reaction, the nanoparticles showed no structural damage, which was attributed to the protective polymer shell. The extent of functionalization was dictated by stoichiometric addition of the amine reagent. Magnetic susceptibility of the magnetomicelles was probed using superconducting quantum interference device magnetometry. Kim and co-workers showed that micelles containing few nanoparticles ($N_{ave} < 4$) have less interparticle coupling than micelles with many nanoparticles ($N_{ave} > 4$). This change was most likely due to increased first-neighbor distance for the micelles with fewer nanoparticles.

KEVIN P. HERLIHY

Novel Saccharide–Peptide Hybrid Polymers Show Potential for Biomedical Applications

Although a few biopolymers synthesized from natural building blocks exhibit good biocompatibility and have found clinical application, their structural diversity and functionality are limited. Recently, however, researchers from the University of California, Irvine, polymerized saccharide and amino acid monomers to form versatile biomaterials that display properties desirable for biomedical applications.

As reported in the October 14 issue of *Angewandte Chemie, International Edition* (p. 6529; DOI: 10.1002/anie.200501944), Z. Guan and co-workers synthesized three hybrid copolymers from a galactose-derived monomer and one of three different L-lysine–derived monomers. Gel permeation chromatography showed that each copolymer—poly(galactaro dilysine), poly(galactaro trilysine), and poly(galactaro tetralysine)—attained a high molecular weight. Enzymatic degradation studies showed that the polymers were almost completely degraded after 5–7 days. The researchers used a standard assay to demonstrate that their polymers exhibited minimal cytotoxicity, that is, toxicity at the cellular level. In addition, immunogenicity responses measured *in vivo* using rats as animal models showed no evidence of antibody response.

The researchers then evaluated their polymers as a vector for gene delivery—a biomedical application for which the polymers are particularly suited because of the cationic charges they possess at physiological pH. Current synthetic cationic polymers, such as poly(L-lysine) (PLL), condense DNA into particles that can enter cells through endocytosis, but these polymers are also cytotoxic. Guan and co-researchers used electrophoretic mobility-shift assays to show that their polymers efficiently complexed DNA under physiological conditions. Atomic force microscopy showed that the condensed polymer–DNA particles are spherical, with diameters (50–200 nm) within the range typical for cellular internalization. Using a standard assay, the researchers found that two of their polymers transferred DNA into cells much more efficiently than PLL. The researchers said that "a diverse family of saccharide–peptide hybrid polymers is currently under development in our laboratory for various biomedical applications including gene/drug delivery and tissue engineering."

STEVEN TROHALAKI

Targeted Delivery of Amphotericin B to Cells Accomplished with Functionalized CNTs

Carbon nanotubes (CNTs) can easily cross cell membranes without damaging them. Recent studies have shown that functionalized carbon nanotubes (f-CNTs) can carry specific drugs to the cells and they are known to be less toxic than existing mechanisms. W. Wu of Institut de

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Biologie Moleculaire et Cellulaire in Strasbourg, France; C. Klumpp and M. Benincasa of Università di Trieste in Italy; and their colleagues have introduced two different and orthogonal functionalizations to CNTs to simultaneously link fluorescent probes (fluorescein FITC) to the CNTs and the antibiotic amphotericin B (AmB). AmB is the most widely used antibiotic in the treatment of chronic fungal infections. The scientists reported their process of functionalizing CNTs in the October 7 issue of *Angewandte Chemie, International Edition* (p. 6358; DOI: 10.1002/anie.200501613).

The exposure of CNTs to oxidative conditions cuts the nanotubes, generates surface defects, and provides abundant carboxylated sites along the sidewalls of the tubes. A series of oxidized multiwalled carbon nanotubes (MWNTs) were prepared by applying different acid conditions and derivatization of the carboxylic groups with *tert*-butoxycarbonyl (Boc) mono-protected diaminotriethylene glycol. To achieve double orthogonal functionalization of the CNTs, the researchers reactivated the oxidized MWNTs as acid chloride and treated them with diaminotriethylene glycol (mono-protected as phthalimide). The pthalimide was subsequently removed, and the free amino group was coupled with fluorescent FITC. The Boc group was then removed, and antibiotic AmB was covalently linked to the amino group. The UV–vis spectra of MWNTs, double-functionalized MWNTs (called MWNT **4**), AmB, and FITC were measured. The typical absorption bands of AmB and FITC were in the range of 340–420 nm and 517 nm, respectively. Upon subtraction of the contribution of MWNTs from MWNT **4**, the ratio between AmB and FITC attached to the nanotubes was found to be 1.5:1.

Human Jurkat lymphoma T cells were incubated with either MWNT **4** or AmB as the control. The cells were grown at 37°C in RPMI medium and treated for 1 h with doses of MWNT **4** increasing 1–40 μg mL^{-1}. In other samples, cells were treated with 10 μg mL^{-1} of AmB. This corresponded with the same amount of AmB in 40 μg mL^{-1} MWNT **4**. At the highest doses, more than 40% of the cells died in the presence of AmB, whereas all the cells remained alive upon treatment with MWNT **4**. Even after a long incubation time of 4–16 h, the Jurkat cells treated with MWNTs **4** remained alive. The cell uptake of MWNT **4** was very fast, as maximum fluorescence was observed after only 1 h of incubation. The scientists demonstrated that f-CNTs were able to enter the cell by a spontaneous mechanism: they behaved like nanoneedles and passed through cell membranes without causing cell death. AmB strongly self-disassociates in aqueous solution and increases the possibility of toxic effects to the cells. In UV–vis spectra of MWNT **4** in water and RPMI, a lower aggregation than that of AmB alone was found. The antifungal activity of f-CNTs was tested against three species of fungi: *Candida parapsilosis* ATCC 90118, *Cryptococcus neoformans* ATCC 90112, and *Candida albicans*. The experiments clearly pointed out that the activity of the drug was not prevented by its covalent binding to MWNTs. Interestingly, MWNT **4** was more effective than free AmB, particularly against *Candida* spp. The scientists said this could be because of increased solubility of the drug by conjugation to CNTs. The scientists concluded that AmB in conjugation with CNTs is less toxic and more effective than AmB alone.

VIVEK RANJAN

Correction

The following credit was omitted from the cover caption for the September 2005 issue of *MRS Bulletin*. The quantum dots referred to in the caption were synthesized according to Derfus et al. [*Adv. Mater*. **16** (2004) pp. 961–966] and generously donated by Dr. Sangeeta Bhatia (MIT).

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