Liquid-liquid Extraction of Vanadyl as a Probe of Vanadium's Suitability as a Surrogate for Astatine
Michael Jones, Noimat Jinadu, and Jonathan Burns

Abstract:
The rapidly growing field of radiopharmaceuticals, specifically Targeted Alpha Therapy (TAT) agents, has necessitated the development of new radionuclides to treat various types of cancer. One promising isotope is \(^{211}\text{At}\), currently of interest due to its simple decay scheme, stable granddaughter nuclei, and short half-life (roughly 7.2 h). Inquiry into At chemistry has been complicated by the lack of a stable, or long-lived isotope, where \(^{212}\text{At}\) is the longest lived \((t_{1/2} = 8.1\text{ h})\). This requires not only very efficient systems for separation and purification, but also that studies occur near facilities capable of synthesizing \(^{211}\text{At}\). Along with its halogen-like properties, At also possesses metallic character, forming the unique oxocation \(\text{AtO}^+\) in acidic conditions. Knowing this, a non-radioactive chemical surrogate would allow for separation systems to be more extensively screened; the vanadyl cation, \(\text{VO}^{2+}\), has a similar geometry to that of \(\text{AtO}^+\); while only having metallic properties, as its frontier orbitals are \(d\)-orbitals compared to the \(p\)-orbitals of \(\text{AtO}^+\). This project looks to probe the suitability of \(\text{VO}^{2+}\) as a surrogate for \(\text{AtO}^+\) by comparing the extraction behavior of both oxocations into either 1-octanol or 3-octanone from either nitric or hydrochloric acid.

Background \(^{211}\text{At}\):

Studies with Vanadyl:
Vanadyl is the only other stable monoxide molecular cation in aqueous solution on the periodic table

\[
\begin{align*}
D_{\text{VO}^{2+}} \text{ into 1-octanol} & \\
\hline
\text{HNO}_3 & \text{HCl} \\
1 \text{ M} & <0.01 & <0.1 \\
2 \text{ M} & <0.01 & <0.1 \\
3 \text{ M} & <0.01 & <0.1 \\
4 \text{ M} & <0.01 & <0.1 \\
5 \text{ M} & <0.01 & <0.1 \\
6 \text{ M} & <0.01 & <0.1 \\
7 \text{ M} & <0.01 & <0.1 \\
8 \text{ M} & <0.01 & <0.1 \\
\end{align*}
\]

Conclusion:
• Vanadyl does not appear to be a good surrogate for \(^{211}\text{AtO}^+\) in liquid-liquid extraction systems

Future Work:
• Examine vanadyl utility as a surrogate for \(^{211}\text{AtO}^+\) in ion exchange systems

Acknowledgments:
This work was supported in part by Department of Energy Isotope Program’s Grant DE-SC0022550, the Horizon-broadening Isotope Production Pipeline Opportunities (HIPPO) program. We also gratefully acknowledge support from the College of Arts and Sciences and the O’Neal Comprehensive Cancer Center at the University of Alabama at Birmingham.