Polymeric Sensors for Explosives Detection

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Chemical sensors for the rapid detection of explosives are important because they have important potential applications, such as tactical and humanitarian de-mining, remediation of explosives manufacturing sites and forensic and criminal investigations. Several polymers have been used to detect nitro-aromatic explosives by a variety of transduction schemes. Detection relies on both electronic and structural interactions between the sensing material and the analyte. The current innovation aims at monitoring the change in the optical parameters as the refractive index, via ellipsometry measurements for electron rich polymers films before and after exposure to nitro-aromatic explosives.

Various methods of explosives detection are currently available, but many simple techniques are often inefficient. Metal detectors are commonly used as an indirect technique for sensing explosive devices packaged in metal. This method is valuable for certain applications such as for landmine and weapon detection, although many modern landmine employ plastic casings. Metal detectors, however, are not useful for other applications, such as for explosives screening in airports. Canines are considered the most reliable tool for the detection of explosive vapors; however, this method is expensive and not well-suited for continuous monitoring because dogs require care and are easily fatigued.

Some methods, though highly sensitive, are expensive and require sophisticated instrumentation that is not easily applied to on-site field testing. Some such methods include gas chromatography coupled with mass spectrometry, surface enhanced Raman spectroscopy, nuclear quadrupole resonance, energy dispersive X-ray diffraction, neutron activation analysis, electron capture detection and cyclic voltametry. Ion mobility chromatography coupled with mass spectrometry, surface enhanced Raman spectroscopy, nuclear quadrupole resonance, energy dispersive X-ray diffraction, neutron activation analysis, electron capture detection and cyclic voltametry. Ion mobility chromatography coupled with mass spectrometry, surface enhanced Raman spectroscopy, nuclear quadrupole resonance, energy dispersive X-ray diffraction, neutron activation analysis, electron capture detection and cyclic voltametry. Ion mobility chromatography coupled with mass spectrometry, surface enhanced Raman spectroscopy, nuclear quadrupole resonance, energy dispersive X-ray diffraction, neutron activation analysis, electron capture detection and cyclic voltametry. Ion mobility chromatography coupled with mass spectrometry, surface enhanced Raman spectroscopy, nuclear quadrupole resonance, energy dispersive X-ray diffraction, neutron activation analysis, electron capture detection and cyclic voltametry. Ion mobility chromatography coupled with mass spectrometry, surface enhanced Raman spectroscopy, nuclear quadrupole resonance, energy dispersive X-ray diffraction, neutron activation analysis, electron capture detection and cyclic voltametry. Ion mobility chromatography coupled with mass spectrometry, surface enhanced Raman spectroscopy, nuclear quadrupole resonance, energy dispersive X-ray diffraction, neutron activation analysis, electron capture detection and cyclic voltametry.

The basic concept of our innovative polymers and copolymers films is to make use of the formation of the Meisenheimer type of complex between the electron deficient nitro-aromatic explosives vapors and the electron rich / super electron rich aromes that works like anchors for these vapors and monitor the resultant change in the refractive indices for the polymer films before and after very short time of exposure to the explosives vapors through ellipsometry testing.

Examples for Electron rich / super rich Arene Polymers:

The change in refractive index of Poly(vinylimidazole) polymer film before (blue curve) and after (red curve) exposure to the vapor of p-Nitrotoluene

The change in refractive index of Poly(VDA-co-Styrene) film before (blue curve) and after (red curve) exposure to the vapor of p-Nitrotoluene

Light and Polarization

Light can be described as an electromagnetic wave traveling through space. For ellipsometry, it is adequate to discuss the electric field behavior in space and time, also known as polarization. The electric field of a wave is always orthogonal to the propagation direction. Therefore, a wave traveling along the z-direction can be described by its x- and y-components. If the light has completely random orientation and phase, it is considered non-polarized. For ellipsometry, we are interested in the case where the electric field follows a specific path and traces out a general polarization is “elliptical”, which combines orthogonal waves of arbitrary amplitude and phase (Figure 1c). This is where ellipsometry gets its name.

The primary methods of measuring ellipsometry data all consist of the following: light source, polarization generator, sample, polarization analyzer, and detector.

Figure 1. Orthogonal waves combined to demonstrate polarization: (a) linear; (b) circular; and (c) elliptical

Figure 2. Rotating analyzer ellipsometer configuration uses a polarizer to define the incoming polarization and a rotating polarizer after the sample to analyze the outgoing light. The detector converts light to a voltage with the time dependence leading to measurement of the reflected polarization.