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Safe and Controllable Methane Storage at Ambient Pressure Enabled by Graphene-Coated Porous Carbon

Methane (CH_4) is a high-energy, abundant fuel with strong potential for cleaner energy applications. However, its storage and transport pose significant challenges. Compressed natural gas (CNG) at around 25 MPa is energy-intensive and carries safety risks. Adsorbed natural gas (ANG) systems, which use nanoporous materials to store CH_4 at moderate pressures (~3.5 MPa), offer a safer and more energy-efficient alternative. However, this method suffers from thermal sensitivity, releasing stored gas rapidly with slight temperature increases.

In this study, we report a novel methane storage strategy that operates at ambient pressure using graphene-coated porous carbon. Graphene is deposited via chemical vapor deposition (CVD), forming a thermally responsive "valve" that controls pore accessibility. The graphene-coated porous carbon material is capable of being charged with CH_4 at high pressure and retaining it at ambient pressure, with no significant release below 318 K, which greatly enhances storage safety. This design enables a reversible volumetric CH_4 capacity of 142 v/v, higher than that of various existing ANG technologies.

This ambient-pressure, thermally controlled system offers a scalable, cost-effective, and inherently safe approach for methane storage. By enabling on-demand gas release via low-grade heat, it presents a transformative pathway for energy storage and gas-handling technologies.