Prototype testing of $^{99}$Mo/$^{99m}$Tc generators using $(n,\gamma)$ $^{99}$Mo
Talking Points

- PESI/PFM novel resin and its application to the production of $^{99}\text{Mo}$ generators
- Past and Current Studies
- Path forward
- Questions
Micro-porous Composite Material (MPCM)

- Preparation of MPCM:
  - MPCM was prepared with or without TiO$_2$ using addition and condensation polymerization techniques in presence of catalyst
  - One of the key ingredients of MPCM resin is chitosan-a biopolymer

MPCM Characteristics

- MPCM has capacity to absorb up to 700 mg Mo/g MPCM
- MPCM is an acid resistant resin
- Temperatures up to 100 °C do not adversely affect the adsorption capacity of MPCM resin.
- The structure of MPCM has been demonstrated to maintain its integrity when exposed to 50 Mrad Co-60 gamma radiation
- The surface area of MPCM is about 15 m²/g with a pore volume of 0.012 cc/g
- TG analysis of both MPCM and irradiated MPCM reveals that the decomposition of the resin starts at ~200°C.
- XRD analysis reveals that MPCM is amorphous in nature

2014-2018

- Conducted prototypical generator tests at approximately 2 Ci, 4 Ci, and ~6 Ci with natural Mo, and ~6 Ci with 98% enriched $^{98}$Mo
- Awarded $2.8$ MM grant from EU (STRATEGMED Biotechnet)
- All tests successfully loaded $^{99}$Mo onto the MPCM in a column
- All tests demonstrated 70 to 80+% $^{99m}$Tc yield
- Elutions were accomplished with pumps or evacuated vials
- No detectable degradation to the resin or eluate
Progress to Date

- Resin Development- accomplished
  - Resin preparation and conditioning
  - Radiation tolerance limit of the resin was conducted up to 75 MRad using e-beam
- Mo specifications- accomplished
  - Mo target material specifications and testing (POLATOM)
  - Demonstration of 2, 4, ~6 Ci generators with Mo-natural and Mo-enriched.
    - confirmed that the MPCM resin could withstand higher levels of radiation, while providing clinically useful doses of Tc-99m.
Progress to Date, cont’d

• Currently
  • Demonstration of a ~1Ci functional prototype generator completed under STRATEGMED program
  • Extensive testing of eluents
    • FDA and US and European Pharmacopeia specifications
    • Biological testing (in vivo and in vitro)
    • Radiochemical and radionuclidic purities

• Extensive Testing of compounding kits
  • Warsaw Medical University
  • Ongoing testing with Sestamibi, Ceretec, and MAG3 test kits to ensure reliable reproducible results
Typical Elution Profile of $^{99}$Mo Prototype Generators

4.8 Ci Column Testing Profile

- Mo-99
- Tc-99m
- total Tc-99m recovered
- Tc-99m max theor

(generator life (hrs))

(mCi)
Typical Elution Profile of ~1Ci $^{99}$Mo Prototype Generators

![Graph showing elution efficiency](chart)

Elution Efficiency

$y = 3.100x + 81.167$

$R^2 = 1.000$

Efficiency (%)

Day

1

2

3
**99Mo Prototype Generators**

<table>
<thead>
<tr>
<th>Eluant Quality Parameter</th>
<th>Typical Value</th>
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<tbody>
<tr>
<td>Radiochemical Purity</td>
<td>&gt; 95%</td>
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<tr>
<td>Radionuclidic Purity</td>
<td>&lt; 0.15 μCi 99Mo/mCi 99mTc</td>
</tr>
<tr>
<td>Other gamma emitting radionuclides</td>
<td>&lt; 0.5 μCi/mCi 99mTc</td>
</tr>
<tr>
<td>Aluminum</td>
<td>&lt; 10 μg/mL</td>
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<tr>
<td>Clarity</td>
<td>Clear</td>
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<tr>
<td>pH</td>
<td>4.5 - 7.5</td>
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</tbody>
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Final Design Goal

- 1-10 Ci (n,γ) $^{99}$Mo generator comparable in size to fission $^{99}$Mo generator
- Column Bed Volume: 2.5 – 16 mL
- Elution process similar to conventional HEU/LEU generator
- Eluate solution compatible with all kits
- Elution elapsed time < 10 minutes using evacuated vials
- Competitive price
- 1 - 4 Ci $^{99}$Mo /g MPCM in column
- Natural Mo and enriched $^{98}$Mo can be used as targets
Path Forward

- Memorandum of Understanding with ENEA (Italian Nuclear Agency)
  - 2018 – Finalize design and construct 0.5 – 2 Ci prototype
  - 2019 – Prototype testing
    - cGMP Production line design
    - Initiate discussions with AIFA
  - 2020 – AIFA accreditation
  - 2021 – Provide 0.5 – 2 Ci generators to Italy and East European market
- 2018-2020 – Develop 6 – 10 Ci generator for US FDA application
Questions?

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