers unveil useful strategies for sustainable gas storage and separation with clathrate hydrates

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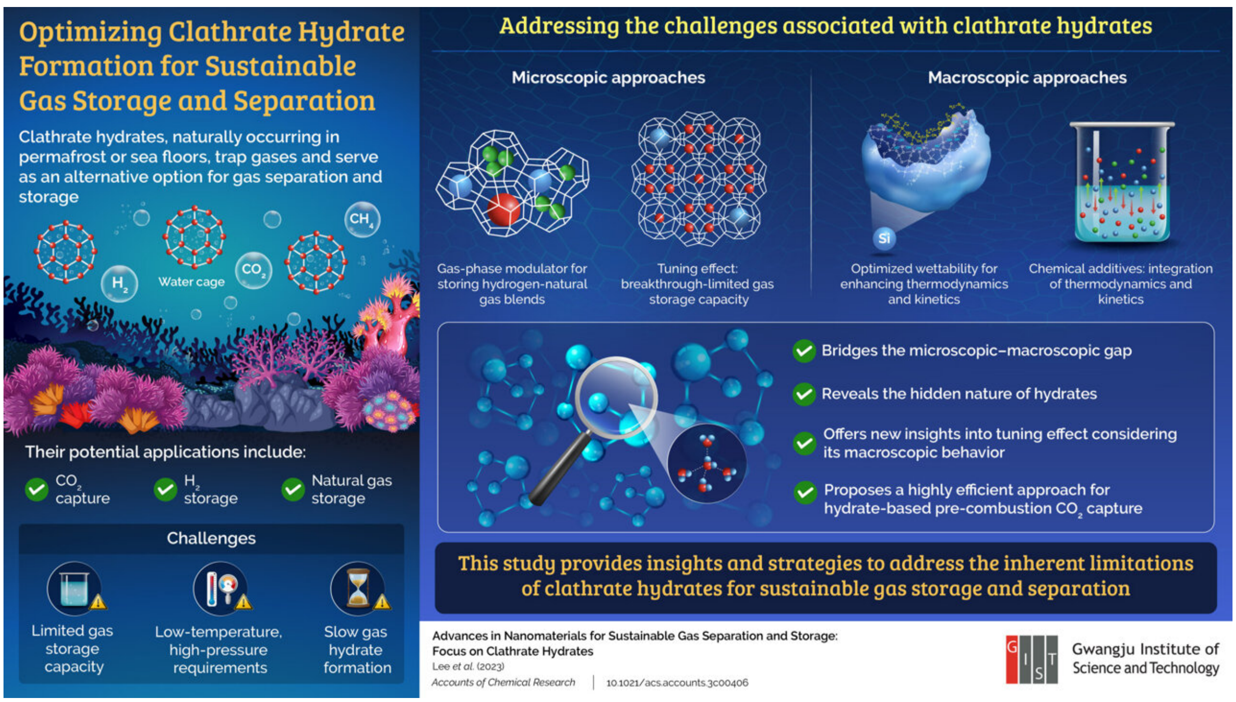

This study by GIST researchers showcases recent advances in clathrate hydrates, which could help address challenges in gas storage and separation applications. Credit: Youngjune Park, Gwangju Institute of Science and Technology, Korea

Clathrate hydrates are ice-like nano porous compounds which consists of nano-sized water cages. They are found in places like permafrost or seabed. Moreover, their unique physical and chemical traits make them beneficial for various separation processes, such as the capture of carbon dioxide (CO_2) before and after combustion, storage of hydrogen gas, transportation of natural gas, desalination of wastewater, and more.

However, using them in real-world applications is still a significant challenge as they have limited gas storage capacities and slow formation rates that require high pressure and low temperature conditions. In a new study led by Professor Youngjune Park from the Gwangju Institute of Science and Technology in Korea, a team of researchers has comprehensively reviewed recent research findings, including their own, that address these myriad challenges associated with clathrate hydrates.

According to Prof. Park, "By exploring the untapped potential of clathrate hydrates, we have effectively mitigated these limitations and provided efficient hydrogen (H_2) storage solutions through the introduction of hydrogen-natural gas blends into clathrate hydrates." Their study was published in the journal *Accounts of Chemical Research*.

The team presents an account of macroscopic and microscopic approaches to bridge the gap between them. The microscopic approach includes techniques like using 'gas-phase modulators' to synthesize hydrates, which enable concurrent storage of light hydrocarbons and hydrogen and prevent chemical waste generation.

Tuning effects, which aid in maximizing gas storage capacity and promote thermodynamic stability, are also discussed. From a macroscopic viewpoint, the study included interfacial interactions with porous substances and how they accelerate kinetics to enhance hydrate formation. Additionally, rapid formation by chemical additives was also summarized.

This study thus helps advance the untapped potential of gas hydrates by bridging macroscopic and microscopic properties and exploring their hidden nature opens various potential applications.

These encompass efficient techniques for pre- and post-combustion CO_2 capture using hydrates, demonstrating practical and economic viability. Subsequently, this can reduce carbon dioxide emissions from power plants and thereby play a role in mitigating climate change in the long run and making carbon capture more affordable.

These insights will also help to increase the storage and transportation capacity of hydrogen and natural gas, which is crucial for industries involved in energy applications using these gases. "This research has significant long-term potential for the gas storage and separation industry, particularly in achieving carbon neutrality. Our findings offer crucial insights for developing clathrate hydrate-based technologies for hydrogen storage and carbon dioxide separation, essential for a future low-carbon society," says Prof. Park.

Other sustainable applications include gas separation processes and desalination processes, thereby providing an avenue for the treatment of water and other substances in industries requiring large-scale processing. Clathrates could also contribute to storing and transporting gases produced in renewable energy processes, such as biogas or syngas, from biomass or waste.

This study underscores the essential link between nanostructures and their macroscopic characteristics, highlighting the importance of comprehending their interaction for economic viability. These reveal the concealed essence of gas hydrates and can help shape new approaches to tackle challenges and establish the foundation for tangible, practical applications.

More information: Yunseok Lee et al, Advances in Nanomaterials for

Sustainable Gas Separation and Storage: Focus on Clathrate Hydrates, *Accounts of Chemical Research* (2023). DOI: 10.1021/acs.accounts.3c00406

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