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Analyzing Breath with Chemical Sensors

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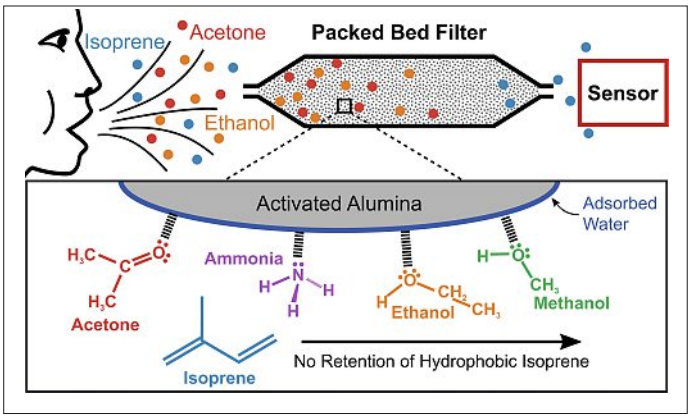
Non-invasive breath analyzers could facilitate rapid and routine disease screening for early stage detection and improved therapies. In fact, elevated breath concentrations of key molecules have been associated to physiological and pathological states, such as ammonia to kidney failure, acetone to diabetes and enhanced fat metabolism or NO to asthma, the latter being applied actively in today's clinical practice. Especially promising to detect these 'breath markers' are solid-state gas sensors due to their compact design and low cost, making them ideal for incorporation into wearable devices.

In specific, gas sensors based on chemo-resistive metal-oxides nanoparticles offer sufficiently low detection limits in the part-per-billion (ppb) range, fast response and recovery times (seconds to few minutes), however, they lack selectivity. This can be tackled for some tracers by material design (*e.g.* Si-doped WO_3 for acetone, Si-doped MoO_3 for ammonia), microporous filter membranes or the combination of sensors to arrays.

Recently, a filter-sensor system was developed for fast and highly selective breath isoprene detection. Isoprene is a promising marker for high blood cholesterol levels. The sensor system consists of a filter of activated alumina in combination with a non-specific but highly sensitive Pt-doped SnO_2 sensor. Isoprene is hydrophobic, in contrast to other major breath compounds including acetone, ammonia, ethanol and methanol. The filter exploits this by ab-/adsorbing and retaining them while isoprene passes unhindered and is registered by the sensor without interference. That way, isoprene is detected quickly (< 5 s) down to 5 ppb with selectivities >100 over other compounds in simulated breath mixtures, unprecedented by state-of-the-art sensors. As a result, this sensor-filter system is promising as breath isoprene detector for non-invasive monitoring of high blood cholesterol levels.

Such sensors can be integrated readily into portable breath analyzers for individualized health monitoring at home. This was demonstrated recently with breath acetone sensors that monitored individual fat burn rates in 20 volunteers during exercise and rest.



Isoprene detector based on an alumina-powder filter to retain hydrophilic compounds and a highly sensitive Pt-doped SnO_2 sensor to quantify isoprene concentrations. Adapted with permission from van den Broek *et al.*, *ACS Sens*. **2018**, *3*, 677. Copyright (2018) American Chemical Society.

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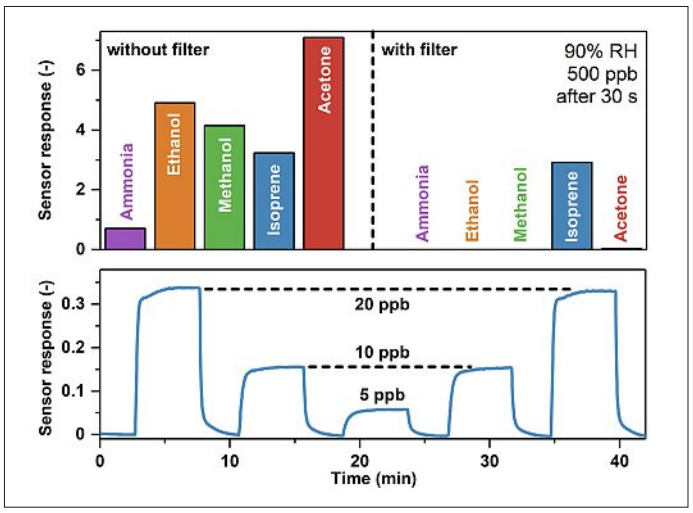

Response of the Pt-doped SnO_2 sensor without (top left) and with activated alumina filter (top right) to 500 ppb of breath-relevant analytes at 90% RH. Response of the filter-sensor system to ultra-low isoprene concentrations of 5, 10 and 20 ppb at 90% RH (bottom). Adapted with permission from van den Broek *et al.*, *ACS Sens*. **2018**, *3*, 677. Copyright (2018) American Chemical Society.

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