Single and Two-Photon DNA-Based Fluorescence Sensors for Pb2+ and Hg2+

Goenawan, Nathaniel

Jin, Liya

Against the backdrop of contamination disasters akin to that of Flint, Michigan's, researchers are striving to develop new approaches for sensitive, selective, continuous detection of heavy metal ions in water, especially Pb2+ and Hg2+. In this study, the researchers proposed development of single and two-photon fluorescence-based biosensors coupled with a fluorophore that rely upon specific oligonucleotides that form stable G-quadruplex structures at room temperature, producing a high fluorescence. Upon exposure to Pb2+ or Hg2+, the DNA's existing metal ion is replaced by that of the heavy metal, quenching the fluorescence of the dye; the degree of decrease in fluorescence intensity merits the effectiveness of the sensor's detection. As such, the oligonucleotide T30695 demonstrated high selectivity for both Pb2+ and Hg2+, yielding detection limits of 4.5 and 4 ppb respectively, which fall below the World Health Organization's maximum for hazardous concentrations. In addition, two-photon spectroscopy was shown to be more optimal for sensitivity, and due to its near-infrared excitation and scattering, the method remains effective in opaque water. The continuous monitoring of heavy metal ions requires—as the sensor is fluorescence based—a fiber optic cable, which in field application would be ideal for excitation and recording of fluorescence. Furthermore, the researchers demonstrated that other oligonucleotide sequences are neither able to form G-quadruplex structures nor display selectivity or sensitivity for specific heavy metal ions. Conclusively, the research shows promise for development of a single and two-photon, fluorescence-based DNA biosensor which allows for continuous detection of heavy metals within a water source.