Optical Biosensors with Nanoscale Inorganic Materials

Optical biosensors generally rank as one of the most sensitive detection technologies for a variety of applications in medicine, environmental monitoring and security. In many cases, some element of the bioassay uses an optical labeling scheme. Current bead-based immunoassays require the use of expensive reagents that suffer from limitations in the ability to multiplex and separate. We apply flame spray pyrolysis in order to engineer a novel type of nanoparticle that has both luminescent and magnetic properties. The particles have magnetic cores of iron oxide doped with cobalt and neodymium and luminescent shells of europium-doped gadolinium oxide (Eu:Gd2O3). We have also used super-paramagnetic iron oxide nanoparticles in the same configuration. Luminescence spectroscopy showed spectra typical of the Eu ion in a Gd2O3 host – a narrow emission peak centered near 615 nm. Co-doping with other elements such as Tb, Dy and Sm is possible. Our synthesis method provides a low-cost, high-rate synthesis route that enables a wide range of biological applications of magnetic/luminescent core/shell particles. Using these particles we have demonstrated a novel immunoassay format with internal luminescent calibration for more precise measurements. The technique has been applied to the detection of toxins in foods, and also to DNA. The assays can be carried out in microdroplets formed in a microfabricated channel. Resonances with the optical cavity formed by the aqueous droplets in oil can support lasing that is tunable by changing the droplet diameter. Resonant fluorescence energy transfer within the microdroplets shows enhancement; applications to biosensors will be demonstrated.