Bio-nanotechnology for Food: Challenges in Nanotechnology for Wageningen

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Nanotechnology in the life sciences

February 13 13:30 Pieter Stroeve (UC Davis)- Size, measurement and sensing
14:30 Mieke Kleijn (WUR)- Surface forces using AFM

February 20 13:30 Pieter Stroeve- (Bio)materials
14:30 Ernst Sudholter (WUR)- Hybrid organic semiconductor FETs

February 27 13:30 Pieter Stroeve- Self assembling molecular structures
14:30 Richard Schasfoort (U Twente)- Surface modification and microfabrication strategies

Friday, March 5 13:30 Pieter Stroeve- Environment
14:30 Keurentje (TU Eindhoven)- Micellar systems for nanoscale engineering of reaction and separation processes

Friday, March 12 13:30 Pieter Stroeve- Life sciences and medicine
14:30 Ton Visser (WUR)- Single-molecule fluorescence in microfluidic devices
Challenges in Nanotechnology for Wageningen

Nanotechnology: A New Frontier in Food Science

Understanding the special properties of materials of nanometer size will allow food scientists to design new, healthier, tastier, and safer foods.
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Nanotechnology—the science and technology that focuses on special properties of a material which emerge from nanometer size—is becoming one of the most promising scientific fields of...
Challenges in Nanotechnology for Wageningen


Editorial overview

Food Colloids … Drifting into the Age of Nanoscience

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Challenges in Nanotechnology for Wageningen

Symposium: New Technologies for Nutrition Research

New Technologies for Nutrition Research

Sharon A. Ross,*2 Pothur R. Srinivas,† Andrew J. Clifford,** Stephen C. Lee,‡ Martin A. Philbert,†† and Robert L. Hettich‡‡

KEY WORDS: • bioactive food components • food science • nanotechnology • proteomics
Challenges in Nanotechnology

- **Materials**
  - gels
  - nanoparticles
  - biocolloids
  - cells
  - emulsions
  - membranes
  - composites

- **Product development**
  - formulation
  - texture
  - nutrition
  - stability
  - taste
  - color
  - smell

- **Processing (on the nanoscale)**
  - nano science
  - synthesis
  - kinetics
  - reaction engineering
  - thermodynamics
  - transport processes

- **Nano-sensing**
  - process control
  - monitoring
  - detection

- **Measurement and Characterization**
  - AFM
  - FFM
  - surface characterization

- **Food Safety**
  - contamination
  - health effects of nanoparticles
Why Bio-nanotechnology at WUR?

• Existing expertise
• Proximity to agriculture and food processing industry
• Off-campus research centers institutes
• History in research on value-added foods
• WUR leadership
Benefits to WUR, Industry, and the Netherlands

- Increase visibility
- Obtain extramural funding
- Attract talented students and professionals
- Train students
- Expand into new research programs
- Stay competitive
- Develop improved research and teaching facilities for bio-nanotechnology
- Enhance student-faculty-industry interactions
- Facilitate public outreach
Challenges in Nanotechnology for Wageningen
from Moraru et al., 2003

Fig. 1—Application matrix of nanotechnology in food science and technology.
Challenges in Nanotechnology
Development of new food products

• Delivery systems for biologically active materials
  - delivery of flavors
  - neutraceuticals
• Utilization of complex phase behavior
  - texture
  - taste
  - appearance
  - color
• Bio supramolecular assemblies
  - internal barriers
  - change of properties
Materials

Fibers: Protein gels

Fig. 4. TEM micrographs of 7% ovalbumin at pH 2 and 0.01 M ionic strength, for various times after dilution: (a) 0 min; (b) 10 min; (c) 105 min; (d) 24 h.
Fig. 1. Structural evolution of oil-in-water emulsions for different aggregation-to-creaming rate ratios. A: aggregation rate ≪ creaming rate: creaming of single droplets. B: aggregation rate ≈ creaming rate: (accelerated) creaming of discrete aggregates. C: aggregation rate ≫ creaming rate: formation of an emulsion-gel network that contracts due to gravity.
Materials
Double emulsions

Processing on the nanoscale separations from Hatton et al., 2003

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

Figure 1. A planar lipid bilayer with a pore in the center. The figure shows the cross-section in the $x-z$ plane. Rotational symmetry around the $z$-axis is indicated. On the left side, the packing of the lipid molecules is shown schematically. The headgroups of lipid molecules are represented by filled circles. The arrow denotes the membrane inclusion, which is shown schematically.
Nano-sensing

- toxins in food, proteins, water
- viruses
- bacteria
- pollutants in water
- bioprocess monitoring
  - process control
- biochemicals
- intracellular activity
- sensors on foods for tracking
Measurement and characterization

AFM

Fig. 4—Surface topography of triticale starch granules. From Juszczak (2003).
Pulmonary toxicology of SWCNT health effects of nanoparticles

Lung tissues from mice instilled with 0.5 mg of SWCNT per mouse and euthanized 90 d after the single treatment showing presence of fibers. (A) Raw fibers in a granuloma. (B) Purified fibers in a granulomas. (C) Purified clumps of fibers in a granuloma (Magnification 900x).

C.W. Lam et al., Tox. Sci., 2004
Challenges in Nanotechnology for Wageningen

- Fundamentals of supermacromolecular and colloidal structures
- Complex phase behavior in biocolloids
- Development of new food products
- Fundamentals of food processing on the nanoscale
- Characterization of food nanostructures
- Measurement and prediction of food properties
- Nanocomposite materials
- Developing nanosensors for biochemicals, toxins, monitoring, etc.
- Food safety