

## Applications of Nanotechnology to Food. Insights from the Nano4Food 2006 Conference

José I. Reyes De Corcuera  
Food Safety and Quality Program Seminar  
April 26, 2007

---

---

---

---

---

---

---

---

### Outline

- Definitions
- Areas of application
  - Separations, controlled delivery, immobilization, sensors
- Safety & Regulations
- Attendees
- Conclusions

---

---

---

---

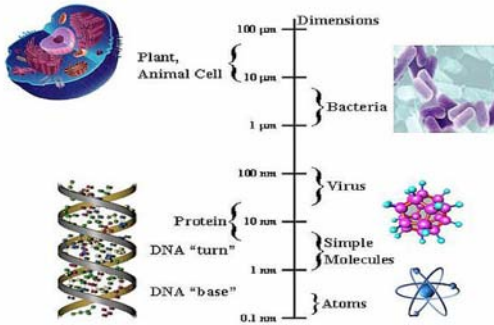
---

---

---

---

### Scale



Warad and Dutta 2006

---

---

---

---

---

---

---

---



### 'Official' Definition

- Nanotechnology is the **understanding and control of matter** at dimensions of roughly 1 to 100 nanometers, **where unique phenomena enable novel applications**. Encompassing nanoscale science, engineering and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale. (<http://www.nsf.gov/news/overviews/nano/index.jsp>)



National Science Foundation  
WHERE DISCOVERIES BEGIN

---

---

---

---

---

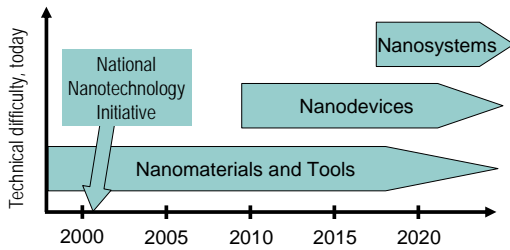
---

---

---



### Nanotechnology roadmap



Adapted from Couttenye and Arora, (2006)

---

---

---

---

---

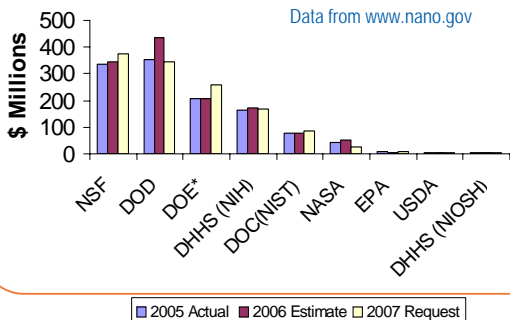
---

---

---



### NNI Funding



2005 Actual 2006 Estimate 2007 Request

---

---

---

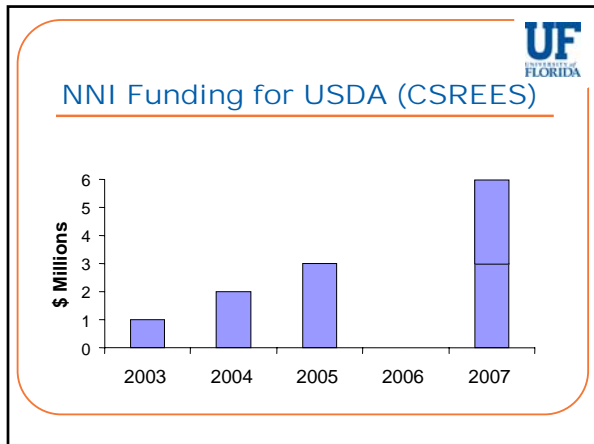
---

---

---

---

---




---

---

---

---

---

---

---

---

- UF**  
UNIVERSITY OF  
FLORIDA
- ### Nanomaterials
- Carbon-based
    - Tubes, particles etc
  - Nanocomposites
    - 1 material in the nm
  - Metals and alloys
    - Particles/ catalysts
    - Ag as antimicrobial
    - Coating (Old but new tribological properties)
  - Biological
    - Protein, peptides, lipid nanocontainers, DNA templated circuits
  - Nano-polymers
    - Linear
    - Branched
    - Dendrimers
  - Nano-glasses
    - Amorphous materials:
      - SiO<sub>2</sub>
      - ITO
    - Optical /photonics (LED)
  - Nano-ceramics
    - Crystalline materials

---

---

---

---

---




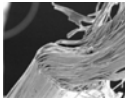
---

---

---

**UF**  
UNIVERSITY OF  
FLORIDA

### Nanoshapes

- Nanoparticles
  - Nanospheres 
  - Nanocapsules 
- Nanotubes 
- Nanorods/nanofibers 

Adapted from [www.nanoroad.net](http://www.nanoroad.net)

---

---

---

---

---

---

---

---

## Applications to food

- Nutrient and additive preparation
- Encapsulation
  - Additive / nutrient
  - Flavor / color
  - Enzymes
- Structure control
  - Texture
  - Heterogeneous mixtures
    - Emulsions
    - Suspensions

---

---

---

---

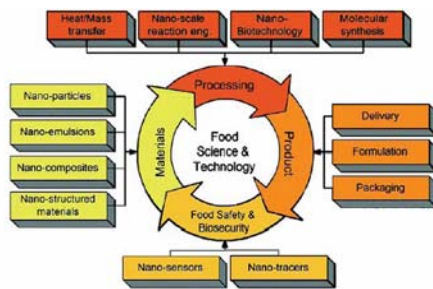
---

---

---

---

## Application matrix of nanotechnology in food science



Reproduced from Stroeve (2006)

---

---

---

---

---

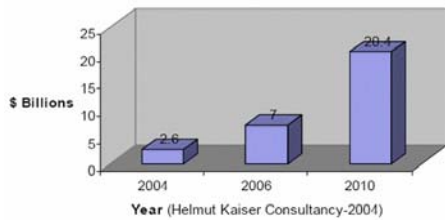
---

---

---

## Nanofood Market

- About 200 companies doing nano research




---

---

---

---

---

---

---

---

## SEPARATIONS

- Separating mixtures
  - Water removal
  - Component extraction
  - Filtration
  - De-emulsification
  - Adsorption
- Preventing mixing
  - Semi-permeable membranes
  - Packaging

---

---

---

---

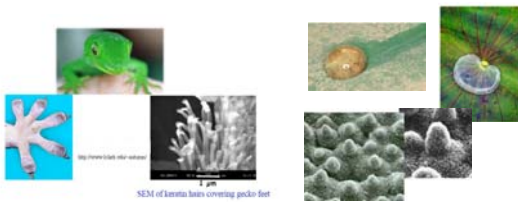
---

---

---

---

## Learning from nature



Gecko's ability to climb

Lotus leaf effect

Modified from Garcia (2006)

---

---

---

---

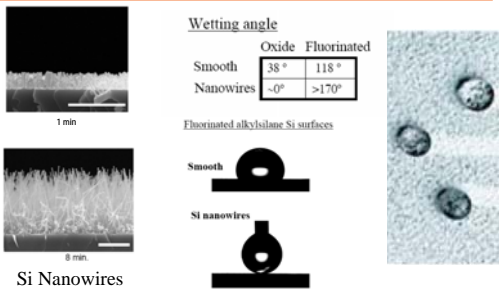
---

---

---

---

## To mimic it



Si Nanowires

Modified from Garcia (2006)

---

---

---

---

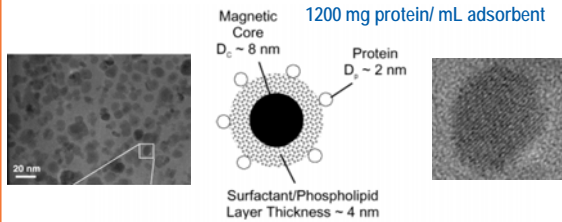
---

---

---

---

### Protein adsorption



**Figure 3.** Schematic illustration of a coated magnetic nanoparticle showing the relative sizes of the particle core, lipid coating and adsorbed protein.

Reproduced from Bucak et al. 2003

---

---

---

---

---

---

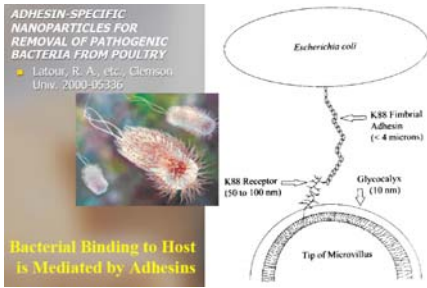
---

---

---

---

### Removal of pathogens



Reproduced from Chen 2006

---

---

---

---

---

---

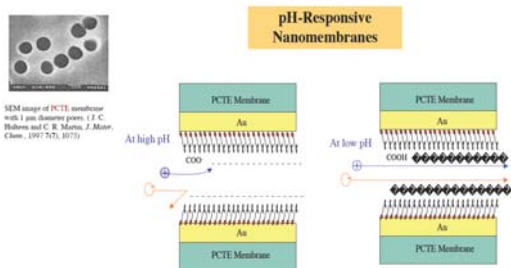
---

---

---

---

### Membrane separations



Modified from Stroebe (2006)

---

---

---

---

---

---

---

---

---

---

## Controlled membrane structure

Center for Research at the Bio/Nano Interface

<http://www.uf-bio-nano-center.org/default.asp>

---

---

---

---

---

---

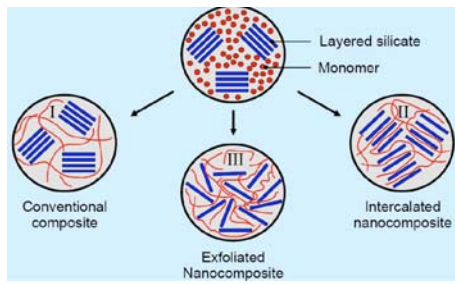
---

---

---

---

## Polymers



---

---

---

---

---

---

---

---

---

---

## Packaging



Silicon oxide clay



Nanoclay with MXD6 Nylon

Adapted from Floros 2006

---

---

---

---

---

---

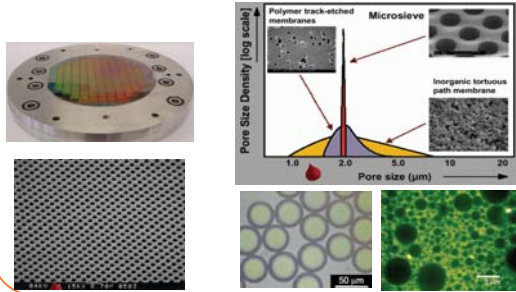
---

---

---

---

### Microsieves (nano???)



Adapted from Kampers (2006)

---

---

---

---

---

---

---

---

### Nutrient/Additive delivery

- Nanoparticles
- Nanocapsules
- Nanoemulsions

---

---

---

---

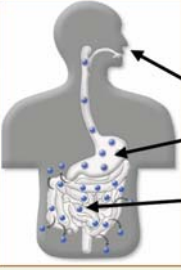
---

---

---

---

### Nutrition and Delivery



**STABILITY**  
Stable against heat, pH and oxidation in food processing

**TASTE & COLOR**  
No unpleasant taste or color

**SAFETY**  
Mild on the stomach because of its insolubility in gastric juices

**BIOAVAILABILITY**  
Sustained release, high absorption and bioavailability

*afmnet*

Reproduced from Yada (2006)

---

---

---

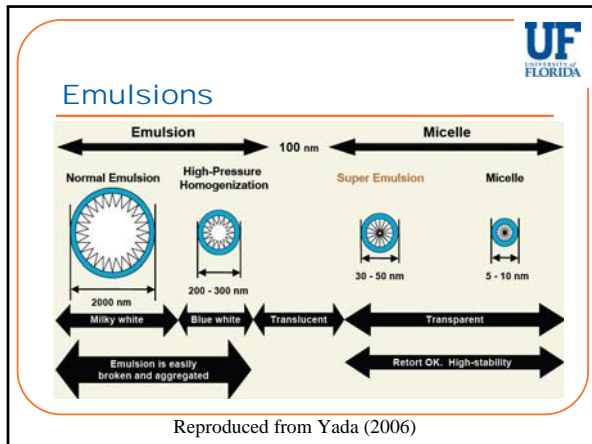
---

---

---

---

---




---

---

---

---

---

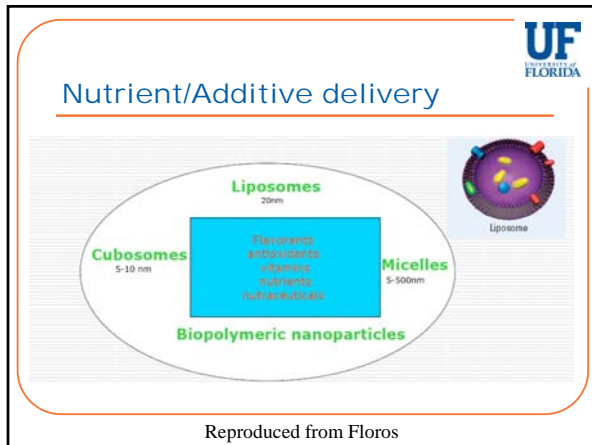
---

---

---

---

---




---

---

---

---

---

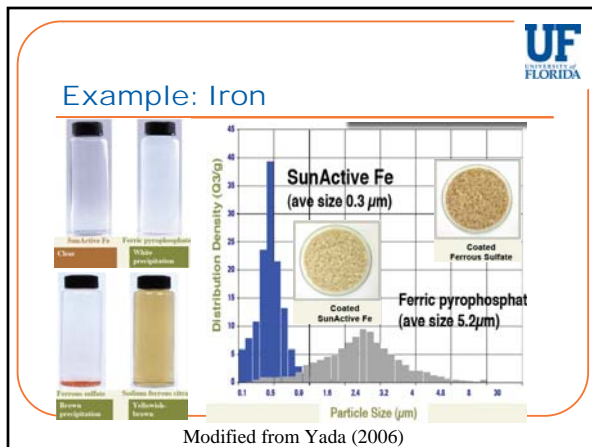
---

---

---

---

---




---

---

---

---

---

---

---

---

---

---

## Commercial Products



Reproduced from Yada (2006)

---

---

---

---

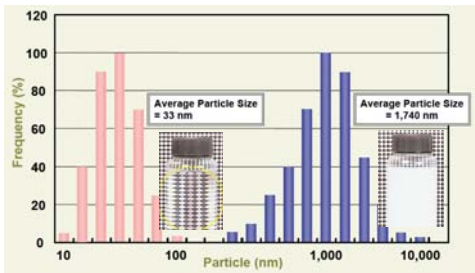
---

---

---

---

## Vitamin E Emulsions (10 mg / 100 mL)



Modified from Yada (2006)

---

---

---

---

---

---

---

---

## SENSORS

- Measurand
  - Physical
    - Temperature, pressure
  - Chemical
    - O<sub>2</sub>, CO<sub>2</sub>, moisture, toxins
  - Biological
    - Enzyme activity, microbial contamination
  - Imaging
  - Tags

---

---

---

---

---

---

---

---

**UF**  
UNIVERSITY OF  
FLORIDA

## Biosensors - Immunosensors

Sample (environmental origin, capture)

Antibodies + Y → Antibodies to organisms and proteins

DNA hybridized to complement

Anti-E. coli

Anti-Listeria

Anti-SEB Toxin

Biorecognition BRE

Signal Probe

Modified form Chen 2006

---

---

---

---

---

---

---

---

---

---

**UF**  
UNIVERSITY OF  
FLORIDA

## Examples of USDA funded projects on sensors

3G2R

PA

2G3R

PB

1G4R

PC

Anthrax, Ebola and SARS were detected simultaneously with 3 DL-DNA nanobarcodes  
Limit of detection  $10^{-18}$  Detection time 15 s

Modified form Chen 2006

---

---

---

---

---

---

---

---

---

---

**UF**  
UNIVERSITY OF  
FLORIDA

## 2005 U\$DA Funded projects

- 10 out of 14 projects focused on:
  - Sensors / Biosensors
  - Assays / Bioassays
- The rest:
  - Nanomaterials
  - Self-assembly

Modified form Chen 2006

---

---

---

---

---

---

---

---

---

---



### 2006 NRI 75.0 Priorities

- Nanoscale recognition, reception and transmission for developing **nano-based sensors** suitable for the targets important for food safety and agriculture biosecurity
- Novel targeted delivery and **controlled release** mechanisms suitable for food matrices
- Understanding nanoscale mechanisms to support the development of nano-based detection and **tracking technologies** for food and agricultural product identity tracking and preservation

---

---

---

---

---

---

---

---



### SAFETY AND REGULATION

- Safety concerns
  - Nanoparticles absorption in the body
    - Ingestion
    - Skin
    - Inhalation
- Marketing concerns
  - Repeat of GMO's syndrome
  - Labeling

---

---

---

---

---

---

---

---



### Discussion on Regulation

- Regulation of nanotechnology
  - Facilities
  - Exposure
- Regulation of nanomaterials
  - Case by case
  - NEW materials

---

---

---

---

---

---

---

---



## CONCLUSIONS

- Many opportunities for food applications
  - There is interest
  - There is some funding allocated to food & agriculture
  - It is just beginning (arguably)
- Several risks and hurdles
  - New materials > new ingredients > controlled release > sensors > packaging
- Only multidisciplinary efforts will succeed
  - Food scientists, food engineers, chemists and chemical engineers, material scientists, molecular biologists, electrical engineers...

---

---

---

---

---

---

---

---



*Thank you*



---

---

---

---

---

---

---

---



## Links

- <http://www.nanoroad.net/>
- <http://www.nano.gov/>
- <http://www.nanotech-now.com/>
- <http://www.nanotechproject.org/>

---

---

---

---

---

---

---

---