

Hand-held, Portable Device to Detect VOCs in Water, Soil and Air Samples

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Environmental Problem

Volatile organic compounds (VOCs) encompass a broad range of chemicals that are present in all parts of the environment. They occur naturally, can be created and emitted by industrial and commercial processes, and are in many common products that are found in the home or work settings (e.g., cleaners, paints, gasoline, lubricants, pesticides, building materials, cosmetics and glues). Some are harmless and others, such as the known carcinogen benzene, are quite deleterious to human health. Historically, the health effects of VOCs were poorly understood, and many chemicals from industrial processes were dumped in waterways and landfills with little regard for the future effects of these chemicals.

Although few of the compounds are acutely toxic, unhealthy effects are typically attributable to long-term exposure and may result in cancer, damage to the liver, kidneys and central nervous system, and respiratory problems. The cumulative effects of long-term exposure to VOCs are difficult to measure, study and define. In addition, measuring and controlling VOCs presents challenges because their high vapor pressures and tendency to evaporate at room temperatures means that the compounds can be detected only in trace amounts. VOC detection traditionally has been a costly and time-consuming process. Samples are sent to commercial environmental laboratories, with processing taking approximately 7–14 days at the cost of about \$150 per sample. The characterization and remediation of a large contaminated site may require analysis of hundreds of samples.

Additionally, many industries, such as the gas and oil industry, face a tremendous amount of regulation regarding VOCs and chemical waste, with no anticipated reduction of regulatory oversight in the near future. The U.S. Environmental Protection Agency (EPA) publishes Regional Screening Levels (RSLs) for many VOCs and other chemicals, which are risk-based concentrations for resident and industrial soil, air and tapwater that are considered protective for humans over a lifetime. RSLs are used to identify concentrations that may pose risks to human health. Furthermore, many states enforce their own regulations for VOC content in water, soil and air. The lack of consistent guidelines between federal, state, tribal and local agencies may cause confusion about which regulations apply to a remediation site.

SBIR Technology Solution

With support from EPA's Small Business Innovation Research (SBIR) Program, Defiant Technologies developed a hand-held, portable device to detect and analyze VOCs in water, soil and air. The FROG-4000™, a portable gas chromatography (GC) instrument, is constructed with miniaturized components used for analytical chemistry. The instrument's gas module contains three key components: a micro preconcentrator that is coated with a designer nanoporous material, a micro gas chromatography column that is 4.8 meters long, and a miniature 10.6 eV photoionization detector (PID) with a replaceable bulb. An integrated heater allows for temperature ramp chromatography that aids in the separation of late eluting compounds. The gas module contains a small pump and valves to manage the air flow through the system. The instrument scrubs ambient air through an inexpensive filter material to use as the carrier gas. The temperature program and air flow parameters are programmed and controlled by the included software, Ellvin™.

The battery powered FROG-4000™ is the smallest and lightest GC system on the market today and provides onsite VOC analysis results in less than 10 minutes. The instrument includes a purge-and-trap collection device on the front end, allowing quick and efficient analysis of water and soil samples. Air samples are collected and processed through a simple attachment that fits into the purge-and-trap components. When an analysis is complete, the chemical name and concentration can be viewed on the device's LCD display, or the user may watch the chromatogram real time on a computer that is running the Ellvin™ software.

Commercialization Information

The FROG-4000™ chemical detector is available via direct sales throughout the United States and through international distributors for the worldwide market. In addition, the FROG-4000™ is available for rent in the United States to allow customers to experience the ease of use and rapid analysis times on a low risk basis. Commercial applications include the rapid site



The portable FROG-4000™ expedites chemical detection and analyses of volatile organic compounds (VOCs) in air, water and soil in real time.



characterization of BTEX (benzene, toluene, ethylbenzene and xylene) contaminants from oil and gas releases; the detection and characterization of trichloroethylene (TCE), perchloroethylene (PCE) and vinyl chloride from industrial process releases, such as dry cleaning businesses or parts degreasing; process monitoring of solvents in industrial manufacturing, such as pharmaceutical and personal care products production; process monitoring in the food industry, such as checking for spoilage for example; and process monitoring in the beverage industry, such as monitoring fermentation processes and confirming purity of CO₂. The FROG-4000™ has been used to characterize chlorinated alkenes in extraction wells at a Superfund site in Tacoma, WA, determine PCE concentrations in ground water at a former landfill site in Valencia County, NM, and characterize remediation excavation sites for BTEX components in soil in rural Michigan. One recent application of the FROG-4000™ occurred at a manufacturing plant that had high toluene levels in the wastewater discharge. The FROG-4000™ was used to trace the wastewater upstream through the manufacturing process to find the source of the toluene, which turned out to be in a water-based, wood-finish product that contained high levels of the VOC. Several universities are considering FROG-4000™ use in food and plant applications, including in viticulture and oenology.

Company History

Defiant Technologies, based in Albuquerque, NM, was founded in 2005 to incorporate micro-fabricated components into chemical detection equipment. The company has developed several systems that analyze liquid, soil or gas samples to determine the concentration of chemicals in the environment. The technology was originally developed for detecting chemical warfare agents,

but Defiant Technologies extended its applications to include toxic industrial chemicals and environmental pollutants. All the systems—FROG 4000™, CANARY-3™ and CANARY-0™—are hand-held, portable devices that provide laboratory capabilities in the field, and offer size, flexibility and accuracy advantages not available in other chemical detectors. Defiant Technologies is a full capability research and development-to-manufacturing company that handles all production phases, from

micro-electromechanical systems (MEMS) manufacturing and heavy machining to electronics and software design. The company now employs a dozen mechanical, electrical, software and chemical engineers, and technicians supported by marketing and administrative personnel. During the past 8 years, Defiant Technologies has established a robust infrastructure that includes efficient operational processes and an accounting system appropriate for government contracts.

SBIR Impact

- Defiant Technologies developed the FROG-4000™, a hand-held, portable gas chromatography instrument to detect and analyze VOCs in water, soil and air in near real time for pennies per sample.
- The FROG-4000™ reduces the cost and time for analysis, allowing the margins of a contaminate plume to be more accurately defined, and facilitating more effective application of *in situ* remediation products or removal of less material at an excavation site. This means less time onsite with expensive heavy equipment and crews.
- The FROG-4000™ chemical detector is available via direct sales throughout the United States and through international distributors for the worldwide market.
- Defiant Technologies has developed multiple, hand-held detection systems to provide laboratory analysis capabilities in the field.

