EDITORIAL

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Since the development of x-rays the ability to image inside our bodies has provided medicine with a potent diagnostic tool, as well as fascinating us with the eerie evidence of our mechanistic mortality. In December 2008 Osamu Shimomura, Martin Chalfie and Roger Y Tsien received a Nobel Prize for the discovery and development of the green fluorescent protein. The award recognised a new discovery that further facilitated our abilities to follow cellular activities and delve deeper into the workings of living organisms.

Since the first observation of green fluorescent protein in jelly fish over thirty years ago, quantum dots have emerged as a potential alternative tool for imaging [1]. The advantages of quantum dots over organic dyes and fluorescent proteins include intense luminescence, high molar extinction coefficient, resistance to photobleaching, and broad excitation with narrow emission bands.

However, one drawback for biological applications has been the layer of hydrophobic organic ligands often present at the surface as a result of the synthesis procedures. One solution to improve the solubility of quantum dots has been to conjugate them with a hydrophilic substance, as reported by Nie et al [2]. Chitosan is a hydrophilic, non-toxic, biocompatible and biodegradable substance and has been conjugated with quantum dots such as CdSe-ZnS [2] for bioassays and intracellular labelling. As well as luminescence, different nanoparticles present a variety of exceptional properties that render them useful in a range of bio applications, including MRI, drug delivery and cancer hyperthermia therapy. The ability to harness these various attributes in one system was reported by researchers in China, who incorporated magnetic nanoparticles, fluorescent quantum dots and pharmaceutical drugs into chitosan nanoparticles for multifunctional smart drug delivery systems [3].

More recently silicon quantum dots have emerged as a less cytotoxic alternative to CdSe for bio-imaging labels [4]. A surface hydroxyl group renders silicon quantum dots soluble in water and the photoluminescence can be made stable with oxygen-passivation. In addition, researchers in Japan have demonstrated how the initially modest yield in the preparation of silicon quantum dots can be improved to tens of milligrams per batch, thus further promoting their application in bio-imaging [5]. In the search for non-toxic quantum dots, researchers at the Amrita Centre for Nanoscience in India have prepared heavy metal-free quantum dot bio-probes based on single phase ZnS [6]. The quantum dots are selectively doped with metals, transition metals and halides to provide tuneable luminescence properties, and they are surface conjugated with folic acid for cancer targeting. The quantum dots were demonstrated to be water-soluble, non-toxic in normal and cancer cell lines, and have bright, tuneable luminescence.

So far most of the quantum dots developed for bio-imaging have had excitation and emission wavelengths in the visible spectrum, which is highly absorbed by tissue. This limits imaging with these quantum dots to superficial tissues. This week, researchers in China and the US reported work developing functionalized dots for in vivo tumour vasculature in the infrared part of the spectrum [7]. In addition the quantum dots were functionalised with glycine-aspartic acid (RGD) peptides, which target the vasculature of almost all types of growing tumours, unlike antibody- or aptamer-mediated targeting strategies that are specific to a particular cancer type.
In this issue, researchers in China and the US demonstrate a novel type of contrast agent for ultrasonic tumour imaging [8]. Contrast-enhanced ultrasonic tumour imaging extends the diagnostic and imaging capabilities of traditional techniques. The use of nanoparticles as ultrasound contrast agents exploits the presence of open pores in the range of 380 to 780 nm in tumour blood vessels, which enhance the permeability and retention of nanoparticles in the tumour vasculature. However, previous reports on techniques to generate nanobubbles have either been slow or problematic due to the resulting development of cardiac dimension reduction, hypotension and tachycardia. Xing and colleagues have now demonstrated the use of polyoxyethylene 40 stearate, which is known to be biocompatible, degradable and non-toxic, as an alternative surfactant for generating nanobubbles.

In the early 1980s scanning probe micrographs of nanosized features unleashed the power of imaging to push forward the science of structures and mechanisms at the nanoscale. The continued development of new and increasingly sophisticated nanoparticles and systems looks set to empower medicine in the same way, providing further means to exploit the mechanistic nature of biological organisms for better health and longevity.

References

[4] Fujioka K et al 2008 Nanotechnology 19 415102