Working Group 1
Stable and enriched isotopes

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August 7, 2008

Isotope Workshop

Goal: The goal of the workshop is to bring together for the first time representatives of the stakeholders (producers and users of isotopes) from a variety of disciplines in an attempt to identify their needs, the challenges towards meeting those needs, and options towards increasing the availability of important isotopes.

1. **Who uses isotopes and why?**
2. **Who produces them and where?**
3. **What is the status of the supply and what is missing?**
4. **What are the needs today and in the future?**
5. **Can present facilities handle the anticipated demand? What are the options for increasing availability and associated technical hurdles?**
6. **Other issues?**

The deliverable will be a report which articulates the Nation's needs for isotopes across the various disciplines, the challenges in meeting those needs, and options for improving the capabilities for meeting the demands.

This is a first step towards development of comprehensive and prioritized strategic plan. NSAC will use this input (and others) to develop a long range plan.

#	Name	Position	Institution
1	John Greene	Target Development Engineer	Argonne Nat Lab
2	Andreas Stolz	Assistant Prof.& Dept. Head of Operations	Michigan State Univ
3	Scott Aaron	Isotope Development Group Leader, NSTD	Oak Ridge Nat Lab
4	Richard Kouzes	Laboratory Fellow	Pacific NW Nat Lab
5	Craig Reynolds	National Cancer Institute	NIH
6	Robert Vocke	Research Chemist	NIST
7	Alfred Yergey	Section Chief	NIH
8	Ercan Alp	Senior Scientist	Argonne Nat Lab
9	Molly Kretsch	National Program Leader, Human Nutrition	USDA
10	Gary Hatch	Chief, Pulmonary Toxicology Branch	EPA
11	Brad Keister	Program Director	NSF
12	Darren Brown	President	Trace Sciences
13	Alfred Wong	Professor	UCLA
14	Thomas Anderson	Product Line Leader	GE Reuter-Stokes
15	Bill Casey	Professor of Chemistry	UC Davis
16	Abdul Dasti	Division of Stockpile Tech and Special Materials	NNSA
17	Victor Gavron	Second Line of Defense Program	LANL
18	Jehanne Simon-Gillo	Acting AD, Office of Nuclear Physics	DOE
19	Clifford Unkefer	Director, National Stable Isotope Resource	Loa Alamos Nat Lab

1. Who uses isotopes and why?

- Materials Science, biology, chemistry, earth sciences
  - Mossbauer - 116 isotopes - gram quantities
  - Nano science - Cd, Se, Pb, O
  - Polymers - D, C
- Human nutrition, obesity, disease prevention, and medical imaging - NIH and USDA -
  - Ca, Zn67-70, Mg25-26, Fe57-58, Se, N15, C13, O17-18, He3, Xe129, D2O18 (double labeled water)
- Food and agriculture - USDA
  - N15, C13, O17-18, Se, Cr, Zn, Ca, Fe,
- Pharmaceutical and FDA
  - C, O, N, S, D
- Double beta decay - fundamental properties of neutrino
  - 1000 kg of Ge76, Se82, Mo100, Cd116, Te130, Xe136, Nd150
- NIST - standards and spike materials
  - Sr84, Pb206, future needs of poly-isotopes
- Homeland security, neutron scattering research, safeguards (IAEA), oil drilling, low-T physics, medical, DOE NA25
  - Li, He3 - 75K liters/yr
- Environmental and toxicology; cosmogenic and earth sciences
  - Li, O17, Si29, Zn67-70, Hg, Pb, Cr, Cd, other heavy metals, Pt group metals
- Atmosphere and hydrosphere
  - Hg, C, N, S, O, Br
- Detector technology
  - In, La, B, Li, Gd, He3, Si, Xe
- Nuclear energy
  - Li, depleted Zn64, B, D2O, noble gases, He3
- DOE and NSF nuclear physics research
  - Isotopes for accelerator beams - Ca48, Ti50, ...
  - Isotopes for targets - highest enrichment of many cases
- SNS cooling of moderator, medical community, fiber optics, semi-conductors, neutron scattering (deuterated compounds)

2. Who produces them and where?

- B, C, N, O - widely produced by distillation and chemical exchange - US, Russia, China, Israel, Georgia, Japan
- D - India, Argentina, Canada, Romania, China, Russia (through TENEX), US inventory
- Alkalies, alkaline earths, and metals - EM separation and centrifuge - ORNL inventory, Russia (EM separation - Trace Sciences and TENEX), China
- Halogens and noble gases - centrifuge and distillation - Holland, Russia
- He3 - tritium decay - Savannah River, Russia (Mayak)
- Russia is the only known supplier of large quantities of these materials for double beta-decay experiments. Only ECP in Russia has provided material in the recent past, but two other Russian sources may be available or some isotopes, although they are not able to provide the Ge76 required. Urenco in the Netherlands is another potential supplier, but not for Ge76 (to date). Devaluation of the U.S. dollar has elevated costs for these large quantities to levels that may limit the ability of U.S. scientists to compete in this area of important science (as designated by NSAC and the scientific community).

3. What is the status of the supply and what is missing?

- B, C, O - widely available domestically (domestic supply exceeds demand)
- N - not available domestically, but current demand is met by sources in China and Georgia
- D - not currently produced in US; current demand is met through foreign sources which can be erratic and expensive
- Halogens and noble gases - not available domestically, but current demand is met by sources in Holland and Russia; this does not include the needs for the double beta-decay experiments
- He3 - demand exceeds current combined capacity of Savannah River and Russia
  - It is possible that there is a DOD stockpile of tritium which has He3 by decay?
- Alkalies, alkaline earths, and metals
  - No new active domestic production, since the U.S. electromagnetic enrichment facility has been in standby since 1998; current demand may be met through foreign sources or domestic inventory.
  - Domestic inventory - all isotopes are available for next 20 years or more (based on prior five-year average demand; this is extremely vulnerable to future spikes in demand), except for those listed in the table given at the end of this document.
- For double beta decay experiments, there is no stockpile of large quantities of the required isotopes; new supplies must be separated.

3. What is the status of the supply and what is missing?

	Years
	Remaining
Isotope	Inventory
GADOLINIUM 154, SECOND PASS	2.5
GALLIUM 69	3.7
NICKEL 62	3.9
OSMIUM 187	5.2
LUTETIUM-176	5.5
RUTHENIUM 99	6.3
OSMIUM 186	7.5
BARIUM 136	7.6
NEODYMIUM 150	7.9
MERCURY 204	10.2
CADMIUM 106	10.7
MERCURY 202	11.5
PALLADIUM 106	12.6
SILVER 109	14.3
ZIRCONIUM 94	18.5
BARIUM 137	19.0
SAMARIUM 149	19.6
GADOLINIUM 157	0.2
PLATINUM 195	12.0
GADOLINIUM 157 SECOND PASS	0.0
LEAD 204, SECOND PASS	0.0
LEAD 207, SECOND PASS	0.0
RUTHENIUM 96	0.0
SAMARIUM 150, SECOND PASS	0.0
TANTALUM 181	0.0
VANADIUM 51	0.0
TUNGSTEN 180, SECOND PASS	0.0

4. What are the needs today and in the future?

Needs today:

- The list of needed isotopes in given for question 1. But, the needs for He3 and certain other isotopes (e.g., Ru96) are not being met from domestic or foreign suppliers.
- Concerns today relate to issues of enrichment and cost. Some human nutrition, medical, and materials science experiments are not performed due to the high cost of some key isotopes., e.g., Fe57, O17, Sn119, Eu151.

Future:

- Large quantities will be needed for double beta-decay experiments - 1000 kg of Ge76, Se82, Mo100, Cd116, Te130, Xe136, Nd150.
- The demand for He3 already exceeds supply and will continue to rise. This isotope has a number of key national security applications.
- The use of isotopes in molecular-tagged vibrational spectroscopy (nuclear resonance vibrational spectroscopy; resonant Raman and infra-red spectroscopy) is increasing and will lead to an increased need for small quantities of many isotopes to differentiate vibrational modes between different ligands.
- The construction of FRIB (the DOE-funded Facility for Rare Isotope Beams) will lead to increased need for isotopes for ion sources and preparation of accelerated beams.
- The supply of O17 is currently adequate to meet demand, but the evolution of future MRI techniques could lead to a large increase in the need.

5. Can present facilities handle the anticipated demand? What are the options for increasing availability and associated technical hurdles?

- He3
  - Current and anticipated demand is not being met. It is possible that alternative strategies could reduce somewhat the large anticipated demand.
  - There is waste of He3 in some applications in other countries, and international agreements could result in new supplies of He3 for our use.
  - Alternate technologies for neutron detection exist and may reduce demand for He3.
- Kilogram quantities of selected isotopes for specific purposes
  - Double beta decay experiments
  - Si for electronics industry
  - La for detectors
  - Indium for low-background detection (100 gram quantities)
  - Option for obtaining these kg quantities - new enrichment techniques such as plasma ion cyclotron resonance separation, acoustic separation, cryogenic distillation, laser ionization, plasma centrifuge.

6. Other issues

We believe that there is a strategic need for an ongoing US stable isotope capability, even expanded to fill the current gaps in domestic supply. The reasons for this increased isotope capability are:

- **Cost - a diversity of suppliers usually leads to more competitive pricing.**
- **Quality - ensure that there is third-party quality verification (such as ISO 9001) of the isotope manufacturer.**
- **Stability of future supply - a domestic supply insulates us from geopolitical influences on foreign supply.**
- **Quickness of response - in some cases a research need for an isotope requires rapid purchase and delivery, best accomplished with domestic supply.**
- **Technical services - some uses of isotopes require conversion to special chemical or physical form, best accomplished with domestic suppliers. For example, ORNL has an Isotope Research Materials Laboratory and LANL has the Stable Isotope Resource Laboratory.**
- **National security - in some cases the US should not depend on the supply of stable isotopes from foreign governments due to the sensitive nature of the isotope applications, e.g., detectors for homeland security.**
- **Brokerage by the funding agency should help control the cost of isotope production if there are multiple needs for a given isotope and a consolidated solicitation is made for the isotope.**

As a result of these issues:

Recommendation. The use of stable isotopes encompasses most areas of scientific research that are strategically important to US research and industry. The U.S. isotope community does not have access to domestic electromagnetic separators or gas centrifuges for production of over half of the isotopes in use. Current demands are being met through existing inventory at ORNL plus production from foreign sources in Russia and China. While there are currently reliable and dependable foreign suppliers, there is no assurance that they will be available to us in the future. We recommend the establishment of a domestic production and supply strategy for all stable isotopes, particularly for those that are not currently available domestically. Users prefer multiple reliable suppliers from a risk management and disaster recovery standpoint. Dependence on single-source availability of products may put in jeopardy research vital to the national interest. Careful consideration should be given to both current and new techniques of isotope separation. Access to less expensive separated and enriched isotopes could lead to unanticipated breakthroughs in science and new technologies. In the short term, reliance on current techniques could give time for the potential development of less expensive technologies in the long term.