Forming Vesicles From Carbon Nanotubes

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Vesicles

- Spherical containers
- Found in animal cells
- Made of a phospholipid bilayer
- Liposome = artificial vesicle
Carbon Nanotubes (CNTs)

- Graphene sheet rolled into a cylinder
- Can be “capped” on the ends
Types of CNTs

- **SWNT**
  - One cylinder
  - Diameter ~ 1.4 nm

- **MWNT**
  - Concentric cylinders
  - Interlayer dist ~ .34 nm
Micelles and Vesicles as Drug Carriers

- Monolayer
- Hold hydrophobic drugs
- Bilayer
- Hold hydrophilic drugs

Phospholipid
Functionalization of CNTs

- Functionalize one end of the CNT with a hydrophilic molecule
- Mimics phospholipid in order to form vesicle
Functionalization Process

1. Grow nanotubes aligned on a substrate

2. Fill in matrix between the CNTs, leaving only tips exposed
Functionalization Process

3. Add COOH to the tips

4. Dissolve the SOG matrix

5. Strip from substrate
Conditions for Self-Assembly

- Dispersion
  - Ultrasonication
  - Surfactants
- Phase Determination

CNTs naturally bundle together

Micelle
Bilayer
Vesicle
Surfactants can coat nanotubes in various ways, so it is not clear whether they will help or interfere with nanotube self-assembly.
Concentration Determining Phase

At critical micelle conc. (CMC)
- Spherical micelle
- Cylindrical micelle

At very high concentrations
- Inverted spherical micelle
- Inverted cylindrical micelle
Molecule Shape Determining Phase

Polar region is bigger than nonpolar region

Polar and nonpolar regions are about the same size

Nonpolar region is bigger than polar region
Conclusions

- Experiment with:
  - Nanotube Concentration
  - Different dimensions of nanotubes
  - Various types and amounts of surfactant (if sonication is not sufficient)

- Develop recipes for each type of phase
  - Can then be replicated easily
Any Questions?