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INTERFACE FOR THE RAPID ANALYSIS OF LIQUID SAMPLES BY ACCELERATOR MASS SPECTROMETRY

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims benefit under 35 U.S.C. §119(e) of U.S. Provisional Patent Application No. 61/452,915 filed Mar. 15, 2011 entitled "interface for the rapid analysis of liquid samples by accelerator mass spectrometry," the disclosure of which is hereby incorporated by reference in its entirety for all purposes.

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT

The United States Government has rights in this invention pursuant to Contract No. DE-AC52-07NA27344 between the United States Department of Energy and Lawrence Livermore National Security, LLC for the operation of Lawrence Livermore National Laboratory.

BACKGROUND

1. Field of Endeavor

The present invention relates to accelerator mass spectrometry (AMS) and more particularly to an interface for the rapid analysis of liquid samples by AMS.

2. State of Technology

Accelerator mass spectrometry (AMS) is the use of a combination of mass spectrometers and an accelerator to measure and analyze samples. L. W. Alvarez and Robert Cornog of the United States first used an accelerator as a mass spectrometer in 1939 when they employed a cyclotron to demonstrate that ^3He was stable; from this observation, they immediately (and correctly) concluded that the other mass-3 isotope tritium was radioactive. In 1977, inspired by this early work, Richard A. Muller at the Lawrence Berkeley Laboratory recognized that modern accelerators could accelerate radioactive particles to an energy where the background interferences could be separated using particle identification techniques. He published the seminal paper in *Science* showing how accelerators (cyclotrons and linear) could be used for detection of tritium, radiocarbon (^{14}C), and several other isotopes of scientific interest including ^{10}Be ; he also reported the first successful radioisotope date experimentally obtained using tritium (^3H). His paper was the direct inspiration for other groups using cyclotrons (G. Raisbeck and F. Yiou, in France) and tandem linear accelerators (D. Nelson, R. Korteling, W. Stott at McMaster). K. Purser and colleagues also published the successful detection of radiocarbon using their tandem at Rochester. Soon afterwards the Berkeley and French teams reported the successful detection of ^{10}Be , an isotope widely used in geology. Soon the accelerator technique, because it was about a factor of 1000 more sensitive, virtually supplanted the older "decay counting" methods for these and other radioisotopes.

SUMMARY

Features and advantages of the present invention will become apparent from the following description. Applicants are providing this description, which includes drawings and examples of specific embodiments, to give a broad representation of the invention. Various changes and modifications

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within the spirit and scope of the invention will become apparent to those skilled in the art from this description and by practice of the invention. The scope of the invention is not intended to be limited to the particular forms disclosed and the invention covers all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the claims.

The present invention in one embodiment provides an interface for the analysis of liquid sample having carbon content by an accelerator mass spectrometer including a wire, defects on the wire, a system for moving the wire, a droplet maker for producing droplets of the liquid sample and placing the droplets of the liquid sample on the wire in the defects, a system that converts the carbon content of the droplets of the liquid sample to carbon dioxide gas in a helium stream, and a gas-accepting ion source connected to the accelerator mass spectrometer that receives the carbon dioxide gas of the sample in a helium stream and introduces the carbon dioxide gas of the sample into the accelerator mass spectrometer.

The present invention in another embodiment provides a method of analysis of a liquid sample having carbon content by an accelerator mass spectrometer including the steps of providing a wire, providing defects in the wire, providing a system for moving the wire, producing droplets of the liquid sample and placing the droplets of the liquid sample on the wire in the defects, converting the carbon content of the droplets of the liquid sample to carbon dioxide gas in a helium stream, and using a gas-accepting ion source to introduce the carbon dioxide gas of the sample into the accelerator mass spectrometer.

The present invention has use in biomedical, environmental and carbon cycle research. The present invention also has use to determine the concentration of ^{14}C , e.g. by archaeologists for radiocarbon dating.

The invention is susceptible to modifications and alternative forms. Specific embodiments are shown by way of example. It is to be understood that the invention is not limited to the particular forms disclosed. The invention covers all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated into and constitute a part of the specification, illustrate specific embodiments of the invention and, together with the general description of the invention given above, and the detailed description of the specific embodiments, serve to explain the principles of the invention.

FIG. 1 illustrates an embodiment of a system for analysis of liquid sample having carbon content by an accelerator mass spectrometer.

FIGS. 2A through 2D show the indentations in the wire in greater detail.

FIG 3A is an example of droplets on an indented wire, FIG. 3B is an example of droplets on a smooth wire.

FIG. 4 illustrates another embodiment of a system for the online ^{14}C and ^{12}C analysis of materials dissolved or suspended in liquids.

FIG. 5 is a flow chart illustrating another embodiment of a system for analysis of liquid sample having carbon content by an accelerator mass spectrometer.

FIG. 6 is FIG. 1 of the Ognibene et al Manuscript showing a schematic layout of the 1-MV AMS system.

FIG. 7 is FIG. 2 of the Ognibene et al Manuscript showing a plot of the recorded $^{14}\text{C}^+$ count rate and $^{12}\text{C}^-$ ion current of four of the 23 peaks recorded over a 30 minute period.