

Nuclear Technology and the Polio program!

Keeping the polio vaccine under refrigeration is often difficult in the third world. But **heavy water** may come to the rescue, says S.Ananathanarayanan



Heavy water

Water consists of an atom of oxygen and two atoms of hydrogen. Oxygen is 16 times as heavy as hydrogen. So water, which is one part oxygen plus two parts hydrogen, is $16+2=18$ times as heavy as hydrogen. Here, by water, while comparing with hydrogen, usually a gas, we mean water in the form of vapour and not liquid water or ice.

Deuterium is the rare, 'heavier', form of the hydrogen atom, exactly like hydrogen in chemical behavior, but with a neutron, a neutral particle, in addition to the proton, in the nucleus. This makes the deuterium atom twice as heavy as the hydrogen atom.

Now if the two hydrogen atoms in water were replaced by deuterium atoms, then we have a 'heavy form of water, called 'heavy water'. This is exactly the same as ordinary water, except that the arithmetic changes to $16+2+2=20$. Or, heavy water weighs 20 units, where ordinary water weighs only 18 units, or heavy water is 10% heavier.

Heavier is slower

The molecules, of a gas or liquid are constantly in motion, bumping into each other and bouncing off the sides their container. The temperature of the substance, in fact, is a measure of the average speed of the particles. Heating the substance sets some of the particles moving faster. As the particles also constantly bounce off each other, this energy soon gets shared by all the particles, which settle down to some higher average speed. But, as the energy of a moving body depends on its mass as well as its speed, heavier particles move slower, for the same temperature.

And molecular motion?

Because each Heavy Water molecule is heavier, it moves slower, at a given temperature, than a molecule of ordinary water. This is really the big difference between heavy water and ordinary water. And it is this 'subtle' difference, that the molecules are in slower motion, which is now found to have a very useful application!

The Polio vaccine

This is a bit of weakened poliovirus, which enables the body to create defenses against possible attack by the real virus. The vaccine is carried in a water base and is administered orally to young children, through massive immunisation campaigns.

The big trouble is that the vaccine is easily damaged or 'denatured' by the impacts of molecular motion of water, at ordinary temperatures. Hence, the vaccine needs to be kept chilled, to slow down the molecular agitation. This is necessary right from the lab where the vaccine is made, all the way to the village, where it is used. Lack of refrigeration, or uncertain power along the way are thus major impediments to the polio eradication drive.

Enter heavy water

Heavy water, with the heavier molecule, has substantially 'slower' molecular motility even at ordinary temperatures. Hence, if the polio vaccine is carried in a base of heavy water, the vaccine is found to stay alive for a few days even without refrigeration. Heavy water, which is produced for nuclear reactors, may thus be used as the vehicle for polio vaccine, and beat the 'cold chain' problem in the third world.
