Highly selective gas sensors enabled by flame-made catalytic filters

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Compact and low-cost gas sensors are urgently sought in emerging applications including air [1] and food [2] quality monitoring or medical diagnostics [3]. While chemo-resistive sensors feature remarkable sensitivities to detect even parts-per-billion (ppb) concentrations, a key limitation is selectivity, impeding commercial use [4]. A simple approach to enhance selectivity is by combining sensors with a modular filters [5]. Particularly suitable are catalytic filters that continuously convert interferants to non-responsive species, while target analytes remain unscathed. State-of-the-art catalytic filters, however, often fail to distinguish volatile organic compounds of similar stability (e.g., alcohols, aldehydes, ketones) or within the same chemical family.

Here, we present a route to design tailor-made catalytic filters for superior sensor selectivity using flame spray pyrolysis. Thereby, catalyst surface acidity and basicity is of key importance. For example, ethanol conversion is favored on basic oxides featuring surface-adsorbed oxygen-and hydroxyl-related species [6]. Hence, a basic ZnO catalyst [7] may be used to enhance sensor robustness towards ethanol, a key advantage in applications where ethanol interference is present (e.g., in gyms, hospitals or indoors, where ethanol evolves from disinfectants [8]). Similarly, a Pt-loaded Al_2O_3 catalytic filter removes ethanol as well as other alcohols, aldehydes and inorganics selectively over acetone [9]. When coupled to a Si/WO_3 sensor, this allows for unprecedented acetone selectivity (i.e., > 250) towards all interferants. Most importantly, this detector features excellent bias (i.e., 25 ppb) and precision (i.e., 169 ppb) even when tested with real breath of nine volunteers [10] during and after an exhaustive exercise intervention [11], as validated by bench-top proton-transfer-reaction time-of-flight mass spectrometry (PTR-ToF-MS). In addition, the modular, low-cost and low-power (e.g., catalyst at room temperature [12]) design of such packed bed filters allows easy integration into compact devices. This is highly promising for acetone, and thus metabolic health monitoring (e.g. obesity), a major concern of today's society [13].

In a broad perspective, the combination of selective and low-power catalytic filters with sensitive sensors opens up exciting new opportunities to systematically design highly sensitive and selective detectors. We envision their use in various applications, including environmental monitoring (e.g., toxic benzene pollution), medical diagnostics (e.g., metabolic acetone) or food quality monitoring (e.g., ammonia in food spoilage).

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