Development of mesoporous alumina using pluronic-123 as a soft template for non-fission 99Mo/99mTc generator column

Research Center for Radioisotope, Radiopharmaceutical, and Biodosimetry Technology, National Research and Innovation Agency (BRIN)

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Indra Saptiama, M.Sc
indra Saptiama@brin.go.id

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Summary

Senior researcher at Research Center for Radioisotope, Radiopharmaceutical, and Biodosimetry Technology-BRIN. Strong background in project radioisotope production technology since 2011.

Experiences

- Developing some new materials adsorbent for Mo/Tc generator column based neutron-iradiated natural molybdenum
- Iodine-125 production by xenon loop technique
- Iodine-131 production with dry destillation process
- Iridium-192 seed for brachitherapy, etc

Education

Bachelor of Science: Chemistry, 2006-2010, University of Indonesia, Indonesia
Master of Science: Medical Sciences, 2017-2019, Tsukuba University, Japan

Outline

1. Organizations and Responsibilities
2. Non-fission Mo-99 productions
3. Brief status of Tc-99m production using non-fission Mo-99
4. Progress study of mesoporous alumina based Pluronic 123 as template for non-fission Mo/Tc generator

Transformation of Research Organization in Indonesia

Before 2022

Center for Radioisotope and Radiopharmaceutical Technology National Nuclear Energy Agency (BATAN)

- The duty to conduct formulation, and control of technical policies, implementation, and guidance in the field of technology in the production of radioisotope and radiopharmaceutical

2022 - present

Research Center for Radioisotope, Radiopharmaceutical, and Biodosimetry Nasional Research and Inovation Agency (BRIN)

Indonesia Research Reactor

- Nuclear science and Appied Tech.

Triga Mark II Reactor

G.A Siwabessy Reactor

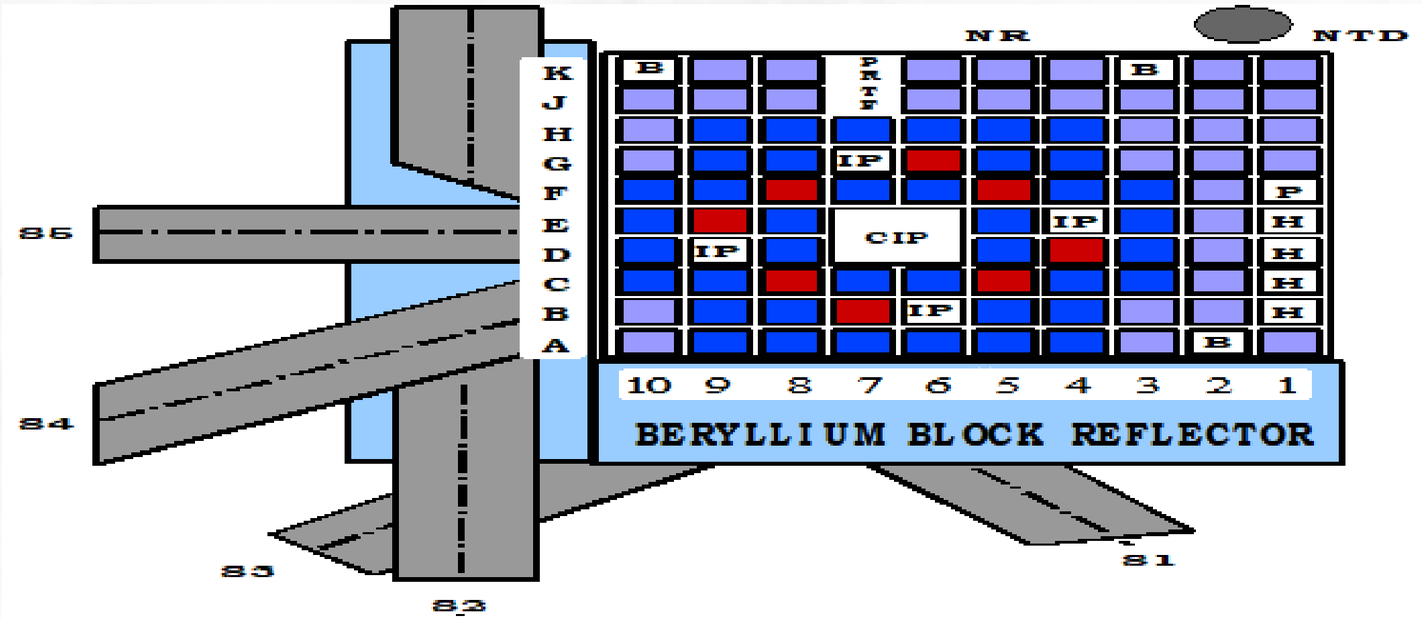
- Radioisotope and Radiopharmaceutical Tech.
- Science and Advanced Material Tech.
- Nuclear Fuel Tech.
- Safety of Nuclear Reactor
- Radioactive Waste Tech.

Kartini Reactor

- Accelerator Science and Tech.
- Polytechnic of Nuclear Tech

Irradiation properties at G.A Siwabessy reactor

Power : 15-30 MW
Neutron Flux : 2.10^14 n/cm.s
Cooling Material: Light water
Fuel Type : MTR
Fuel Material : U3Si2Al
235U enrichment: 19.75%
235U Density : 2.96 gr/cm3
Absorber : AgIn-Cd



= FUEL ELEMENT
= CONTROL ELEMENT
= BERYLLIUM ELEMENT
CIP = CENTRAL IRRADIATION POSITION
IP = IRRADIATION POSITION
NR = NEUTRON RADIOGRAPHY
NTD= NEUTRON TRANSMUTATION DOPING FACILITY

PRTF = POWER RAMP TEST FACILITY
B = IRRADIATION POSITION
S = BEAM TUBE
P = FAST RABBIT SYSTEM
H = NORMAL RABBIT SYSTEM

FIG. 2. CONFIGURATION OF RSG-GAS CORE

Non-Fission Molybdenum-99 production

1 **Target Preparation**

2 **Irradiation**

3 **Post Irradiation**

Non fission Mo-99 is produced by neutron-irradiating of natural molybdenum (Mo3) in G.A Siwabessy reactor

Non-Fission Molybdenum-99 production

Number of process	Mass of MoO3	Irradiation time	Position	Total Mo-99 activity	Specific activity (Ci Mo-99/g Mo)
1	4 grams	99.7 hours	CIP D-6(T) (B)	1.24 Ci	0.45
2	4 grams	97.3 hours	CIP D-6 (T)	2.40 Ci	0.88
3	4 grams	98.5 hours	CIP D-6 (T)	1.51 Ci	0.55

*Mo-99 solution is used to research purpose only

Brief status of Tc-99m production using non-fission Mo-99 (neutron-irradiated natural Mo)

01.

Extraction method

Extraction of Tc-99m from (n,gamma) Mo-99 using MEK, purification and concentration of Tc-99m using acidic alumina column

02.

Mo-99/Tc-99m generator based on ZBM

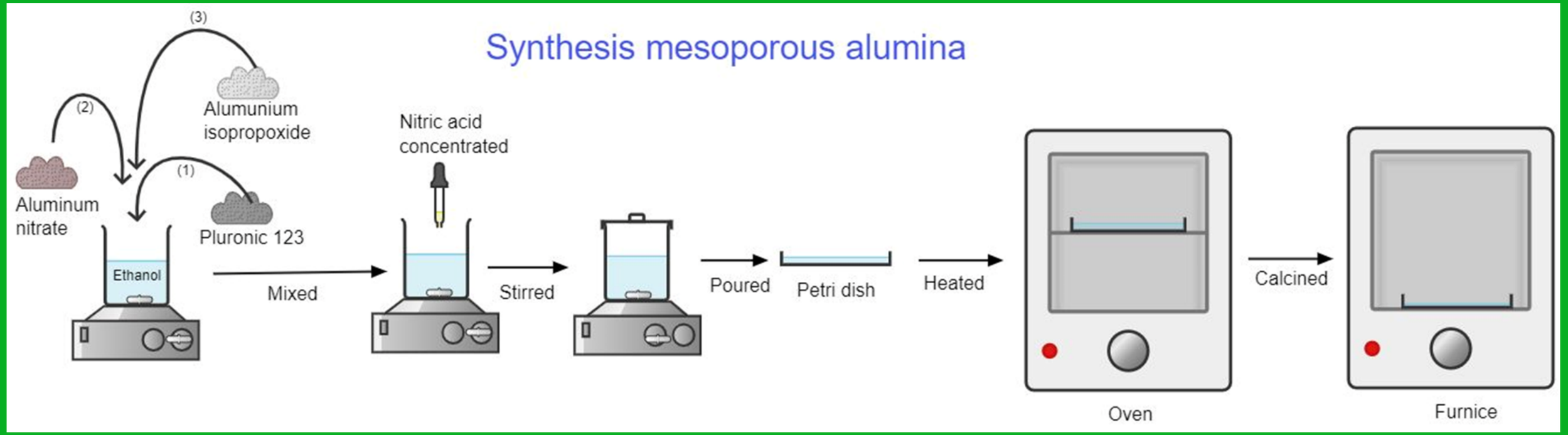
Developing the synthesize of Zirconium-Based Material (ZBM), as an adsorbent for Mo-99/Tc-99m generator column

03.

Mo/Tc generator based on nano /meso porous material

Synthesis and modifying nano and mesoporous material used as a matrix for Mo-99/Tc-99m generator column

Progress study of mesoporous alumina based Pluronic 123 as template for non-fission Mo/Tc generator column



Sample analysis (1)

Table 1. Textural properties of mesoporous alumina samples

Samples	Specific surface area (m2/g)	Pore size dia. (nm)	Pore volume (cm2/g)
MA-700	253.5	5.21	0.46
MA-800	240.9	5.94	0.49
MA-900	201.5	5.76	0.40

The surface area of the MA-700 is the highest surface area value among the other samples (MA-800 and MA-900)

Sample analysis (2)

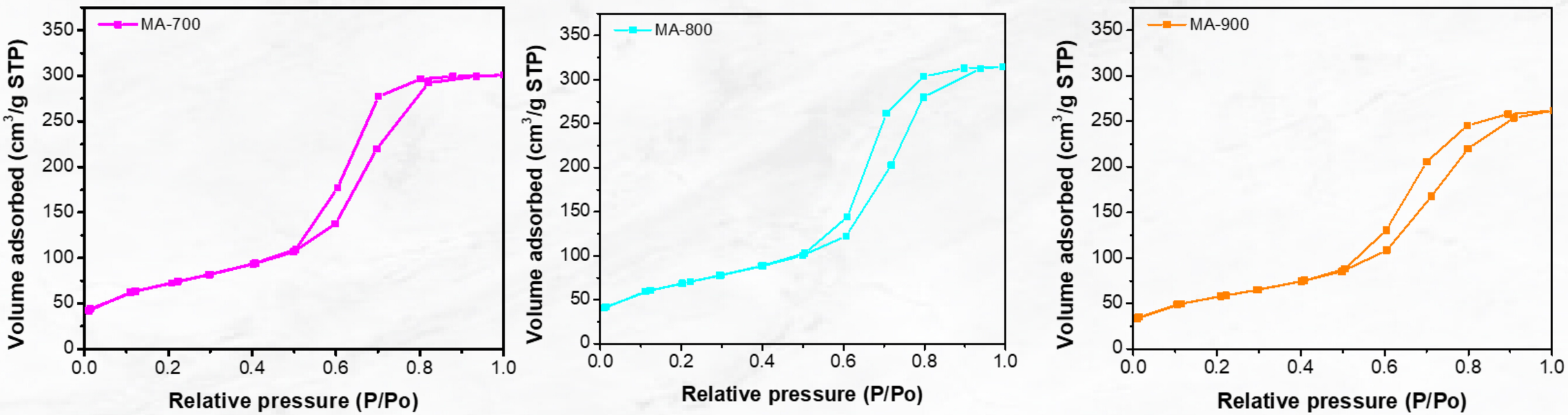
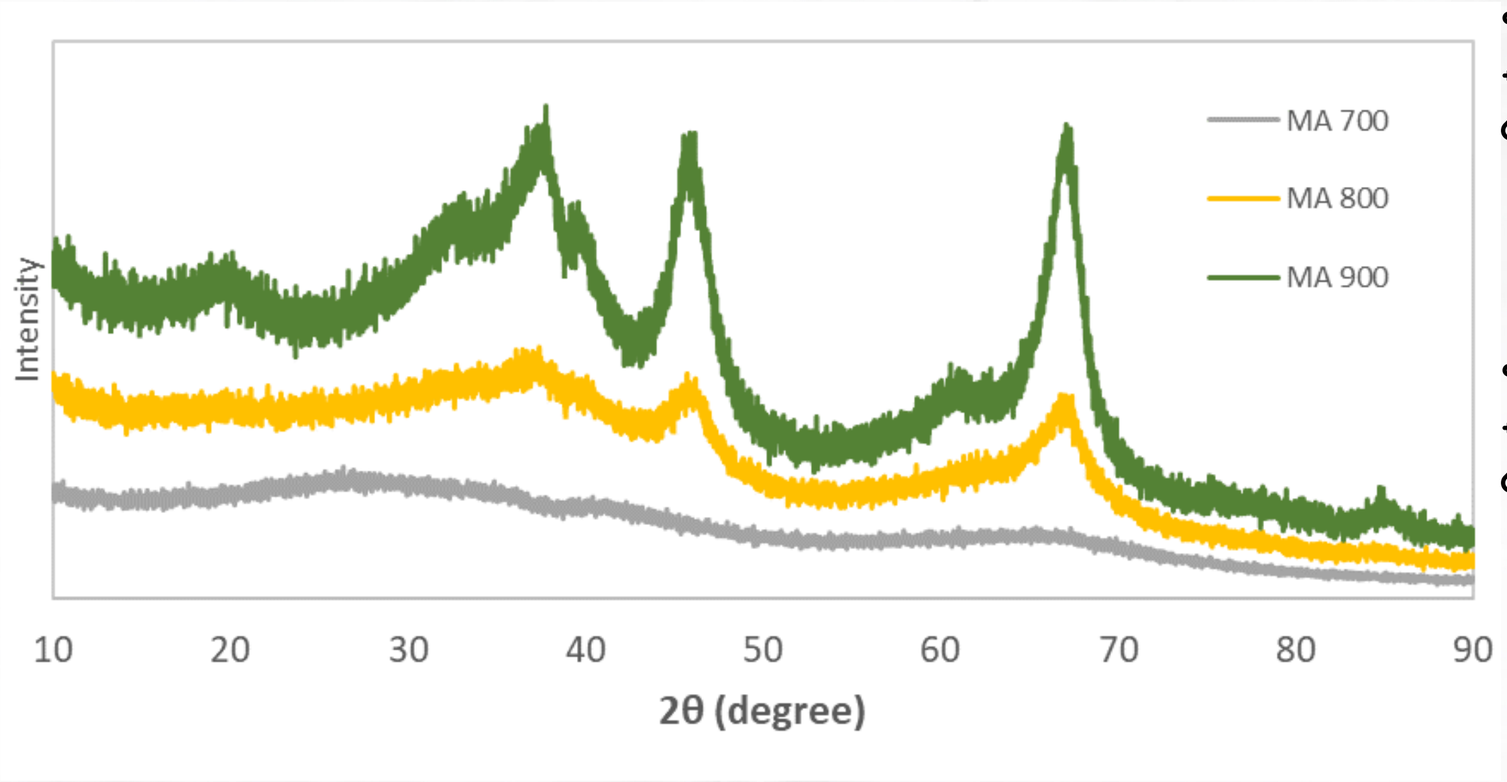


Figure 1. Hysteresis loop of mesoporous alumina samples

- **The nitrogen adsorption-desorption isotherm of the mesoporous samples including MA-700, MA-800, and MA-900 all display type IV isotherm, which are characteristics of mesorporous materials.**

Sample analysis (3)

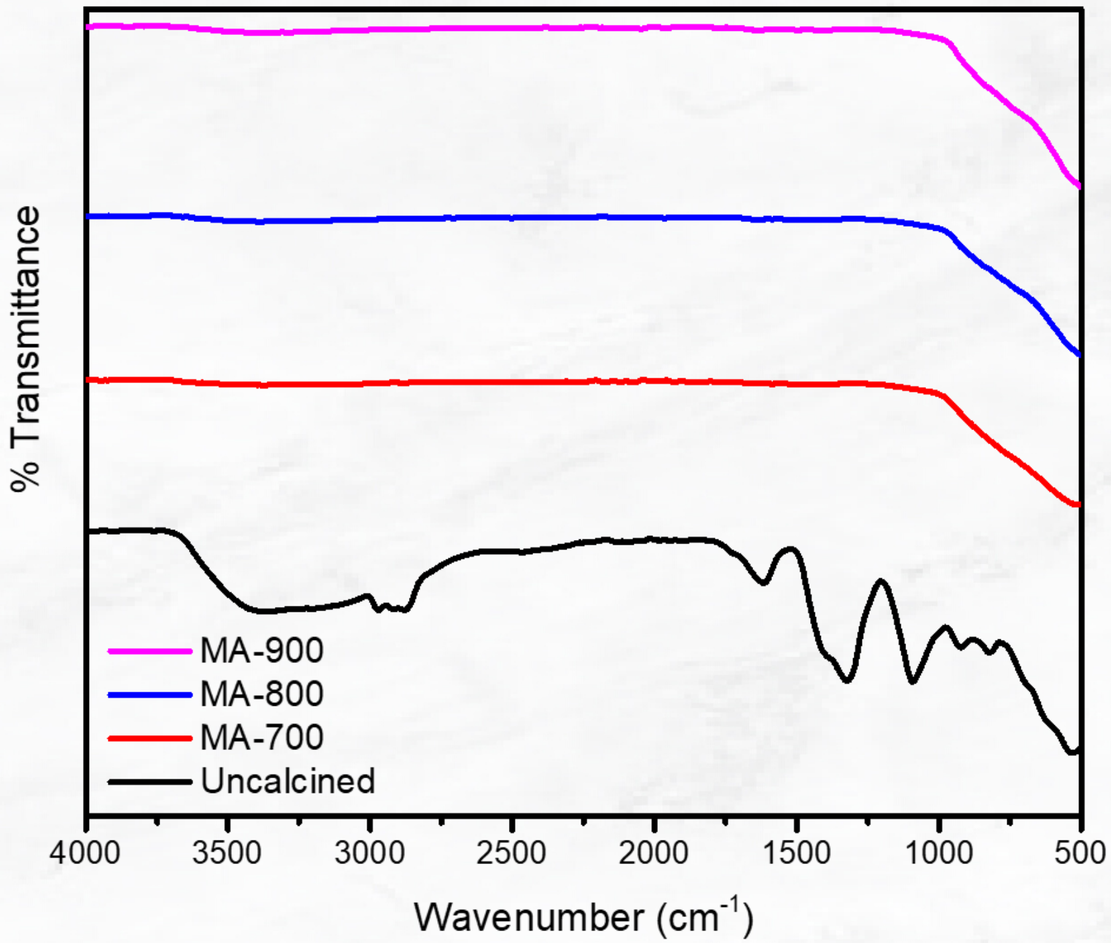


- MA-700 sample is amorphous , whereas the XRD pattern of MA-800 can be indexed to gamma alumina and the weak intensities of the peak indicate the the obtained gamma alumina is poorly crystalline

- In contrast, the diffraction peaks of MA-900 is gamma alumina with more strong intense indicate its high crystallinity

Figure 2. Diffractogram of mesoporous alumina samples

Sample analysis (4)

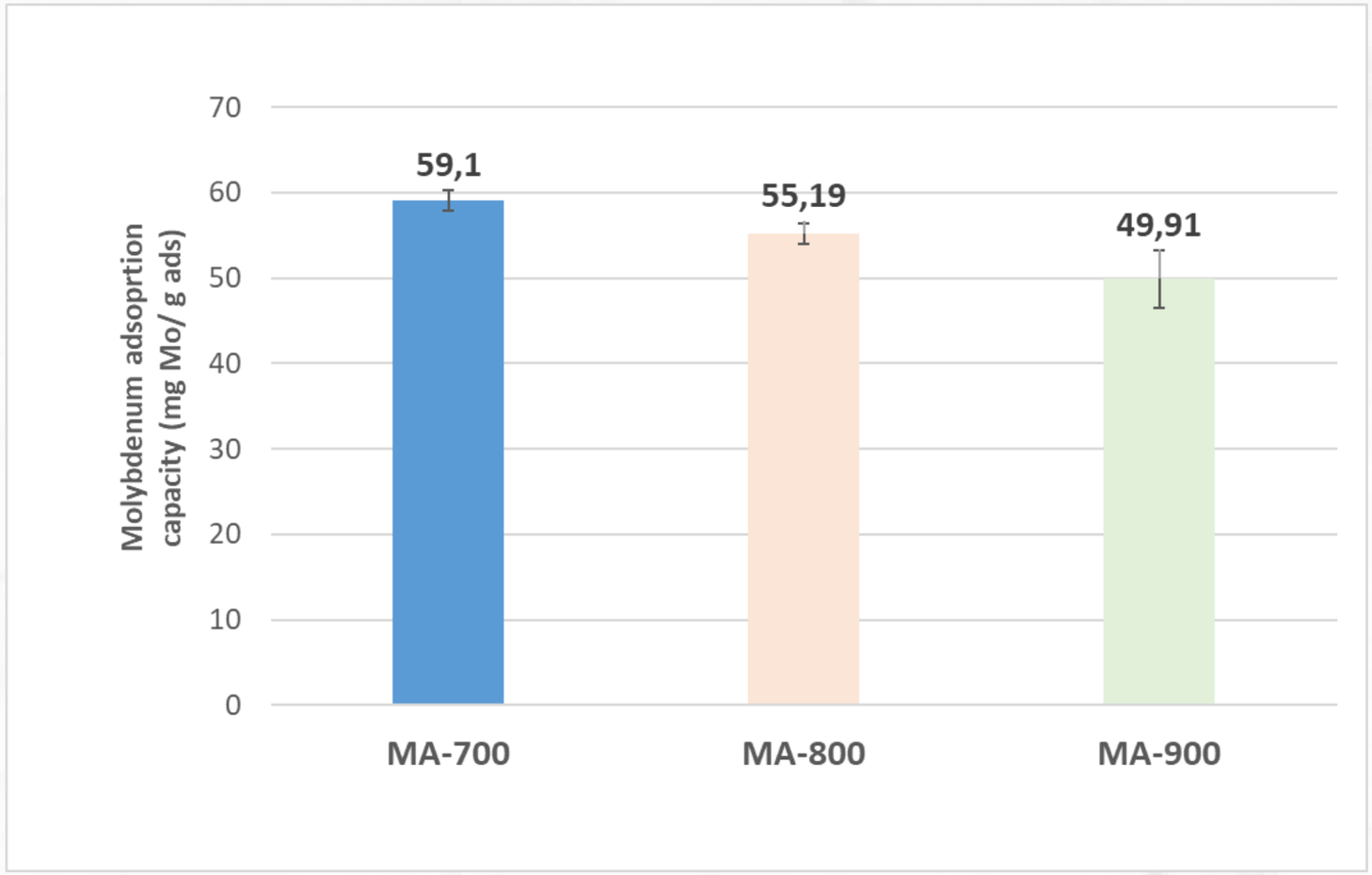


All mesoporous samples (MA-700, MA-800, and MA-900) exhibit almost identical FTIR spectra

The FTIR spectra of uncalcined sample assign the existance of template, and then it is disappear after calcination

Figure 3. FTIR spectra of mesoporous alumina samples

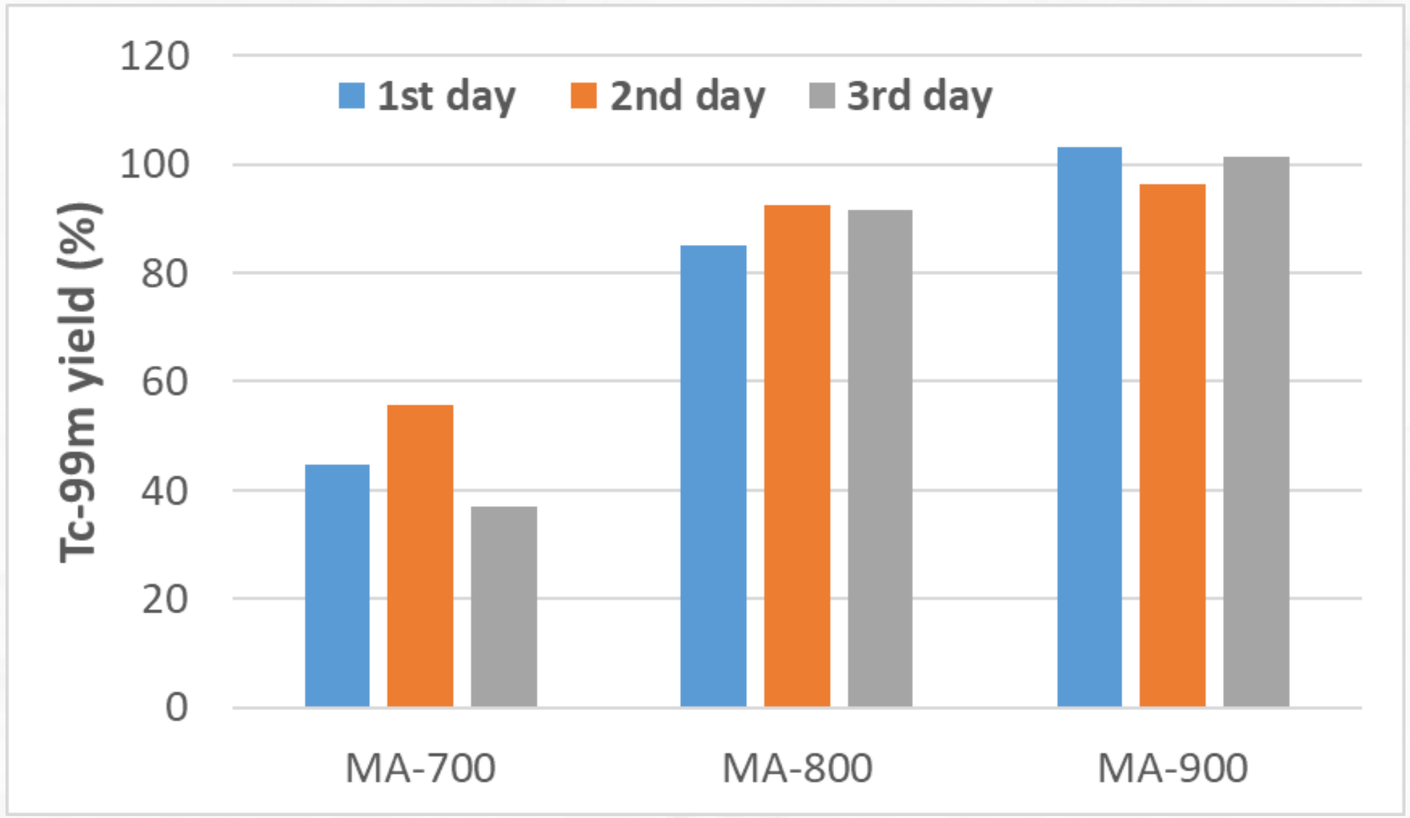
Mo-99 adsorption test



- The MA-700 sample is the highest of molybdenum adsorption capacity among other samples (MA-800 and MA-900)

Figure 4. Mo-99 adsorption capacity of mesoporous samples

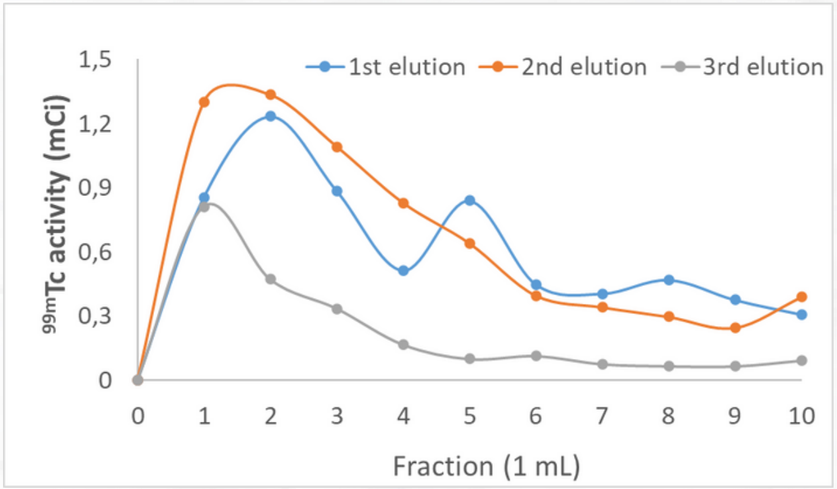
Performance of Mo-99/Tc-99m generator column

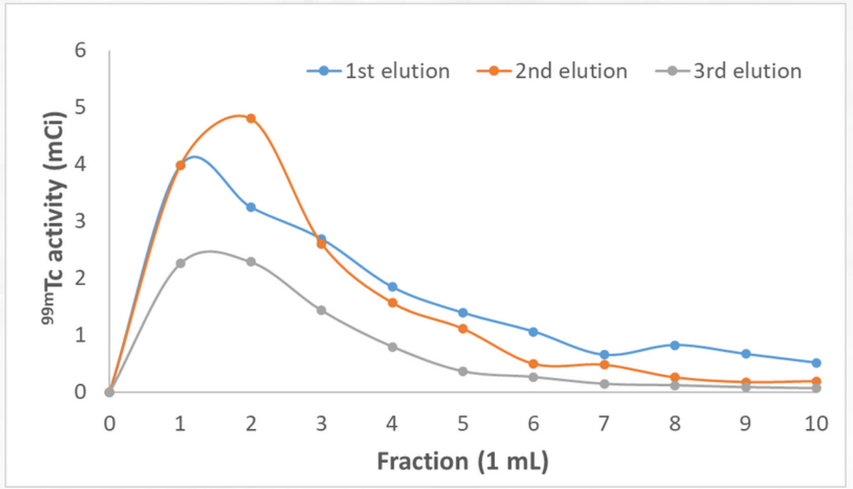


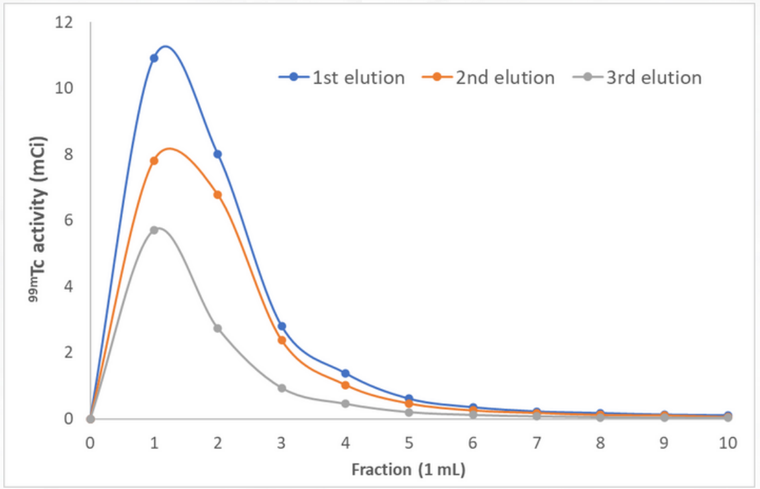
The percentages yield of MA-900 is above 95% from three times elution, higher than those of MA-800 and MA-700.

Figure 5. Tc-99m yields of mesoporous alumina samples

Performance of Mo-99/Tc-99m generator column







MA-700 **MA-800** **MA-900**

Figure 5. Tc-99m elution of Mo-99/Tc-99m generator using mesoporous alumina samples

Preparation of Mo-99/Tc-99m generator column

Table 1. The quality control of Tc-99m eluates

Parameters	MA-700	MA-800	MA-900
pH	5	5	5
Mo-99 breaktorugh (uCi Mo-99/ mCi Tc-99m) *0.015 uCi Mo-99/mCi Tc-99m	1st day: 0.128 2nd day: 0.11 3rd day: 0.008	1st day: 0.026 2nd day: 0.012 3rd day: 0.010	1st day: - 2nd day: - 3rd day: 0.031
Alumunium breakthrough	1st day: > 5 ug/mL 2nd day: < 5 ug/mL 3rd day: < 5 ug/mL	1st day: > 5 ug/mL 2nd day: > 5 ug/mL 3rd day: < 5 ug/mL	1st day: < 5 ug/mL 2nd day: < 5 ug/mL 3rd day: < 5 ug/mL
Radiochemical purity (%)	>95%	>95%	>95%

The Mo-99 breakthrough of all mesoporous samples do not comply with the minimum standard of Tc-99m eluates

The alumunium breakthrough of MA-900 is only the one sample that meet the minimum standard of Tc-99m eluates

Conclusion

1. **Non-fission Mo-99 production have been successfully conducted in Indonesia through neutron-irradiated of natural Mo with specific activity of 0.5 -0.8 Ci/gram**
2. **The Tc-99m production based non-fission Mo-99 was developed by extraction, Mo/Tc generator using ZBM, nano and porous materials.**
3. **The mesoporous alumina synthesized using pluronic-123 as a template, can be used as a high capacity adsorbent for non-fission Mo-99/Tc-99m**

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BADAN RISET
DAN INOVASI NASIONAL

Contact Information

EMAIL ADDRESS

indra.saptiama@brin.go.id
indra.saptiama@gmail.com

WEBSITE

www.brin.go.id