Rapid detection of toxic compounds

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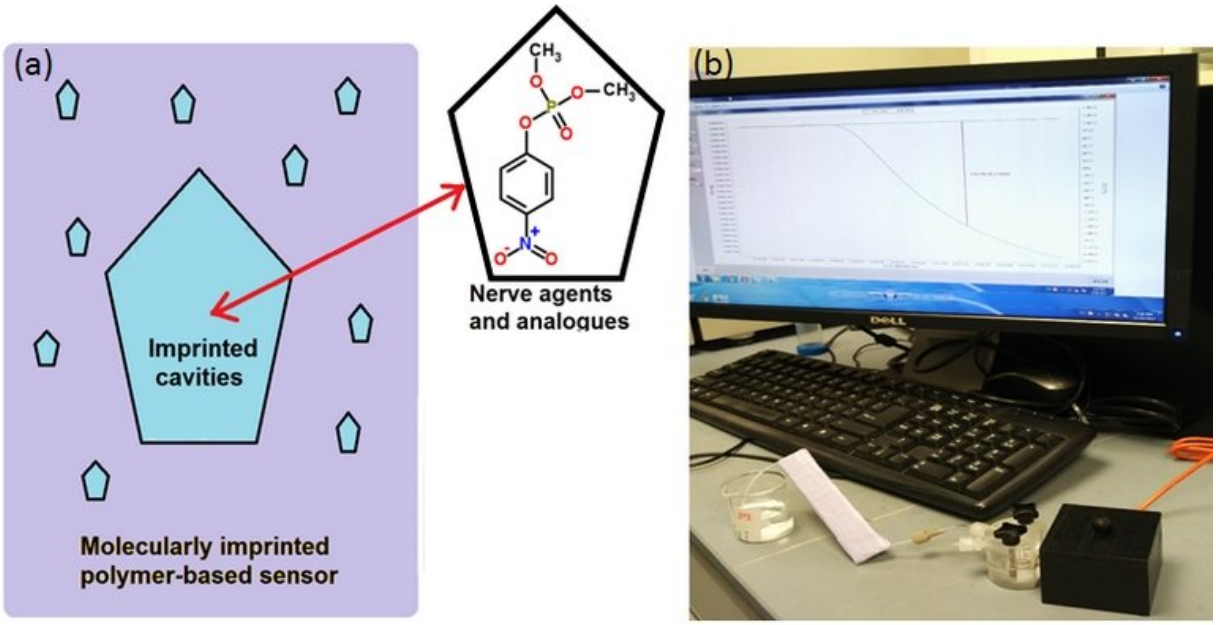

Figure shows (a) the principle of MIP-based sensors, in which unique patterns of the target molecules are imprinted on a polymer-based sensor film and (b) an experiment being carried out using the MIP-based sensor in the laboratory. The sensor response captured by the QCM is displayed on the screen. Credit: National University of Singapore

NUS chemists have developed highly selective and sensitive sensors based on molecularly imprinted polymers (MIPs) for the rapid onsite detection of toxic agents.

Nerve agents, such as the well-known agent VX, are a class of

phosphorus-containing organic compounds that severely impact our nervous system. These organic compounds, known as organophosphates, are widely used in many insecticides and herbicides. Conventional analytical techniques to detect them include chromatography, fluorescence spectroscopy and immunoassay. However, these techniques usually involve sophisticated equipment or tedious time-consuming procedures that make detection particularly challenging.

A research team lead by Prof Sam LI from the Department of Chemistry, NUS has developed two types of analytical sensors which can detect these nerve agents and other toxic chemical compounds in an easier way, providing the results in a much shorter time. One of the sensors, which targets non-water soluble compounds, is made from a commercially available thermoplastic material, polyvinylidene fluoride (PVDF). The PVDF thermoplastic was fabricated using a unique MIP-based method developed by the team that uses polymers directly instead of monomers. The other sensor for detecting chemical compounds in aqueous solutions uses a biologically compatible polymer, polydopamine (PDA). The team had developed a "dry" MIP-based process during the pre-assembly stage so that a larger variety of molecular species can be detected by these sensors.

The sensors are produced using an imprinting technique at the molecular scale to create unique patterns of the target molecules on polymeric materials. These patterned polymers, known as MIPs, will then contain specific patterns with spaces that fit exactly with the target molecules. It is like an artificial tiny lock in which the target molecule serves as the miniature key. The target chemical compounds, if present in the environment, will get attached to the sensor film, causing an increase in the mass. By attaching a piezoelectric quartz crystal microbalance (QCM) to it, this minute change in mass can be easily detected.

Prof Li said, "The MIP-based sensors could accurately detect less than

20 micrograms of organophosphate pesticides, which are chemicals commonly used for fruit and vegetable farming in 1 litre of water, in as quickly as three minutes. Conventional methods typically complete the analysis in a time range of about 5 to 15 minutes."

Prof Li added, "The size of the detection kit could potentially be miniaturised to about half that of an iPhone 8 so that it can be carried around easily for the rapid onsite analysis of potential threats."

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