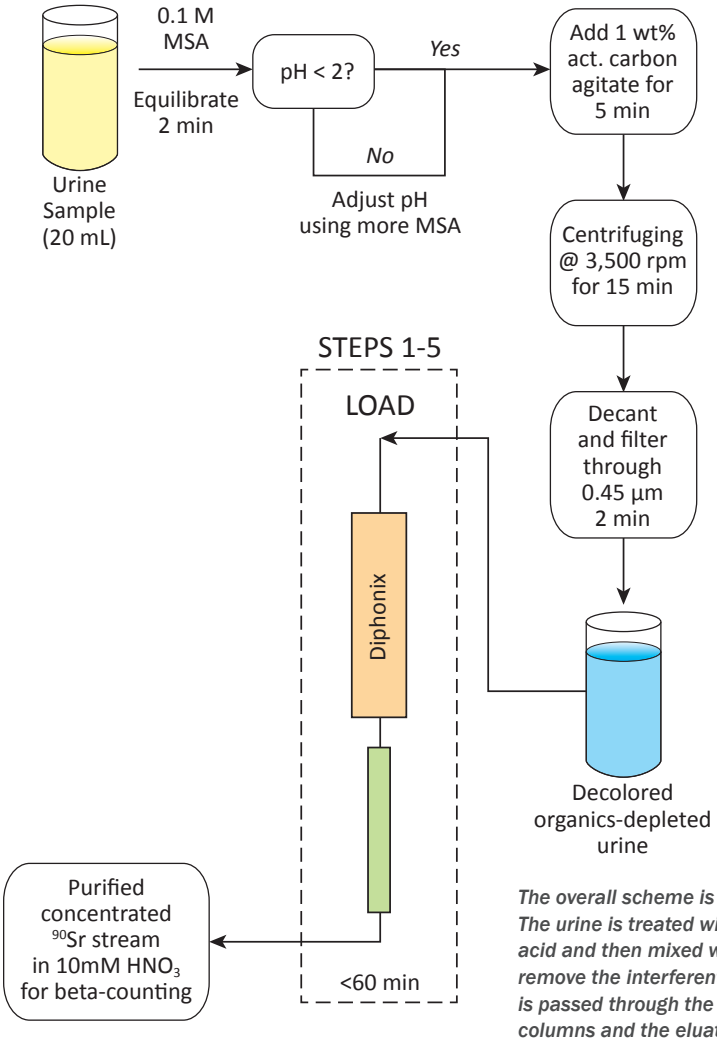
Argonne Technology Provides More Rapid Detection of Strontium in Urine Samples (ANL-IN-10-037)

Strontium-90 (Sr-90) is a radioactive isotope that results from nuclear fission. It is a carcinogen that can be released into the atmosphere and exposed to humans through nuclear weapons and accidents. Argonne researchers have created a new and improved detection method that provides more rapid and accurate identification of Sr-90 in urine samples.

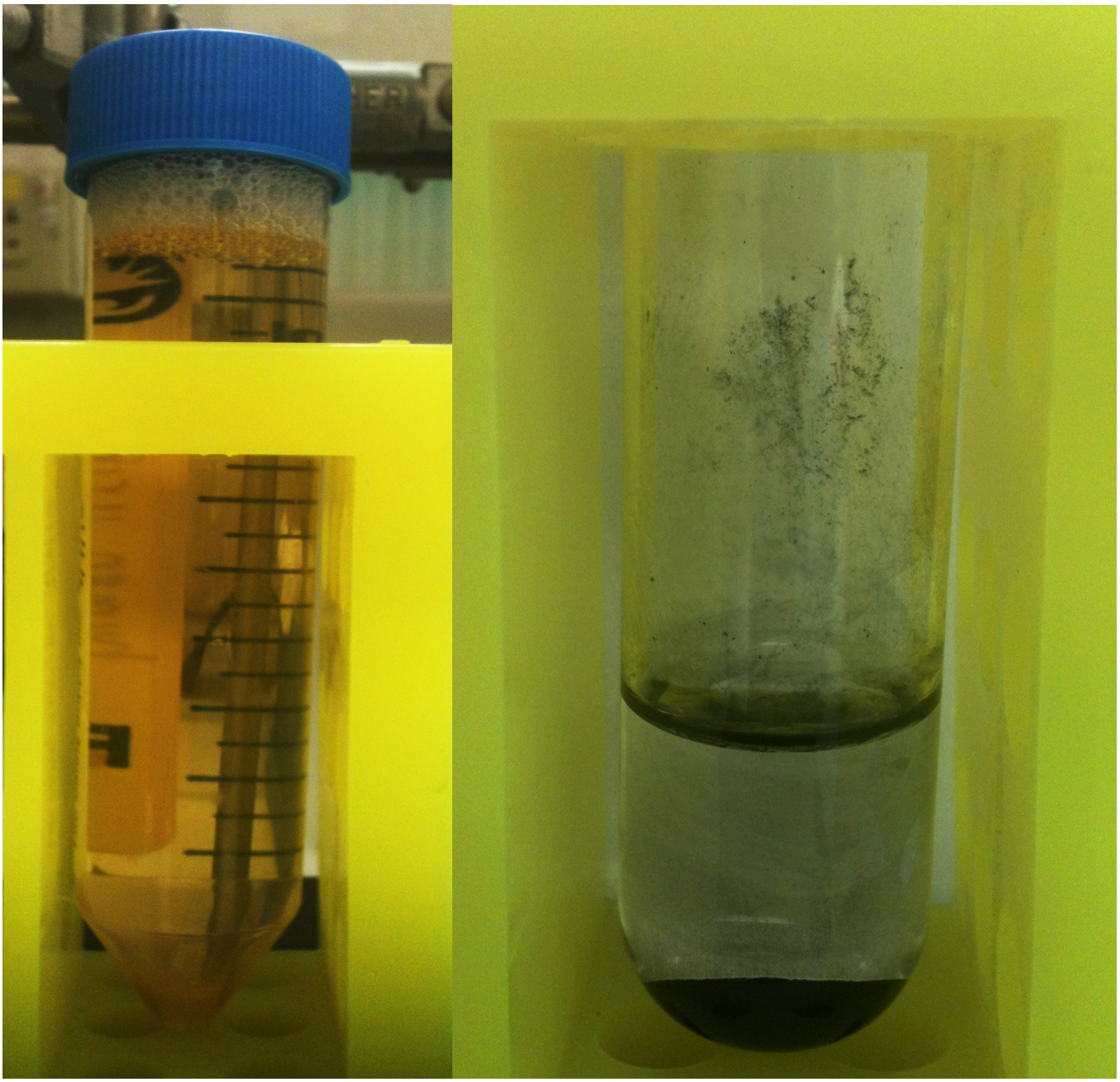
Background and Need

Sr-90 is a product of nuclear fission and can be released from events such as dirty bombs, radioactive fallout or a nuclear reactor accident like the Fukushima Daiichi nuclear disaster in March 2011. Sr-90 can be inhaled or penetrate the skin via beta radiation, but the greatest health concern is through the ingestion of contaminated food and water. Strontium is chemically similar to calcium and tends to migrate to human bone structures, replacing calcium and making its way into bones and teeth. Once in the body, Sr-90 is very difficult to remove and long-term accumulation can cause cancers of the bone, bone marrow and tissues around the bone.

The Center for Disease Control (CDC) is interested in developing an automated strontium detection method that will process about 10,000 samples per day using multiple separation columns. The current strontium identification process can only process about 10-20 samples per day. This test is very important in the event of a nuclear-related attack or accident.



The overall scheme is described above. The urine is treated with sulfonic acid and then mixed with charcoal to remove the interferents. The resultant is passed through the chromatographic columns and the eluate is counted by radiometric means.



On the left, a raw urine sample is shown, colored with pigments and containing numerous proteins that mask the presence of the target radionuclide. On the right, a clarified urine sample is shown after it has been treated with the sulfonic acid and then mixed with charcoal to remove the pigments and organic molecules.

The Invention

Argonne has developed a novel, practical, inexpensive and automated technology to quickly and accurately determine the dose levels of Sr-90. A small urine sample, with as little as 5 mL, is sufficient to provide an accurate strontium count.

Raw urine is colored with pigments and contains numerous proteins that mask the presence of the target radionuclide. To eliminate the pigment and proteins, the current strontium detection method requires precipitating salt from the urine which carries the radioactive strontium. This precipitate is then heated to destroy the organic molecules creating the interferences. The resulting precipitate is then re-dissolved before separations are performed. This testing approach is very slow and complicated.

With Argonne's method, the urine is treated with sulfonic acid and then mixed with charcoal to remove interferents, such as pigments and organic molecules. The clarified urine is ready for processing. The sample is passed through the chromatographic columns and the eluate is counted by radiometric means. The resins used in this method are expected to be reusable up to 100 times after washing. This method greatly reduces the time required to condition samples and the amount of analyst time required in conditioning and performing elemental separations on the samples.

Benefits

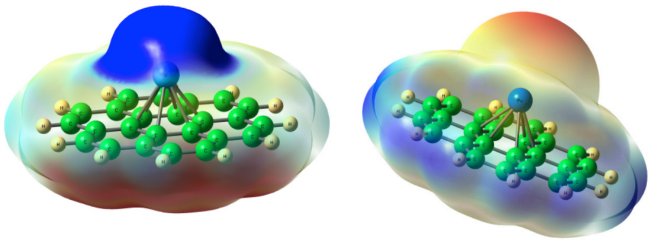
The Argonne-developed process allows CDC to reach its goal throughput of 10,000 samples per day using existing sampling equipment and analytical facilities. The innovative method conditions the samples in minutes and can be fully automated, reducing the need for an analyst, who would only be required to refill reagents and initially load and remove the samples. Importantly, this approach provides a final, small volume of solution suitable for radioanalytical counting using existing equipment at the CDC laboratories.

The technology also demonstrates the utility of miniaturizing separations schemes that permit dramatic reduction in analysis times. In addition, miniaturization permits the potential use of novel detection systems that can be cheaper and easier to operate. Such systems are thus portable and can then be brought into the field for direct measurements. This could impact analysis for environmental samples as well as medical diagnostics.

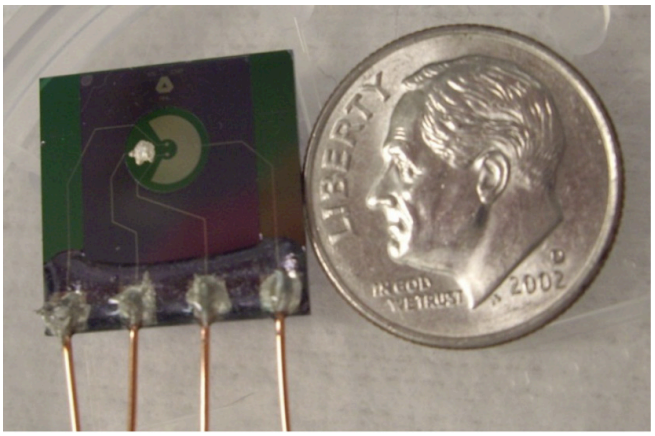
Applications and Industries

In addition to strontium detection, this testing method may have medical uses in detecting other radioisotopes, compounds or proteins, but no development has been done in these areas. Further development in extending this process to other radioisotopes will depend upon the resin uptake.

This separation scheme is an example of miniaturization and automation that could also improve other detection systems (see examples below).



A plasmon sensor is capable of detecting the molecular electrostatic potentials of single atoms such as Uranium (left) and Plutonium (right), as well as other chemical, biological and environmental agents, such as carbon dioxide.



This electrochemical detector features carbon nanotubes grown on its surface to enhance the collection, quantification and signal strength of electroactive species, including many actinides, radionuclides and chemicals.

Developmental Stage

Argonne has demonstrated the individual steps of the invention in batch experiments with actual urine. The research team is currently modifying the flow sheet to permit sampling of very small volumes of urine expected in a potential emergency. Importantly, the stability of the resin columns is being quantified to determine the extent of reusability of the columns.

Availability/Commercial Readiness

All reagents employed in this separation scheme are available commercial off-the-shelf (COTS). The automated controls are available from many suppliers.

Patent Information

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