

Fluorescence Modulation of Nanodiamond NV⁻ Centers for Chemical Detection

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Nanodiamond (ND) particle sensors, based on modulation of their lattice defect centers, represent a recent direction in diamond-based sensing, while maintaining inherent advantages of the diamond material seen with other applications. In this work, red fluorescent, carboxylated ND particles with negatively charged nitrogen vacancy (NV⁻) centers were investigated for quantitative chemical detection in aqueous media, with focus on medical and environmental applications. The first set of studies involved the neurochemicals, dopamine, caffeine and ascorbic acid which are not fluorescent, but were shown to modulate the ND fluorescence at 685 nm when mixed in a neutral phosphate buffer media. Fluorescence quenching with a linear concentration dependence was observed in the nanomolar concentration range for each species. Over a larger concentration range (nanomolar to micromolar), non-linear relationships for caffeine or dopamine detection fit well to a Langmuir isotherm, supporting surface adsorption during detection. Ascorbic acid switched from quenching to enhancing the fluorescence when at micromolar concentrations. Preliminary selectivity assessments using two-component mixtures of these molecules were made challenging by these adsorption phenomena.

In separate studies with interest in wastewater contamination, concentration-dependent fluorescence modulation by bivalent metal ions (Pb²⁺, Cu²⁺, Cd²⁺, Ni²⁺, Zn²⁺, Co²⁺) was observed in micromolar concentration ranges and as a function of pH, and in some cases, metal valency. The quenching or enhancement behavior varied with the type of ion. Overall, these initial studies are encouraging that the fluorescence modulation of ND may provide a new sensor modality for analyte detection.