Nature's Templates Improve Environmental Monitoring

Advances in the emerging technology of artificial olfaction (AO) promise more accurate and sensitive environmental monitoring. By borrowing from nature's templates, AO has achieved breakthroughs in detecting substances to the parts per billion – a thousand-fold increase in sensitivity over traditional methods. AO – the science of complex gas sensing – mimics the biological sense of smell. It provides an objective and quantitative assessment of odour, and can target non-odorant gases in complex mixtures.

Determining the strength, quality and source of environmental odours is difficult with current techniques. But AO is a fast and accurate tool for monitoring of odours from many industries that produce odours - including animal product processing, wastewater treatment and chemical processing. Prototypes using AO technology are already deployed in composting facilities, landfill areas and piggeries.

The technology is also being used to identify and monitor indoor pollution, with AO prototypes deployed to detect the presence of mould in buildings.

Rebecca Simpson, Technical Director of the EU-funded artificial olfaction research network GOSPEL, says the emerging technology presents many opportunities for environmental monitoring.

Artificial olfaction

Olfaction means, literally, to smell. This human sense is vital to our interpretation of the world. Understanding how the nose works, and mimicking biological olfaction, is a major focus for research groups. Detecting non-odorant gases, even when they are present in complex mixtures, will become possible as advances are made in understanding the olfactory process.

"AO is essential to mitigate environmental odours coming from a variety of sources, such as landfill sites, wastewater treatment plants, paper or sugar factories, and breweries. It is also used to develop and implement policy, such as the minimum distance required between pig farms and homes," Simpson says.

GOSPEL researchers have turned to nature for inspiration to improve environmental monitoring. The result has been unprecedented increases in accuracy and sensitivity in detecting odours.

Mouse urine holds the key

A GOSPEL research team used proteins in mouse urine to develop a powerful new generation of biologically-inspired sensors. A thousand-fold increase in sensor sensitivity has been demonstrated using mouse Major Urinary Proteins (MUPs) coated on a traditional piezoelectric crystal.

"MUPs are giving us very high sensitivity and selectivity – at levels that are unachievable with conventional sensing," says Prof Krishna Persaud at Manchester University, a lead researcher in the project.

The work was inspired by animals' delicate sense of smell and the way mice mark their territory. Mice secrete a phenomenal amount of protein in their urine – up to 40mg per ml. MUPs are part of a protein family with a cage-like structure, which traps odorant molecules and then releases them slowly. This helps mice to mark and defend their territory, and it is this feature that makes MUPs stable and useful as a biosensor.

The same sort of odorant binding protein occurs ubiquitously in the noses of mammals, insects and reptiles, and scientists are trying to understand their precise role in olfaction. It is not clear whether they carry molecules away from or towards olfactory detectors, or both.

The proteins are small and very specific about what they bind to, but can be easily engineered to bind to a number of materials. "The unusual properties of MUPs make them particularly suitable for sensors and sensing," says Prof Persaud. "Development of these concepts will give us sensors which are much more sensitive than traditional systems."

The team applied MUPs to piezoelectric materials, which resonate with a precise frequency when an electric potential is applied. Target molecules were shown to bind to the MUP coating, changing the mass of the material and altering its resonant frequency.

This technique is well known in artificial olfaction, though detection limits were typically in the range of parts per million.

"The mouse urine is giving us sensitivity to the parts per billion," says GOSPEL leader Dr Udo Weimar at Germany's University of Tübingen.

"GOSPEL's multidisciplinary approach, and the blending of traditional AO techniques with genetics, molecular biology and biochemistry, is giving us the basis for a whole new generation of sensor."

"Earlier attempts to develop artificial olfaction systems tried to compete with nature. We've realised the futility of this approach, and now we're collaborating with nature. Nature has given us the tools to target those molecules of specific interest to us."

The new sensors have many potential applications; though will first be applied to environmental monitoring. They work well in water so may be used to detect oestrogen levels in processed sewage.

Detecting contamination before it happens

AO already has a strong track record in water monitoring. Now a novel gas sensor developed at Manchester University has emerged as the instrument of choice for the detection of contaminated water before it wreaks havoc in treatment plants.

GOSPEL is developing several projects to better tackle environmental odours:

- Clear-up – a project integrating AO with other technologies to develop demand-controlled ventilation and reduce energy use in buildings.
- BioReal – a project investigating odours in chemical processing. BioReal brings together biology and technology partners to measure odorous compounds such as amines, ketones and aldehydes. It will work on the expression of odorant receptors and their incorporation in sensor systems.

Recently rated by the UK's Water Research Council (WRC) as the best device for the monitoring of trace hydrocarbons, it out-performed optical or fluorescence-based sensors for sensitivity and robustness.

Following WRC recommendations, the instrument is being tested by Thames Water, Yorkshire Water and Southwest Water. It is being commercialised by Multisensor Systems Ltd which Prof Persaud spun out of Manchester University in 2007.

Essentially a gas detector based on metal oxide sensors, but with intelligence built into it, the multisensor system is designed to look for abnormalities and recognise unusual events. The device sits above an inlet stream and can detect hydrocarbons or other contaminants with extremely high sensitivity. By tuning the sensor to recognise particular

contaminants, it can detect diesel or petrol in water at fifty parts per billion or 50 micrograms in a litre.

The device has also been tested for detection of unusual or abnormal loads entering sewerage plants.

Most sensors fail rapidly when immersed in toxic and corrosive sewage, which gives gas sensors a competitive edge. The device being developed by Manchester and Multisensor Systems is configured to provide data via a telemetry system, which allows remote monitoring. It is designed for long-term unattended use with mains power.

GOSPEL (General Olfaction and Sensing Projects on a European Level) is a Network of Excellence funded by the European Community under the Sixth Framework Programme. It is coordinated by the University of Tübingen and integrates the expertise of 25 research groups across Europe. It also works with over 100 Associate Members from industry and academia worldwide.

Replacement of a filter bed in sewerage plant can cost up to €16m, so the water industry is very interested in early detection of contamination. "Illegal discharges such as a farmer dumping chicken blood or a brewery flooding a sewer with beer is the equivalent of fly-tipping in the water world," Prof Persaud says. "These events cause tremendous problems to the operators of sewerage plants, which are typically unmanned and remotely located."

Detection of contaminated water before it arrives in the plant gives operators time to divert the flow to a holding area for slow release at a rate that bacteria can cope with.

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New Relative Humidity Sensor

Vaisala (Finland) has introduced a new generation Vaisala HUMICAP® relative humidity sensor, the Vaisala HUMICAP®180R used in Vaisala industrial humidity transmitters. This new type of capacitive humidity sensor has been developed especially to cope with chemical interference. In most humidity measurement applications, the sensors are also exposed to chemicals other than water vapor. Such vapors are present in most environments, even in normal office air. As the responses to some gases and vapors are very slow, in many cases several weeks or months, the effects are often described as 'drift' or 'aging' of the sensor and not as chemical interference.

The resistance of the Vaisala HUMICAP®180R to chemical interference has been achieved by developing a new type of chemical resistant polymer and a special new structure. The structure slows down the migration of adverse chemicals, or completely prevents them, from entering the active polymer layer. The chemical resistant active polymer further contributes to the stability of the sensor, making it the recommended Vaisala sensor for relative humidity measurement.

The new Vaisala HUMICAP® sensor has been tested both in laboratory conditions as well as in typical humidity sensor applications. The sensors perform better both in laboratory high chemical concentration tests as well as in long-term field stability tests. The results show that the new polymer makes the sensor highly resistant to chemical interference and therefore provides improved long-term stability for the relative humidity measurement.

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The First Intrinsically Safe NDIR Gas Sensor

N.E.T. Srl (Italy) launches the IRIS series at SENSOR 2008 stand 7-346. Incorporating innovative patent-pending optics, the new IR sensor series from N.E.T. comprises a standard sensor, IRIS-7P, including optics and intrinsically safe (IS) circuitry with a 7 pin output, and IRIS-PRO, an intelligent sensor containing all the necessary integrated electronics, IS interface and software to provide user friendly outputs, including a pellistor equivalent output.

Designed especially for the fixed apparatus, the standard 32 mm size (typical 7-series) with a patent cavity allows to meet the 60079-29-1 Standard in terms of performance. The IRIS-PRO hardware has been developed to comply with SIL specifications and SIL 3 for the software.

Both the sensors IRIS-7P and IRIS-PRO are available for hydrocarbons, including methane, in % LEL and % vol and for CO_2 with detection level in ppm, low % vol and high % vol. They have been designed and certified to be used in potentially explosive atmospheres classified as zone 1, 2, 21 and 22 together with an appropriately certified interface/enclosure.

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