THE IAEA COOORDINATED RESEARCH PROJECT: PRODUCTION OF MO-99 USING LEU FISSION OR NEUTRON ACTIVATION

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ABSTRACT

Since late 2004, the IAEA has been planning and organizing a Coordinated Research Project (CRP) to assist countries interested in initiating indigenous, small-scale production of Mo-99 to meet local nuclear medicine requirements. The objective of the CRP is to provide interested countries with access to non-proprietary technologies and methods to produce Mo-99 using LEU foil or LEU mini-plate targets, or for the utilization of Mo-99 obtained by neutron activation of molybdenum trioxide target, e.g. through the use of gel generators. The work initiated with a significant consultancy meeting in Vienna directly following the RERTR 2004 International Meeting, and continued with a Mo-99 Potential Producers Workshop held in Buenos Aires, Argentina 17-20 May 2005. Five technology donor countries have been awarded IAEA Research Agreements, and five institutions in four countries have been awarded IAEA Research Contracts (a sixth institution is expected to be awarded a contract in the near future). The First Research Coordination Meeting (RCM) for this CRP will be held in Vienna December 6-9, 2005. The paper describes the background and history of the CRP, its planning and formulation, including the Buenos Aires workshop, plans for the first RCM, and the content of the project as well as the activities likely to take place over the next year. The results and experience gained from the CRP will help strengthen local capability for undertaking small scale Mo-99 production in participant countries.

1. Introduction

Technetium 99m, the daughter product of Molybdenum 99 (Mo-99), is the most commonly utilized medical radioisotope in the world. Annually, it is used for approximately 20-25 million medical diagnostic procedures, alone comprising some 80 % of all nuclear medicine procedures.

Today, most Mo-99 is produced in research, test or isotope production reactors by irradiation of Highly Enriched Uranium (HEU) targets that are subsequently processed primarily to recover Mo-99. There are only a few major commercial producers of Mo-99, all of them utilizing HEU targets and dedicated processing facilities.

However, in line with RERTR, and the objective of minimizing and eventually eliminating the use of HEU in civil commerce, international efforts are underway to shift the production of medical isotopes away from the use of HEU.

Consequently, a small amount of the current global Mo-99 production is derived from the irradiation of Low Enriched Uranium (LEU) targets. Additionally, very small volumes of Mo-99 are being made from the irradiation of molybdenum 98 (neutron activation technique).to produce Tc-99m. Since 2002, Argentina has been producing Mo-99 from LEU targets. Australia has been producing limited quantities of Mo-99 from LEU targets but plans to greatly increase such production after its new OPAL reactor goes critical in 2006. Both of these producers are servicing local or regional markets. In addition, a number of laboratories, research organizations, and commercial entities in Member States continue to explored various technological aspects of developing and implementing production of Mo-99 from new LEU targets.

Some developing Member States are seeking to become small scale, indigenous producers of Mo-99 to meet local nuclear medicine requirements. Such production is potentially attractive in order to further develop domestic nuclear technology capabilities, take advantage of relevant nuclear facilities and expertise, reduce dependence on foreign supply, and save hard currency expenditures.

In order to pursue such production, countries need access to LEU fission target tehnology or alternative means to produce Mo-99 through n,gamma neutron activation, as HEU is no longer freely available. Tus, the objective of the IAEA CRP is to provide support for small-scale local production of Mo-99 for TC99m generators by fostering the use of LEU targets for fissión product Mo-99 and to foster the development of alternative technologies in particular by improvement and adoption of Tc-99m gel generator technology. The IAEA's avenue to acheive these objectives is the IAEA Coordinated Research Project on Developing Techniques for small-scall indigenous production of Mo-99 using LEU fisión or neutron activation (T1.20.18).

2. Coordinated Research Projects (CRP)

A CRP is a collaborative research arrangement organized, executed, and funded by the IAEA to promote technology transfer through the dissemination of peaceful applications of new nuclear technologies. A CRP typically involves approximately five institutions from countries which have successfully implemented a particular nuclear or isotopic technique, and a similar number of institutions which are seeking to establish the technology. (For full description of CRPs, see http://www-crp.iaea.org/).

The IAEA notifies member states of approved CRPs so that interested countries may apply to take part.

Technology "donor" institutions (agreement holders) participate in the CRP free of charge, although their attendance at the Research Coordination Meetings (RCM) are financially supported by the IAEA. Technology "recipient" countries (contract holders) receive nominal funding from the IAEA (generally $5000 per year) for an agreed set of activities, but must supplement the IAEA funding with institutional and national resources. Their expenses to participate in the RCMs are also financially supported by the IAEA.

CRPs are usually planned and structured based on a coordinated set of activities which will take place over the 3-5 years duration. Work plans and coordinated activities, including standardized procedures and protocols, are determined in the First Research Coordination Meeting (RCM). Additional RCMs take place at approximately 15-18 month intervals, to monitor progress in the work plans and coordinated activities and to prepare a written report (normally an IAEA TECDOC) on the results and outcomes.

3. History

This effort was initiated with an IAEA Consultants Meeting in Vienna immediately following the November 2004 RERTR International Meeting. This meeting was attended by participants from Argentina, Belgium, Canada, Netherlands, South Africa and the U.S., including representatives of the four major commercial producers of Mo-99. The meeting reached a consensus on the scope, methodology, and objectives of the projected CRP, including that the work should include technology transfer related both to LEU fission production of Mo-99 but also to n,gamma neutron activation (gel generators) technology. The U.S. Department of Energy pledged to make an extrabudgetary contribution to permit the CRP to begín in 2005, whereafter it would be funded from the IAEA regular budget.

Based on the outcome of the Consultants Meeting, a draft CRP proposal was written by IAEA staff and submitted for internal review. The CRP proposal was approved by the IAEA Research Contracts Committee in February 2005, and plans were initiated to convene a Potential Mo-99 Producers Workshop in May 2005 in Buenos Aires, Argentina.

The workshop was hosted by the National Nuclear Energy Commission (CNEA) of Argentina, which also provided most of the lecturers, along with lecturers from Argonne National Lab (USA) and ANSTO (Australia) on aspects related to fission moly production and from Brazil and India, concerning gel moly production. There were participants from eleven countries, who also made presentations on their national requirements for Mo-99, current means for satisfying local demand for Mo-99, and their technical capabilities and facilities for producing Mo-99. Two commercial companies involved in target fabrication for Mo-99 production attended as observers, but none of the four major commercial producers of Mo-99 participated.

Following the workshop, interested countries submitted proposals for both research agreements and research contracts, and the IAEA convened a Consultants Meeting in July 2005 in Vienna to review the proposals and to make recommendations on which should be approved. The proposals were evaluated by the Scientific Secretaries of the CRP, submitted for approval to the Research Contracts Committee, which approved the recommendations in September 2005. Planning then formally for the First Research Coordination Committee (RCM) meeting to be held in Vienna 6-9 December 2005.

4. Objectives

The objectives of the CRP are to:

- Assist member states with the development, transfer, and adaptation of LEU-based technology and neutron activation methods,
- Demonstrate technical efficacy of LEU and neutron activation production of Mo-99,
- Foster capacity building for local/regional self-sufficiency to meet Mo-99 needs,
- Advance international non-proliferation and nuclear security objectives, while promoting sustainable development and the sustainability of nuclear research institutes.

The CRP does not include the objective of conversion to LEU of the large-scale, HEU-based commercial production of Mo-99, but the active participation of the major commercial producers in carrying out the objectives of the CRP is welcomed.

5. Purpose

The CRP aims to assist recipients to research, test, and evaluate so-called "Freeware Technology" for LEU fission and gel moly production of Mo-99. Contract holders will be assisted in evaluate options to access such technology, build their own technology, or purchase alternate LEU and neutron activation based technology. The experimental evaluation of Freeware Technology will be used to disseminate information of the technological options and requirements.

6. Freeware Technology

The "Freeware Technologies" which arose out of the November 2004 Consultancy are:

- LEU-modified Cintichem process with LEU foil targets (developed by Argonne National Lab, USA, under further evaluation with research partners in Indonesia and the Republic of Korea), and
- Neutron activation of natural molybdenum oxide targets and utilization of gel generators (open source literature, with customized research and development programs in Brazil and India).

The Argentine-developed LEU dispersion mini-plates are also a relevant candidate for transfer, but there are some associated proprietary concerns.

While the "freeware" technologies have been published in the open literature, there are proprietary issues regarding the specific implementation of the techniques in individual countries.

7. CRP Activities/Output

The technology transfer to be carried out under the CRP will include all necessary production steps, including target preparation (including by purchase of targets), irradiation, radiochemical processing, safety, quality control and quality assurance, and waste management.

The following specific activities will be covered by the CRP;

- Develop country specific work plans and schedules,
- Identify infrastructure and regulatory requirements, including safety analysis report, environmental and waste management issues, solutions,
- Identify sources of material and technical support for each contract holder (from the agreement holders, through the IAEA, or other sources),
- Provide necessary materials, including LEU targets and molybdenum trioxide,
- Develop coordinated program, including to establish and implement an experimental program for:
  --preparation, irradiation, and processing of LEU targets,
  --irradiation and processing of MoO3 targets, and
  --preparation of Mo-99 "moly gel" powder and gel column generators,
- Compare and interpret results, provide follow-up, and suggest adaptive modifications,
- Provide expert assistance to recipient institutions,
- Establish procedures and protocols, including quality control and assurance,
- Results of irradiation and processing will be compared in the 2nd and/or 3rd RCM, with assessment of whether product meets specifications and purity requirements.

It is expected that as a result of the work undertaken in the CRP, participants will acquire an understanding of the various technologies in order to be able to decide whether to proceed with domestic production of Mo-99. Participants will have the necessary know-how for Mo-99 production using transferred LEU fission or neutron activation technologies. The final output will be an Agency publication that will review the work that occurred, results achieved, and to define standardized technological approaches.

8 Schedule

As noted, the first RCM will be held 6-9 December in Vienna. Its objectives are to review, refine, and finalize individual country work plans for the CRP, to agree upon the material and expert assistance requirements to be provided to the contract holders (including on what basis, cost-free or contractual), and develop the coordinated activities and program, including procedures, protocols and an experimental program. There will also be discussion about possible minimum training packages.

9. Participants

Five institutions in four countries have been awarded research contracts:

- Chile: LEU mini-plates
- Kazahkstan: gel generators
- Pakistan: LEU fission and gel generators
- Romania1: gel generators
- Romania2: LEU modified Cintichem foil targets

An additional institution in Libya has been recommended for receipt of a research contract and this is expected to occur around the time of the first RCM.

Five institutions in five countries have been awarded research agreements:

- Argentina: LEU mini-plates
- Republic of Korea: development of LEU foil targets
- India: standardization of gel generators and feasibility of fission moly
- Indonesia: development of LEU foil targets
- U.S.: LEU-modified Cintichem foil targets.

10. Conclusions

This Coordinated Research Project is directly supportive of RERTR objectives, as it will help encourage the further use of LEU and neutron activation technologies by building experience and consensus on their use, within the context of an internationally-coordinated project. The results and experience gained will also help strengthen local capability for undertaking small scale Mo-99 production in participant countries, and could add to security of supply for this important medical radioisotope. In addition, it will facilitate enhanced utilization of research reactors by local production of radioisotopes, and consequently could serve to improve sustainability of such institutions.