2018 Mo-99 Topical meeting
Molybdenum-99 production technology development
September 23-26, 2018
Knoxville, TN

Argonne NATIONAL LABORATORY

ARGONNE SUPPORT FOR DOMESTIC AND INTERNATIONAL MO-99 PROGRAMS

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ARGONNE'S ROLE IN MO-99 PROGRAM

- Assisted and/or currently assisting multiple potential US Mo-99 producers
  1. BWXT – Aqueous Homogeneous Reactor
  2. NorthStar – Neutron Capture
  3. NorthStar - Accelerator
  4. SHINE – Accelerator-driven process for fission Mo-99
  5. Niowave – Accelerator-driven process for fission Mo-99
  6. GMIS – Accelerator-driven process for fission Mo-99
- Provided foreign Mo-99 producers with possible front-end processes to allow use of high density LEU-foil targets
  1. Low-pressure system for acidic dissolution
  2. Electrochemical dissolver
- Assisting IRE in their conversion efforts
- Cooperated with Necsa and NTP in developing
  - Recycling and downblending of spent HEU from Mo-99 production
  - Potential waste forms for irradiated LEU
- Cooperated with Indonesian BATAN and Argentine CNEA to develop and demonstrate the annular LEU foil target
- Cooperated with BATAN to develop and demonstrate the LEU-Modified Cintichem Process currently being used for their production of Mo-99
- Played a major part in many IAEA CRPs on conversion of Mo-99 production to LEU

MO-99 PRODUCED AT ARGONNE FITS IN THE EXISTING MARKET

- Sent >1 Ci Mo-99 produced at Argonne to GE Healthcare in the UK
- Mo-99 produced at Argonne loaded on GE Healthcare's Drytec™ Tc-99m generator
- Tc-99m product successfully tested with GE Healthcare's Myoview™ and Ceretec™ radiopharmaceutical kits

GE Healthcare

SHINE Medical Technologies

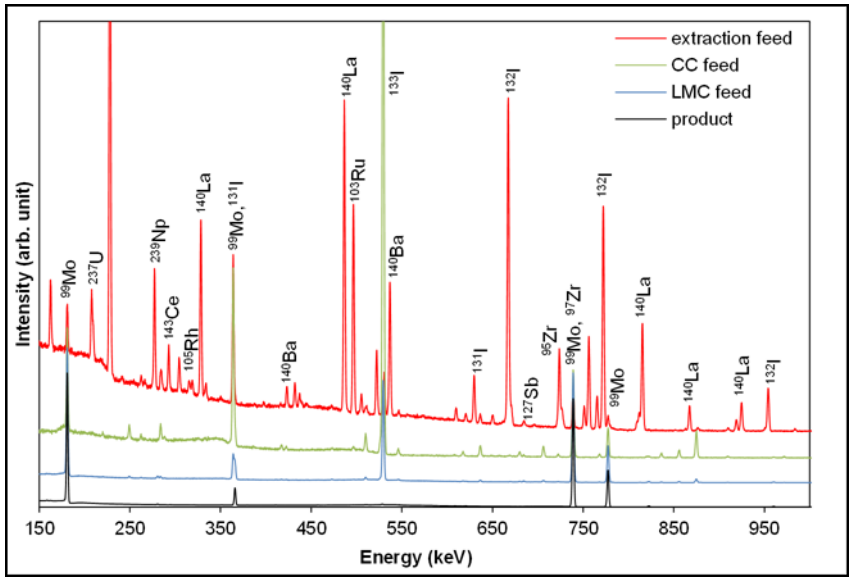
PRESS RELEASE

It Takes Two: GE Healthcare and SHINE team up to solve longstanding radiopharmaceutical supply concerns in medical imaging

Successful generation of Tc-99m is a supply chain advancement that can help ensure patient access to critical medical imaging scans.

CHALFONT ST. GILES, UK – 9 November 2015 – Technetium-99m (Tc-99m) is used in more than 40 million medical imaging procedures each year, primarily stress tests to assess heart disease, and bone scans to determine the stage of cancer progression. This essential medical isotope is generated in pharmacies and hospitals from another isotope—molybdenum-99 (Mo-99). Despite using half of the world's supply of Mo-99, the United States does not produce any domestically and imports 100 percent of its supply from foreign nuclear reactors. Many of these reactors are beyond their originally intended lifespans and outages have caused major shortages of Mo-99.

Ratio	Determined value 36 hrs after EOB	Product specification	Within specification
$^{131}I/^{99}Mo$	5.3E-06	$\leq 5\times10^{-5}$	YES
$^{103}Ru/^{99}Mo$	4.9E-06	$\leq 5\times10^{-5}$	YES
$\Sigma\alpha/^{99}Mo$	6.5E-12	$\leq 1\times10^{-9}$	YES



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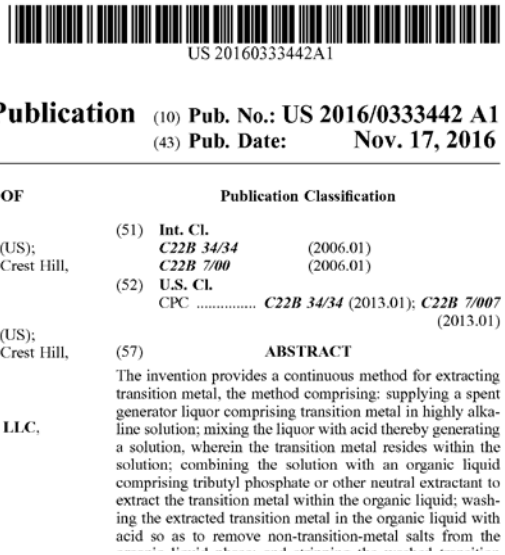
PATENT FOR MO RECYCLE



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(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2016/0333442 A1**

Tkac et al. (43) **Pub. Date: Nov. 17, 2016**

(54) **RECOVERY AND PURIFICATION OF TRANSITION ELEMENTS**

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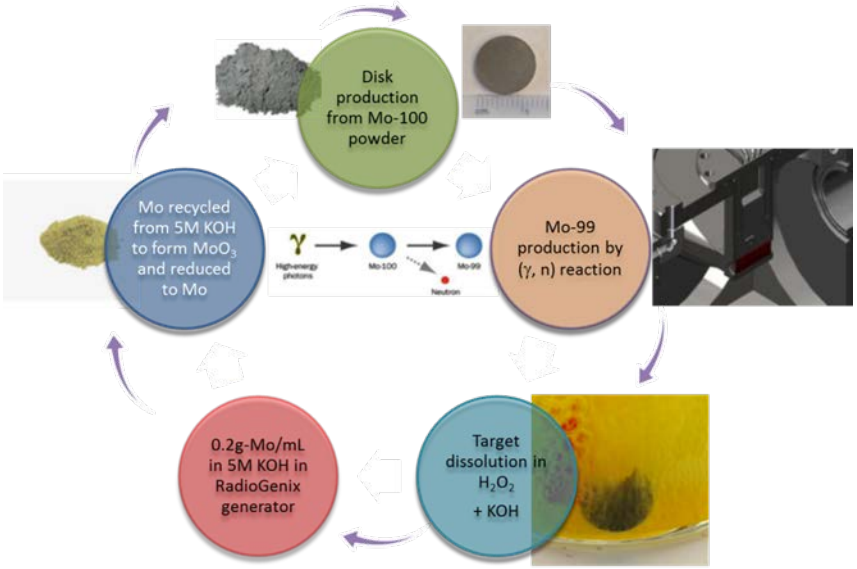
C22B 7/00 (2006.01)

(52) **U.S. Cl.**
CPC *C22B 34/34* (2013.01); *C22B 7/007* (2013.01)

(57) **ABSTRACT**

The invention provides a continuous method for extracting transition metal, the method comprising: supplying a spent generator liquor comprising transition metal in highly alkaline solution; mixing the liquor with acid thereby generating a solution, wherein the transition metal resides within the solution; combining the solution with an organic liquid comprising tributyl phosphate or other neutral extractant to extract the transition metal within the organic liquid; washing the extracted transition metal in the organic liquid with acid so as to remove non-transition-metal salts from the



- Currently in application phase
- Useful for potential producers using enriched Mo targets

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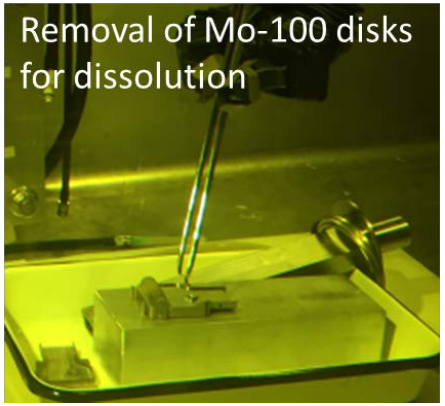
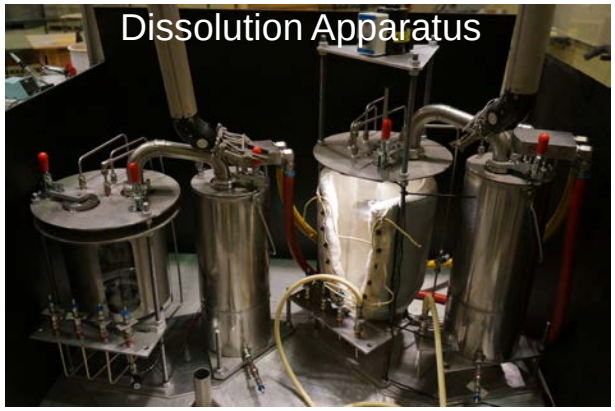
MO-99 PRODUCED AT ARGONNE TESTED WITH RADIOGENIX™ SYSTEM





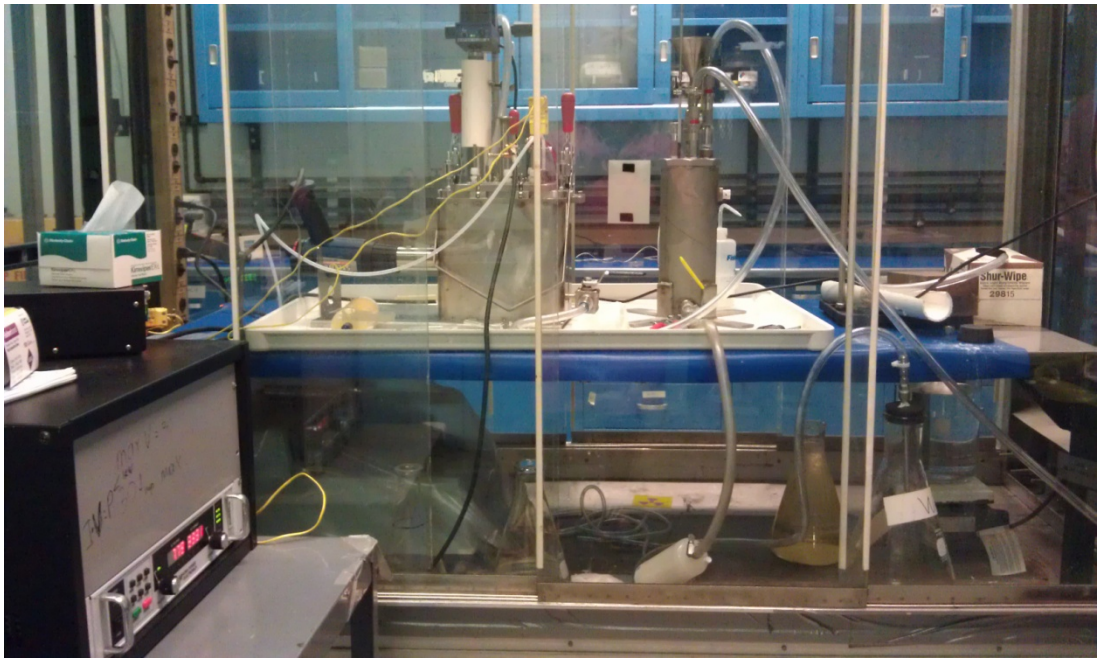
- 7-day irradiation using electron linac
- Six 95.08% Mo-100 enriched disks
- 12.4 Ci of Mo-99 produced in 6 disks and shipped for testing on Radiogenix™
- LANL developed and fabricated target

ARGONNE HD-TARGET FRONTEND PROCESSES

ACID PROCESS

- An acid process used nitric acid to dissolve LEU followed by Mo-99 recovery/separation on a titania column.

ELECTROCHEMICAL PROCESS



- An electrochemical process utilized anodic dissolution of LEU in carbonate followed by calcium precipitation.

IRE ASSISTANCE

- Argonne personnel attended 2 separate meetings in Belgium in FY-18 (February and August) to assist with their conversion efforts
- Argonne provided recommendations for improving iodine recovery

NECSA ASSISTANCE

- Argonne provided recommendations on their uranium down-blending report
- Argonne personnel visited NECSA in December 2017 to discuss progress on current work and consider direction of future work
- Argonne trained NECSA reactor analysts at Argonne in October 2017

TRAINING OF STAFF FROM MULTIPLE POTENTIAL US MO-99 PRODUCERS AT ARGONNE

- Argonne trained staff from multiple potential Mo-99 producers
- Staff from these companies are able to use the skills at their facilities

MULTIPLE TECHNICAL REPORTS AND JOURNAL PUBLICATIONS

- Over 112 technical reports generated – links available
- 11 peer-reviewed journal publications over the past 6 years

Fission-Produced 99Mo Without a Nuclear Reactor
Controlling Pu Behavior on Titania: Implications for LEU Fission-Based Mo-99 Production
Design of a Fission Mo Recovery Process and Implications towards Mo Adsorption Mechanism on Titania and Alumina Sorbents.
A Solution-Based Approach for Mo-99 Production: Considerations for Nitrate versus Sulfate Media.
Capture chromatography for Mo-99 recovery from uranyl sulfate solutions: minimum-column volume design method,
Molybdenum(VI) Coordination in Tributyl Phosphate Chloride Based System
MOEX: Solvent extraction approach for recycling enriched 98Mo/100Mo material
Recycle of enriched Mo targets for economic production of 99Mo/99mTc medical isotope without use of enriched uranium
A Novel Method for Anodic Dissolution of LEU Foil for Mo-99/Tc-99m Recovery
Design and Experimental Activities Supporting Commercial US Electron Accelerator Production of Mo-99
Simulations of a LINAC-based photoneutron source

ACKNOWLEDGEMENTS

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