On-site Soil Screening for Volatile Pollutants with an Electronic Nose

J. Goschnick, W. Andlauer, M. Harms, M. Kochbeck, R. Körber
Forschungszentrum Karlsruhe, Insitut für Instrumentelle Analytik,
Postfach 3640, D-76021 Karlsruhe, Achim.Goschnick@ifia.fzk.de

SUMMARY

The mobile electronic nose KAMINA (Karlsruhe Micronose) developed at the Institute for Instrumental Analysis was employed in two ways in order to screen soil and soil surfaces for volatile pollutants, i.e. to localize sources of gas emission. Firstly, a handheld soil tester based on KAMINA was realized allowing the investigation of areas of some square meters. This soil tester also enables sampling at different depths, yielding depth profiles of the pollution in the soil. For the investigation of extended areas up to some square kilometers a mini airship was equipped with the KAMINA which was provided with a sampling tube. Scanning a terrain in a raster course with the airborne KAMINA enables detection of gas leaks in industrial facilities, odor sources hidden in landfill etc.

Keywords: Electronic Nose, Rapid On-site Analysis, Soil Screening

Subject category: Applications

ABSTRACT

In the same way as a human or animal nose an electronic nose is able to localize a gas source by making use of its gas analytical capability. An EN, however, offers several advantages over its biological relative. It is not only able to detect more gases but can also be applied in hazardous areas and is not subject to adaptation-caused changes in sensitivity.

A rapid on-site analysis can be performed with an electronic nose (EN) in order to localize and characterize volatile organic pollutants in surface-near regions of soil or to find the position of sources of gas emission. Although artificial olfaction is usually not able to resolve an odor originating from a soil vapor mix into all of its components, an EN certainly is the appropriate instrument for chemical classification of the entire pollutant cocktail, combined with quantification of the pollution level. Moreover, a rapid measuring instrument with spatially resolved sampling and a continuous output allows quick investigation of a raster of sampling sites, localizing the contaminated terrain and its borderlines. However, it is crucial that the instrument is rapid and sensitive enough to do the job within an acceptable time and that it is mobile and robust for its on-site use in the field as well. The Karlsruhe Micronose KAMINA has been developed at the Institute of Instrumental Analysis of the Karlsruhe Research Center. Its primary objective is to meet the requirements of consumer products which actually are similar to the requirements of on-site field screening, namely: a small, inexpensive instrument with appropriate analytical power and low power consumption.

The heart of KAMINA is a novel type of microarray, the size of a thumbnail. The microarray is based on a sputtered metal oxide film, the electrical conductivity of which sensitively depends on the composition of the ambient air. The thin metal oxide film is subdivided by parallel platinum electrode strips (needed for the measurement of the electrical conductivity), yielding the sensor segments of the microarray in on production step. This is the key to the inexpensive production of the microarray chip. A gradient technique is used to differentiate the initially identical sensor segments with respect to their gas response. The standard microarray chip comprises 38 sensor segments on an area of 4 by 8 mm^2. Four platinum heaters on the reverse side of the microarray enable an operation at 200-400°C. The KAMINA including the microarray chip, a micro-pump, the complete µp-controlled electronics providing operation and on-line data evaluation with 1Hz is not much larger than a mobile phone. In spite of the simplicity of the microarray structure, a high discrimination power for gases or odors is obtained at a response time of a few seconds. For most organic as well as inorganic gases detection limits ≤ 1 ppm are achieved.

Two different ways of employing the KAMINA for field screening were pursued in this work. Firstly, the KAMINA as a handheld soil tester equipped with an insertion probe for the analysis of soft soils. This soil tester, suitable for the investigation of areas in the square meter range allows lateral resolution of some centimeters and sampling at different depths, yielding depth profiles of the pollution. Some results will be presented showing the sensitive detection and clear distinction of model soil contamination with toluene, methylene chloride and car fuel. The investigation of a raster of sampling spots contaminated with a modeled distribution of toluene in sand further confirms the rapidity of such profiling measurements with the KAMINA.