Nanoporous chemical receptors on microcantilever-like sensors for explosives detection in vapor phase

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In recent years, there has been a growing need for rapid detection and identification of terrorist threats including chemical and biological warfare agents, and explosives. None of the methods investigated to date solves the simultaneous problems of sensitivity, selectivity, reliability and speed required. This partly stems from the fact that explosives are composed of many chemicals, many being notoriusly difficult to detect due to their physical and chemical properties. The main problem as far as vapor phase detection is concerned is their low vapor pressure in the pure form (it ranges between 10^{-2} Pa to 10^{-7} Pa at 25ºC). In this scenario, the incorporation of pre-concentration units for trace detection in small volumes has revealed crucial for the satisfactory performance of any analytical device. Then, there is the problem of reliability: the ability of the sensor to discriminate between explosive markers and a wide variety of volatile hydrocarbon products accompanying most modern travelers (cosmetics, perfums, synthetic fabrics…) must be guaranteed to avoid false alarms. The most effective and efficient method in current use is sniffing dogs, but they also suffer from some limitations like behavioral variations and deterioration performance over time. Accordingly, extensive efforts have been devoted to the development of innovative and effective detectors, capable of monitoring explosives both in time and location, for homeland security and counter-terrorism applications. In theory, any chemical analysis scheme should be applicable for concealed explosives detection. Indeed, nearly of all known instrumental methods have already been investigated for their applicability. In particular for rapid vapor phase detection, the most extended commercial hand-held equipments (<10 kg) for explosives detection are based on ion mobility spectrometry (IMS) with advertised sensitivity of 10 ppt (52 k$ for Ion Track Instruments ITMS Vapor Tracer); gas chromatography with electron capture detector for vapor concentration >1ppm (5 k$ for JGW International, Ltd. Graseby GVD4) and thermal redox detector with LOD <1 ppb (23 k$ for Scintrex/IDS EVD-3000). Apart from the costs, the limited portability, the operational complexity makes them inadequate for on-site monitoring. Thus, there is still need for quick, highly sensitive, robust and dependable technologies that can be readily operable by untrained first responders and homeland security operatives in the field.

In view of the molecular recognition properties that nanoporous solids can offer, main strategy followed in our lab for explosives detection involves the use of nanoporous solids (micro and mesoporous; i.e zeolites, M41S, titanosilicates) as added elements on already existing platforms of sufficient sensitivity silicon microcantilevers provided with internal heating elements. Thus, different examples will be described to illustrate the progress of our work in this topic. In addition, some preliminary results on micropreconcentrator units involving zeolite policrystalline layers solids as specific coatings will be anticipated.