Solid Hydrogen Formed for Atomic Propellants

Several experiments on the formation of solid hydrogen particles in liquid helium were recently conducted at the NASA Glenn Research Center at Lewis Field. The solid hydrogen experiments are the first step toward seeing these particles and determining their shape and size. The particles will ultimately store atoms of boron, carbon, or hydrogen, forming an atomic propellant. Atomic propellants will allow rocket vehicles to carry payloads many times heavier than possible with existing rockets or allow them to be much smaller and lighter.

Solid hydrogen particles are preferred for storing atoms. Hydrogen is generally an excellent fuel with a low molecular weight. Very low temperature hydrogen particles ($T <$ 4 K) can prevent the atoms from recombining, making it possible for their lifetime to be controlled. Also, particles that are less than 1 mm in diameter are preferred because they can flow easily into a pipe when suspended in liquid helium. The particles and atoms must remain at this low temperature until the fuel is introduced into the engine combustion (or recombination) chamber. Experiments were, therefore, planned to look at the particles and observe their formation and any changes while in liquid helium.

During the experiments, a small amount of liquid hydrogen was poured onto the surface of the liquid helium. The liquid helium was kept in a Dewar to keep it cool and was held at 3 to 4 K. The liquid hydrogen that flowed onto the surface was at 14 K, just above its freezing point. As the liquid hydrogen fell toward the helium surface, it began to freeze, and particles formed immediately after hitting the helium surface. The figure shows a frame from the videotape of the experiment. The small particles were allowed to float on the helium surface for 20 to 60 minutes. Very quickly, they began to stick together, or agglomerate. In the final fuel application, the particles may be used to gel the liquid helium, as well as store the atoms. Gelling the helium would prevent the particles from sticking together. The particles also changed from clear crystals to cloudy crystals, indicating a transition from face-centered cubic (FCC) to hexagonal close-packed (HCP) molecule packing.

Solid hydrogen particles floating in liquid helium.

Find out more at the Fuels and Space Propellants Web site.

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