Potential new breathalyzer for lung cancer screening

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Researchers from Chongqing University in China have developed a high sensitive fluorescence-based sensor device that can rapidly identify cancer related volatile organic compounds—biomarkers found exclusively in the exhaled breath of some people with lung cancer.

Their work, described in a paper published this week in the journal *Review of Scientific Instruments*, from AIP Publishing, demonstrates the potential of the device to be used as a breathalyzer for early lung cancer detection—possibly a safe and effective method of detecting cancer early that may save lives.

According to the researchers, the laboratory results are promising, but the device would still need to prove effective in clinical trials before its widespread adoption as a diagnostic tool.

"Our results show that the device can discriminate different kinds and concentrations of cancer related volatile organic compounds with a nearly100 percent accurate rate," said Jin-can Lei, the primary researcher and a postdoc from the College of Optoelectronic Engineering, Chongqing University. "This would also be a rapid method in that the entire detection process in our experiment only takes about 20 minutes."

Based on a small, circular plate called fluorescent cross-responsive sensor array, a specially-designed rotary gas chamber and a data collection and processing system, the device can detect lung cancer related gases at very low concentration, or below 50 parts per billion (ppb), showing a potential to identify lung cancer at the early stage. Lei said. Parts per billion is a technical unit used to describe very low-concentration contaminants, the amount of one parts per billion can be imagined as one pinch of salt in 10 tons of potato chips.

"Thus, given a complete fluorescent-image database of all lung cancer related gases, this device could be used to identify and quantify various gases characteristic of lung cancer from people's exhaled air, " said Chang-jun Hou, the team leader and a professor from the College of Bioengineering, Chongqing University. "This may lead to a simple, rapid breathalyzer for early diagnosis of lung cancer."

A Common, Primary Cancer

According to the World Health Organization (WHO), lung cancer is one of the most common cancers for both men and women, accounting for 1.8 million new cases and 1.6 million deaths worldwide in 2012. In the United States, the number of people who die from lung cancer each year has steadily increased over the last 15 years to 159,260 people in 2014, and deaths continue to rise among women, according to the U.S. Centers for Disease Control and Prevention (CDC). Part of the problem is that lung cancer tends to be a deadly form of cancer, which is why even though more Americans are diagnosed with cancer of the breast or prostate every year compared to lung cancer, far more people die from lung cancer.

Cancer screening may be an important tool for preventing cancer deaths by allowing doctors to catch it early, when it is more treatable. But while there are already existing ways to screen for lung cancer, there is a great need for even more safe and effective methods to save even more lives.

Currently doctors can detect lung cancer in its earliest stages by using methods like CT scans, and CT screening is shown to reduce lung cancer deaths among long-time heavy smokers. But there are no simple, safe and effective methods that can detect lung cancer at the early stage, Lei said.

According to Lei, a large number of studies have shown that some kinds of volatile organic compounds, originating from oxidation of unsaturated fatty acid in carcinogenesis, appear only in the exhaled air of people with lung cancer, raising the possibility that these compounds could be used as biomarkers to identify cancer.

Hou's team designed and fabricated a cancer-related gas detector, whose key functional part is a small (about 50 millimeter diameter) circular plate—technically a fluorescent cross-responsive sensor array. The sensor consists of a disposable array with 35 chemically responsive spots evenly located around the sensor edge. The spots are then filled with seven different kinds of lab-synthesized sensitive materials (porphyrin and its derivatives) as sensor elements.

When the sensor is exposed to and interacts with specific analytes or volatile organic compound gases, the fluorescence effects of sensor elements will change. By collecting the fluorescent emission spectrum of the sensor array before and after the reaction, the researchers can eventually obtain the responsive spectrum characteristic to each analyte.

The system is based on a fluorescent cross-responsive mechanism, Hou said, which means rather than a specific sensor element responding to a specific analyte, the whole array system will produce a composite and distinct fluorescent response pattern unique to a specific analyte, just like providing "fingerprints" for analytes.

In the experiments, Lei and his coworkers selected four kinds of lung cancer related volatile organic compounds, called p-xylene, styrene, isoprene and hexanal, which are uniformly distributed in a specially designed rotatory gas chamber to each responsive spot in the sensor array. A light source containing three different wavelength lasers are employed to excite the fluorescent spectra of the array, which are later collected and analyzed by the data processing system to produce a unique spectrum for each gas. By extracting the characteristic matrix of spectra and comparing with the existed fluorescent database, researchers can identify and quantify a specific gas.

"The experiment shows that the fluorescent cross-responsive sensor can accurately distinguish the four cancer-related gases and discriminate the gas concentrations, ranging from 50 to 500 parts per billion," Lei said, which indicates another possible application for cancer staging.

The next research step, Hou added, is to refine the method and establish a complete fluorescent database for lung cancer related gases.

More information: "A novel device based on a fluorescent cross-responsive sensor array for detecting lung cancer related volatile organic compounds" *Rev. Sci. Instrum.* 86, 025106 (2015); dx.doi.org/10.1063/1.4907628

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