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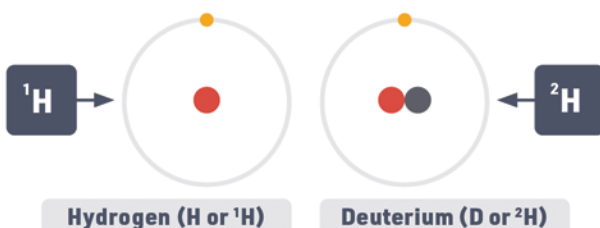
A collaboration between C&EN and
Andy Brunning, author of the popular
graphics blog *Compound Interest*

THE SCIENCE AND USES OF DEUTERIUM

Harold Urey discovered deuterium, a stable isotope of hydrogen, in 1931. Here we look at how deuterium's properties differ from those of hydrogen and list some of deuterium's applications.

WHAT IS DEUTERIUM?

Deuterium is an isotope of hydrogen. Isotopes are atoms of an element that are made up of the same number of protons and electrons but different numbers of neutrons.

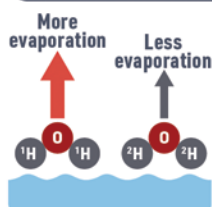


● Proton ● Neutron ● Electron

Hydrogen and deuterium undergo the same reactions, but the rates of reaction can differ because of deuterium's larger mass, a phenomenon called the kinetic isotope effect. Heavy water (D_2O) has slightly different physical and chemical properties from normal water.

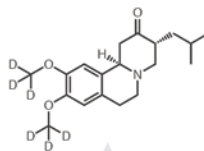
	Water	Heavy water
Structure		
Color	Pale blue	Colorless
Density	0.9998 g mL ⁻¹	1.107 g mL ⁻¹
Melting point	0 °C	3.8 °C
Boiling point	100 °C	101.4 °C

HOW IS DEUTERIUM USED?



Climate science

Scientists can use the ratio of deuterium to hydrogen in ice core samples to calculate past temperatures. Heavy water molecules evaporate less easily, so the $^2\text{H}:^1\text{H}$ ratio can be used as a thermometer.



Medicinal chemistry

Replacing hydrogens in some drug molecules with deuteriums can slow the compound's metabolism in the body. The first deuterated drug, deutetrabenazine, was approved in the US in 2017.

Ethanol (in CDCl_3)



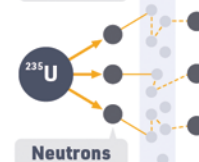
Ethanol (D_2O added)



NMR spectroscopy

In hydrogen nuclear magnetic resonance spectroscopy, deuterated solvents stop hydrogen-containing solvents from producing peaks that overwhelm signals from the target molecule. Additionally, deuterium can replace a hydrogen in some functional groups, like alcohols, making the groups' peaks disappear.

Moderator



Nuclear reactors

Heavy water is used in some nuclear reactors as a moderator, slowing down neutrons so they propagate nuclear chain reactions more effectively. Deuterium is also used in prototype fusion reactors.