Northeast
GAS ASSOCIATION
NYSEARCH

Technology Brief

Novel Integrated Nano-Sensors for Analysis of Chemical Compounds in Natural Gas Applications

Description: **A project to develop a "smart nose" array to detect and measure analyte compounds in natural gas at low levels using nano-sensor technologies.**

Status: **The artificial olfactory sensor system has been proven to detect and distinguish analytes of interest in a gas sample with relatively low limits of detection. An engineering prototype has been built for field simulated testing.**

BENEFITS

Nanotechnology has revolutionized processes in various sectors such as medicine, electronics, and energy. Harnessing the potential applications of nanotechnology in the natural gas industry will provide benefits of small, field deployable technologies to overcome current limitations in gas monitoring and analysis. A successful outcome of this project would provide one of the earliest nanotechnology-based portable sensory systems able to detect analytes of interest to the gas industry. Currently, no field portable system exists for this type of analysis. The availability of a multi-analyte, portable field system would provide a tool for operations that will measure concentrations in a repeatable and reliable fashion, and allow work-flow to proceed efficiently without the need to wait for laboratory results. The development of this nanotechnology may also lead to additional nano-sensors able to measure other compounds of interest to the industry.

BACKGROUND

Western Kentucky University (WKU) has developed nano-sensor based technology that was proven to detect explosive and flammable gases at the ppb level for Homeland Security purposes. These sensory devices simulate the function of the human nose, as they can detect multiple analytes at the same time; thus, the term used to describe them is "smart nose". Such "smart nose" technology can be developed as stand-alone sensors or as a network of sensors delivering information wirelessly. Based on the earlier success of this technology, the potential exists for the application of these advanced sensory devices in the gas industry.

NYSEARCH and WKU are working on a multi-phase program to determine the feasibility of using such a smart nose in the gas industry and to develop such an instrument. Phase 1 was completed as a feasibility study and established the ability to detect selected analytes of interest. These analytes are specific compounds that natural gas distribution companies are interested in measuring and monitoring in the field. Further testing was completed to establish ability to measure the analytes accurately and establish a sensor selectivity capacity for the unique smell prints of each analyte. Early Phase II involved the development of an engineering prototype sensor array based on the feasibility study results and with a reduced number of sensors. Further Phase II work is now focused optimizing the electronic nose further to yield repeatable, reliable results without losing sensitivity.

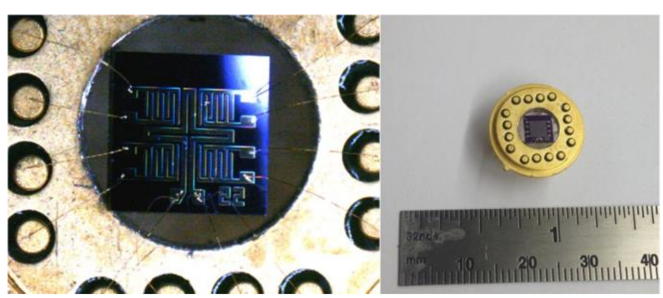

Figure 1. Nano-sensor, building block of the "smart nose"

TECHNICAL APPROACH

The feasibility study demonstrated that the integrated sensor system can successfully recognize the analytes of interest and measure their concentrations. The foundation for integrated chemical sensors are chemi-resistors; devices whose electrical resistance is changed by the molecular adsorption of specific gases on their surface. These changes in resistance are proportional to the partial vapor pressure in the atmosphere and therefore a chemi-resistor converts the concentration of gaseous chemicals into a measurable corresponding electrical signal. The electrical signal is distinguished and recognized by a decision-making algorithm to identify the analytes. Refer to Figure 2 for the principle of operation of an integrated chemical sensor.

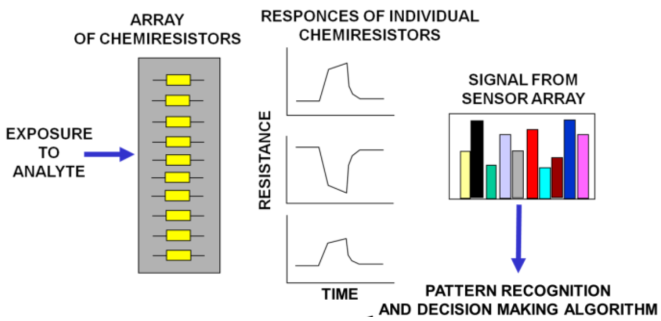

Figure 2. Chemi-resistor recognition path

Tin oxide served as the base nanoscale compound in the chemi-resistors for the sensors. Each sensor was doped with different compounds to tune the sensor towards the properties of the analytes to be measured. The metal oxide sensors are activated by heat to generate the electronic signals for measurement.

With air as the background carrier gas, the electronic signatures of all analytes could be detected in the ppb range. However, with methane as the background carrier gas, the electronic signatures of all analytes were detected at higher levels, indicating that a pre-concentrator may be necessary to achieve the desired detection limits.

In Phase II, the integrated sensor system was further optimized by reducing the number of sensors and integrating different activation temperature set points to heat compounds without affecting sensitivity, selectivity, and discrimination power. Relative limits of detection were also optimized, while the introduction of a pre-concentrator to lower the relative detection limits has shown promising results and is being evaluated further.

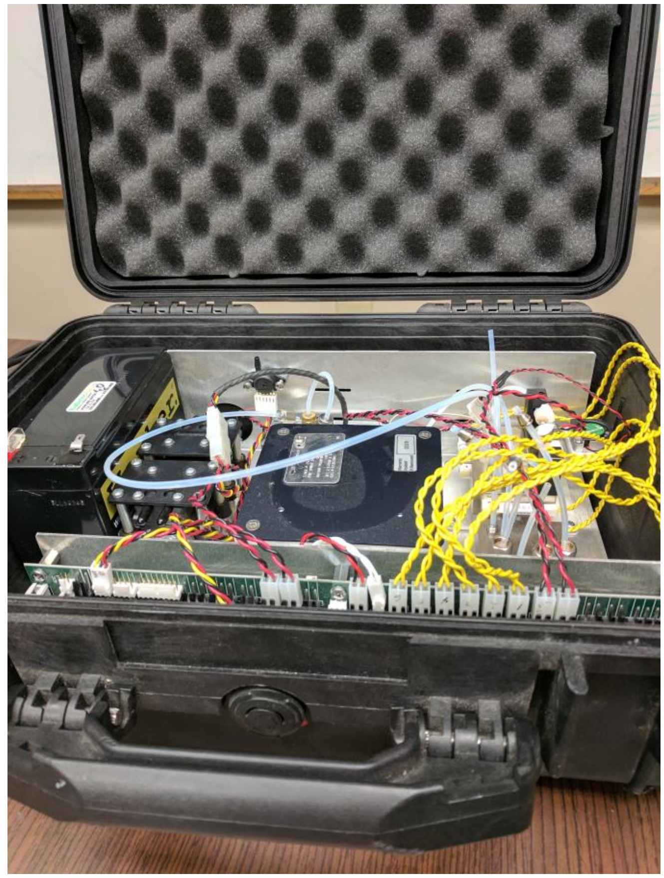

Figure 3. Engineering prototype of metal oxide nano-sensor integrated system with pre-concentrator

PROGRAM STATUS

An engineering prototype instrument has been developed for field simulated testing (see Fig. 3). A pre-concentrator has also been designed and has been integrated to be used with the analytical instrument. The pre-concentrator will be used in cases where methane (natural gas) is the background carrier gas and will allow the achievement of detection limits at levels desired by the industry and set by regulations. Further laboratory testing is being completed to refine detection limits of each analyte of interest prior to carrying out field demonstrations of the instrument.

For more information contact:
admin@NYSEARCH.org