Element 106: Soviet and American Claims in Muted Conflict

The 14th transuranium element to be produced by man has apparently been synthesized more or less simultaneously by groups in the United States and the Soviet Union. The Soviet group announced their synthesis of element 106, eka-tungsten, at an international conference last June in Nashville. The American group made a similar announcement in Atlantic City last month at a meeting of the American Chemical Society. The American claim seems to be on firm ground, but the Soviet claim appears less so, and the Americans are still trying to duplicate the Soviet results. The two groups have agreed that neither will assign a name to the new element until the priority of synthesis is established.

The relative soundness of the two claims is a result of the techniques used to detect and identify the newly formed eka-tungsten. These techniques, in turn, are dependent on differences in the method used to produce the element. And the principal difference is the size of the ions used to bombard the target substrate.

The Soviet group, headed by Georgi N. Flerov of the Joint Institute for Nuclear Research in Dubna, used much heavier ions than the Americans did. In a series of related experiments, the Soviet group bombarded a target of lead atoms with ions of various weights. First, they used argon ions (atomic number, 18) to form a short-lived isotope of fermium (atomic number, 100) that decayed by spontaneous fission. Then they used ions of titanium (atomic number, 22) to produce a similarly short-lived isotope of element 104—which will be named either kurchatovium or rutherfordium, depending on the settlement of Soviet and American claims of priority of synthesis. Satisfied with these results, they finally used ions of chromium (atomic number, 24) to produce what they think to be element 106.

The presumed element 106, which is thought to have either 151 or 152 neutrons, also decays by spontaneous fission with a half-life of about 4 to 10 milliseconds. And therein lies the problem. The Soviets assume that the chromium and lead will combine to form element 106 and that the fission results from that product, but it is equally likely that it results from a spallation product—that is, from lead nuclei being shattered by the chromium ions. Theoretical calculations lead to the prediction, in fact, that it is highly unlikely that eka-tungsten would be formed in the collision of chromium with lead, and many American investigators are arguing that more conclusive evidence is necessary before they will accept the Soviet claim.

In contrast, the American group, headed by Albert Ghiorso of the University of California's Lawrence Berkeley Laboratory, used their newly modified super-HILAC accelerator (Heavy Ion Linear Accelerator) to bombard a target of californium-249 (atomic number, 98) with ions of oxygen-18 (atomic number, 8). The oxygen ions combine with molecules in the target, release four neutrons per collision, and become eka-tungsten–263. This isotope of element 106 has a half-life of 0.9 second but, contrary to earlier predictions, it does not decay by spontaneous fission. Instead, it emits an alpha particle with an energy of 9.06 million electron volts to become an isotope of element 104. This previously observed daughter isotope emits an alpha particle with an energy of 8.8 million electron volts to become nobelium-255 (atomic number, 102). Nobelium-255, in turn, is known to emit an alpha particle with an energy of 8.11 million electron volts. The experimental observation of this complete sequence of transmutations is considered conclusive proof of the formation of eka-tungsten.

A 4-Year Delay

The American investigators first observed element 106 in 1970, but lead impurities in the target made it difficult to obtain conclusive evidence that the new element existed. Shortly thereafter, the HILAC accelerator was shut down for 2 years for installation of the improvements that were to make it the super-HILAC. After it was reopened, other experiments took priority, and it was only recently that the group, which includes Glenn T. Seaborg, J. Michael Nitschke, Jose R. Alonso, Carol T. Alonso, and Matti Nurmia, had a chance to repeat their experiments.

The group also used the time for the preparation of a new, purer target. Ultimately, E. K. Hulet and R. W. Lougheed of the Lawrence Livermore Laboratory devised a technique for separating volatile lead fluoride from the slightly less volatile californium fluoride. With this technique, they achieved a 30-fold additional increase in purification, and produced an aluminum-sheathed, 265-microgram target that contained less than 10^{-9} gram of lead. After development of the target, the rest of the synthesis was a straightforward repetition of the techniques the same group had used in the synthesis of elements 104 and 105, although the cross section for formation of the new element was a factor of 10 smaller, so the experiment was about ten times harder.

The isotope synthesized at Berkeley contains 157 neutrons, which seems to be nearly the maximum number for stability. It has become a rule of thumb (for which there is no explanation) in the synthesis of the transuranium elements that those containing more than 157 neutrons are exceptionally unstable with respect to spontaneous fission. Although many isotopes containing 157 neutrons have been synthesized, only one has been prepared containing more. And that isotope, fermium-258, has a half-life of 380 microseconds, more than a thousand times shorter than that of its congener fermium-257. Similarly, no evidence has been obtained to suggest that isotopes containing more than 157 neutrons have been formed in underground nuclear explosions, even though theory predicts that such isotopes should be formed. It is thus possible that the American group is near the upper atomic number limit of elements that can be synthesized by their technique.

The American group is thus very interested in demonstrating that the results obtained at Dubna are correct. If the Soviets have, in fact, succeeded—and the Americans are not convinced that they have—then they will have demonstrated an entirely new approach to the synthesis of new, even heavier elements. With the use of heavier ions to bombard relatively small nuclei, it may be possible to make elements of higher atomic number while still keeping the total number of neutrons below the critical threshold of 157.

—Thomas H. Maugh II