CYCLOTRON INSTITUTE
TEXAS A&M UNIVERSITY

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CHEMISTRY for the Bottom of the Periodic Table

Techniques to investigate chemical properties of superheavy elements lead to improved methods for separating heavy metals

THE SCIENCE

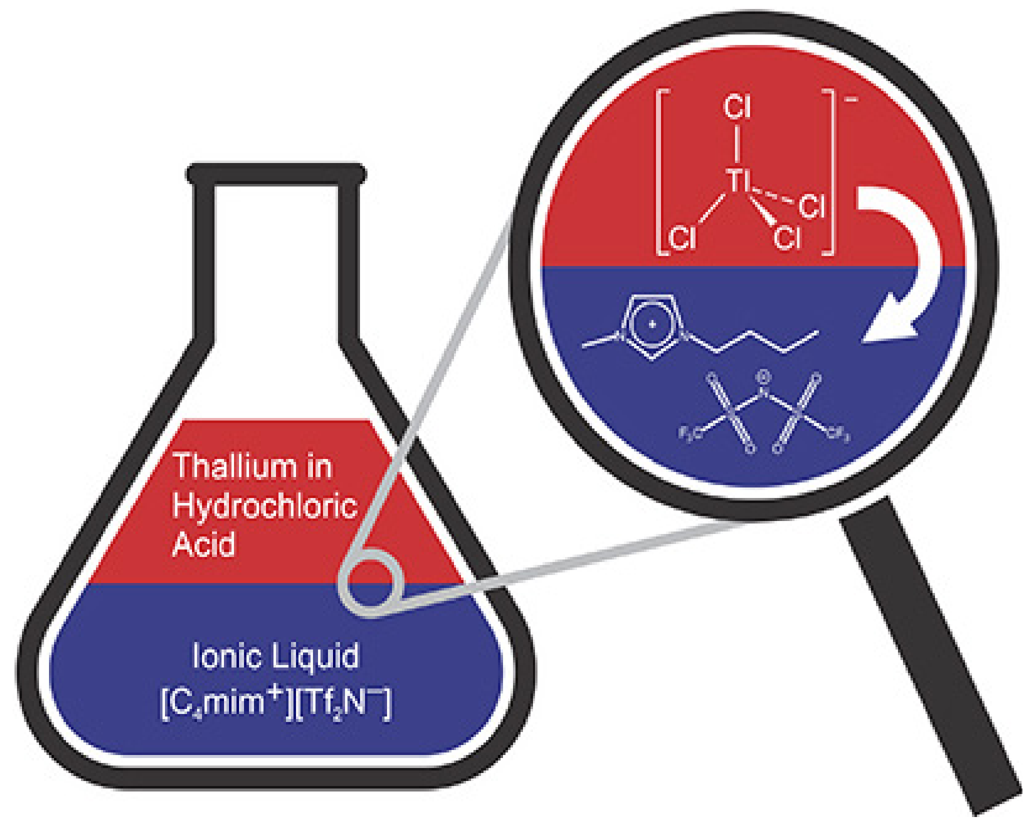
The chemical properties of superheavy element 113, nihonium, are almost completely unknown, so a team of researchers from the Cyclotron Institute at Texas A&M University and the Institut Pluridisciplinaire Hubert Curien in France are developing techniques that could be used to study this fleeting element. As part of that effort, they are comparing the properties of nihonium to the chemically similar elements indium and thallium; to do so, the team studied the separation of these two elements using a new class of designer molecules called ionic liquids.

THE IMPACT

Measuring the chemical properties of nihonium and other superheavy elements will increase our understanding of the principles that control the Periodic Table. Comparing the data from nihonium to results for similar elements, obtained using the team's fast, efficient, single-step process, reveals trends that arise from the structure of the Periodic Table. This research could also lead to better methods of re-using indium, a metal that is part of flat-panel displays but not currently mined in the United States.

SUMMARY

The distribution of indium and thallium between the aqueous and organic phases is the key to understanding the separation of these elements. An aqueous solution, containing trace amounts of the metals dissolved in hydrochloric acid, is put in contact with an ionic liquid. The latter is a class of non-toxic organic salts that are liquid at room temperature, in contrast with traditional salts, which are solids. The acid and the ionic liquid do not mix, like oil and water, so measuring which phase contains a certain metal can reveal its behavior and chemical form under these conditions. Thallium is preferentially found in the ionic liquid, and a systematic study of the reaction mechanism has shown that the key step is to convert thallium from its 1+ oxidation state to its 3+ oxidation state. This new technique could potentially be applied to the study of nihonium (recently recognized by the International Union of Pure and Applied Chemistry, the body that decides on the validity of elements) to help determine how many oxidation states it has, which is currently unknown.



The proposed mechanism of transfer. Thallium (Tl) bonds with chlorine (Cl) and moves into the ionic liquid (in blue).

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PUBLICATIONS

E.E. Tereshatov, M. Yu. Boltoeva, V. Mazan, M.F. Volia, and C.M. Folden III, "Thallium transfer from hydrochloric acid media into pure ionic liquids," Journal of Physical Chemistry B 120(9), 2311-2322 (2016).

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ABOUT THE CYCLOTRON INSTITUTE: *Dedicated in 1967, the Cyclotron Institute serves as the core of Texas A&M University's accelerator-based nuclear science and technology program. Affiliated faculty members from the Department of Chemistry and Department of Physics and Astronomy conduct nuclear physics- and chemistry-based research and radiation testing within a broad-based, globally recognized interdisciplinary platform supported by the United States Department of Energy (DOE) in conjunction with the State of Texas and the Welch Foundation. The facility is one of five DOE-designated Centers of Excellence and is home to one of only five K500 or larger superconducting cyclotrons worldwide.*