Nanotechnologies in Food/Packaging

- What is Nanotechnology?
- Applications for food and food packaging;
- Current status and future prospects;
- Benefits and potential risks;
- Safety and regulatory aspects
Nanotechnology

A broad set of processes, materials, and applications that span physical, chemical, biological and electronic sciences and engineering fields that involve manipulation of materials in the nano-scale (1 and 100 nm).

\[ 1 \text{ nm} = 1 \text{ billionth of a meter} \]

- 1/5,000,000 the size of an ant
- 1/80,000 of the diameter of a human hair
- 1/90 the size of HIV virus

Nanoparticles of various shapes and forms
- Uniform/irregular shaped
- Dispersed particles/agglomerates
- Free/bound form

Nano-Scale - Where Less may be More

- Properties and behaviour of materials can change at the nano-scale;
- Extremely small size = very large surface area = increased reactivity per equivalent weight
- Nano-sizing may also generate new properties/functionalities.

Novel material properties = New products/applications

Sector Applications

- Cosmetics and personal care products [60%]
- Paints & coatings [10%]
- Catalysts & lubricants [10%]
- Security printing
- Textiles & sports
- Medical & healthcare
- Food and nutritional supplements
- Food packaging
- Agrochemicals
- Veterinary medicines
- Water treatment
- Construction materials
- Electrical & electronics
- Fuel cells & batteries
- Paper manufacturing
- Weapons & explosives

Over 1300 consumer products already available*

*Source: www.nanotechproject.org/inventories/consumer/

Agri-Food Applications

- Efficient food production (less use of agrochemicals)
- Nutrients and Functional foods (improved uptake and bioavailability)
- New tastes, flavours (less salt, fat, sugar, etc)
- Fresh, ‘natural’, wholesome foods (less colours, flavours, preservatives)
- Lightweight, strong, functional packaging (less cost of transportation, safety of foods in the supply chain)
- Hygienic food processing and packaging (Less food-borne diseases)
- ‘Smart’ & ‘Intelligent’ packaging (food safety, authenticity, traceability)
Example Applications

- **Inorganic materials:**
  e.g. calcium, magnesium, selenium, iron, zinc, silver, gold, platinum ......

- **Organic ‘soft’ materials:**
  nutraceuticals, vitamins, antioxidants, preservatives, etc.

- **Agrochemicals**
  biocides, pesticides, veterinary medicines

- **Food packaging**
  improved, active, intelligent packaging

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Market Status

- Increasing applications for agri-food and packaging worldwide;

- Global market for nanofood applications estimated at US$4 million in 2006, and predicted at between US$ 6-20 billion by 2010-2012 - almost half of which relates to packaging applications;

- The most promising areas predicted for the near-future are ‘Active’ and ‘Smart’ packaging, health-foods and functional foods.

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Example Applications

- **Improved mechanical properties:**
  - Improvements in flexibility, temperature/moisture stability; durability, flame resistance; flame resistance;

- **Enhanced barrier properties against gases, moisture:**
  - Nano-clay composites with PA, nylons, polyolefins, PS, EVA copolymer, epoxy resins, polyurethane, PET.

- ‘Active’ nano-composites:
  - Polymer composite with antimicrobial nanomaterials, e.g. silver, zinc oxide, magnesium oxide.
  - Claimed to preserve foodstuffs longer by inhibiting microbial growth at the food contact surface.

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Example Applications

- **Nano-coatings**
  - Gas-barrier coatings – e.g. silica;

  - Hydrophobic coatings for self-cleaning surfaces for hard-to-reach parts of machinery, conveyer belts, etc.

  - Antimicrobial coatings for hygienic surfaces - e.g. silver, titanium dioxide, zinc oxide.
**Smart/ Intelligent Packaging Concepts**

- Nanoparticle based intelligent inks or reactive nanolayers provide analyte recognition at nanoscale;
- Printed labels that can indicate:
  - temperature
  - Time
  - Pathogen
  - Freshness
  - Humidity
  - Integrity

**Nano Barcodes**

- commercially available Nanobarcodes® particles by Nanoplex [<www.nanoplextech.com>]
- encodeable, machine-readable, durable, sub-micron sized taggants
- manufactured by electroplating inert metals- such as gold, nickel, platinum, or silver- into templates that define the particle diameter, and then releasing the resulting striped nano-rods from the templates

**Nano-sized substances - Safety Considerations**

- Nanoparticles may cross membrane barriers, and reach new targets in the body;
- Nanoparticles may interact with biological entities close to the molecular level;
- Main safety concerns relate to internal exposure of insoluble/biopersistent nanomaterials;
- Substances formulated at nano-scale that are degradable should not raise special safety concerns;

**Nano-sized substances in food contact materials**

- What migrates out of packaging?
- Can it affect consumer safety?
- Will there be any environmental implications?
- Will consumers accept nanotech packaging?
Potential Migration of Nanoparticles

Two nanotech FCMs tested:

- **Bottles containing nanoclay composite embedded between PET layers**
  No detectable migration of nanoclay from PET.

- **Food containers made of polypropylene-nanosilver composite**
  Very low level of silver migration (less than the limit of quantification).

- In either case, the presence of nanoparticles did not affect migration of non-nano components.

- Similar lack of migration of TiN reported in PET containers (EFSA Opinion).

- Some reassurance in the safety of nanotech FCMs based on data from these limited tests – more needed.

Knowledge Gaps

- **where low or no migration of nanoparticles into food:**
  - Surface biocidal effects and resulting safety of packaged foodstuffs may only be marginal.
  - How long the antimicrobial effects be maintained - especially in reusable FCMs?

- **where nanoparticles are released into food:**
  - they will be considered food additives;
  - will require risk assessment of the long-term exposure to biocidal nanoparticles via food.

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Migration of Nanoparticles from Food Packaging

Little or no migration from polymers, except for very small nanoparticles (lower range of the nano-scale) that are not bound in a relatively low dynamic viscosity polymer matrix.
Regulation of Nanomaterials in Food/Feed in Europe

**Novel Foods** [Council Regulation (EC) N° 258/97]
- implicitly covers nanomaterials. The new legislation adopted in November 2015 will require a Novel Food authorisation for nanomaterials before use in foodstuffs, and safety assessed by the European Food Safety Authority;

**Food Additives** [Regulation 1333/2008] - A new risk assessment is required for:
  - new additives and for already authorised additives when there is a "significant change in the production methods or in the starting materials used, or if there is a change in particle size, for example through nanotechnology";
  - where flavourings and enzymes are obtained from new production processes giving rise to significant changes in the production process.

**Food Packaging**
[Regulation (EU) N°10/2011 on measures for plastic materials and articles]:
- As from 1 May 2011, nanomaterials can only be used if listed in its Annex I.
- Article 9(2): "Substances in nanof orm shall only be used if explicitly authorised and mentioned in the specifications in Annex I".
[Regulation (EC) N°450/2009 for active and intelligent materials and articles]:
- Article 6: "substances deliberately engineered to particle size which exhibit functional physical and chemical properties that significantly differ from those at a larger scale".

**Food Information Regulation** [(EU) No 1169/2011]

Summary

- Early days for nano-food/packaging applications: Packaging applications have been projected as the main growth area for the near future;
- Potential benefits: Improved food hygiene, extended shelf life, better traceability and safety of packaged food products;
- Safety and regulatory challenges: The use of nanomaterials in food contact materials will need safety assessment and authorisation in Europe.
  - More research is needed on certain aspects relating to the potential effects of insoluble, biopersistent nanoparticles.

More Information

**Applications and implications of nanotechnologies for the food sector**

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Abstract

A review of current and projected nanotechnology-derived food ingredients, food additives and food contact materials is presented in relation to potential implications for consumer safety and regulatory controls. Nanotechnology applications are expected to bring a range of benefits to the sector; including new textures, tastes and sensations, less use of fats, enhanced absorption of nutrients, improved packaging, recyclability and security of food products. The review has shown that nanotechnology-derived food and health food products are set to grow worldwide and, moreover, a variety of food ingredients, additives, carriers for nutrients/supplements and food contact materials is already available in some countries.

More Information