New projects for regional or global molybdenum-99 supply

- Kijang New Research Reactor (KJRR) Project -

2017. 7. 17

UL JAE PARK
Radioisotope Research Division
1. Overview of KJRR Project
2. Current Issues of KJRR Project
4. Plan to increase demand or supply
5. Summary
Insecurity of Medical Radioisotopes (Mo-99) Supply in Korea ➔ Major issue (100% from Outside)
- Self-sufficiency of RI demand became an issue for health care
- Require to secure the medical welfare.

New Research Reactor Project in Korea
- Launched in 2012.
- Location: Kijang, Busan.
- Phase: PSAR review for C.L.
- Main function
  - Fission Mo Production Capacity: 2,000Ci/w.
  - Ir-192, I-131, 125, Lu-177 etc.
Quantum Jump in RI Production

Lab-scale RI production

1962

TRIGA MARK II (250 kW)

- Lab-scale production

1973

TRIGA MARK III (2 MW)

- Iodine 131 (n, γ): 2~3 Ci/batch
- Mo-99 (n, γ): small-scale

1996

HANARO (30 MW)

- Iodine 131 (n, γ): 30~40 Ci/batch
- Mo-99 (n, γ): 200 Ci/Yr
- Ir-192: 200,000 Ci/Yr

Commercial-scale production

2022

Kijang Research Reactor (15 MW)

- Iodine 131 (n, γ) + (n, fission): hundreds Ci/batch
- Mo-99 (fission): 100,000 Ci/Yr
- Ir-192: 500,000 Ci/Yr

1. Scale-up of commercial RIs
2. Diversifying research RIs

Routine production of medical RIs

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Significance of KJRR
KJRR Location

City of Busan (2nd, 3.5 M)
City of Ulsan (7th, 1.2 M)

Furthest from North Korea
✅ Construction Permit
- Request CP on Nov 24, 2014
- Recent earthquake (Magnitude 5.8) near the site (Sept 12, 2016)
- KINS requires us to show enough seismic margin

✅ Budget increase
- Review of project plan properness by MOSF and KISTEP
- Facility size increased considering GMP, waste treatment, etc.
Development of Fission-based Mo-99 Production Process and Facility
FM Target and KJRR Reactor Model
• Containing 15 g Uranium (3g U-235), overall weight is 53 g including the aluminum cladding and matrix.
• Density of the target meat is 2.6 g-U/cc
Process Scheme

Fission Mo Targets (UAl₅)

Dissolving process
Dissolution of Target in NaOH Solution (8 target plates)

Uranium Filter

Vacuum Tank

Iodine removal
Iodine Adsorption Column

Chemical Treat.
Al removal

Solid Waste I
Uranium Precipitates

Solid Waste II
Aluminum residue Iodine Column

Conditioning
Optimization for the Separation of ⁹⁹Mo

Further purification
Purification columns
FM final product

QC/ Packaging & Transport

Liquid Waste
Intermediate Level Liquid Waste

Precipitation of aluminum oxides

Gas Waste
Iodine Removal Xenon Treatment
Full-scale Prototype System (cold test)

- Dissolver
- Columns and Vessels
- Master-slave manipulator
- Mock-up hot cell
- Process control box
Arrangement of Reactor and FMPF

Reactor

FMPF (Fission Molybdenum Production Facility)

FM Production
Hot Cells

Irradiated FM target
Transfer Elevator
Domestic Demand: Korean $^{99}$Mo Market

- **High dependence on imported supply** of $^{99}$Mo
- **Only generators are manufactured** in a domestic company
- **Occurrence of $^{99m}$Tc supply shortage in 2008**

<table>
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<tr>
<th>Year</th>
<th>2003</th>
<th>2005</th>
<th>2007</th>
<th>2009</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
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<tr>
<td>Mo-99</td>
<td>20</td>
<td>1,973</td>
<td>3,301</td>
<td>3,225</td>
<td>5,811</td>
<td>5,746</td>
<td>4,774</td>
<td>4,167</td>
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<tr>
<td>Tc-99m Generator</td>
<td>5,963</td>
<td>6,490</td>
<td>5,676</td>
<td>2,919</td>
<td>1,650</td>
<td>1,968</td>
<td>2,218</td>
<td>2,584</td>
</tr>
<tr>
<td>Total</td>
<td>5,983</td>
<td>8,463</td>
<td>8,976</td>
<td>6,144</td>
<td>7,462</td>
<td>7,714</td>
<td>6,992</td>
<td>6,751</td>
</tr>
</tbody>
</table>

**Factors affecting the use of Mo-99/Tc-99m in Korea**
- Price increase by conversion of target: HEU to LEU
- Lack of reliable supply chain

Source: Korean Association for Radiation Application
International Mo-99 Supply Chain (Present)

- HFR Mallinckrodt
- BR2 IBA/CIS
- OSIRIS GE Health Care
- MARIA NTP Europe
- LVR-15 Mallinckrodt

Map showing locations and connections for the Mo-99/Tc-99m supply chain.
2,000 Ci/week Mo-99 will be produced from KJRR. (~18% international market share)

150 Ci/week is for domestic market.

1,850 Ci/week is for international market.

Supply will increase eventually over few years. (Flexible according to the market demand)

No Plan for further increment in Mo-99 supply.