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Chemical Sensors – Analytical Instruments

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Abstract. Recent developments in our laboratory belonging to two main areas of current interest, namely amperometric gas sensors and capillary electrophoresis instrumentation, are highlighted. An improved design of the former devices allows the determination of electroactive gases, such as ethylene, ethanol, and sulfur dioxide down to 1 ppb (*v/v*) levels. For capillary electrophoresis, a field-portable instrument with electrochemical detection was recently devised.

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Introduction

There is much to be gained by taking chemical analysis out of the laboratory and bringing it to the sample site. Sampling, storage, and transport efforts are minimized, time is saved and remedial action can be taken without delay. However, conventional bench-top instruments are often not suited for field and process analysis as they are not portable and not robust enough. Field instruments and chemical sensors do exist, but current devices are often not adequate. Two examples of our recent progress made in the design of sensors and analytical instruments which address these needs are presented below.

Amperometric Gas Sensors of High Sensitivity

Available amperometric gas sensors rely on the diffusion of the analyte gas through a membrane to a working electrode contained in an aqueous electrolyte solution. By placing the electrode on the gas-facing side of an ion-exchange membrane, the diffusion barrier can be largely eliminated, leading to a much higher sensitivity and detection limits about 3 orders of magnitude lower than obtained using the conventional approach. Ethylene, acetylene, ethanol, acetaldehyde and sulfur dioxide can be determined down to about 1 ppb with such sensors [1–6]. The dynamic response to sulfur dioxide in the

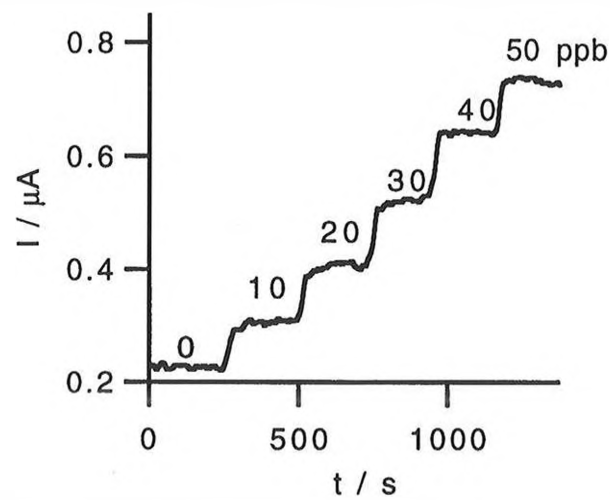

Fig. 1. *Current reponse recorded at an Au-Nafion SPE sensor with 1*M *NaOH internal cell electrolyte solutions to 10-ppb step increases of SO_2 in air*

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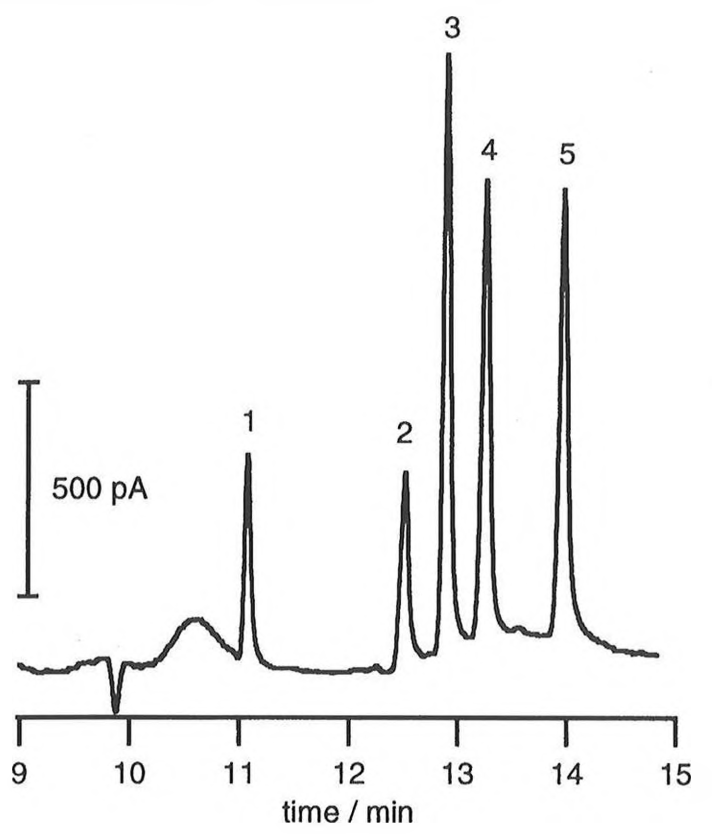

Fig. 2. *Electropherogram for the carbohydrates saccharose (1), lactose (2), galactose (3), glucose (4), and fructose (5) detected amperometrically on a copper-wire electrode*

lower ppb range is illustrated as an example in *Fig. 1*.

Applications for these sensors exist in cool stores for fruit, vegetables and flowers, where ethylene and ethanol are involved in the ripening metabolism, and their concentrations require accurate control in order to optimize the storage conditions. Ethylene is also often added to the controlled atmosphere as a degreening agent before delivering fruit to the market. The development of a commercial instrument for this application is in progress. Sensing of sulfur dioxide is of environmental importance where the relevant concentrations are usually in the low ppb range. The sensor is suitable for this range, and by careful selection of operating conditions the interference from normally problematic gases could be eliminated.

Field-Portable Capillary Electrophoresis Instruments

Currently available field instruments include devices for specific needs such as pH meters, dissolved-oxygen and conductivity meters, but also versatile instruments such as polarographs, gas chromatographs, and even mass spectrometers. However, there are practically no portable methods for the general analysis of small ions and molecules. Capillary electrophoresis is well-suited for this purpose as the method is versatile and the basic instrumentation is simple. We believe that the portable instruments developed in our laboratory are the first such devices reported [7][8]. In order to achieve the low power consumption and robustness required, the main focus was placed on a redesign of the detector. Potentiometric, amperometric, conductometric as well as optical absorption detection using light-emitting diodes were further developed for this purpose [9–12]. A new potentiostat circuitry was constructed to accommodate a much simplified amperometric detector arrangement. The separation and amperometric detection of a mixture of carbohydrates is illustrated in *Fig. 2*.

Other research interests in the area of chemical sensors and analytical instrumentation are currently being pursued.

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