Magnetically Induced, Visual Detection of Trace Arsenic Contaminants in Water Using Fe3O4 Photonic Crystal Structures

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Arsenic, a highly toxic metal contaminant commonly found in our drinking water, is responsible for many accidental deaths. Currently, the only visual arsenic-in-water detection system is tedious, and can detect arsenic concentrations of 250ppb or more, well above the EPA 10ppb water-action-level. To combat arsenic drinking water contamination, a sensitive, inexpensive, portable, and easily-visualized detection system is needed and has been developed in this research. To begin, superparamagnetic, SiO2-coated, polyacrylic acid-capped Fe3O4 colloidal nanocrystals (CNC's) were synthesized, and their photonic and physical properties characterized via SEM and UV-Visible spectroscopy. Application of 80-140G magnetic field from a portable, 3" magnet altered the refractive indices of the photonic structures, so that long-to-short wavelength, red-to-blue color change is easily visualized from the native brown CNC solution color. Addition of 1ml of 10ppb Arsenic, however, to 2ml of 8mg/ml CNCs causes alteration of the photonic characteristics so that long-wavelength shift occurs with an applied magnetic field (native brown to orange). This new color changing behavior is specific to the arsenic contaminant, and attributed to As-O interactions at the surface of the SiO2-coated CNCs. Other typical metal contaminants did not share this same metal-oxide CNC-coating affinity. For the consumer-friendly, rapid Arsenic-in-water assay, a color code was developed to detect/indicate as little as 10ppb As-contaminant, with a color change at 10ppb increments. In the field, drops of suspect water are added to the CNC solution at 1:2 (v/v) in a small vial; Arsenic contamination is determined in seconds via color change through the application of a small magnet.

Awards Won:
Intel ISEF Best of Category Award of $5,000
First Award of $5,000
Spectroscopy Society of Pittsburgh: Second Award of $1000