A nose for business

Reproducing human senses using technology has long interested companies wanting to detect odours in their packaging. WR Grace has overcome the drawbacks of its quality control process with an electronic nose, as Steven Pacitti discovers

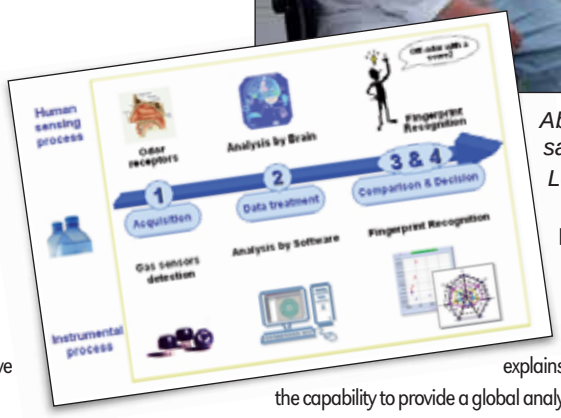
If you don't know an E-nose from the nose on your face, then it's worth knowing what this piece of technology can bring to your business, especially if you work in the plastics industry and are involved with products for direct food contact.

The rapid development of plastics for food contact applications in the packaging industry has increased the need for safety and organoleptic quality testing and since polymeric packaging materials are not totally inert they can interact with the food product. Permeation of gases and vapours across the package, migration of package components and additives into the food, and sorption of food components are all common.

The migration of certain components from the packaging material – which can be a source of off-flavour and off-odour in food – could be caused by the formation of carbonyl groups from overheated polyethylene, residual catalysts in the polymer resin or antioxidant additives in the resins. For example, drinking water stored in plastics bottles can have a faint waxy flavour.

So, with the need for effective quality control procedures becoming essential, and the compounds responsible for off-flavours generally only present at very low concentrations in the food, and therefore difficult to detect, what is an electronic nose (E-nose) and what can it do for you?

For the last 15 years, studies have tried to develop the technologies of E-noses, while the main stages of the recognition process of odours and flavours are similar to human olfaction. The human nose perceives odour/flavour as a global fingerprint and does not isolate each chemical compound coming from the product.



Above: WR Grace's Estelle Bricout (right) says the E-nose saves her company millions of Euros
Left: The E-nose principle

For a long time, gas sensors have been used as a detection system; their physical properties are modified when in contact with volatile compounds, and this change is recorded by the computing system. E-noses usually include arrays of sensors, each being sensitive to all molecules, but in a specific way. The detection system in the E-nose reacts to volatile compounds.

E-noses are used in various industrial areas, such as polymers, plastics and packaging, flavours and fragrances, food and beverage. One of their advantages is the absence of sample preparation. In most cases (solid or liquid form, paste or resin) the product is directly introduced within a vial and heated to generate odorous compounds.

E-noses can reproduce results but what distinguishes these analysers from other analytical techniques? Marion Bonnefille, communication manager for France-based Alpha M.O.S., a manufacturer of E-noses, explains: "E-noses have the capability to provide a global analysis of the odour/flavour without destruction of the sample. There is the possibility to correlate E-nose results to human assessment, and results can be obtained in around 10-20 minutes whereas other methods can last hours."

Among other applications, E-nose systems are used in the packaging industry to detect residual catalysts and antioxidants in plastics resins; organic volatiles formed in a polymer during package fabrication (process selection, new product development); residual solvents that can be released from printing inks, coating and adhesives and organoleptic interactions between the product and its package system.

Smell of success

When specialty chemicals and materials company WR Grace, which owns Darex, the world's leading supplier of sealants and coatings for cans and closures to the packaged food and beverage industry, decided that it needed to overcome drawbacks in its quality control methods, reduce the inventory period and increase the number of tests conducted and reduce the need for panelists, it did so with the purchase of a Gemini E-nose by Alpha M.O.S.

The equipment was installed at its production quality control lab and, as a first step, used for the quality control of polyolefin pellets, of which WR Grace manufactures more than 20 varieties for packaging. Once freshly produced pellets have been cooled, a larger number of samples is collected and analysed with the Gemini within minutes. Disputed lots are further assessed by the sensory panel to make a final decision on the release. In order to guarantee the highest level of quality, the

instrument is configured to be stricter than human tests.

Estelle Bricout, senior chemist closure sealant at the European Technical Centre for WR Grace, was aware of E-nose technology long before her company bought Alpha M.O.S.'s Gemini system but, despite trials in 1998 with another E-Nose company, Grace had had no success with it. This all changed in 2005 with the installation of a Gemini E-nose in the company's laboratory in France and the subsequent installation of a second E-nose internationally in 2006.

"We see the benefits from the E-nose more in terms of faster customer response, more consistency in the marketplace, and leadership in providing organoleptic analysis for the food packaging industry," says Bricout. "It can analyse a new sample every ten minutes."

The system used by WR Grace includes six sensors in order to make an odour unit. A radar figure (or finger print) is determined for each sample and compares this with a reference sample. The upper and lower limits have been determined by correlation between the odour unit and the company's standard taste test. Specifications have also been found for each product.

All WR Grace's products have different formulations depending on the final application (such as plastics caps, metal crowns, metal roll over proof), but in the off-taste/odour tests, the company has established a reference scale for its panelists: no taste, 0; uncertain taste, 2; slight taste, 4; medium taste, 6; strong taste, 8; and very strong taste, 10.

"Unlike a human taste panel, which needs a scale to rate against, the E-nose compares the volatile fingerprint of the material with that of known good samples," explains Bricout. "If there is a strong correlation it is passed. If, however, the volatile profile is different, a sign that the material may have an organoleptic issue, then it is rejected and the batch passes through the standard human test.

"In the food packaging industry, the cost of poor organoleptics is measured in millions of Euros. Our customers expect the quality standards of their suppliers to continuously improve, without passing the costs on to them. Our use of the E-nose has enabled Darex to not only meet this commitment, but also strengthen its position in the market," she adds.

Alternative technologies

For chemical analysis, techniques such as gas chromatography and mass spectroscopy are also used by companies to identify compounds and their concentrations.

However, the results are not directly linked to information produced by humans. These techniques are not always convenient for quality control purposes.

"Organoleptic assessment is often performed by human sensory analysis," says Alpha M.O.S.'s Bonnefille. "The advantages of human sensory panels are the human sensitivity to some molecules (concentrations in the sub-ppb range) and the selectivity of the human nose. However, sensory panels are very dependent upon various parameters (physical condition, mood, fatigue). Moreover, electronic noses are more sensitive than the human nose for some molecules.

"E-nose instruments can perform qualitative or quantitative analysis for quality control of raw materials or development of new products. To set up an analysis with an E-nose, the first step consists of training the analyser with qualified samples so as to build a database of reference. Then, the instrument can recognise new samples by comparing data to those stored in its memory.

Can it introduce savings?

While some brand users and contract packers will ask what an E-nose can do for them, many already have systems installed. At SunAllomer Ltd, a Japanese joint venture with resin producer Basell, the batch quality control of polypropylene resins shifted from sensory panel to Gemini E-nose, enabling an increase in the number of tests conducted and an improvement in their reliability.

Sabic Germany also installed a Gemini E-nose in the quality control laboratory to implement instrumental organoleptic testing of HDPE pellets. The analyser brought the company a simplification of sample preparation, and results correlated with the sensory panel.

"For food and beverage companies or contract packers, E-noses are a means to check materials (caps, films, liners) upon arrival within the plant. The analysers allow them to monitor batch variation, detect interaction with cardboards or possible contamination during storage in warehouses," says Bonnefille.

The return on investment of an E-nose is usually less than one year, says Bonnefille, although this depends on the techniques used by the customer.

"Companies that comply with EN standards spend a lot of time preparing samples to be tested. Plastics or polymer samples have to be soaked in water for hours (other industrials perform UV aging for days) before being tested by at least three panelists. To measure volatile compounds of the same samples with an E-nose, it is only necessary to introduce pellets or caps, freshly produced in a vial and analyse them directly to obtain results within minutes. Therefore, the rapidity of results delivery allows you to considerably speed-up decision periods and batch release, and decrease storage times and costs."

Food and beverage companies or contract packers, meanwhile, have to test the plastics packaging batches before use so that the analysing period does not delay the whole product release.

"From a QC lab point of view, the use of an E-nose significantly simplifies sample preparation and generates easy to understand results," adds Bricout of WR Grace. "As for production, it can dramatically decrease storage times and costs, diminish the need for panel tests and provide a more representative score (larger number of samples tested)."

WR Grace found that the number of analyses increased and that human behaviour no longer influenced results. It was also possible to analyse during the night.

The term electronic nose, which was first used in 1987, and made commercial in a device in 1993, is probably one that you will hear increasingly often in the packaging industry as demands on food contact requirements continue to intensify.

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