Periodic Graphics

A collaboration between C&EN and Andy Brunning, author of the popular graphics blog *Compound Interest*

More online

To see more of Brunning's work, go to **compoundchem.com.** To see all of C&EN's Periodic Graphics, visit **cenm.ag/periodicgraphics.**

FUELS FOR SPACECRAFT

Rockets require a huge amount of energy to launch into orbit. Here we look at the different types of fuels used to get rockets off the ground and how spacecraft continue to propel themselves in space.

GETTING OFF THE GROUND

Rocket engines generate thrust with propellants that combine an oxidizer and a fuel to produce hot gases. The mixtures can be solid, liquid, or a mix of both.

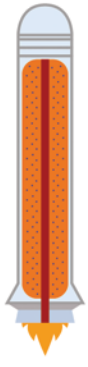
SOLID PROPELLANT

Oxidizer

Example
Ammonium perchlorate

Fuel

Example
Aluminum powder



These propellants consist of granules of a solid oxidizer, a powdered fuel, and a plastic binder to hold everything together.

Generates a lot of thrust in a short amount of time. Used in boosters.

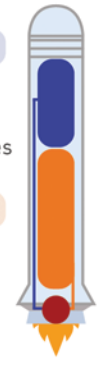
LIQUID PROPELLANT

Oxidizer

Examples
Liquid oxygen, liquid nitrogen oxides

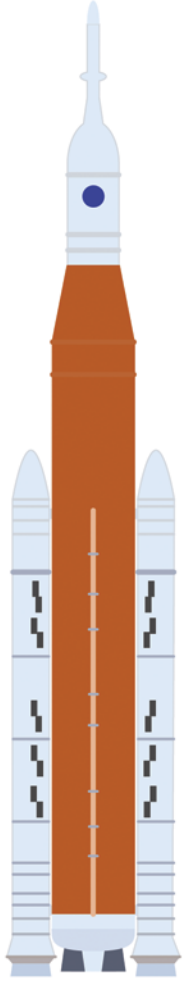
Fuel

Examples
Liquid hydrogen, liquid methane



The liquids used in these propellants start as gases that then get cooled and compressed to turn them into liquids.

These propellants are commonly used in rockets' main engines.

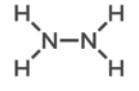


PROPULSION IN SPACE

Once spacecraft have escaped Earth's gravity, they still need a means of propulsion. Vessels can use several propulsion methods.

CHEMICAL PROPULSION

Chemical propulsion uses reactions that produce hot gas to generate thrust. Hydrazine is the most common fuel used, but it is toxic, and scientists are developing greener alternatives.



Hydrazine

Ir catalyst

Decomposition

Ammonia

Nitrogen

Hydrogen

ELECTRIC PROPULSION

Electric propulsion commonly uses electrostatic or electromagnetic fields to ionize propellants and then accelerate the ions to produce thrust.

Xe XENON → Ionization → Xe⁺ XENON → Acceleration → Thrust

ADVANCED PROPULSION

Scientists have proposed a number of other propulsion technologies and in some cases tested them. For example, solar sails, which harness the momentum of sunlight, could propel spacecraft through space without any fuel.

PERIODIC GRAPHICS