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Air monitor instantly detects beryllium, other elements

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LOS ALAMOS, N.M., Jan. 4, 2000 -- Researchers at the Department of Energy's Los Alamos National Laboratory have developed a portable, ultrasensitive air particulate monitor that instantly and continuously identifies virtually all known constituent elements in the periodic table and their relative concentrations.

"I've no doubt that this portable instrument will greatly reduce, or in some cases eliminate, the risk of worker exposure to hazards related to operating processes," said principal investigator Yixiang Duan of Los Alamos' Analytical Chemistry Sciences Group. "The instrument is ideal for work sites that handle hazardous materials."

The inexpensive device, which can be used indoors or outdoors, takes advantage of the fact that all elements in the periodic table have well-characterized atomic energy levels. A miniature microwave plasma source in the device excites the atoms, permitting quick, easy identification of air particulate samples based on the energy levels of those elements. With a minor modification, the device also can identify elements in solution.

The monitor is ideal for facilities that handle highly hazardous materials such as beryllium, Duan said. Exposure of workers who are sensitized to beryllium can lead to chronic beryllium disease, which scars the lungs and can be fatal.

"The monitor can detect almost all hazardous elements, although our project's initial focus was on creating an ultrasensitive monitor for detecting beryllium air particulates," Duan said.

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Steve Abeln, project leader for beryllium technology at Los Alamos, added, "There are currently more than 100 cases of chronic beryllium disease within the DOE complex. A primary deficiency in protecting workers from exposure to airborne beryllium particulates has been that exposure levels were always determined after the fact through laboratory analyses."

Los Alamos instrument

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"This instrument can provide real-time feedback to workers, allowing them to take prompt action and avoid overexposure," Abeln said.

DOE recently lowered the beryllium exposure action limit to one-tenth of its former level, from 2 micrograms per cubic meter to 0.2 micrograms. The new portable monitor can reach a detection limit for beryllium air samples of 0.12 micrograms per cubic meter. In solution, the monitor possesses a beryllium detection limit as low as 9 trillionths of a gram per milliliter.

"The monitor is about ten times more sensitive for air particulate monitoring than laser-based techniques, which are the only field technologies currently available," said Duan. "The new monitor is easier to use and can detect and quantify multiple elements simultaneously."

The microwave plasma source-based monitor possesses several other advantages over inductively-coupled plasma atomic emission instruments, which are used for analyzing air and solution samples. These include better tolerance to air particulate sampling; lower power and gas consumption; and smaller size.

Researchers pump an airborne sample through a tube into the heart of the microwave plasma source. Argon and helium are most frequently used as plasma gases for analyzing metal and nonmetal elements.

A fiber-optic cable alongside the plasma source detects the optical emissions from the elements and feeds that information to a palm-sized spectrometer, which converts the information into a graph that shows each element's specific wavelengths and signal peaks on a laptop computer screen. The wavelengths identify the elements; the peak intensities reveal their concentrations.

Samples in solution are analyzed in the same way. The operator simply changes the initial air sampling pump to one suited for handling solution samples. Results are virtually instantaneous, requiring about 100 milliseconds.

The monitor weighs about 55 pounds and is about the size of a milk

crate. The team currently is shrinking it further and making it easier to use. A patent is pending.

Initial funding came from Los Alamos' Laboratory-Directed Research and Development Program. DOE's Defense Programs Office provided additional funds through its Advanced Design and Production Technology Initiative.

Duan, Analytical Chemistry Sciences Group colleagues Yongxuan Su and Zhe Jin, and Abeln collaborated on the project.

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