Hydrogen Storage in Molecular Compounds

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At low temperature (*T*) and high pressure (*P*), gas molecules can be held in ice cages to form crystalline molecular compounds that may have application for energy storage. We synthesized a hydrogen clathrate hydrate, $H_2(H_2O)_2$, that holds 50 g/liter hydrogen by volume or 5.3 wt %. The clathrate, synthesized at 200–300 MPa and 240–249 K, can be preserved to ambient *P* at 77 K. The stored hydrogen is released when the clathrate is warmed to 140 K at ambient *P*. Low *T* also stabilizes other molecular compounds containing large amounts of molecular hydrogen, although not to ambient *P*, e.g., the stability field for $H_2(H_2O)$ filled ice (11.2 wt % molecular hydrogen) is extended from 2,300 MPa at 300 K to 600 MPa at 190 K, and that for $(H_2)_4CH_4$ (33.4 wt% molecular hydrogen) is extended from 5,000 MPa at 300 K to 200 MPa at 77 K. These unique characteristics show the potential of developing low-*T* molecular crystalline compounds as a new means for hydrogen storage.

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