Californium-252 Newsletter

"To promote the exchange of information among ^{252}Cf users"

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Modified ^{252}Cf Source Form Available

At the recent Winter Meeting of the American Nuclear Society (see reverse page), ORNL's Radiochemical Engineering Development Center (REDC) announced the availability of the first modified ^{252}Cf source form in over a decade. REDC's standard commercial product, a cermet wire (Cf_2O_3 in a palladium matrix), which was previously limited to diameters exceeding 1 mm and specific activities up to ~20 μg of ^{252}Cf per mm of wire, has now been demonstrated with ~0.75-mm diameter and several-fold greater specific activity. Inquiries regarding this very high specific activity wire can be directed to J. B. Knauer at (865) 574-5909 or E-mail address *knauerjbjr@ornl.gov*.

Californium User Facility Activities

Several neutron irradiations were performed at the Californium User Facility for Neutron Science (CUF) at the REDC over the past year. Early in the year, an irradiation was performed to evaluate the neutron radiation hardness of several avalanche photodiodes for potential use as photon detectors. This activity was a follow-on to previous CUF irradiations in support of development of the planned Compact Muon Solenoid detector for the Large Hadron Collider at the European Center for Particle Physics (CERN) [see J. Broadhurst and R. Rusack, *Trans. Am. Nucl. Soc.* **82**, 94S95 (2000)].

More recently, some limited irradiations were performed to evaluate damage formation in ceramic specimens and to induce genetic damage in seeds prior to germination. Preirradiation discussions suggested that the availability of neutron beams with a fission energy spectrum has become very restricted, due to the continuing closure of research reactors. If any readers are familiar with suitable facilities outside the CUF, please inform the newsletter editor at *martinrc@ornl.gov*.

Permanent Magnets for the Advanced Photon Source

The most comprehensive CUF irradiation during 2000 investigated neutron damage effects on high-field permanent magnets used at the Advanced Photon Source (APS) at Argonne National Laboratory (ANL). When placed inside APS insertion devices, these neodymium-iron-boron permanent magnets (~1 tesla) are exposed to high-energy photons and neutrons. In collaboration with Julie Alderman and P. K. Job of the APS Operations Division, two irradiations were conducted, one with a fission neutron spectrum and another with a thermalized neutron spectrum (moderated by 10 to 20 cm of polyethylene). A fast neutron flux of 4×10^8 cm^{-2} s^{-1} was achieved, and thermal fluxes ranging from 10^6 to 2×10^7 cm^{-2} s^{-1} were employed. The results indicated that fast neutrons were more damaging in the degradation of magnetic field strength, despite the charged particle emission resulting from thermal neutron capture by the boron within the magnets. A summary of this work has been submitted for presentation at the Annual Meeting of the American Nuclear Society (June 2001), and a full paper will shortly be submitted for journal publication.

Next ^{252}Cf Sessions at IRRMA 2002

The next major technical sessions on the applications of ^{252}Cf are planned for the Fifth Topical Meeting on Industrial Radiation and Radioisotope Measurement Applications (IRRMA 2002), to be held in Bologna, Italy, on June 9S14, 2002. IRRMA is a triennial conference previously held in Raleigh, North Carolina. Sessions on the industrial, medical, and research applications of ^{252}Cf and other radioisotopes are planned. Additional information will be provided in future newsletters. Individuals who may be interested in presenting their work or assisting in session organization should contact the newsletter editor. A review of the most recent ^{252}Cf technical sessions follows on the reverse page.

Upcoming SPIE Radiation Physics Conference

An SPIE conference on "Hard X-Ray, Gamma-Ray, and Neutron Detector Physics III," with emphasis on radiation detection and sources, X-ray/neutron optics, and medical applications, will be held in San Diego the week of July 29, 2001, in conjuction with the SPIE International Symposium. Abstracts are due by February 28. Further information is available from the newsletter editor or, more authoritatively, from Ralph B. James at (925) 294-2782.

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American Nuclear Society Winter Meeting

The ANS Winter Meeting was held in November in Washington, D.C. In addition to two sessions dedicated to the medical and industrial applications of ^{252}Cf, the use of ^{252}Cf sources was frequently discussed elsewhere (e.g., as calibration sources during the "Neutron Detection, Spectrometry, and Dosimetry" sessions). R. A. Craig et al. of Pacific Northwest National Laboratory had a very interesting presentation ("Land-Mine Detection Using Timed Neutron Detection") on their evaluation of the use of timed neutron emission from a very low activity ^{252}Cf ionization chamber source to detect nonmetallic land mines. Detection works on the principle of neutron backscatter from the plastic within the land mine to the aboveground detector. Another presentation described a major new neutron activation analysis (NAA) facility at Fluor Hanford that operates with >80 mg of ^{252}Cf (G. L. Troyer and M. A. Purcell, "Californium-252 Neutron Activation Analysis of High-Level Processed Nuclear Tank Waste").

Medical Applications of ^{252}Cf

One presentation in the ^{252}Cf sessions involved a planned prompt gamma NAA medical facility for the measurement of human body composition (protein, fat, etc.), including the rationale for using ^{252}Cf rather than Am-Be neutron sources (J. C. Arbo et al., "In Vivo Neutron Activation Measurement of Nitrogen and Carbon"). Some of the most exciting developments in ^{252}Cf use involved ^{252}Cf brachytherapy for cancer treatment. Several presentations were given by Mark Rivard, Anita Mahajan, and coworkers at the New England Medical Center on their preparations for ^{252}Cf brachytherapy trials ("A Phase I/II Protocol Using ^{252}Cf for the Treatment of Cervical Carcinoma") and related research ("Plaque Therapy and Scatter Dose Using ^{252}Cf Sources" and "Investigation of a Diamond Detector for Mixed-Field Dosimetry of ^{252}Cf").

Dr. Sharwin Zeng of Cafmed provided a fascinating review of ongoing neutron brachytherapy in China (S. X. Zeng and J. H. Gu, "Californium-252 Neutron Therapy in China"). In 1998, a Russian-designed high dose rate (HDR) ^{252}Cf source was imported, and a clinical trial using an indigenous neutron brachytherapy system (NBS) for intracavitary treatment was begun in Chongqing. To date, five NBSs have been deployed to hospitals with ~100 patients already treated, with potential deployment of over 30 NBS units within the next 5 years. The current NBS can handle up to 1000 μg of ^{252}Cf, with typical loads of ~750 μg in a double encapsulated source with outer dimensions of 12 × 2.8 mm.

R. C. Martin reviewed the development of ^{252}Cf brachytherapy over the past 30 years and discussed ongoing efforts at the REDC to develop miniature HDR sources, the topic of a future newsletter article.

Technical Note: Cf Isotopes and Properties

Cf-252 sources contain several Cf isotopes. Although newly processed Cf contains >80% ^{252}Cf, isotopes such as ^{249}Cf, ^{250}Cf, and ^{251}Cf contribute the balance. Sources that are >15 years old (and still in use!) begin to exhibit a nontrivial contribution to neutron emission from ^{250}Cf decay (13-year half-life). Pure ^{249}Cf (obtained from decay of ^{249}Bk) is available from the REDC for research purposes. The REDC recently provided fairly pure ^{251}Cf (i.e., acceptably low neutron emission for routine handling) from the reprocessing of 30-year-old ^{252}Cf sources. Cf-254 is a very interesting isotope. With 99.7% of decay by spontaneous fission and a 60-day half-life, neutron emission from 2 μg of ^{254}Cf equals that from 1 mg of ^{252}Cf! Unfortunately, there is no simple way to separate ^{254}Cf during a heavy element campaign.

Occasionally, we receive academic inquiries on the physical and chemical properties of Cf. We recently responded with the melting (900°C) and boiling points (1472°C) of pure Cf metal, which is very reactive and apparently bright silver in color as prepared in an inert atmosphere with room-temperature density of 15.1 g/cm^3. The following titles are probably the best references for Cf chemistry:

(1) R. G. Haire, "Californium," in *The Chemistry of the Actinide Elements*, Vol. 2, J. J. Katz et al., eds., 2nd ed., Chapman and Hall, London, 1986, chapter 11.

(2) *Gmelin Handbuch der Anorganischen Chemie*, beginning with the volume "Np, Pu ... Transuranium Elements—Index," Springer-Verlag, Berlin, 1979. This is the most comprehensive reference available, and fortunately some of it is in English.

High Flux Isotope Reactor (HFIR) Update

In October 2000, we reported that the HFIR began a scheduled 6-month shutdown for replacement of its beryllium reflector. Since then, detection of leakage from a processing line has impacted planning and delayed the scheduled restart until late 2001. Users of ^{252}Cf will not be affected, as the REDC is currently processing >250 mg of ^{252}Cf from the latest heavy element campaign, a quantity sufficient to supply demand for several years.

For Further Information

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