The FROG-4000™ : A Next Generation Portable GC for Monitoring VOCs in Air

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The FROG-4000™ is a MEMS (micro electro-mechanical systems) based chemical analysis microsystem developed by Defiant Technologies. Thanks to small, low power micro-devices, Defiant has constructed a truly portable gas chromatograph (GC). When analyzing a sample, each chemical name and concentration can be read directly from the FROG's display. Additionally, the FROG-4000™ may be connected to a computer to see a live plot of the chromatogram. Measurements commensurate with a bench top GC system can be obtained with the FROG-4000™ (Figure 4), but instead of waiting for days using an offsite lab, results are available immediately following its 7 minute operation. This short cycle time enables correlation with other short cycle time data, for instance wind speed, a feat not possible with summa canisters (Figure 5). A micro-preconcentrator (PC) coated with a selective sol gel material collects and concentrates VOCs from the ambient air (Figure 2). The micro-PC has an integrated heater that enables it to reach 350°C in less than 1 second, which makes for a good injection into our micro GC column. While most portable GCs run isothermally, Defiant's micro GC has an integrated heater so that the GC may be temperature ramped (Figure 3). This feature greatly diminishes the analysis time for lower-vapor-pressure VOCs. These components combined with a miniature PID are able to determine VOCs in ambient air at concentrations lower than 0.1 part per billion.

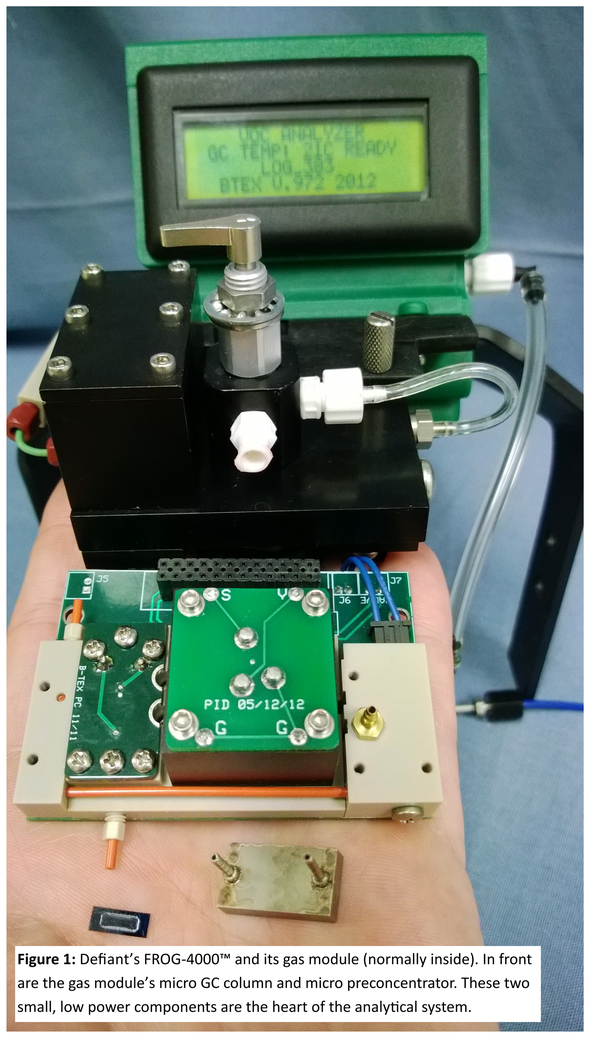

Figure 1: Defiant's FROG-4000™ and its gas module (normally inside). In front are the gas module's micro GC column and micro preconcentrator. These two small, low power components are the heart of the analytical system.

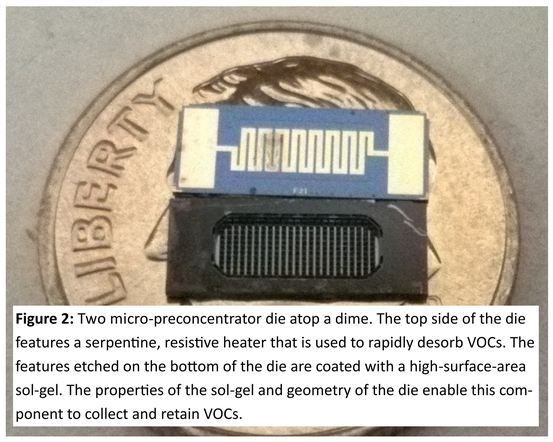

Figure 2: Two micro-preconcentrator die atop a dime. The top side of the die features a serpentine, resistive heater that is used to rapidly desorb VOCs. The features etched on the bottom of the die are coated with a high-surface-area sol-gel. The properties of the sol-gel and geometry of the die enable this component to collect and retain VOCs.

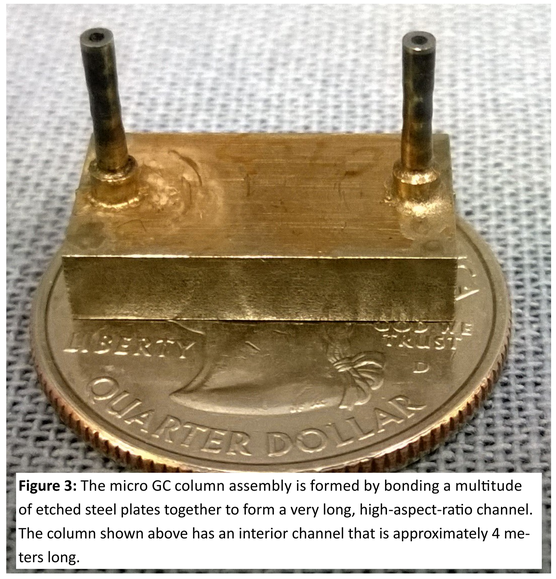

Figure 3: The micro GC column assembly is formed by bonding a multitude of etched steel plates together to form a very long, high-aspect-ratio channel. The column shown above has an interior channel that is approximately 4 meters long.

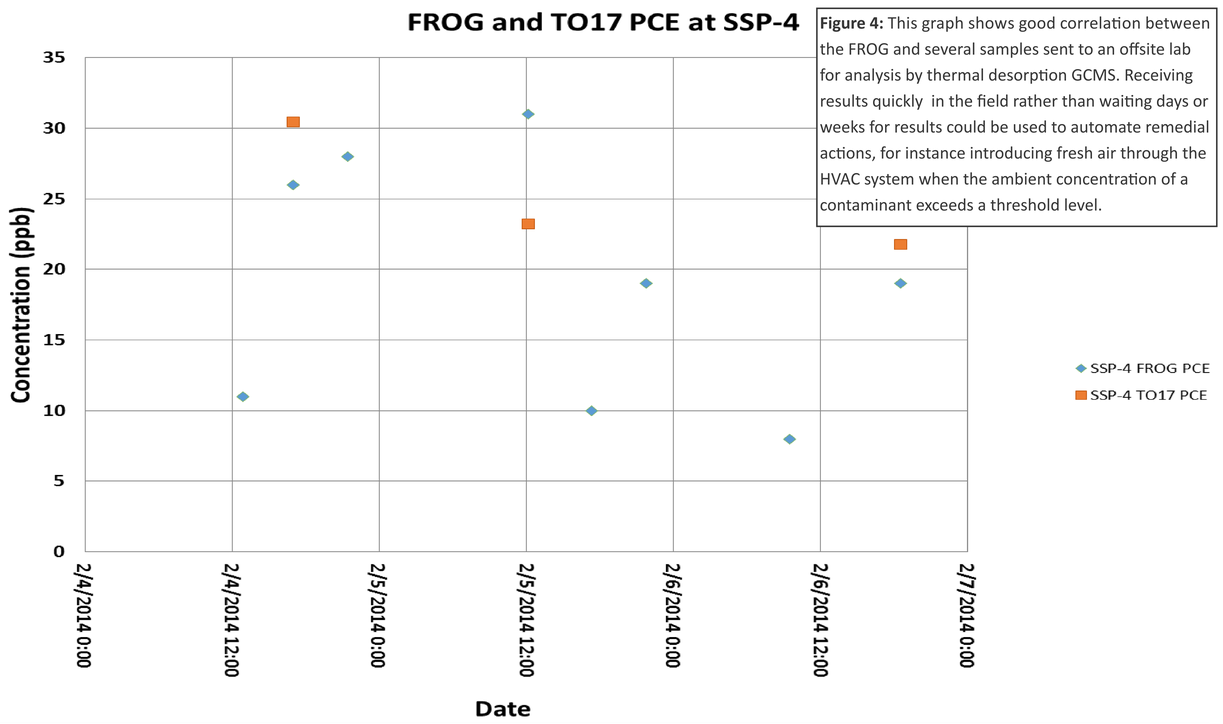

Figure 4: This graph shows good correlation between the FROG and several samples sent to an offsite lab for analysis by thermal desorption GCMS. Receiving results quickly in the field rather than waiting days or weeks for results could be used to automate remedial actions, for instance introducing fresh air through the HVAC system when the ambient concentration of a contaminant exceeds a threshold level.

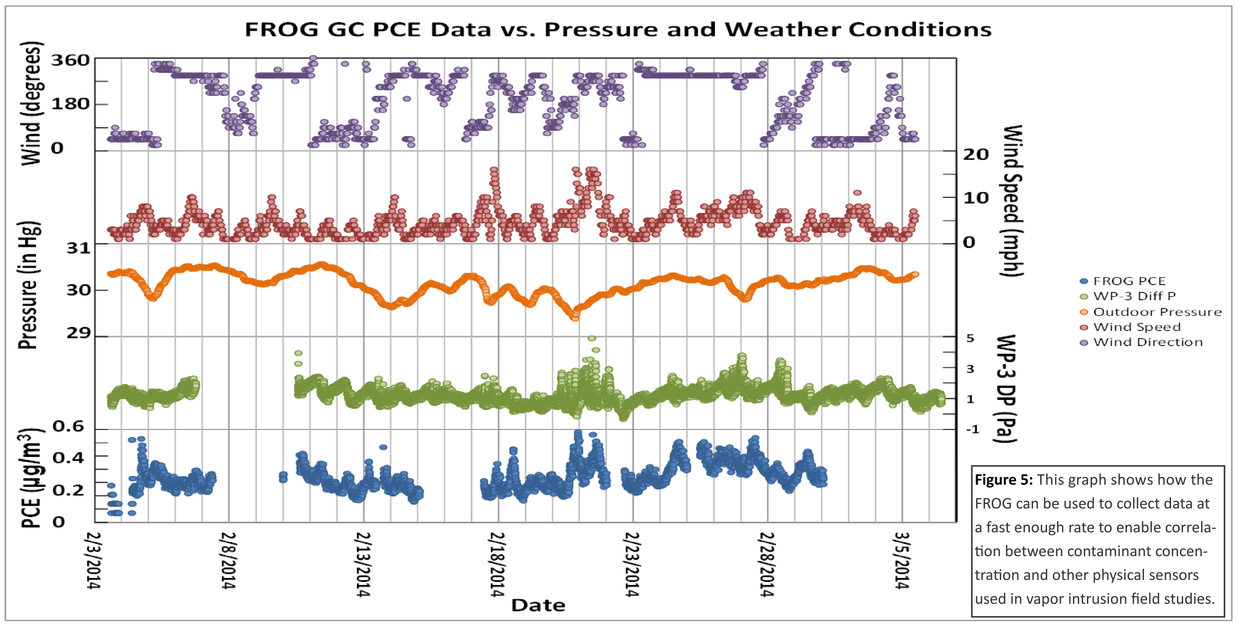

Figure 5: This graph shows how the FROG can be used to collect data at a fast enough rate to enable correlation between contaminant concentration and other physical sensors used in vapor intrusion field studies.

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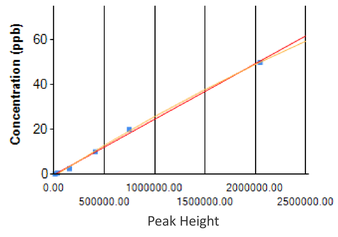
Data

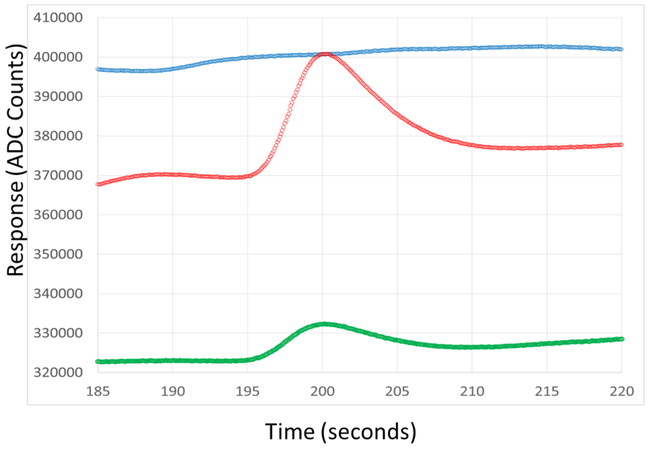
	Peak	Time	Height	Area	Width	Concentration
▸	2	194.42	11354	171652	0	0.1
	3	192.25	34774	640652	0	0.5
	4	193.67	153364	2953606	0	2.5
	5	194	411002	8285307	0	10
	6	193.5	747786	15958278	0	20
	7	193.92	2047378	45175652	0	50

Height

EQ	Y=-1.6736E-012X²+ 2.8276E-005X + -8.2029E-001
QUAD R²:	0.99888
EQ	Y=2.4793E-005X + -2.2287E-001
LINE R²:	0.99768



Blue- Outdoor Sample taken at curb away from the home at the tailgate of truck
Red- FROG detects 0.9ppbv at 422 Basement Corner Crack S/N=270 (entry point)
Green-FROG detects 0.36ppbv at 422 Basement Cistern Crack S/N=52



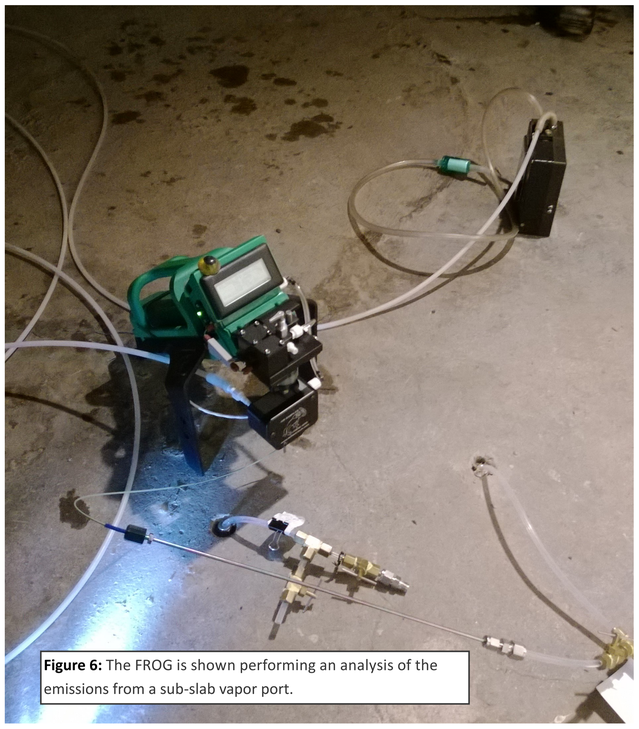
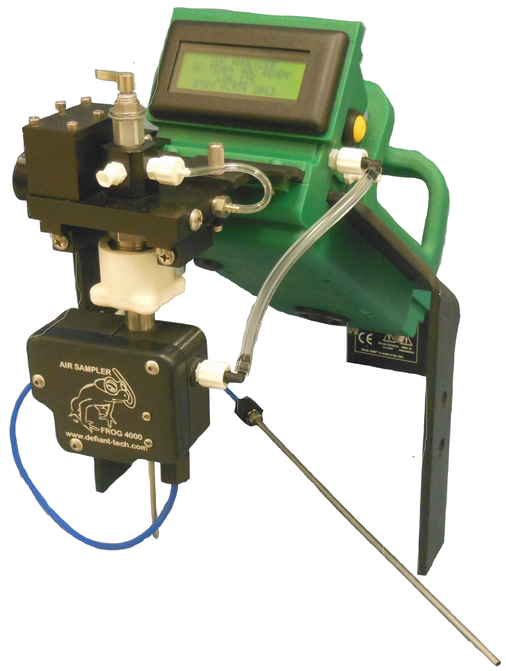


Figure 6: The FROG is shown performing an analysis of the emissions from a sub-slab vapor port.



FROG 4000