

New Modified Thin PDMS Membranes for IMS Detection of Volatile Chemical Agents

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Abstract

Detectable warfare agents in soil is important problem after using them. Now this problem are urgent and it should be prepared technics to detect warfare agents from soil and vapors from soil. One of most common methods is using devices base on Ion Mobility Spectrometry. In this communicate we propose possibility to increase membrane sensitivity and selectivity, to develop relatively simple method to detect warfare agents in the soil. To increase sensitivity and to reduce detection time in the Ion Mass Spectroscopy detectors there are required thin Polydimethylsiloxane PDMS membranes impermeable to the water vapors and permeable, selective to the tested volatile chemical agents. To obtain mechanically strong and thin PDMS membranes a porous supports were applied and to increase permeability of chemical agents addition of selected poly(ethylene oxides) were tested.

Membranes for Ion Mass Spectroscopy Detectors

In the IMS instruments in the gas inlet port, prior to the Ni-63 ionization chamber there is placed Polydimethylsiloxane PDMS membrane, which is impermeable to the water vapor and on the other hand permeable to the tested volatile organic agents. Membrane permeability P depends on the Diffusion and Solubility of tested compounds

$$P = D \times S$$

To increase the Diffusion D there are required relatively thin PDMS membranes, which also has to be mechanically strong and resistant to the varied pressures [1,2]. We have decided to test different mechanical porous supports (Figure 1), which will be modified with PDMS/Hexane (Sylgard 184) 10% w/w solution to obtain after drying and hot temperature curing (120 °C for 2 hours) films with thicknesses in the range of 3-5µm only.

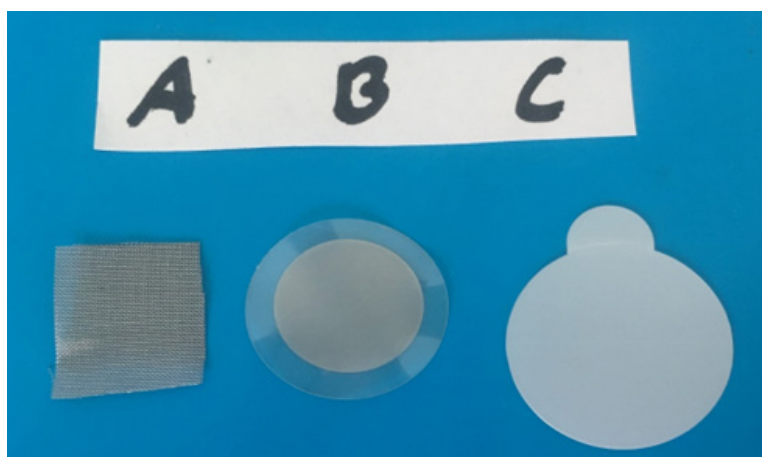


Figure 1: Mechanical porous supports for thin PDMS membranes: A-stainless steel screen; B-PET laser track membrane with 8 µm openings; C-ceramic alumina porous foil.

To increase solubility *S* of tested volatile chemical agents we have decided to add to the PDMS matrix membrane 20phr of poly(ethylene oxide) PEO; poly(propylene oxide) PPO or calixarene derivative with different molecular masses, total 6 additives are tested.

Colorimetric Detection of Volatile Organic Agents

In the experimental procedures, studying different mechanical

supports, PDMS membranes with varied thicknesses and added modifying additives there is necessary to use a fast and reliable method for testing permeability of different chemical compounds, especially volatile simulants of the Chemical Warfare Agents CWA [3]. We have decided to use Paper Chemical Agent Detector 6665-21-858-8494 [4] which in contact with liquid CWA agents rapidly changes color (Figure 2).



Figure 2: Brown self-sticking paper colorimetric detector (right) changing rapidly colour after contact with liquid CWA (left).

But there is an open question how these colorimetric detectors will react in contact with not liquid but vapor form of chemical agent. We are running experiments with different PDMS membranes, covering paper detector and observing how this covering membrane is affecting the reaction time-change of the color. On

Figure 3 (a-c) there are presented results of visual observations of paper colorimetric detectors being placed in coverings of glass 10 ml vials over 20 μ l of CWA liquid simulants (methyl phosphonic acid dimethyl ester DMMP; Methyl Salicylate SM; Dimethoxy propanol DPGM).

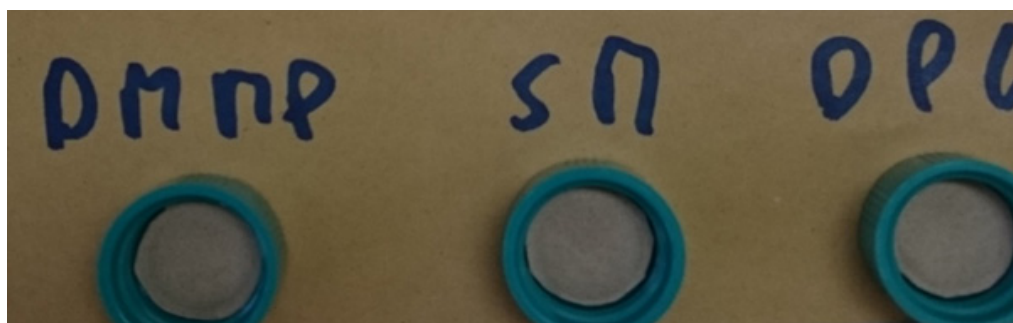


Figure 3a: Paper detectors placed in RT 70 mm over drops of liquid DMMP; SM; DPGM simulants.



Figure 3b: Paper detectors placed in RT 70 mm over drops of liquid DMMP; SM; DPGM simulants after 48 hours.



Figure 3c: Paper detectors placed in RT 70 mm over drops of liquid DMMP; SM; DPGM simulants after 168 hours.

Note color change of paper detector in contact with vapor phase of DMMP (turn brown) and SM (turns red). For DPGM simulants we do not observe color change, both in liquid and in the gas phase.

Conclusion

Paper colorimetric detectors can be used for testing different PDMS membranes to select the best one for the IMS instrument. We want to select a thin membrane, relatively strong due to the presence of mechanical support and modified with PEO or PPO derivatives rapidly reacting to the CWA simulants action in the gas phase.

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