Steps Forward in Astatine-211 Production and Chemistry at Texas A&M University

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New since 2020

• Beam Development
  – Higher Current (over 8 uA overnight)
  – Stability

• Target Development
  – Thinner, Less Bismuth, Ultrasonic Soldering Iron
  – 90º from beam, Directly Cooling Back

• Target Extraction:
  – Air monitoring system

• Dissolution & Separation:
  – Column can capture ~95% of astatine activity from >50mCi dissolved activity
  – 86% of the captured activity eluted in 1\textsuperscript{st} 2 mL EtOH strip

K150 Cyclotron

- $^{209}\text{Bi} + \alpha \rightarrow ^{211}\text{At} + 2n$
- Energy: 28.8 MeV
- $+1$ charge state
Bi-209 Targets

- Bi pellets
- Hot plate
- Ultrasonic soldering iron
Target Apparatus

Water directly on target
Tested with an industrial heat gun and thermocouple
Beam Uniformity

- 37 Faraday Cups
- 5 s read time
Current on Target: July 2021

The graph shows the current (µA) over time of day for July 2021. The data points are scattered across various times, indicating fluctuations in current throughout the day. The x-axis represents the time of day, while the y-axis shows the current in µA. The data points are visualized as blue dots.
CdTe Detector

- X-Rays
- Confirmation of Clean Extraction
- Working on efficiency to confirm amount produced

End of Beam (EOB) ~20 min

Noise

76.8 keV
79.2 keV
89.5 keV
92.4 keV
Target Extraction

• ALARA
• Air Monitoring System
<table>
<thead>
<tr>
<th>Irradiations</th>
<th>Highest Instantaneous Beam Current (pμA)</th>
<th>Average Beam Current (pμA)</th>
<th>Irradiation Length (h)</th>
<th>At-211 Activity at EoB (mCi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 2019</td>
<td>4.4</td>
<td>2.7</td>
<td>8</td>
<td>24 ± 2</td>
</tr>
<tr>
<td>March 2020</td>
<td>3.5</td>
<td>3.2</td>
<td>9</td>
<td>41 ± 3</td>
</tr>
<tr>
<td>June 2020</td>
<td>4.5</td>
<td>2.1 (Unstable)</td>
<td>9.4</td>
<td>8.0 ± 1.3</td>
</tr>
<tr>
<td>August 2020</td>
<td>2.6</td>
<td>2.4</td>
<td>9.6</td>
<td>21 ± 2</td>
</tr>
<tr>
<td>September 2020</td>
<td>7.4</td>
<td>5.1</td>
<td>7.3</td>
<td>22 ± 2</td>
</tr>
<tr>
<td>October 2020</td>
<td>5</td>
<td>4.0</td>
<td>7.9</td>
<td>12 ± 1</td>
</tr>
<tr>
<td>November 2020</td>
<td>7.2</td>
<td>4.2</td>
<td>9.7</td>
<td>24 ± 2</td>
</tr>
<tr>
<td>December 2020</td>
<td>6.8</td>
<td>4.8</td>
<td>13.6</td>
<td>47 ± 5</td>
</tr>
<tr>
<td>April 2021</td>
<td>8.2</td>
<td>5.6</td>
<td>15.6</td>
<td>17 ± 5</td>
</tr>
<tr>
<td>May 2021</td>
<td>7.0</td>
<td>4.8</td>
<td>14.2</td>
<td>14 ± 1</td>
</tr>
<tr>
<td>June 2021 a</td>
<td>8.6</td>
<td>7.0</td>
<td>14.8</td>
<td>24 ± 2</td>
</tr>
<tr>
<td>June 2021 b</td>
<td>11.7</td>
<td>8.8</td>
<td>14.8</td>
<td>42 ± 4</td>
</tr>
<tr>
<td>July 2021 a</td>
<td>11.9</td>
<td>7.59</td>
<td>15</td>
<td>60 ± 6</td>
</tr>
<tr>
<td>July 2021 b</td>
<td>12.1</td>
<td>9.2</td>
<td>19.7</td>
<td>53 ± 5</td>
</tr>
</tbody>
</table>
Column Chemistry


Column sat for 3.5 hours.
Continued studies of liquid-liquid astatine extraction

\[ \frac{D_{\text{At}}}{C_{\text{aq}}/C_{\text{org}}} \]

\[ K_{\text{ext,At}} = 126 \pm 32 \]
\[ K_1 = 0.62 \pm 0.27 \]
\[ \beta_2 = 0.237 \pm 0.033 \]
Summary

• **Beam and Targets:** Approximately doubled $^{211}\text{At}$ production capability in the past year.

• **Separation:** Column extracts At-211 from Bi quickly, automated system underway.

• **Shipping:** Successfully shipped to MD Anderson.

• **Fundamental Chemistry:** Oxidation state studies & ligand exchange experiments ongoing.

• **Availability:** In the future, through NIDC
TAMU At-211 Team

Jon Burns (now UAB)
Evgeny Tereshatov
Gabriel Tabacaru
Laura McCann (GS)
Kylie Lofton (UG)
Alex Tabacaru (UG)
Steve Schultz (GS)
Sherry Yennello

Operations:
Dan Menchaca (RSO)
Brian Roeder (AP)
Acknowledgments

• Cyclotron Operations & Rad Safety Staff
• Texas A&M University System National Laboratories Office
• Los Alamos National Laboratory
• Isotope Program: DE-SC0020958
• DOE: DE-FG02-93ER40773
• NNSA Grant: NA-DE0003841 (L.A. McIntosh)
• Bright Chair at TAMU
• T3 Grant from TAMU
• TAMU Nuclear Solutions Institute
• NSF GRFP (L. McCann)
Questions?