## Nanotechnology Highlight

# Nanoengineered Shells for Encapsulation and Controlled Release

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The project NANOSHELLS is developing new technologies based on nano-encapsulation to solve industrial problems related to controlled release of drugs and other chemicals. The overall objective of NANOSHELLS is to make the breakthrough necessary to enable the production and application of nano-capsules with targeted controlled release properties of chemicals. For this, first, we are developing new types of nanoparticles used as core/vectors for active molecules. The second phase involves nano-engineered ultrathin layer assembly to build a capsule shell of pre-determined composition, designed for special release properties, around the active materials. Saying in simple words, we are trying to design tiny (<1/1000 millimeter) "submarines" which will carry drug molecules and deliver them directly to sick cells, easily passing narrow blood vessels due to their minute dimensions.

We synthesized 500-nm particles of important drugs: furosemide, dexamethasone, and carmustine, then assembled very thin walls around these drug cores, using only a few molecular layers of biocompatible polymers. We are introducing antibodies into the wall of these shells, which will target and anchor the capsules to the sick cells.

An example of results for these experiments is given in the figure below. Furosemide crystals were encapsulated with polyions and gelatin to control the release of the drug in aqueous solutions. Charged linear polyions and gelatin were alternatively deposited on drug nanocrystals through layer-by-layer nanoassembly. Sequential layers of six gelatin / poly(styrenesulfonate) (PSS) bilayers were adsorbed, with a corresponding total capsule wall thickness of 110 nm. The release of furosemide from the coated microparticles was measured in aqueous solutions of pH 1.4 (acidic gastric environment) and 7.4 (blood pH). At both pH values, the release rate of furosemide from the encapsulated particles was reduced by 300 times compared to uncoated furosemide, which shows that nanoencapsulation is a method of achieving prolonged drug release through self-assembly of polymeric shells on drug microcrystals.
By varying the wall composition, one can have different rate of the drug release.

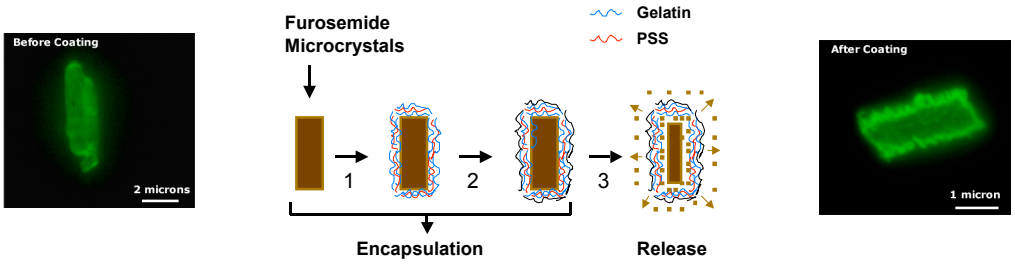


**Illustration of furosemide microcrystal encapsulation with (PSS/Gelatin)$_6$ shell and drug release and the drug crystal fluorescent image before and after coating.**

1. H. Ai, S. Jones, M. DeVilliers, Y. Lvov, **J. Controlled Release**, 2003, v.86, 59-68, "Nanoencapsulation of Furosemide Microcrystals for Controlled Drug Release"
2. M. McShane, Y. Lvov, "Fluorescent sensors based on encapsulation of indicator dyes with polyion shells," *2001-06 (US Patent App.* **#10/360,328.** *from February 7, 2003)*