Tritium trinkets

Scientists take nomenclature seriously, but tritium was named in a casual aside. Brett F. Thornton and Shawn C. Burdette discuss the heavy, radioactive hydrogen isotope that is available for purchase online.

Why is ^{3}H called tritium and not simply hydrogen-3? More specifically, why have ^{2}H and ^{3}H been named as if they are elements, when thousands of other isotopes are not deemed worthy? In the early 1900s, a number of radioactive isotopes held individual names, but these fell out of use long ago. IUPAC formally disallowed isotope names, except those of hydrogen, in 1957. Only a few unsanctioned exceptions — such as radiocarbon for ^{14}C, thoron for ^{220}Rn and ionium for ^{230}Th — persist in specialized fields.

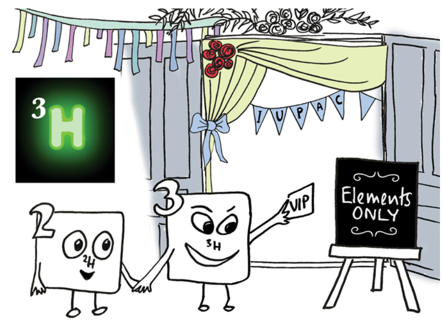
When the concept of isotopy was realized, many isotopes that had previously been seen as unique elements were grouped together as single elements on the periodic table due to their apparently identical chemistry. Although slight chemical differences had been observed for some isotopes, the discovery of hydrogen isotopes was a significant inflection point. ^{2}H and ^{3}H clearly did not behave exactly like 'ordinary' ^{1}H in chemical reactions, which provided a clear rationale for naming them separately. Soon after the discoveries of ^{2}H and ^{3}H, chemistry teachers were told[1] to exercise "caution in stating that the chemical properties of the isotopes of an element are identical" — a caution that even today is not always heeded.

American scientists Harold Urey, George Murphy and Ferdinand Brickwedde, who had discovered deuterium in 1932, proposed the name tritium for the not-yet-discovered ^{3}H in their 1933 report[2] in which the name deuterium was suggested for ^{2}H. This pre-emptive proposal for ^{3}H added further controversy to what soon became an acrimonious public debate over the appropriateness of the name deuterium[3]. Across the Atlantic, Ernest Rutherford endorsed diplogen for ^{2}H and diplon for its nucleus. His fame provided visibility to these alternatives. Soon thereafter, in early 1934 at Cambridge University, Mark Oliphant, Paul Harteck and Ernest Rutherford reported[4] producing ^{3}H by 'diplon' bombardment of 'diplogen'. The article conspicuously did not mention, or suggest, a name for the new isotope.

The initial Cambridge report incorrectly claimed ^{3}H was stable, because the other reaction product, ^{3}He, was believed to be the source of radioactivity[3]. By the time the opposite was shown to be true[5], the name tritium was already in common use. Shortly before his death in 1937, Rutherford penned a retrospective on ^{3}H advocating for the name triterium (ref. [6]). Despite his efforts, triterium did not displace Urey's tritium, and triplogen, the counterpart to diplogen, gained even less support.

Tritium occurs naturally on Earth, although in vanishingly low concentrations. It is produced in the stratosphere, where cosmic ray spallation releases neutrons that impact ^{14}N to yield ^{12}C and T. The natural amount of tritium in the entire atmosphere may be less than 2 kg, but testing of fusion weapons produced about 200 kg more by the early 1960s. Its decay (12.3 year half-life) has proven useful for many geophysical tracer studies, especially in surface and groundwater systems, as well as the oceans. Tritium is an extremely weak β-emitter, not harmful unless inhaled or ingested in unlikely large quantities. Furthermore, its decay product is the stable ^{3}He. These characteristics make tritium one of the most widely available radioactive substances. A wide selection of keychains, necklaces and watches can be easily purchased online that incorporate a minuscule amout of tritium, whose decay excites a phosphor, such as copper-doped ZnS, providing self-luminescence for years without batteries or external power.

Tritium remains special amongst the isotopes — and not just on account of its name. The T + D reaction is the most promising one for fusion energy in the future. As the isotopes of an element differ only by their number of neutrons, the relative mass difference between an element's isotopes is greater for lighter elements, and greatest by far for hydrogen. Vast fields of research now depend on slight variances in isotope chemistry, often driven by the differing masses. But although ^{208}Pb is about 0.5% heavier than ^{207}Pb, and ^{13}C is about 8.5% heavier than ^{12}C, T is about 200% heavier than ^{1}H. With this huge relative mass difference, T versus ^{1}H is an extreme outlier compared to isotope pairs of other elements. A pity, perhaps, that the relatively short half-life and rarity make its bulk chemistry more difficult to study, as tritium is truly in a class of its own for isotope effects. ❐



Credit: Emma Sofia Karlsson, Stockholm, Sweden

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