# Uuh? No. It's livermorium!

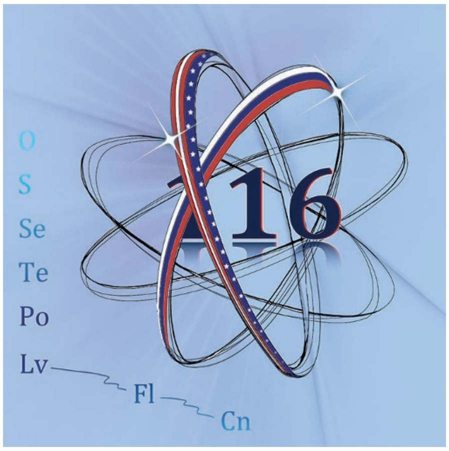
Alpha decay into flerovium? It must be Lv, says **Kat Day**, as she tells us how little we know about element 116.

At the end of last year, the International Union of Pure and Applied Chemistry (IUPAC) announced the verification of the discoveries of four new chemical elements, 113, 115, 117 and 118, thus completing period 7 of the periodic table[1]. Though now named[2] (no doubt after having read the Sceptical Chymist blog post[3]), we shall wait until the public consultation period is over before In Your Element visits these ephemeral entities.

In the meantime, what do we know of their close neighbour, element 116? Well, after a false start[4], the element was first legitimately reported in 2000 by a collaborative team following experiments at the Joint Institute for Nuclear Research (JINR) in Dubna, Russia. There, scientists bombarded a $^{248}$Cm target with accelerated $^{48}$Ca ions. Just by simple summation of the respective atomic numbers, 96 and 20, one might predict that element 116 would make an appearance; and so it proved, as the team successfully detected the alpha decay of a single such atom. The results were later repeated by the same group, and have since been confirmed by other laboratories[5].

Element 116 was officially named livermorium (Lv) in May 2012, having been known previously by its systematic designation, ununhexium, with the symbol Uuh. The new name recognized the Lawrence Livermore National Laboratory in California — host to some of the original team responsible for the discovery, provider of the curium target, and an institution that has contributed much to the advancement of nuclear science generally. It was said in 2011 that the Russian vice director of the team at JINR favoured the name moscovium, after the Moscow region, for the new element. It now seems that this suggestion will be employed for element 115.

Like all of the superheavy elements, livermorium is very unstable. The isotopes $^{292}$Lv, $^{291}$Lv and $^{290}$Lv all have half-lives of less than twenty milliseconds. Even its longest-lived isotope, $^{293}$Lv, has a half-life

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of only about sixty milliseconds before decaying into flerovium (Fl, element 114), and in turn copernicium (Cn, 112) (ref. 6). As a consequence, scientists have been unable to collect a significant quantity for determination of its physical properties. Indeed, only about 35 atoms of it have ever been observed.

That said, thanks to its position in the periodic table, we can perhaps make some predictions. It falls into group 16 — known as the chalcogens — which also contains oxygen, sulfur, selenium, tellurium and polonium. Like the others in its group, it's predicted to have six electrons in its valence shell, with an electronic configuration of $7s^2\,7p^4$. However, electrons in superheavy elements move much faster than those in lighter atoms. As a result, the $7s$ and $7p$ electron energy levels are expected to be very stable, the $7s$ particularly so due to the inert pair effect. Two of the $7p$ electrons are also expected to be more stable than other four.

The upshot is that the +2 oxidation state is likely to be favoured[7]. There should also be an accessible +4 oxidation state, although it would probably only be achievable with very electronegative ligands such as fluorine (for example, $LvF_4$). Conversely, the +6 oxidation state — observed for all the other elements in this group bar oxygen — is unlikely to occur due to the difficulty of removing the $7s$ electrons. We see comparable patterns of behaviour in polonium, which we'd expect to have very similar chemistry. The most stable class of polonium compounds are polonides, for example $Na_2Po$ (ref. 8), so in theory $Na_2Lv$ and its analogues should be attainable, though they are yet to be synthesized.

Experiments carried out in 2011 showed that the hydrides $^{213}BiH_3$ and $^{212m}PoH_2$ were surprisingly thermally stable[9]. $LvH_2$ would be expected to be less stable than the much lighter polonium hydride, but its chemical investigation might be possible in the gas phase, if a sufficiently stable isotope can be found.

Despite the considerable challenges posed by the short-lived nature of livermorium, scientists are keen to explore its chemistry experimentally. As Robert Eichler, head of the heavy elements research group at the Paul Scherrer Institute in Switzerland concludes, more model studies will be required to establish the most efficient way to produce these new superheavy element species, but "chemistry has arrived on the island of stability of superheavy elements"[9]. It seems unlikely that scientists will ever carry out experiments on test tubes full of livermorium, but new insights may not be that far away. ❒

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