Novel Colorimetric Sensors for Detecting Chemicals in Vapor, Liquid, and Solid Phases

Jiang, Helena (School: F. W. Buchholz High School)

Convenient and inexpensive colorimetric chemical sensors (like pH paper), which change color when exposed to chemicals with different concentrations, are attractive due to low cost, ease of operation, and relative accuracy. I have demonstrated proof-of-concept of a new type of colorimetric sensor by testing two hypotheses: (1) by combining the concepts of shape memory polymers (SMP) with bio-inspired structural colors, novel colorimetric sensors can be built to determine concentrations based on the colors of the sensors, and (2) rapid diffusion of chemicals in vapor, liquid, and solid phases into thin SMP layers can trigger rapid microstructural changes for chemical sensing. Three model systems have been tested. The first is an ethanol sensor to specifically detect ethanol in commercial fuels. The second sensor is to detect trace amounts of common industrial pollutants (e.g., benzene/toluene/xylene or BTX) in water. I have demonstrated that trace amounts (10 ppm) of BTX can be detected by my sensors. The third solid-phase sensor is based on my independent discovery of a new phenomenon – rapid color changes of a SMP sensor triggered by diffusion of small molecules at a solid-solid interface; it will be the first solid-phase colorimetric sensor on the market, yielding many benefits. Besides simple qualitative visual readouts, a convenient smartphone-based platform has been utilized in achieving quantitative analysis. These novel sensors have an enormous variety of important applications, from detection of toxic gases in residential houses and detrimental plasticizers in kids toys to overall environmental monitoring in order to alleviate the global pollution crisis.

Awards Won:

Intel ISEF Best of Category Award of $5,000

First Award of $3,000

American Chemical Society: First Award of $4,000