Sensor Systems for Environmental Monitoring

Sensor Systems for Environmental Monitoring

Conference with Posters

Organised by the Automation and Analytical Management Group
Royal Society of Chemistry

Thursday, 14th October 2010

At The Royal Society of Chemistry,
Burlington House, Piccadilly, London

Email: conference@aamg-rsc.org
Website: http://www.aamg-rsc.org

RSC | Advancing the Chemical Sciences

Sensor Systems for Environmental Monitoring

Thursday 14th October 2010
The Royal Society of Chemistry,
Burlington House, Piccadilly, London

09.45 – 10.15 Registration and coffee

Session 1 Monitoring Aquatic Environments

Chairman: **Dr R Narayanaswamy**, University of Manchester, UK

10.15 Emerging tools for monitoring the chemical quality of water in support of the European Union's Water Framework Directive
Graham Mills *University of Portsmouth, UK*

10.40 In-pipe water quality sensing in water transmission and distribution system: Experimental Evaluation
Angeliki Aisopou *Imperial College, UK*

11.00 DEPLOY - Smart Catchment Demonstration: Long-term deployment of sensor monitoring system
Antóin Lawlor *Dublin City University, Ireland*

11.20 Project Watersense, An integral decision support system (DSS) for water management
Martha Buitenkamp *Anantis, The Netherlands)*

11.40 Measurement of metal ions in aqueous environments
Daniel Harvey *Aston University, UK*

12.00 Classification & authentication of water sample using e-tongue supported by partial least squares method
Madhusree Kundu *National Institute of Technology, India*

12.20 LUNCH & POSTER Session

Session 2 Monitoring Atmospheric & Other Environments

Chairman: **Dr A Braithwaite**, AAMG-RSC, UK

13.45 A range of sensors for environmental monitoring
Pat Pollard *The Robert Gordon University, Aberdeen, UK*

14.10 Trace vapour sensors using insect olfaction
Mathilde Briens *BBSRC, UK*

14.35 Low-cost sensor Units for Measuring Urban Air Quality
Olalekan Popoola *University of Cambridge, UK*

14.55 Evaluation of coated quartz crystal microbalance (QCM) sensors for the detection of atmospheric ozone
Simon Stanley *Nottingham Trent University, UK*

15:15 Tea

15.45 Palladium coated polymer optical fibre hydrogen sensor for humid environments
Mohammed Akmez Nabeerasool *University of Manchester, UK*

16.05 Chemical sensors suitability criteria for ubiquitous wireless sensor networks
Marco Brini *Minteos s.r.l., Italy*

16.25 A modular sensor array for online monitoring of radioactive waste O 2
Paolo Finocchiaro *INFN Laboratori Nazionali del Sud, Italy*

16.45 Concluding Remarks and End of Conference

Abstracts

Emerging Tools For Monitoring The Chemical Quality Of Water In Support Of The European Union's Water Framework Directive

Graham A. Mills and Richard Greenwood,
Faculty of Science, University of Portsmouth, Portsmouth, P*O1 2DT,*
United Kingdom (e-mail: graham.mills@port.ac.uk)

ABSTRACT

The European Union's Water Framework Directive (EU-WFD) is the most comprehensive and significant international legislative agreement ever to be introduced in the field of the management of water quality. The aim of the legislation was to replace a number of older European Directives, to prevent further deterioration of water quality and to protect and enhance the status of aquatic ecosystems across Europe. The EU-WFD (2000/60/EC) came into force on December 2000 with a number of key objectives defined until 2015, by which time, 'good quality' status of all European water bodies (surface and ground waters) is to be achieved. Management plans for the various water bodies are implemented at the river basin level and also include the coastal fringe (a similar approach for the marine environment was incorporated into the Marine Strategy Directive adopted in 2008 with assessments starting in 2012).

Large scale monitoring activities are required within the EU-WFD to cover a number of 'water quality elements' including, physico-chemical, hydro-morphological, biological and chemical parameters. Chemical monitoring is based on a specific list of 33 priority chemicals (inorganic and organic pollutants and substances) that is reviewed every 4 years; additional emerging substances of concern are likely to be added to this list in the future. Environmental quality standards (EQS) for these chemicals have been set for different water bodies and these standards are based on either the annual average concentration (AA-EQS) or the maximum allowable concentration (MAC-EQS). Within the EU-WFD three different monitoring regimes are recognised and include: *surveillance* monitoring, *operational* monitoring and *investigative* monitoring. The EU-WFD, however, does not mandate what specific monitoring methods need to be applied for these activities.

Most water quality monitoring has relied heavily on spot or bottle sampling followed by instrumental analytical measurements in the laboratory to determine pollutant concentrations. Despite a number of advantages, this procedure has considerable limitations in terms of (*i*) temporal and spatial resolution that may be achieved at reasonable cost, and (*ii*) the information on bioavailability that may be obtained. The full and successful implementation EU-WFD across all Member States will require the establishment and use of emerging and low-cost tools as part of on-going monitoring programmes. These techniques may complement monitoring already in place by providing additional information with the aim to obtain a more representative picture of the quality of a water body.

This presentation initially discusses the requirements of the EU-WFD and considers some of the limitations associated with current monitoring practice in meeting its objectives. It will then overview some of the emerging biological and chemical monitoring tools that may become part of a 'toolbox' of techniques for use by those in charge of assessing water quality. Biological monitoring techniques include: biomarkers, biosensors, biological early warning systems and whole-organism bioassays. Sampling and analytical tools developed for chemical assessment comprise biosensors, immunoassays, passive samplers, and sensors. Descriptions of these devices and a discussion of their suitability for different types of monitoring detailing advantages and limitations are presented. Finally, quality assurance and quality control and method validation issues are summarised.

References:
I.J. Allan *et al*. Trends in Analytical Chemistry, 2006, **25**, 704-715.
I.J. Allan *et al*. Talanta, 2006, **69**, 302-322.
M. Coquery *et al*. Trends in Analytical Chemistry, 2005, **24**, 117-126.
D. Hering *et al*. Science of the Total Environment, 2010, **408**, 4007-4019.
P. Lepom *et al*. Journal of Chromatography A, 2009, **1216**, 302-315.

In-Pipe Water Quality Sensing In Water Transmission And Distribution System: Experimental Evaluation

A Aisopou, I. Stoianov and N. Graham
Imperial College London

ABSTRACT

Monitoring the quality of drinking water from the treatment plant to the consumers tap is critical to ensure compliance with national standards and WHO guideline levels. While the application of continuous monitoring of hydraulic parameters such as pressure and flow has gradually increased in recent years, there are limited options for automatic, in-pipe, reagent-free water quality monitoring. Advances in electrochemistry, interdigitated microelectrodes, and digital signal processing are facilitating the development of sensors for continuous in-pipe monitoring of various physical and chemical water quality parameters. This paper reviews the principles and state-of-art in water quality monitoring and discusses limitations, trends and novel developments and how these affect operational and modelling scenarios. A multi-parameter water quality sensor probe currently under trial by UK water companies is implemented in laboratory and operational field conditions and its performance is evaluated. In the field trials continuous water quality and high frequency hydraulic data are acquired to gain understanding on the water quality transformations in operational pipes. The data show good dynamic response but uncertain total accuracy and repeatability of the sensors. The data acquired presents evidence that demonstrate that water quality parameters exhibit daily changes and that unsteady state flow conditions can affect the water quality.

DEPLOY - Smart Catchment Demonstration: Long-term Deployment of Sensor Monitoring System

Antóin Lawlor*[1], Javier Torres[2], Brendan O'Flynn[2], John Wallace[3] & Fiona Regan[1].
[1]NCSR, Dublin City University, Ireland [2]Tyndall National Institute, Cork, Ireland [3] IDS, Killaloe, Co. Clare, Ireland.

ABSTRACT

DEPLOY is a technology demonstration project representing an important collaboration between research centres with technical and analytical expertise to deploy, maintain and evaluate a series of multi-sensor systems to assess the effects of long-term sensor deployment on water quality monitoring systems and sensor data. The project demonstrates how state of the art technology can be implemented to provide more up-to-date information, for cost effective, continuous, real-time monitoring of a catchment. The project is seen as an important building block in the realisation of a wide area autonomous network of sensors capable of monitoring the spatial and temporal distribution of important water quality and environmental target parameters, thus demonstrating the potential for the adoption of such technology as part of a monitoring programme in Ireland. The demonstration sites chosen are based in the River Lee, which flows through Ireland's second largest city, Cork, and include monitoring stations in five zones considered typical of significant river systems. The selection of stations and different technology in the DEPLOY project is motivated by a mix of scientific value and the requirement to demonstrate the range of technology available and how it can be successfully deployed and maintained. The data is available on-line at http://www.deploy.ie.

Project Watersense,
An Integral Decision Support System (DSS) For Water Management

***Martha Buitenkamp**, (on behalf of the collaborating partners)*
WMD
Postbus 18, 9400 AA, Assen ,The Netherlands

ABSTRACT

The WaterSense project applies advanced sensor systems technology to the agricultural and water sectors. In WaterSense partners develop an integral Decision Support System (DSS). WaterSense constantly monitors a region of approximately 30.000 hectares using 100 sensors measuring soil moisture and electrical conductivity.

The aim of the DSS is to turn these data into practical advice for farmers and water managers.

The WaterSense approach is to combine sensor data, together with other environmental and meteorological data, with hydrological and vegetation growth models. In this way the models are constantly validated with real-time data, providing the best insight into short and long-term developments of the water balance in a region. The DSS provides water managers and farmers with advice regarding overhead irrigation and water-level management. As a next step the DSS will include water quality aspects, related to the use of crop protection agents and fertilisers.

The project partners for this three year research project are the regional water company, the regional water authority, three private enterprises, the province of Drenthe, and two knowledge institutes.

Measurement Of Metal Ions In Aqueous Environments

Daniel Harvey*[1]*, Brian Tighe[1], Neil Hayes[2]

1. Biomaterials Research Unit Aston University. 2. EvanesCo Limited, 4 & 5 Forde Court, Forde Road, Newton Abbot, Devon, TQ12 4AD, UK

ABSTRACT

Metal ions are present in many aqueous environments; however if the levels of these are out of balance, they can lead to health problems, such as the Alzheimer's disease which has been linked to aluminium in water[1]. We are developing a versatile sensor system using fibre optic sensor technology and combining it with SMART hydrogels. It's versatility lies in the range of metal ions that can potentially be detected, as well as in the portability of the system. In this paper two examples of targeted metal ions will be discussed, namely sodium and aluminium. This versatile approach depends upon the design and synthesis of a purpose-designed "locking" terpolymer used as a means of immobilising the chemotropic agents. For the detection of aqueous potassium, sodium tetra phenyl borate is used, and Morin is used for the detection of aqueous aluminium. These are used in situ with an existing fibre optic sensing system, configured with a loop that is in contact with a water sample, which gives an immediate signal loss reading. This signal loss can be linked to the level of the target metal ion present in the sample. This system is readily adaptable to other target metal ions, such as iron and calcium.

1) Rondeau, V.; Jacqmin-Gadda, H.; Commenges, D.; Helmer, C.; Dartigues, F. (Feb 2009). "Aluminum and silica in drinking water and the risk of Alzheimer's disease or cognitive decline: findings from 15-year follow-up of the PAQUID cohort". *American journal of epidemiology* 169 (4): 489–496

Classification & Authentication of Water Sample Using E-Tongue Supported by Partial Least Squares Method

[1] Palash Kundu, [2]***Madhusree Kundu***[1]Electrical Engineering Department, Jadavpur University, Kolkata, India[2]Department of Chemical Engineering, National Institute of Technology, Rourkela, India
[2]*Corresponding Author:* E-mail: mkundu@nitrkl.ac.in,
Phone: +91661-2462263, Fax: +91661-2462999

ABSTRACT

The present article proposes the development of electronic tongue (E-tongue) instrumentation system for water sample classification and authentication, in real life, using a pulse voltametry method with silver electrode. E-tongue include arrays of solid state ion sensors, transducers even of different types, data collectors and data analysis tools, all oriented to the classification of liquid samples and authentication of unknown liquid sample. The time series signal and the corresponding raw data represent the measurement from multi-sensor system. This proposed system, implemented in a laboratory environment for 7 numbers of different water samples (Aquafina, Bisleri, Kingfisher, Oasis, Dolphin, McDowell and Tap water) available in India. A PCA (principal component analysis) based classification & authentication tool has been developed in the present study as the machine learning component of the E-tongue system. A proposed Partial Least Squares (PLS) based classifier, which is dedicated as well; to authenticate specific category of water sample can be considered to be an integral part of the E-tongue instrumentation system. The developed PCA & PLS based E-tongue system emancipates encouraging authentication percentage accuracy, of the order of upper 95% for most water categories and even producing accuracy results exceeding 98%, for several categories.

Keywords: Water sample authentication; Electronic tongue; machine learning; PLS; pulse voltametry; PCA

A Range Of Sensors for Environmental Monitoring

Pat Pollard
Centre for Research in Energy & the Environment
The Robert Gordon University, Aberdeen

ABSTRACT

This presentation will give examples of the application of electrochemical sensors for in-situ soil monitoring, IR spectroscopy for on line hydrocarbon monitoring and in-situ fluorescence sensing in marine/effluent monitoring.

A hand-held instrument capable of real-time in-situ detection and identification of heavy metals in soils has been developed. The electrochemical system provides the facilities found in a traditional laboratory-based instrument but in a hand held design, without the need for an associated computer. The electrochemical instrument uses anodic stripping voltammetry. The sensors comprise a small disposable plastic strip of screen-printed electrodes. The system is designed for use by a surveyor on site, allowing them to locate hotspots, thus avoiding the expense and time delay of prior laboratory analysis. Spectroscopy techniques lend themselves to direct in-situ analysis. A wide range of IR sensors are available for gas analysis such as methane, CO_2, NO_x and SO_x but many other analytes can be monitored directly as well, including hydrocarbons. A further example of the application of an optical sensor in environmental monitoring is given with of the use of discrete fluorescent species in an environmentally stable host that has been investigated to replace existing more toxic, broad band molecular dye tracers. The narrow band emission signals offer the potential for tracing a large number of signals in the same environment. This will give increased data accuracy and allow multiple source environmental monitoring of environmental parameters.

Trace Vapour Sensors Using Insect Olfaction

Mathilde Briens
Inscentinel Ltd

ABSTRACT

Inscentinel ltd is developing sensitive, flexible, rapidly re-targeted biosensors for trace vapour detection by harnessing the acute olfactory ability of honeybees. This technology allies the sensitivity of a biological system with the convenience of a machine. The device houses sniffer bees trained to detect odours. For most compounds, bees are at least 10 times more sensitive than humans and our studies indicate that they are at least as good as sniffer dogs. They can detect high parts per trillion (pptv) concentrations. Inscentinel is currently developing a user friendly light handled detector (the VASOR136) containing 36 bees which has been tested by the UK Home Office and shown high potential for explosives detection.

Inscentinel trains honeybees to associate an odour of interest with a food reward (Pavlovian conditioning). Training takes a matter of hours and bees show a conditioned proboscis (tongue) extension reflex when they encounter the learnt odour. The trained bees are held within individual bee holders and loaded into the detector where sample odours are introduced into the constant stream of clean air which is maintained over the bees. An optical sensor records the bees' responses and software interprets the responses and outputs a simple electronic YES/NO (present/absent) result. The detection relies on a statistical population of bees.

Inscentinel is seeking partnership with companies or organisations which can use its technology to deliver solutions to their customers. We have demonstrated the potential for using the extraordinarily acute sense of smell of living bees for detecting a wide range of natural and man-made chemicals such as explosive materials, drugs, dry rot or food contaminants.

The technology is protected by a number of granted patents and additional patent applications. Inscentinel is currently developing devices to automate the bee handling so any operator can use the system.

Inscentinel is a creative, dynamic UK company, a spin out of the internationally renowned research institute Rothamsted Research based in Harpenden, Hertfordshire.

Low-Cost Sensor Units for Measuring Urban Air Quality

M. I. Mead[a], ***O. A. M. Popoola[a]***, G. Stewart[a], T. Hodgson[a],
M. McLeod[a], P. Landshoff[b], M. Hayes[c], M. Calleja[c], R. L. Jones[a].

a: Centre for Atmospheric Science, Cambridge.
b: Centre for Mathematical Sciences, Cambridge.
c: The Cambridge eScience Centre, Centre for Mathematical Sciences, Cambridge.

ABSTRACT

Measurements of selected key air quality gases (CO, NO & NO_2) have been made with a range of miniature low-cost sensors based on electrochemical gas sensing technology incorporating GPS and GPRS for position and communication respectively. Two types of simple to operate sensors units have been designed to be deployed in relatively large numbers. Mobile handheld sensor units designed for operation by members of the public have been deployed on numerous occasions including in Cambridge, London and Valencia. Static sensor units have also been designed for long-term autonomous deployment on existing street furniture. A study was recently completed in which 45 sensor units were deployed in the Cambridge area for a period of 3 months. Results from these studies indicate that air quality varies widely both spatially and temporally. The widely varying concentrations found suggest that the urban environment cannot be fully understood using limited static site (AURN) networks and that a higher resolution, more dispersed network is required to better define air quality in the urban environment. The results also suggest that higher spatial and temporal resolution measurements could improve knowledge of the levels of individual exposure in the urban environment.

Evaluation of Coated Quartz Crystal Microbalance (QCM) Sensors for the Detection of Atmospheric Ozone

Jennifer B. A. Muller[1], Michael I. Newton[2] , ***Simon Stanley***[2,**] and Carl J. Percival[1*]
1. Centre for Atmospheric Science, The School of Earth Atmospheric and Environmental Sciences, The University of Manchester
Oxford Road, Manchester, M13 9PL, UK.
2. School of Science and Technology, Nottingham Trent University,
Clifton Lane, Nottingham NG11 8NS, UK.
** corresponding author email C.Percival@manchester.ac.uk, ** presenter of the paper*

ABSTRACT

Tropospheric ozone is an important greenhouse gas and thus has a major impact on the earth's radiative balance. It plays a central role in the atmospheric chemistry of many species on local to global scales, e.g. NOx, VOCs, halogenated organics, aerosols. Ozone also has the greatest irritant effect in the human respiratory tract of all of the commonly occurring gas phase pollutants (Bates, 1995; PORG, 1997). Apart from the implications of ozone for human health, it is also known to be phytotoxic, causing damage to crops and sensitive natural ecosystems (Ollerenshaw and Lyons, 1999). Knowledge of the atmospheric ozone budget is thus important in regional and global chemical modelling, especially in regional assessments of oxidant behaviour. Therefore novel and improved techniques and technologies for the detection of ozone are constantly being developed.

A coated acoustic wave sensor has been developed to selectively detect atmospheric ozone. The selective detection has been assessed using a variety of coatings: beeswax, gallic acid, indigo carmine, polybutadiene, potassium iodide and sodium nitrite. Polybutadiene was the most sensitive with a limit of detection of 55 ppb. The sensitivity was improved by operating at higher harmonics and was shown to increase linearly up to the 11th harmonic. This novel work shows that ozone detection can be improved by operating at the crystals' harmonic frequencies and in conjunction with a suitable flow rate, a potentially highly sensitive and fast response sensor can be created based on acoustic wave technology.

References

Bates, Environmental Health Perspectives, 103, Suppl. 6, 243 (1995).
Ollerenshaw and Lyons, Environmental Pollution, 106, 67 (1999).
Fourth report of the Phototchemical Oxidants Review Group (PORG), 1997.ISBN 1-870393-30-9.

Palladium Coated Polymer Optical Fibre Hydrogen Sensor For Humid Environments

M.A.Nabeerasool, J.Vaughan, R.Maier[1], R.Narayanaswamy, P.J.Scully
The University of Manchester
The Photon Science Institute, Alan Turing Building,
Oxford Road, Manchester, M13 9PL
[1]Heriot Watt University, Edinburgh, Scotland, EH14 4AS

ABSTRACT

Hydrogen sensors exploiting the Palladium/Palladium Hydride reaction are affected by humidity, whether based on optical or electronic/catalytic detection, which pose difficulties for operation in field or real life conditions. Gases being monitored require pre-conditioning such as drying, to facilitate sampling at low humidity, and the sensor coating requires heating to maintain it at a constant temperature. We present a palladium based optical hydrogen sensor with minimal response to fluctuations in ambient humidity and temperature. The sensor uses Polymer Optical Fibre (POF) and a range of configurations have been investigated.

POF was selected due to ruggedness, ease of termination and high sensitivity to evanescent field. Applications include fuel cell cabinets, hydrogen storage and generation, industrial process plants, submarines and nuclear fuel power generation and plant decommissioning; all of which present a challenge for the rapid detection of hydrogen leaks in hostile and humid environments. The proposed sensor showed a response rate of 6 seconds to 9.1% hydrogen in air, and is sensitive to hydrogen concentrations as low as 0.35%. Having achieved inertness to relative humidity, further work will focus on sensor optimisation for sensitivity and response rate in addition to develop methods of sensor deployment in hostile environments.

Chemical Sensors Suitability Criteria for Ubiquitous Wireless Sensor Networks

Mihai T. Lazarescu, ***Marco Brini***
Minteos s.r.l., Turin, Italy
lazarescu@minteos.com, brini@minteos.com

ABSTRACT

Wireless Sensor Networks are an effective means for monitoring environment pollution and life hazards, for example air quality in the cities and around storage and processing facilities such as ports, plants and dumps, fire warning through specific combustion gas detection, water pollution, dangerous or lethal gas warning in mining and oil industry.

Ubiquitous sensor node deployment allows for timely alerts and real-time monitoring of the evolution of hazardous conditions. For instance, concentric sensor lines around plants detect early spills and provide useful real time data for civil protection and decontamination, as pollutant type, concentration and affected area. Likewise, sensors along water flows detect in real time water pollution type, level, and speed and diffusion rate of the peak.

Low cost and low maintenance sensors and wireless nodes are of particular interest to affordable achieve an ubiquitous coverage of many areas. We present sensor and node characteristics selection criteria and usage patterns emphasising their relation to the up front and exploitation costs of the sensor network. A range of real world settings and applications for cost-effective environment monitoring using affordable off the shelf chemical sensors and low cost custom wireless nodes are presented and analysed.

A Modular Sensor Array For Online Monitoring Of Radioactive Waste

L.Cosentino, C.Calì, P.Litrico, A.Pappalardo, M.Piscopo,
C.Scirè, S.Scirè, and ***P.Finocchiaro***
INFN Laboratori Nazionali del Sud, via S.Sofia 62, 95125 Catania, Italy

ABSTRACT

A prototype array of modular sensors for online monitoring of radioactive waste is currently being developed and tested at INFN-LNS. Such a system is planned to be distributed, fine-grained, robust, reliable, and based on low-cost components.

With the main purpose of counting gamma radiation, we implemented a new kind of mini-sensor, based on Silicon PhotoMultipliers and scintillating fibres, that behaves like a cheap scintillating Geiger-Muller counter. It can be replicated, for instance, in shape of a fine grid around each single waste drum in a repository.

Front-end electronics and an FPGA-based counting system was developed, in order to handle the data flow coming from the field sensors. Such a system also deals with the redundant data transmission toward a console with a graphical user interface and a data storage system. The redundant transmission is done simultaneously on differential cables and wireless using ZigBee units.

A robotic arm is being developed for remote ad-hoc inspection and operations around the waste drums.

Test results with radioactive sources showed very encouraging performance in terms of sensitivity, therefore we are planning to install a small demonstrator system around real radioactive waste drums quite soon.

Poster Abstracts

Project SAWA, Sensor Development And Application In Drinking Water

Martha Buitenkamp, (on behalf of cooperating parties)
WLN
Rijksstraatweg 85, 9756 AD Glimmen, The Netherlands

POSTER ABSTRACT

The Dutch project SAWA, Sensors and Water, aims to develop and improve sensors for drinking water applications. SAWA starts with techniques and sensors based on already developed measuring principles, which will be used to develop new sensors, applicable in the production and supply of drinking water. These new products will be tested with integrated data, obtained from different sensors. Within this project there are three parts:

1. A security system for the intake of surface water.
2. Rapid detection techniques for to measure the regrowth potential of the produced drinking water.
3. A real-time monitoring system for both the quality and physical parameters of the drinking water.

The project includes a sensor centre with facilities to test and calibrate the sensors on different water qualities. The participating parties are two water companies, four knowledge institutes, seven sensor companies and a water laboratory. The budget for this three year research project amounts to 8,4 million Euros, half of which is financed by the Dutch Ministry of Economic Affairs and the European program OP EFRO.

Early-Warning Portable Gas Sensor-System for Environmental Air Monitoring Applications

M. Penza, D. Suriano, R. Rossi, M. Alvisi, G. Cassano, P. Aversa, V. Pfister
ENEA, Brindisi Technical Unit of Technologies for Materials, PO Box 51, Br-4, I-72100 Brindisi, Italy

POSTER ABSTRACT

A portable sensor-system based on solid-state gas sensors has been designed and implemented as proof-of-concept for environmental air-monitoring applications. Commercial gas sensors and nanotechnology sensors are arranged in a configuration of array for multisensing and multiparameter devices. Wireless sensors at low-cost are integrated to implement a portable and mobile node, that can be used as early-detection system in a distributed sensor network. Real-time and continuous monitoring of hazardous air-contaminants (NO_2, CO, SO_2, BTEX, etc.) has been performed in field measurements. Validation of the sensing performance of the portable system has been realized by means of the chemical analyzers of the Italian environmental air monitoring agency (ARPA-PUGLIA). A medium-term experimental campaign has been performed and the results will be presented to address the comparison between sensor-system and chemical analyzers regulated by EU standards. The results demonstrate that the sensor-system is a complementary valid tool to realize a low-cost sensor node in a distributed network for environmental-air monitoring applications.

Monitoring Malodours From A Waste Site By A Portable Gas Sensor-System: Comparison Between Olfactometry And Sensor-System

M. Penza, D. Suriano, R. Rossi, M. Alvisi, G. Cassano, P. Aversa, V. Pfister
ENEA, Brindisi Technical Unit of Technologies for Materials,
PO Box 51, Br-4, I-72100 Brindisi, Italy

M. Brattoli, L. Trizio, G. De Gennaro
University of Bari, Department of Chemistry, Via Orabona, 4, I-70126 Bari, Italy
M. Amodio
Lenviros srl, Via Orabona, 4, I-70126 Bari, Italy

POSTER ABSTRACT

A portable sensor-system based on solid-state gas sensors has been designed and implemented as proof-of-concept to monitor the malodours in the field at a waste site. Gas sensors are configured in an array for multisensing and multiparameter devices. Wireless sensors at low-cost are integrated to implement a portable and mobile node, that can be used as early-detection system in a distributed sensor network. Real-time and continuous monitoring of hazardous air-contaminants (NO_2, CO, H_2S, BTEX, etc.) and greenhouse gases (e.g., CO_2, CH_4) has been performed in field measurements at an urban waste site. Validation of the sensing performance of the portable system has been realized by means of the chemical analyzers. A short-term experimental campaign has been performed and the results will be presented to address the comparison between sensor-system and chemical analyzers regulated by EU standards. Odour quantification has been validated by off-line conventional olfactometry measurements. The results demonstrate that the sensor-system is a complementary valid tool to realize a low-cost sensor node in a distributed network for environmental odour air-monitoring applications to assess potential annoyance zones.

The Development Of Low-Cost, Robust, Reproducible Optical Chemical Sensors Using Inkjet Printing

Dylan Orpen, Stephen Beirne, Cormac Fay,
Brian Corcoran, King-Tong Lau, and Dermot Diamond

Clarity Research Centre, School of Chemical Sciences,
Dublin City University, Dublin 9, Ireland

POSTER ABSTRACT

This work presents the development of multiple, identical, low-cost, low-power, robust, optical chemical sensors which can be mass calibrated in a single calibration. For too long the development of chemical sensors, has relied upon poor manufacturing methods. The use of painting, drop casting, spin coating, and screen printing have led to the production of sensors exhibiting low levels of reproducibility, meaning an expensive individual calibration for each sensor. In this work a novel paired emitter detector diode sensor has been optimised for trace acetic acid detection. The sensing operation is based upon the use of two inexpensive LEDs. They are setup to function as both a light source and photo detector. The light capture device is then coupled with an inkjet printed pH sensitive film, modulating the amount of light passing between the LEDs. In this work the chemical films have been manufactured utilizing the reproducibility of the inkjet printing process, and have already exhibited a limit of detection of 13 ppb for 100% acetic acid in air. Ongoing work includes analysis of the slides using atomic force microscopy, as well as characterization of each individual printed sensor. This work will demonstrate the level of accuracy and reproducibility within the inkjet printing process and demonstrate if the goal of a reproducible batch of low-cost trace chemical sensors has been realised.

Thermoacoustic Analyzer For Water Content Detection In Hydrocarbon Emulsion

Tariq Younes & Mohamad Alia

Al Balqa' Applied University, Faculty of Engineering Technology

POSTER ABSTRACT

The problem of water detection in hydrocarbon emulsion is an important issue in oil production. This work presents a simple computerized method of water content detection in hydrocarbon emulsion using thermoacoustic effect. The work focuses on the detection of water in kerosene. Experimentally, it was found that the produced acoustic signal can be used as informative parameter in quality control and testing of quality of petrochemical oil products. The suggested method is based on the assumption that there will be a relation between the content of the hydrocarbon emulsion and the parameters of the generated acoustic wave resulting by inundation of heated rod in the emulsion.

Cantilevers for the Detection of Waterborne Pathogens

Helen Bridle, Ann Walker, Yifan Lu and Will Shu

University of Edinburgh and Heriot-Watt University

POSTER ABSTRACT

We have utilised micro-cantilevers for the detection of the waterborne pathogen, *Cryptosporidium Parvum*, using both optical and electrical read-out mechanisms. We have also investigated the use of immunomagnetic beads to enhance the response, lowering the detection limit. Additionally, we have explored the use of a novel magnetoelastic material for cantilever applications, enabling wireless interrogation of cantilever responses.

Trypan Blue based Polymer Optical Fibre Sensor for Assessing Cell Growth in 3-D Culture Systems

***Soumya M. A. Jabur*[1],** Catherine Merry[2], Nick Goddard[1], Louise Carney[2] and Peter Fielden[1]

[1]Manchester Interdisciplinary Biocentre,
The University of Manchester, 131 Princess Street. Manchester. M1 7DN

[2]School of Materials, The University of Manchester,
PO Box 88, Manchester M60 1QD, UK

POSTER ABSTRACT

We propose the development of an optical sensor based on transmission of light to detect changes in wavelength corresponding to cell growth and apoptosis (cell death). Three-dimensional culture systems have led to an increased understating of cell-cell interactions, cell signalling, cell matrix interactions and morphologies in tissues and organs of interest. Cell encapsulation exploits temporary three-dimensional scaffolds that provide a steady environment for cell growth and development [1], which in turn limits the amount of materials and formulations that can be used during encapsulation [1]. Initial studies were focused on the use of alginate as an encapsulating material based on which in depth studies were designed and carried out. Results obtained showed that $CaCl_2$ solution and the NaCitrate buffer at a concentration of 50 µM caused very little disruption to cell growth and percentage cell viability. These formulations were used to solidify and dissolve the alginate gel beads respectively.

The proposed sensor will exploit the evanescent field properties of Polymer Optical Fibres (POF) coated with a mixture of cell culture and dye mix (trypan blue) to assess the transmission of light through the fibre over a period of time (7 days). We expect a change in colour in the dye and by acquiring transmitted power signals over time, variation of cell contents can be determined. Data obtained will facilitate the determination of percentage cell viability and cell apoptosis (cell death) in two and three dimensional cell cultures. This colour optical sensor will potentially provide researchers with a reliable, accurate and speedy technology to assess percentage cell viability and apoptosis. Further work is needed to determine the optimum conditions to provide a steady environment for more sensitive and complicated cells.

Reference:

[1] Garret D. Nicodemus and Stephanie J. Bryant, *Cell Encapsulation in Biodegradable Hydrogels for Tissue Engineering Applications.* Tissue Engineering, 2008. 14(2): p. 149-165.

Sensitive Real-Time Detection Of Heavy Metals In Liquids Using Cavity Enhanced Absorption Spectroscopy And Broad Bandwidth Supercontinuum Radiation

***Ssegawa-Ssekintu Kiwanuka*[1],** Toni K. Laurila[1], and Clemens F. Kaminski[1,2]

[1] Department of Chemical Engineering and Biotechnology,
University of Cambridge, UK
[2] SAOT School of Advanced Optical Technologies,
Max Planck Institute for the Science of Light, Erlangen, Germany

POSTER ABSTRACT

Concentration measurements of chemical trace species in liquids are of great importance in analytical chemistry. Here we report on a novel implementation of cavity enhanced absorption spectroscopy (CEAS) in liquids using broad bandwidth supercontinuum (SC) light [1], expanding on our previous gas phase work [2, 3]. The high sensitivity of the technique makes it useful for measurements of toxic compounds at trace concentrations. Many heavy metal compounds are currently difficult to detect and require specialized and expensive equipment that may be difficult to calibrate. We demonstrate that SC-CEAS offers an efficient alternative for its measurement. An example is nickel sulphate which is generally considered to be toxic to humans at concentrations higher than 5 mg/l. Absorption spectra of 10 mg/l and 20 mg/l concentrations of $NiSO_4$ were acquired with 50 ms acquisition times using SC-CEAS, from which a limit of detection of 0.5 ± 0.2 mg/l was estimated. Broad spectral bandwidth and rapid acquisition times afforded by the presented technique permit multi-component mixtures to be analysed in real time.

References

1. S-S. Kiwanuka, T. Laurila, C.F. Kaminski, "A sensitive method for the kinetic measurement of trace species in liquids using cavity enhanced absorption spectroscopy with broad bandwidth supercontinuum radiation", Analytical Chemistry (2010), accepted.
2. J.M. Langridge, T. Laurila, R.S. Watt, R.L. Jones, C.F. Kaminski, J. Hult, “Cavity enhanced absorption spectroscopy of multiple trace gas species using a supercontinuum radiation source”, *Opt. Express* (2008), 16, 10178-10188.
3. R.S. Watt, T. Laurila, C.F. Kaminski and J. Hult, “Cavity enhanced spectroscopy of high temperature H_20 in the near-infrared using a supercontinuum light source”, *Applied Spectroscopy* (2009), 63, 1389-1395.

Continuous On Site Monitoring Of Low Levels Of Methane Using Tunable Diode Lasers

A Kannath [a,b], J. Hodgkinson [a], R. Gillard [b], R.Riley [b], R.P.Tatam [a]

[a]Engineering Photonics Group, School of Engineering,
Cranfield University, Bedfordshire, MK43 0AL
[b]Geotechnical Instruments Ltd, Leamington Spa, CV31 3JR

POSTER ABSTRACT

Global warming concerns have put greater focus on accurate measurement of greenhouse gases such as methane. Under the Kyoto Protocol, methane can now be traded for carbon credits. Many industries have hence felt the need to accurately measure low ppm levels of residual methane whilst monitoring the output of flare stacks and exhaust gases from methane combustion engines. Conventional instruments based on NDIR spectroscopy are unable to satisfactorily meet customer demands of high selectivity and sensitivity coupled with fast response times.

Here we discuss the development of a robust tunable diode laser based system for accurate ppm level measurements of methane. A Wavelength Modulation Spectroscopy (WMS) scheme was employed with second harmonic detection. Advanced data processing techniques were incorporated to achieve higher signal to noise ratio (SNR) to meet the target detection limits. The system maintains its calibration and offers a completely automated continuous monitoring solution for remote on site deployment.

Estimating Thickness of Oil Spills in Water

J. P. von der Weid

Pontifical Catholic University of Rio de Janeiro
Research Centre for Inspection Technology
Rua Marques de S Vicente 225, Rio de Janeiro, 22451-900, Brazil

POSTER ABSTRACT

Knowledge of the thickness of the oil layer in water is of paramount importance for the effectiveness of any action aiming to collect the pollutant. A number of different sensor technologies can detect and eventually estimate the thickness of oil spills. Their applicability and cost can be very different, ranging from satellite installations to ship borne or airborne equipments much closer to the action scenario.

Radar has been efficiently used for the detection of oil slicks due to the damping of capillary waves it causes. Although efficient in detecting oil spills, it is not clear that this method can be efficiently used for estimating the thickness of the oil layer. Infrared thermal radiation can be used to detect oil spills because the emission of thermal radiation changes when an oil layer is present. The difference between thermal properties of water and oil allows the estimation of the thickness of the layer. Although other techniques can also be used to estimate thickness under certain conditions, the two most practical are indeed radar and infrared.

The physical principles supporting each technology will be considered in order to evaluate its effectiveness and compare them focusing on the estimation of the oil layer thickness.

Analysis of Pesticides in Water by Proton Transfer Reaction Mass Spectrometry

Milan Patel, Robert S. Blake, Paul S. Monks, Andrew M. Ellis

Department of Chemistry,
University of Leicester

POSTER ABSTRACT

A new technique has been developed for the rapid determination of the pesticide content of aqueous samples. This technique makes use of proton transfer reaction mass spectrometry (PTR-MS), which is more commonly employed for investigating trace organic molecules in gaseous samples.

A heated inlet source was developed for the conversion of water samples into a form suitable for PTR-MS analysis. Two sample preparation techniques were used for the determination of pesticides: (i) direct sample injection and (ii) a liquid-liquid extraction method. In method (ii) pesticides were extracted from water samples by the use of hexane/toluene mixtures. Sample and solvent were mixed for ten minutes at 30°C and a small aliquot from the organic layer was injected into the mass spectrometer for analysis. A lower limit of detection of 1 µg/mL was achieved with direct sample injection while 0.2 µg/mL was achieved with the liquid-liquid extraction technique.

GC/MS is currently the main analytical technique used for determination of pesticides in water samples. The primary advantage of the new PTR-MS approach is its speed, which requires a total analysis time of less than 15 minutes per sample compared to 30 – 45 minutes by GC/MS.

Establishing a Network of Electrochemical Sensors to Enhance Understanding of Urban Air Pollution

***G.B. Stewart*[a],** M.I. Mead[a], O.A.M. Popoola[a], J.J. Baldovi[a], T.F. Hodgson[a], M.W. McLeod[a], R.L. Jones[a], M. Calleja[b], P. Landshoff[c]

a: Centre for Atmospheric Science, Cambridge
b: The Cavendish Laboratory, Cambridge
c: Centre for Mathematical Sciences, Cambridge

POSTER ABSTRACT

Urban air quality issues are becoming an increasing environmental concern in the UK and further afield. As a result, it has become more important to study the behaviour of pollutants in urban environments and to better understand their sources. The development of a mobile sensing system at the University of Cambridge has been furthered to incorporate the same electrochemical sensors for CO, NO and NO_2 into a dense urban network capable of capturing data with high temporal resolution for several months. Laboratory tests have established that the sensors used respond well to parts-per-billion levels of the relevant target gases. Preliminary results from a three month campaign show large variation in concentrations measured, with wind speeds and directions important. Bivariate polar plots, relating concentrations to wind behaviour, are one type of tool being used to analyse the data.

An Optical Microbial Biosensor Using *Sphingomonas* Immobilized Onion Inner Epidermis As A Reusable Biocomponent For Detection Of Methyl Parathion Pesticide

Jitendra Kumar and S. F. D'Souza

Nuclear Agriculture and Biotechnology Division,
Bhabha Atomic Research Centre Trombay, Mumbai-400 085, India

POSTER ABSTRACT

Organophosphorus pesticides such as methyl parathion have been widely used in the field of agriculture for insect pest control. These pesticides and their degradation products cause environmental pollution and ecological problem. With a view to monitor these pesticides biosensor are being developed. A bacterium *Sphingomonas sp.* from field soil has been isolated and identified in our laboratory that hydrolyzes the methyl parathion upto a chromophoric product, p-nitrophenol (PNP). PNP can be detected by electrochemical and colorimetric methods, which can be exploited to develop a biosensor for detection of pesticide. Whole cells of *Sphingomonas* bacteria were immobilized directly onto the surface of onion inner epidermis using glutaraldehyde as the cross linker. SEM study confirmed the immobilization of *Sphingomonas sp.* Immobilized bacterial onion membrane was associated directly with the optical transducer. The system can analyze rapidly a large number of samples. Detection range of the biosensor was 4-80µm methyl parathion. A single cells immobilized onion biocomponent was reusable upto 52 reactions and stable for 32 days when stored at 4°C. This is the first report where onion membrane was exploited as natural support for microbial cells immobilization and development of biosensor for detection of pesticide.

*Presenting Author. Tel.: +91-22-25593832; Fax: +91-22-25505151.

E-mail address: jkumar@barc.gov.in (Jitendra Kumar)