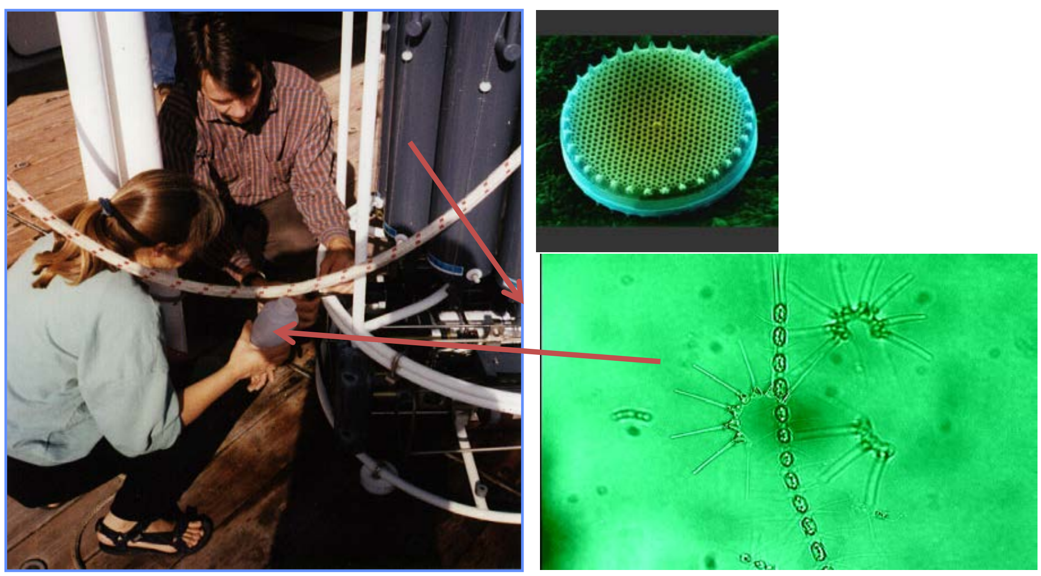
NIDC NATIONAL ISOTOPE DEVELOPMENT CENTER

Managed by the U.S. Department of Energy's Office of Nuclear Physics

## Silicon-32 is an Important Radiotracer in Assessing Global Climate Models

In a collaboration initiated by the U.S. Department of Energy (U.S. DOE), scientists from TRIUMF, Canada's National Laboratory for Particle and Nuclear Physics, delivered two proton irradiated potassium chloride (KCl) targets to radiochemists at Los Alamos National Laboratory (LANL). The highly radioactive targets, containing spallation-produced Si-32 and other isotopes were processed remotely using complex radiochemical extraction procedures to successfully produce a solution of silicic acid labeled with purified silicon-32 (Si-32). The solution is well suited for oceanographic research applications.

Marine biologists have successfully used silicic acid labeled with various silicon isotopes as a tracer to measure silica production rates in coastal seawater. The radiotracer Si-32, a pure beta-emitting isotope, has advantages over stable isotope tracers because it is significantly easier to use due to the easily detected low energy radioactive emissions. This enables real-time quantitative radioanalytical measurements of silicic acid uptake rates in samples at sea. This research is valuable to understanding and modeling the global climate.



***Researchers collect sea-water samples containing diatoms (imaged microscopically at right).***

The availability of Si-32 in the early to mid-1990s stimulated a flurry of research activity to assess biogenic silica production by microscopic single-cell phytoplankton known as diatoms.  Silicon in the form of silicic acid is an essential nutrient for diatom blooms in the oceans. The diatoms transform the silicic acid to a solid silica shell surrounding each cell. The rate of bloom of these tiny photosynthesizing sea-dwellers provides researches with insight into carbon dioxide consumption at various times and locations in the oceans. This is because atmospheric carbon dioxide ($CO_2$) is dissolved in the surface seawater and is metabolically transformed to sugars by the diatoms consuming large amounts of the green-house gas. The rate of consumption of the vital nutrient silicic acid can be followed using the Si-32 radiotracer giving a measure of the total mass of silica produced and the amount of carbon-dioxide consumed by the diatoms in the oceans. This information is important in assessing the role of the oceans in climate models.

### What's Inside This Issue?



**NIDC Newsletter - # 05**
**January 2014**

## Silicon-32 is an Important Radiotracer in Assessing Global Climate Models (continued)

Efficient production of the Si-32 tracer requires the use of high energy proton beams accelerated onto potassium chloride (KCl) targets. During the late 1990's, a reconfiguration of U.S. high-energy accelerator operations limited access to irradiation facilities of sufficient proton beam energy and current resulting in a lull in the supply of Si-32 to researchers. This ultimately stimulated a joint agreement between TRIUMF and the U.S. DOE in the late 2000's to use the 500 MeV irradiation facilities in Vancouver, BC for Si-32 production. The irradiated KCl targets were shipped from Vancouver to Los Alamos, NM and processed at LANL in shielded hot cells. Final purification chemistry for the Si-32, a pure beta-emitter, is extremely labor intensive to recover the isotope from the activated KCl and obtain a high-purity research-grade product. Due to this new production effort, oceanographic researchers now have a new supply of the Si-32 to support their on-going research efforts. Silicon-32 is also used by researchers as a long-term source of its daughter isotope, phosphorus-32 (P-32). The P-32 is a short-lived isotope used as a tracer in biological and environmental research.

A byproduct of the Si-32 production is Aluminum-26 (Al-26). Radiochemists at LANL were able to isolate and purify a small quantity of Al-26 that is also available to researchers. Al-26 has historically been used for biological and geological research.

If you are interested in Si-32 or Al-26 for your research needs, please request a quotation through the NIDC website, www.isotopes.gov

For more information, please contact Dennis Phillips (Dennis.Phillips@science.doe.gov).

## Progress Towards Restoring Domestic Stable Isotope Production

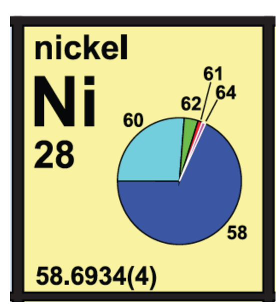
***DOE Office of Nuclear Physics awards R&D project to ORNL to upgrade 10 mA EMIS***

The United States does not have an operating stable isotope enrichment facility. The demand for a stable isotope enrichment facility has been growing and ORNL was awarded an R&D grant in May 2013 from DOE Office of Nuclear Physics to upgrade a nominally 10 mA R&D Electro-Magnetic Isotope Separator (EMIS) located on the ORNL campus with a higher ion current, developmental ion source. Design and prototype ion source assembly activities are ongoing. Once upgraded, the higher ion current EMIS will be the production prototype included in ORNL's proposed Enriched Stable Isotope Production Facility discussed below.

The R&D EMIS also continues to be used for testing in support of isotope enrichment technology development projects while the ion source upgrade development is in progress. This EMIS was described in the June 2013 NIDC Newsletter with some preliminary molybdenum isotope enrichment results. The article also included several references to scientific conference presentations. More recently, a small pilot enrichment of nickel isotopes (ca. 100 mg total collected, >98% individual isotope enrichment) was completed using $NiCl_2$ as the feed material. Some of the current stable Nickel isotopes available at the NIDC are Ni-58, Ni-60, Ni-61, Ni-62, and Ni-64. The NIDC also offers the radioactive Ni-63.

***Repurposing of ORELA Space for Future Enriched Stable Isotope Production Facility***

A renovation project is underway to repurpose space formerly associated with the Oak Ridge Electron Linear Accelerator to support ORNL's proposed Enriched Stable Isotope Production Facility. The renovation is aimed at maximizing the potential of this space to house electromagnetic and gas centrifuge isotope separators optimized for stable isotope production for a wide range of elements (typically from silicon to lead on the periodic table). This renovation project is scheduled to be completed early 2014.




***Natural distribution of nickel isotopes (Source: IUPAC Periodic Table of the Isotopes)***

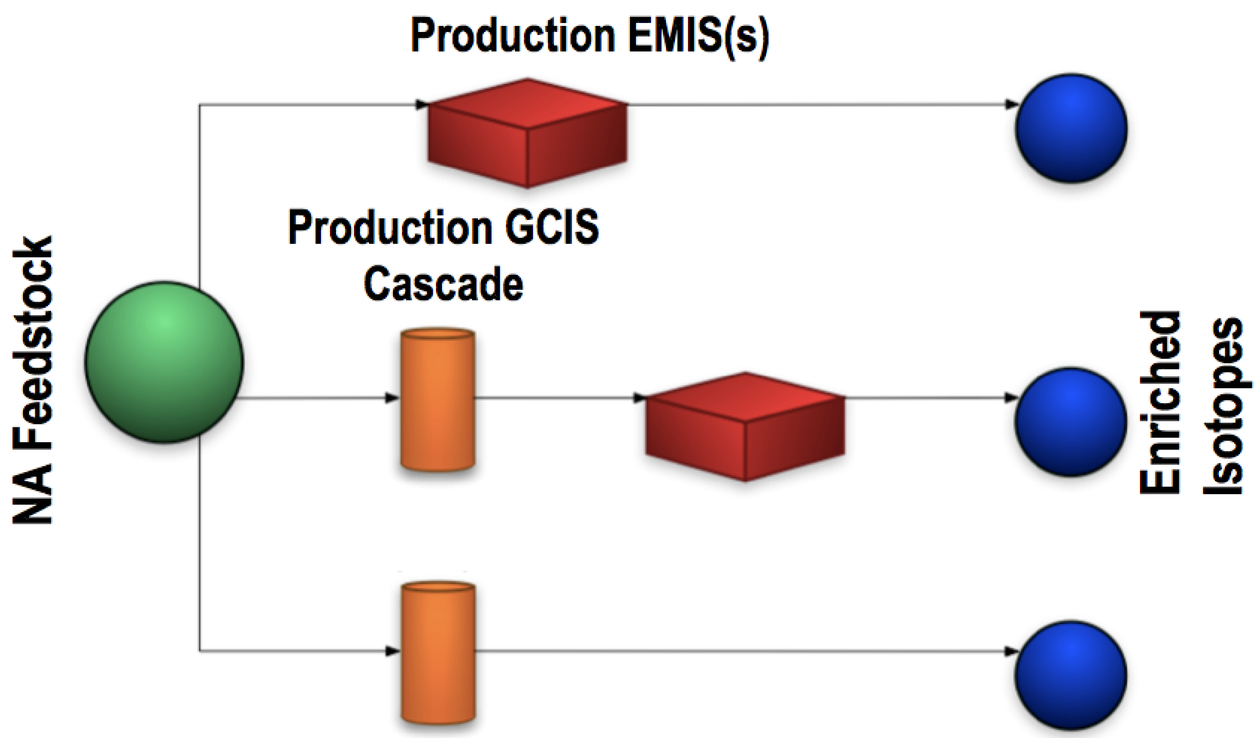
## Progress Towards Restoring Domestic Stable Isotope Production (continued)

***DOE Office of Nuclear Physics Approves Start of the Prototype Enriched Stable Isotope Production Facility***

ORNL has proposed to DOE Office of Nuclear Physics an integrated approach to stable isotope production that includes both electromagnetic and gas centrifuge isotope separators. The 10 mA EMIS and the planned upgraded EMIS are capable of high enrichment for most elements but are not capable of high throughput (i.e. several 10's of g to 1000's g annual quantities). More typically, applications requiring high enrichment, high throughput isotope separation look to methods such as gas centrifugation configured in large cascades to meet the desired production quantity and desired enrichment. The proposed prototype Enriched Stable Isotope Production Facility (ESIPF) will have both a high ion current EMIS and a small cascade of gas centrifuges. The small gas centrifuge cascade will be capable of pre-enriching target isotopes to produce an EMIS feedstock material for those elements where a suitable volatile gas can be identified. The use of pre-enriched feed material will magnify the throughput of the production EMIS for the selected isotopes since the separated ion current is proportional to the feedstock isotopic composition. The proposed production capacity is in the range of milligrams to 10's of grams, depending on the target isotope. The ESIPF design is scalable and can be expanded to include a larger number of EMIS and gas centrifuge machines, depending on future isotope demand and funding opportunities. Larger gas centrifuge cascades would be capable of achieving high enrichment and high throughput for select isotopes.

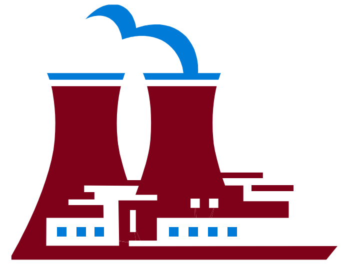
In August 2013, DOE Office of Nuclear Physics conducted an onsite peer review of ORNL's ESIPF proposal. The ESIPF effort was approved to start on December 12, 2013.

For more information, please contact Joel Grimm (Joel.Grimm@science.doe.gov).




***ORNL Proposed Production Scheme for the prototype Enriched Stable Isotope Production Facility (NA: natural abundance, EMIS: Electromagnetic Isotope Separator, GCIS: Gas Centrifuge Isotope Separator).***

## DOE/EPRI Joint Effort to Mitigate Potential Lithium-7 Commercial Supply Disruptions



The DOE Isotope Program (IP) has created an internal DOE Working Group on Li-7, which is working with the Electric Power Research Institute (EPRI) to minimize the impact to the U.S. nuclear power industry from potential supply disruptions of enriched lithium-7 (Li-7). High purity (99.99%) enriched Li-7 hydroxide monohydrate is used in sixty-five U.S. pressurized water reactors (PWR) as a corrosion inhibitor that neutralizes the acidic effects of boric acid. Boric acid is added to the primary circuit water in PWRs for reactivity management. Without the presence of the Li-7 buffer, important reactor components would be subjected to potential corrosion degradation.

Kilogram quantities of bulk Li-7 hydroxide monohydrate are distributed by a number of commercial chemical supply companies to the US nuclear power industry. The chemical supply companies purchase the bulk Li-7 directly from China and Russia where the isotope enrichment facilities are located. Although current supplies are sufficient to meet demand, there is some concern that increased growth in the Chinese domestic nuclear power industry could reduce any market surplus. In addition, normal supply chain disruptions associated with a small number of international suppliers can be foreseen, as would be the case with any other commercial commodity.

The DOE and EPRI are taking steps to mitigate any potential constraints on the Li-7 supply, including investigating Li-7 recycling options from PWR resin beds. In addition, the DOE IP is funding peer-reviewed research and development on new lithium separation technologies, has created a reserve of Li-7 DOE to process and make available to the general community should the need arise, has been investigating cost-effective processing approaches of Li-7, has worked with the National Isotope Development Center to identify an accurate estimate for demand of Li-7 in the United States (which was independently confirmed by EPRI), and is increasing awareness of risks in the supply chain through communication with stakeholders, such as EPRI and at the 2nd Federal Workshop on Isotope Supply and Demand.

For more information, please contact Jehanne Gillo (Jehanne.Gillo@science.doe.gov).

## Shortage of Helium-4 Averted


Helium gas has a long history of being used for filling our birthday party balloons, yet there are some larger industries that utilize this element as well. Naturally abundant helium-4 gas, not to be confused with its less abundant sister isotope helium-3, occurs in nature at >99.99%. One of the biggest consumers of helium is MRI systems in the medical industry. One of the most critical aspects in operating an MRI system is the superconducting magnet that is cooled at about 4.2 Kelvin or -452°F. To allow the magnets to be cooled at this temperature and still retain their strength, up to 12,000 liters of liquid helium is needed to be allocated per system. Some of the other applications of helium are for the aerospace industry, computer chip and optical fiber manufacturing, aluminum helium arc welding, and national defense applications such as engine testing, surveillance devices, missiles, and scientific balloons.

Currently the Bureau of Land Management (BLM) maintains the country's largest helium reserve, pipeline, and crude helium processing plant near Amarillo, TX. This program alone supplies nearly half of the U.S. crude helium demand and about a third of the world's demand. Money made with sales, storage fees, and related revenues are credited to the Helium Production Fund. Once the total debt of about $1.2 billion dollars has been repaid to the U.S. Treasury, the current law requires the Helium Production Fund to be terminated.

Without the production fund the BLM would have to stop operations of the processing plant, pipeline, and storage reserve. The BLM also does not have the authority to accept funding from third party users; therefore, a lapse in the program would produce a global shortage of helium impacting the medical imaging and patient care industry to national defense. The government took action and passed the Helium Stewardship Act of 2013. The act stated that the government seeks to mitigate a helium shortage by allowing the Secretary of the Interior acting through the BLM to continue to sell crude helium from the Federal Helium Reserve. This act included three phases to provide minimal market disruption. The first phase was to continue to operate as-is until September 30, 2014. The second phase, beginning in FY 2015, indicated that 10% of helium volumes made will be auctioned. After FY 2015 the percentage auctioned will increase by 10%. The last phase states that when three billion cubic feet of helium remain in the Federal Reserve it will limit sales to Federal users. There is ongoing research to find alternatives for helium, but finding one has been difficult. At this time natural gas mining has allowed for small amounts of helium to be economically extracted; therefore, as countries begin to mine for natural gas, opportunities to produce helium expand.

The DOE Isotope Program has formed an interagency group to consider He-4 supply, demand, alternatives and recycling. The IP Program is currently working with the DOE National Laboratory Chief Scientist Council to collect information on He-4 recycling technology as input to the Interagency Working Group.

For more information, please contact Jehanne Gillo (Jehanne.Gillo@science.doe.gov).