FOOD MATERIALS FUNCTIONALITY

John R. Dutcher

Polymer Surface & Interface Group

University of Guelph
Guelph, Ontario N1G 2W1
• complexity of foods
  – foods as soft materials
  – need for multidisciplinary approach

• Advanced Foods & Materials Network (AFMnet)
  – sophisticated techniques
  – diverse expertise
  – projects involving nanoscience

• opportunities & challenges for nanoscience in food research

• summary & conclusions
FOODS ARE COMPLEX

• complexity and diversity of processed foods
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• complexity and diversity of processed foods

• can think of these foods as gels, emulsions & foams

• apply concepts of materials science
SOFT MATERIALS

- soft materials are characterized by several universal features
  - weak bonding
  - large response to external stimulus

  self-assembly

- properties vary over large range of length scales
- properties vary over large range of time scales
• concepts of soft material science shed light on
  – interparticle interactions, particle & foam stability, phase separation, gelation & glass formation
• used to understand behavior of complex systems
  – small polymers added to stable colloidal suspension
  – depletion zone around each colloidal particle
  – when depletion zones overlap, excluded volume for polymers is reduced → net attraction for colloids

Tuinier et al. (2003)
• foods are mixtures of many different components
  – fats, carbohydrates, proteins, water

• food components not usually found in natural environment
  – far from equilibrium
  – will relax & self-assemble when perturbed
    – different relaxation rates at different length scales

• mechanical action can also change properties

• presence of water near interfaces is common
  – water is structured on nanoscale
    – hydrogen bonding, clustering

  need multidisciplinary approach
• AFMnet is a Canadian Network of Centres of Excellence
  – covers natural sciences & engineering, medical sciences & social sciences
  – in Structure-Dynamics-Function theme
    – expertise in food science, physics, chemistry, molecular biology, microbiology, mathematics, chemical engineering, biochemistry, plant science, nutrition
  – 9 projects involving 55 investigators at 22 institutions
  – combine state-of-the-art experiments with theory & computer simulations
  ➡️ unique training of students

www.afmnet.ca
• emphasis on
  – food security
    – biofilms, cationic antimicrobial peptides
  – biosensing
    – protein sensors on nanostructured surfaces
  – controlled release delivery systems
    – incorporate bio-material & food-grade components
    – delivery of active components
      – probiotics, antimicrobials
  – value-added products
• take advantage of huge influx of research infrastructure awarded by Canada Foundation for Innovation

• sophisticated experimental techniques
  – surface & bulk
  – imaging
  – spectroscopic
  – genetic manipulation

• state-of-the-art computational techniques
  – shared computational networks

• capitalize on access to international large scale facilities
  – neutron scattering (Chalk River, NIST, SNS, ILL)
  – synchrotron facilities (CLS, APS, ALS, Brookhaven)
• correlative microscopy & scattering measurements of bacteria, biofilms & their components
  – TEM, AFM, confocal, STXM
  – neutron scattering
• bacteria consist of an amazing array of specialized biomaterials
  • isolate and purify components
    – exploit unique properties in variety of applications

membrane vesicles

nanowires

PNAS 2006

peptidoglycan sacculi

nanominerals

J Bacteriol 2006

Appl Environ Microbiol 2001
• three strategies to investigate sequence requirements in CAPs [Hancock/Beveridge]
  – substitution, sequence scrambling, random libraries

• protamine through porins in hydrophobic membranes [Pink/Hanna/Gill]
• tethered lipid membranes with applied electric field

• nanostructured surfaces
  – block copolymers
  – biosensors

Lipkowski/Dutcher

Prudhomme/Bazuin
CONTROLLED-RELEASE SYSTEMS

- develop platforms for controlled release of bioactive compounds
  - biopolymer-based hydrogels
    - gelatin-maltodextrin mixtures cross-linked by genipin
  - prebiotics/probiotics
    - production, characterization & encapsulation of plant-derived oligosaccharides & probiotic bacteria

  two-stage phase separation
  - two emulsions

Paulson/Rousseau
• oil-water-protein emulsions
  – protein conformations at oil-water interfaces
  – light scattering, atomic force microscopy

ΔX = 11 nm

Touhami et al.
• distinguish between
  – nanoscience: properties at nanoscale
  – nanotechnology: products based on nanoscale properties

• use nanoscience tools & concepts to determine relationship between structure, dynamics & function
  – novel experiments
  – ambitious computer simulations

• identify promising nanostructures & nanoscale properties
  – exploit self-assembly to create novel microstructures & macroscopic properties

• identify & develop promising nanotechnologies & products
• complexity of food materials
  – apply concepts of soft materials science
  – use multidisciplinary approach

• nanoscience research in AFMnet
  – use of experiments & computer simulations
  – basic & applied studies related to food security, biosensing, delivery systems & value-added