UNIVERSITY OF CAMBRIDGE enterprise

Electronic nose

BACKGROUND

This technology "represents a considerable advance in the state-of-the-art…Highly original and building from a sparse amount of previous research"- Prof Krishna Persaud, e-nose pioneer

What would we recognise if our sense of smell was as sharp as our vision? The natural world communicates vast quantities of information both inadvertently (e.g. breath biomarkers, bacterial strain metabolites) and advertently (e.g. synchronised ripening and plant pest attack). Volatiles can also provide information about manmade processes (e.g. weapons, pollution or gas leak triangulation). If we could recognise these compounds easily and cheaply, it has the potential to transform many industries and save lives.

Electronic noses, which aim to address this problem via inspiration from mammalian olfaction, combine unspecialised gas sensing with data processing. Current e-nose solutions can be considered to take two forms. The first method involves complementary coatings to the molecule of interest, which limits discrimination ability by the number of devices. The second method gauges the size of the molecule and roughly recognises the shape. This approach, which is presently considered the gold standard, requires extremely expensive and bulky equipment. More importantly, both types of current e-nose lose the ability to identify molecules with increasing size. Compositionally similar molecules, which includes many of biological origin, are most challenging to discern. This represents the key hurdle to astonishing progress across industry sectors. An analogy to understand value in molecular shape is that we know that the information contained within DNA relates to the position of bases within the molecule. In the same way, there is significance in knowing the structure of a molecule.

Biomarkers relating to easy to access markets such as in agritech/food storage/veterinary science and transport have the potential to be recognised, as well as the more lucrative medical markets which pose greater barriers to entry due to stringent regulatory approval requirements. Testing of a range will form the next steps in establishing further markets.

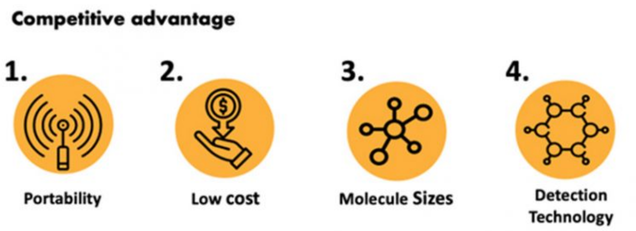
Low barrier to entry agritech market

Each year, between 20-40% of crops are expected to be lost worldwide to disease. Rice and other grain are particularly susceptible to the recurring blast epidemics which claim 10-30% of the yield. Methyl jasmonate, a plant stress hormone, is released by a wide variety of plants in response to damaging conditions including mechanical damage from pests, UV damage, insufficient water among other stressors. The specifics of the damage are often conveyed via different compounds that can be directly linked to a metabolic process of the plant, bacteria in the soil or fungus e.g. malondialdehyde. Consequently, an all-purpose and damage cause identifying e-nose may be developed to monitor the health of crops so that preventative measures can be taken to isolate the damage. This may be used along with signatures in volatile compounds, like acetone, which also indicate optimum harvest time. Vertical farming is a prime subject for the application of e-nose sensors due to the confined nature of this practice. Agritech applications extend to animal husbandry and veterinary science. An estimated 50 million cows are infected with TB worldwide. Bovine TB could be monitored via recognising the presence of methyl nicotinate.

Higher barrier to entry health-tech market

Human TB may be recognised from the same bovine TB biomarker, a disease which infects two billion people worldwide. Testing with key breath biomarkers should demonstrate further value as a breath sensor.

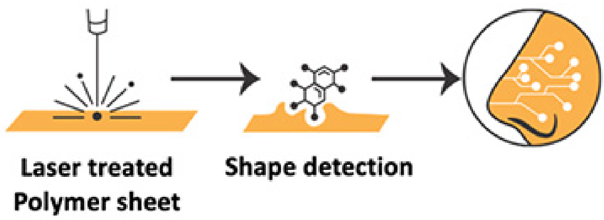
The number of preventable deaths attributed to MRSA which were reported in the UK alone between 2021 and 2022 was 13,501. Via the profile of volatiles released from infected tissue, the bacterial strain responsible may be identified – this extends to being able to distinguish MRSA and MSSA. Our device would be particularly well suited to this job due to the range of sizes of molecules, their organic nature, the number of volatiles that must contribute to a diagnosis, the device cost and portability. This global issue is a strain on hospital resources in the preventative measures required and the healthcare demands once a patient is infected. This represents a more ambitious target once recognition of more diseases with more simple chemical signatures are proven.



TECHNOLOGY OVERVIEW

- Unique spectra have been determined for breath and urine biomarkers of diabetes, fruit ripening, plant fungal infection and two compounds in the most abundant families of molecules that are known to occupy a given range and ratio in the breath of healthy individuals. A portfolio of key information carrying volatiles relating to these and other industries has been determined and testing is ongoing.

- A fabrication process which creates conductive nanometre-sized graphene regions in carbon-rich polymer matrices.
- The conduction characteristics indicate tunnelling is happening along switching pathways.
- Tuneable sensor properties through tailorable fabrication process.
- The heterogeneous distribution of conductive regions and attachment points across the channel imparts a molecular shape dependent affinity to the device.
- The consequent charge rearrangement across the channel results in distinctive spectra in the presence of each gas.
- The nature of the sensor operating mechanism permits the detection of an unlimited range of airborne molecules.
- Sensors are based on lightweight, bioinert and flexible polymer films.
- Laser fabrication using polymer precursor is cheap and single-stage.



BENEFITS

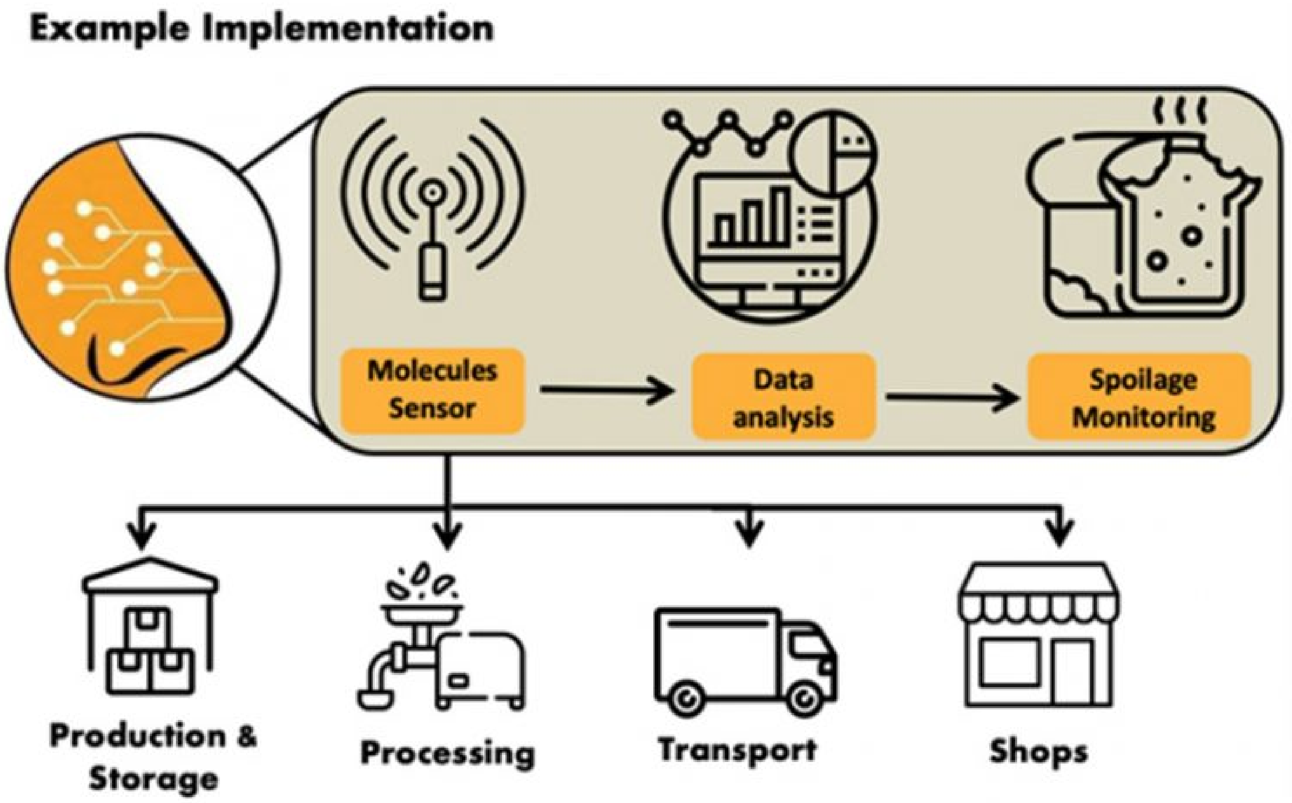
- Shape selective sensing allows discrimination of more challenging to identify and larger molecules.
- Chemical profiling of huge range of airborne molecules
- Lightweight
- Low cost
- Compact form factor
- Flexible, bioinert device
- Longevity due to fouling resistance
- Fabrication step can be used to create many kinds of devices/wires/antenna which leads to possibility of subsequent integration
- Robust and simple fabrication approach gives high yield
- Prior exposure to molecule may not be necessary to identify family, groups or size.
- Very low carbon footprint fabrication approach.

APPLICATIONS

Applications for this technology include:

- Food industry e.g. storage, transport, production
- Medical diagnostics e.g. via bodily fluids, breath biomarkers
- Plant health and optimum crop harvest time in traditional farming

- Vertical farming
- Animal husbandry/veterinary diagnostics
- Environmental monitoring
- Safety and security
- Wearable health monitors
- Air quality or sanitation sensors
- Industrial processes
- IoT sensors
- Volatile receivers
- Triangulation of gas leaks/disturbances
- Presence of pathogenic or pollutant biofilms e.g. hospitals or rivers
- Biomedical research
- Quality control
- Microbe strain e.g. soil, infection, cultured yeasts
- Biomedical research
- Wearable health monitors
- Air quality sensors



OPPORTUNITY

We are seeking industrial partners to help to commercialise the technology. We are also interested to commercialise the technology via formation of a spinout company.

INVENTORS

Dr Melanie Whitfield

Dr Melanie Whitfield is a recipient of EPSRC Impact Acceleration Award and is working on the development of the sensor within Prof Andrew Flewitt’s group within the Department of Engineering. This work follows on from her recent completion of a PhD in Electronic Engineering in which the IP was developed under the supervision of Dr David Hasko. She received an MSc in Biomedical Engineering with Medical Physics from Imperial College London, and an MRes from the UCL-Cambridge Photonics CDT in Integrated Photonic and Electronic Systems Engineering. Prior to this, she gained industrial experience working with power systems at Rolls-Royce and has lectured for a module ‘Nanoelectronics and Nanomaterials in Healthcare’.

David Hasko

Dr David Hasko has been Laboratory Manager with the Electrical Engineering Division, Department of Engineering, Cambridge University, since 2009. He has published over 250 papers and three patents in the areas of electron beam lithography, nanoelectronic device fabrication and characterisation, as well as in quantum mechanical effects in solid state devices.

PATENT

GB patent application no. 2313455.4 for sensing method, sensing device and method of manufacture was filed on 4th September 2023.