Editorial

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Nanotechnology offers a host of new materials and novel functionalities that can be exploited for biological and chemical sensors. In many cases, materials at the nanoscale have unusual optical, magnetic, catalytic and mechanical properties which differ greatly from their bulk material counterparts. These unique properties are beginning to be harnessed for the development of novel sensors and transduction systems with improved spatial resolution, reduced detection volumes, higher sensitivity levels, and faster response times. Since a majority of biological processes occur at the nanoscale, these characteristics are highly desirable for biological sensing applications. In a typical cell, most of the major building blocks are nanoscale molecules that interact at nanometre length scales. Cell membranes and DNA are only a few nanometres wide, while the largest cellular proteins can be tens of nanometres in diameter. Such small dimensions require nanoscale sensors to accurately and sensitively probe highly complex biological systems.

Nanoscale biological sensors, or nanobiosensors, are biological sensing systems that have at least one feature size of 100 nm or smaller or perform measurements over nanometre length scales. Like most sensors, nanobiosensors are composed of both a recognition element and a transduction element which define their mode of operation. The recognition element, which is often a biological molecule or biologically (chemically) reactive compound, specifies the interaction between the sensor and the biological target. The transduction element converts the recognition event into a measurable signal through electrical, optical or mechanical processes. To date, nanobiosensors have utilised each of these signal transduction mechanisms, although a majority has been based upon optical and electrical mechanisms.

An emerging class of biosensors are those that utilise nanomaterials or nanoscale technologies to enhance sensor performance or provide new mechanisms for detection. For example, Wolter et al. Describe nanoscale ‘thermometers’ made from carbon nanotubes for in vivo thermal sensing and control applications. This type of nanoscale sensor is enabled by ongoing efforts in fundamental materials science and materials synthesis. This is emphasised in the review by Zhang et al., which describes the synthesis and use of gold-nanotube composites, primarily for biosensing applications. As with any emerging technology, nanotechnologies must meet worldwide health and safety standards. Biosensors, therefore, have an obvious role to play in the analysis of nanomaterial toxicity and safety. To this end, McAuley et al. describe the novel use of electric cell-substrate impedance sensing (ECIS) to study the toxicity of metallic nanoparticles, including copper and silver.

Biological sensing and analysis has been demonstrated using nanoscale materials, but is also being executed using technologies originally developed for non-biological applications. This is evident in my work (Cady et al.), in which traditional semiconductor manufacturing techniques have been employed for the development of lab-on-a-chip detection systems for bacterial pathogens. Other groups have also employed this approach, such as Kurouski and Lednev, who analysed amyloid fibril morphology using deep UV Raman spectroscopy and a truly nanoscale analysis method, atomic force microscopy (AFM). Further, the article by Kawde describes electrochemical-based DNA detection using sensitive oligonucleotide probes and a unique magnetic separation technique.

In summary, nanotechnology has advanced our ability to develop biosensors that interrogate, interact with, and examine biological targets at the molecular scale. The aim of this issue is to illustrate the role of nanotechnology in biosensor development, and to focus on the specific ways in which nanotechnology has enhanced sensor-target interactions, selectivity and sensitivity, biorecognition, and how existing nanotechnologies can be leveraged for novel biosensing approaches.