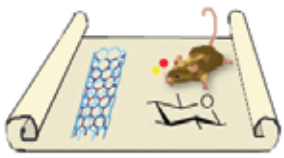
Sugarcoated radiotherapy

Hong, Tobias, Al-Jamal, Ballesteros, Ali-Boucetta, Lozano-Perez, Nellist, Sim, Finucane, Mather, Green, Kostarelos and Davis
Filled and glycosylated carbon nanotubes for in vivo radioemitter localisation and imaging. Nature Materials 2010 9 : 485-490

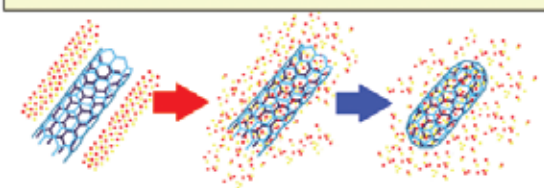
In the unforgiving English summer heat, Oxford chemists try to master localised radiotherapy - used to treat cancer, in new and inventive ways.

Radiotherapy is performed by an ionising source, such as a radio-isotope of iodide. Two things are particularly problematic about iodide use in the body: an iodide transporter steals most of it to the thyroid, and almost all ionising iodide leaves the body within 24h.

Single-walled nanotubes (SWNTs) to the rescue! SWNTs are cylinders made of a carbon hexamer called benzene. The cylinder interior can hold cargo. With this in mind, Oxford chemists used SWNTs, a salt of the radioactive iodide isotope I^{125} and a sugar coating to make a drug delivery vehicle.



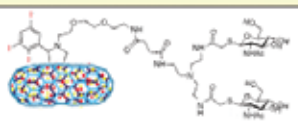
Step 1: Encapsulate the drug
SWNTs, mixed with radioactive sodium iodide salt, are first heated to 900°C to melt the salt. The resulting liquid is densely radioactive and enters the SWNT cylinders by capillary force. As the mixture cools, kinetic energy allows the SWNT's open ends to seal, forming a more stable, united hexameric network where electrons are more delocalised. In the process, SWNTs trap radioactive particles. Any untrapped cargo is removed.



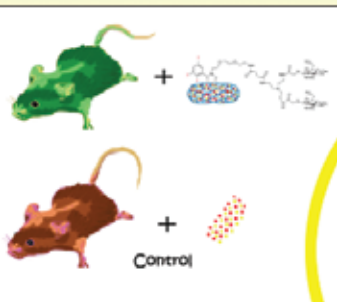
However, carbon nanotube applications face two problems: their influence on cells is the subject of controversy and they mix poorly with water. Therefore Oxford chemists set out to alter the SWNT surface to improve biocompatibility.

Step 2: Tag the SWNT and confirm results
The chemists tag the SWNT with a link that allows them to attach other chemical groups at its end. Both the tag and the cargo are visible using electron microscopy.

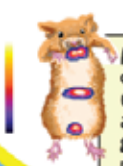
Step 3: Improve biocompatibility and target the tissue
They put sugars onto a branching molecule and sugar-coat the SWNT via the link.



The drug delivery-vehicle is ready for testing! $Na]^{125}$ radiotherapy enters the bloodstream either as SWNT cargo or unencapsulated, as a control.



Single photon emission computer tomography shows that sugar-coated SWNTs and their cargo are rapidly contained in the lungs. They remain there for a month without causing either cyto-toxicity or fibrosis.



Non-encapsulated iodide, on the other hand, ends up in the thyroid, stomach and bladder. The body gets rid of most of it within a day.

The team managed to deliver an unprecedented high dose of radiotherapy, stably incapsulated and highly localised to the lung. Here, it can act long-term, or alternatively be used to image the tissue non-invasively.

Next the researchers will investigate the sugarcoated SWNT's fate in the body in more detail. They want to explore the delivery vehicle's clearance kinetics and find out how to steer the SWNT elsewhere. Ultimately, they aim to tame the sugar-code, to target any tissue for therapy.

Stay tuned!

by Caroline Dean, in conversation with Ben Davis