OPTICAL NOSE
NEST ADVENTURE

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A breath of hope from molecular fingerprints

Diagnosis of many medical conditions may be possible through breath testing, but technological and scientific barriers are slowing progress towards this goal. OPTICAL NOSE intends to tackle them head-on through two complementary strands of investigation – one into advanced mid-infrared fibre-laser sources and sensitive spectroscopic detection methods, the other into the relationship between breath composition and the progression of colorectal cancer and chronic obstructive pulmonary disease.

Nitrogen, oxygen and carbon dioxide together make up virtually all of the air in any breath exhaled by a human. The remainder is a complex mixture of many gases. Researchers have already identified traces of more than 3 000 volatile organic compounds (VOCs) in human breath. Trace-gas composition can tell us a great deal about the particular human who exhaled the breath. However, the connections between specific trace gases and their causes in the body remain unclear, and few breath tests have been devised to exploit the diagnostic potential of the breath.

The OPTICAL NOSE team has set itself the task of tackling head-on the two main obstacles holding back progress. Their practical objective is to exploit new fibre-laser technology to create a fast, sensitive and versatile trace-gas analyser for early detection of selected diseases. The consortium unites the expertise of four research centres and one company, which together cover the broad field of theoretical and applied modern optics, with the expertise of two medical research centres working on the study of colorectal cancer and chronic obstructive pulmonary disease.

Laser spectroscopy matures

First among the obstacles is the catalogue of limitations of established diagnostic detection technologies. Gas chromatography (GC) is typical. It is expensive and insufficiently sensitive for ready quantification of the ultra-low concentrations of VOCs in the human breath. Therefore, accumulation is needed which results in delays of hours before analysis results are ready. It is also slow and it can analyse only one gas species at a time.

In recent years, the increasing maturity of sophisticated laser technologies has recommended them for trace-gas detection. The consortium hopes to realise a step change in their versatility, to measure all trace-gas species present in complex gas mixtures in a single operation. Their apparatus will need to measure light absorption by the gas mixture at tens of thousands of discrete wavelengths per second. Another big challenge is the wavelength range, which must cover the molecular fingerprint region, stretching from 2.5 to 10 microns. Between these limits, most important gas molecules possess dense series of

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The breath may be the key to convenient and early diagnosis of many medical conditions.

AT A GLANCE

Official title
The OPTICAL NOSE: An on-line, non-invasive and total-profiling instrument for trace gas sensing applications in medical sciences

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strong absorption lines which reveal their chemical composition.

To achieve these aims, they will investigate optical parametric oscillators (OPO) – lasers based on non-linear optics – for generating microsecond pulses of rapidly tuneable wavelengths in the mid-infrared region. An OPO of this kind operating at around 3 microns has already been reported. The partners hope to improve on its kind by experimenting with tuneable ytterbium-, erbium- and thulium-doped silica-fibre lasers to pump the OPO. In this way, they expect to increase the duty cycle to an acceptable level and, in particular, to enable the signal laser to be tuned rapidly across the whole molecular fingerprint region.

New medical data

The second obstacle is the scant nature of our knowledge of the relationship between the breath trace-gas composition and its causes. The two medical-research partners are to collect data relating the progression in patients of colorectal cancer (CRC) and chronic obstructive pulmonary disease (COPD) to the composition of breath samples taken from them. They will measure disease progression with state-of-the-art clinical techniques, and breath samples with the best extant trace-gas analysis techniques.

Results from these studies are essential if the final configuration of the laser-spectroscopy apparatus is to be validated, and then optimised, for breath-test detection of CRC and COPD. They may also serve to accelerate the search for VOC signatures more discriminating and reliable than those beginning to emerge in the medical literature.

Screening by breath

Breath tests could, in time, become as ordinary and versatile in medical screening as blood tests are today.

If the team demonstrates a practicable optical nose, it is not too fanciful to suppose that breath tests could, in time, become as ordinary and versatile in medical screening as blood tests are today. But it would be a mistake to think that this exhausts the possibilities. Applications in numerous fields are easy to imagine – from measuring the effect foodstuffs have on the body, and monitoring industrial chemical plants, to improving security in public places through detection of explosives and drugs.

SIXTH FRAMEWORK PROGRAMME