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New Understanding of Astatine's Chemical Properties Aids Targeted Alpha Therapy for Cancer

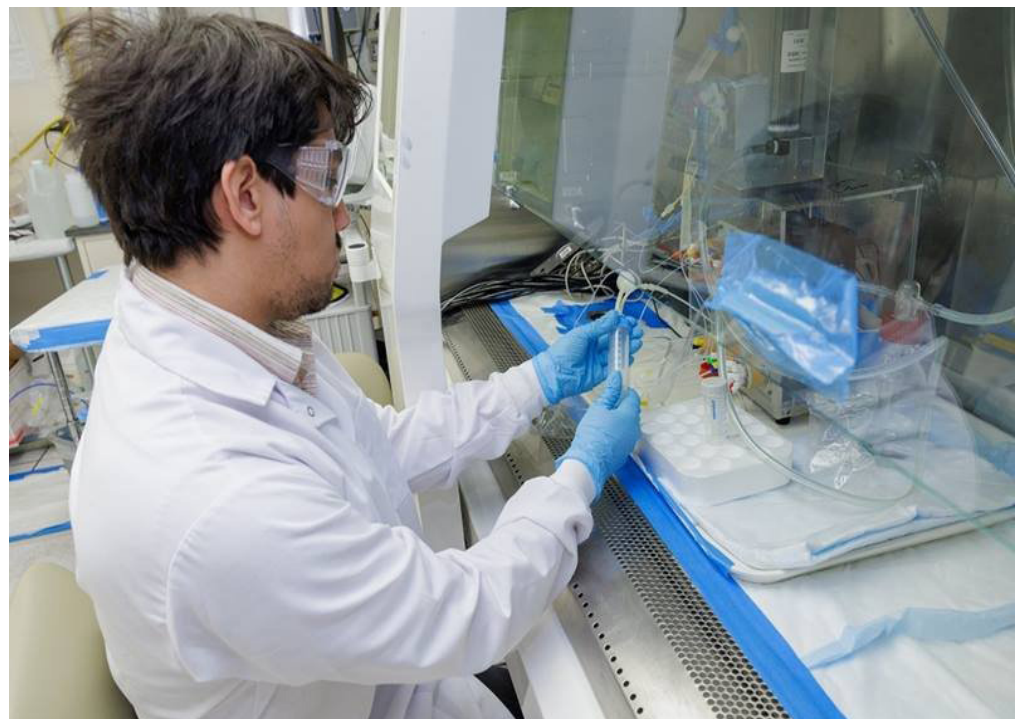
Researchers gain novel insight into how At-211 interacts with resins commonly used to purify the isotope for therapeutic use

THE SCIENCE
Astatine is one of the least-studied elements of the Periodic Table, because all isotopes of astatine are unstable, with the longest half-life barely exceeding 8 hours. Thus, only radiochemists at production facilities (limited worldwide) can have access to this element to study its properties in a timely manner. Most of these isotopes undergo alpha decay. This type of radioactive decay releases alpha particles, which consist of two protons and two neutrons. These alpha particles can target and destroy diseased cells in the body. One such isotope, astatine-211 (At-211, which has a 7.2-hour half-life), is among the most promising alpha emitters for cancer therapy. In this research, scientists investigated and explained astatine's behavior when interacting with ion exchange and extraction chromatography resins. Ion exchange and extraction resins are able to selectively isolate and purify radioactive isotopes to make them available for use as cancer therapies. The research examined a variety of different resins to optimize At-211 separation and purification and determined fundamental chemical parameters responsible for the strength of At-211 bonding to various extraction and ion exchange resins..

THE IMPACT
Targeted Alpha Therapy (TAT) is one of the most powerful cancer treatments. It takes advantage of alpha particles' ability to cause large amounts of damage near a tumor cell while keeping the surrounding tissues practically intact. Alpha therapy is also efficient: one short-range alpha particle can cause as much damage to tumor cells as 10,000 longer-range beta particles. At-211 is currently a promising radionuclide choice for TAT. One of the challenges for TAT is how to selectively deliver the radioactive material to a tumor site. Since astatine exhibits both metal and nonmetal properties, it can have different behavior than other related halogens on the periodic table, reacting more like a radiometal depending on the oxidation state. The new discovery on At-211's chemical properties in this research helps scientists understand how it binds to a targeting molecule and therefore allows for the optimization of its radiolabeling for TAT.

SUMMARY
At-211 is available through the Department of Energy Isotope Program (DOE IP). As a part of the DOE IP University Isotope Network, Texas A&M's K150 cyclotron is capable of producing medically relevant quantities of At-211 and can deliver it to nearby facilities using overnight shipping.

In this study, researchers investigated and explained the behavior of At-211 upon its interaction with commercially-available ion exchange and extraction chromatography resins. These resins consist of organic spherical beads with different functional groups. The chemical interaction of At-211 with any of these groups results in bonds forming between selected analytes. The results shed light on the strength of At-211 binding to molecules with a variety of functional groups. The researchers conducted the numerical estimation of the strength using mathematical modeling of possible chemical processes at the border between liquid aqueous and solid organic phases. This knowledge helps to plan and optimize radiolabeling procedures for efficient TAT drug development. Understanding the fundamental chemical properties of At is essential for tuning parameters leading to efficient application of TAT drugs and reliable delivery of At-211-containing molecules to tumor cells.



Student working in a Texas A&M University laboratory processing astatine-211. (Credit: Texas A&M University)

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PUBLICATIONS
Tereshatov, E.E., et al., "Mechanism of Astatine and Bismuth Sorption on Extraction Chromatography Resins from Nitric Acid Media," Chemical Engineering Journal 464, 142742 (2023).

Tereshatov, E., et al., "Ion exchange behavior of astatine and bismuth," New Journal of Chemistry 47, 12037-12047 (2023).

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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 the 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.*