Novel Chromogenic Vapor Sensors Enabled by Shape Memory Polymers

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The detection of toxic chemical vapors is a significant issue in environmental monitoring, disease detection and national security, yet no cheap, user-friendly, multipurpose sensor is currently available. The purpose of this experiment is: 1) to develop cheap chromogenic vapor sensors using a new type of shape memory polymer (SMP); 2) to further the basic understanding of SMP's behavior in response to vapors; and 3) to develop a practical method of identifying different chemical vapors. Experiments were conducted using SMPs fabricated through 1) the self-assembly of multilayer silica colloidal crystals on glass slides; 2) the introduction of a monomer mixture to fill up the gaps between the silica nanoparticles; 3) the photopolymerization of the monomers; and 4) the removal of the silica templates. The resulting macroporous SMP films were exposed to various chemical vapors (acetone, benzene, dichloromethane, hexane, and methanol), and color change was measured by both an optical spectrometer and a smart phone color-analyzing application. Data was analyzed with Origin Pro, IDL, & Excel. Also, a MatLab program was used to simulate the reflective spectra of an SMP membrane upon exposure to the chemical vapors. The results indicate that each chemical vapor can trigger a unique optical response in macroporous SMPs, and thus these inexpensive films can function as chromogenic vapor sensors. The actual wavelength responses to the different vapors are consistent with the simulation results. Furthermore, a linear relationship was found between the surface tensions of the chemicals and the peak wavelengths. Finally, preliminary tests with the smart phone application show that the color responses of the SMPs to vapors are detectable by smart phones through their unique RGB values.