Introduction to Microencapsulation of Functional Ingredients in Food Products

Short Course on Micro- and Nano-encapsulation of Functional Ingredients in Food Products
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Outline

Introduction to Microencapsulation
- A brief overview
- Why encapsulate?
- Release Mechanisms

Microencapsulation in the Food Industry
- Relevance to food & functional food market
- Ingredients of interest
- Examples of encapsulated ingredients

Development of Microencapsulated Ingredients
- Factors to Consider
- Multidisciplinary approach

Nanoencapsulation

Selected References
Introduction to Microencapsulation
Microencapsulation – Applications in various industries

Well-developed in the pharmaceutical industry, cosmetic and chemical industries but relatively new to the food industry
Getting used to terms – The vocabulary

• **Encapsulated ingredients**
  – Encapsulated particles
  – Delivery systems

• **Active (component that is encapsulated)**
  – Core
  – Load / payload
  – Internal phase

• **Encapsulant**
  – Exterior phase
  – Wall
  – Shell
  – Coating
  – Carrier
Microencapsulation

Process by which small particles of solid, liquid or gas (active core) are packaged within a secondary material (encapsulant) to form a capsule

- Microcapsules (micron size range 1 - 1000µm)
- Nanocapsules (submicron range)

A schematic representation of microencapsulated components

Types of Particles

(a) Single core
(b) Dispersed core in polymer matrix
(c) Multilayer capsule
(d) Dual core capsule
(e) Single core – multiple shell capsule
# Active Cores for Encapsulation - Examples across various industries

<table>
<thead>
<tr>
<th>Industry</th>
<th>Core of Interest</th>
<th>Function</th>
</tr>
</thead>
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<tr>
<td>Textile</td>
<td>Anti-microbials</td>
<td>Prevent Odour</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Pesticides</td>
<td>Slow release over time</td>
</tr>
<tr>
<td>Space</td>
<td>Phase change materials</td>
<td>Thermal protection systems for spacecraft (NASA)</td>
</tr>
<tr>
<td>Pharmaceutical</td>
<td>Aspirin</td>
<td>Slow release from microcapsule decrease risk of stomach damage</td>
</tr>
<tr>
<td>Food</td>
<td>Flavours / Bioactives/ Food additives</td>
<td>Stabilisation and controlled release</td>
</tr>
</tbody>
</table>
## Materials for Encapsulation - Examples

<table>
<thead>
<tr>
<th>Hot melts</th>
<th>Dispersions</th>
<th>Polymer solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ethylene-vinyl acetate polymer</em></td>
<td>Tricalcium phosphate slurries</td>
<td>Alginate</td>
</tr>
<tr>
<td><em>Fatty alcohols</em></td>
<td><em>Teflon®</em></td>
<td>Carrageenan</td>
</tr>
<tr>
<td>Fatty acids</td>
<td><em>Aquateric</em></td>
<td>Caseinate</td>
</tr>
<tr>
<td>Fats</td>
<td><em>Aquacoat</em></td>
<td>Cellulose Derivatives*</td>
</tr>
<tr>
<td><em>Hydrocarbon resin</em></td>
<td></td>
<td>Chitosan</td>
</tr>
<tr>
<td>Mono-, di-, tri-glycerides</td>
<td></td>
<td>Gelatin</td>
</tr>
<tr>
<td>Waxes</td>
<td></td>
<td>Gums (Food)</td>
</tr>
<tr>
<td><em>Polyanhydrides</em></td>
<td></td>
<td><em>Polyvinyl alcohol</em></td>
</tr>
<tr>
<td>Polyethylene glycols</td>
<td></td>
<td><em>Polypectate</em></td>
</tr>
<tr>
<td>Shellac</td>
<td></td>
<td>Starch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sugar Derivatives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shellac</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zein</td>
</tr>
</tbody>
</table>

**Blue:** Mainly non-Food Grade Applications (Some cellulose derivatives are food grade)

**Black:** Food Grade Applications (Food ingredients, GRAS - Generally regarded as safe status)
## Methods used for Encapsulation

<table>
<thead>
<tr>
<th>Physical Processes</th>
<th>Chemical Processes</th>
</tr>
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<tbody>
<tr>
<td>Spray drying</td>
<td>Simple coacervation</td>
</tr>
<tr>
<td>Spray chilling</td>
<td>Complex coacervation</td>
</tr>
<tr>
<td>Fluidized bed coating</td>
<td>Solvent evaporation</td>
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<tr>
<td>Extrusion</td>
<td>Liposomes</td>
</tr>
<tr>
<td>Spinning disk coating</td>
<td>Chemical adsorbents</td>
</tr>
<tr>
<td>Use of supercritical fluids</td>
<td>Inclusion complexation</td>
</tr>
</tbody>
</table>

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![Diagram](image_url)
Why encapsulate?

• To produce particles that control mass transport behaviour
  – Shell material – prevents diffusion of material from the microcapsule or into a microcapsule for required period

• To control release of core
  – Release of flavours when in contact with saliva or on chewing of gum

• To improve the stability of the core
  – Protection of sensitive ingredients from its environment (e.g. $O_2$, light, stomach acids, enzymes)

• Masking odour or taste
  – Mask off–flavours (e.g. masking bitterness of peptides)

• To convert liquids into free-flowing powders
  – Freeze drying/spray drying of liquid emulsions into powders
Functionality of microencapsulated food ingredients

Protect sensitive ingredients from degradation

• encapsulated probiotics allows storage at ambient temperature and higher water activity and reduces loss of viability;
• encapsulated polyunsaturated acids/vitamins/carotenoids/essential oils are stabilized against oxidation and off-flavour development

Convert liquid cores into powders

• use of high fat powders for delivery of oils - easier handling and improved storage stability
• allows dry blending of ingredients in formulations
• enables tabletting

Isolate the core – prevent participation in undesirable interactions

• compartmentalizing pro-oxidant iron salts to reduce their interactions with unsaturated oils (as well as mask taste of minerals) in formulations
• isolation of calcium from soy proteins to prevent Ca-induced precipitation of proteins in Ca-fortified beverages (as well as mask taste of minerals)
Oxidative stability of sardine oil in powdered mixtures

Powdered mixtures of Sardine Oil with:
A = starch (simply mixed)
B = freeze dried egg white
C = spray dried egg white

Functionality of microencapsulated food ingredients

Improve the nutritional content

- without affecting taste, aroma or texture (e.g. encapsulating fish oils to enable delivery of long chain omega-3 fatty acids through supplements or food)

Control release of desirable flavors and/or masking undesirable flavors

- control mint flavor release in chewing gum
- mask bitterness of peptides

Controlled release functional food ingredients

- at the appropriate time during processing or storage, or enable controlled, sustained or delayed release of the ingredient
- encapsulated leavening agents that are released during baking
- controlled release of encapsulated antimicrobial agents
- targeted site of release of a bioactive *in-vivo*
Triggering release of core from microcapsule

- Capsules are **stable during storage** – disallowing transport of material
- **Trigger event** – when this occurs, there is release of the core into the surrounding environment or transport

**Release governed by how encapsulating material responds to the trigger**
Release of core from microcapsules

**Typical trigger events:**
- Heat
- Osmotic pressure
- Addition of water
- Mechanical rupture
- Alteration of pH
- Enzyme action

**Release rates are affected by:**
- Diffusion coefficient of the substance
- Thickness of the shell /matrix
- Saturation concentration of the substance (degree of loading)
- Mechanical and chemical stability of microcapsule (eg degree of cross-linking)
Release Mechanisms – Examples

• **Dissolution / Osmotic pressure/ Diffusion**
  - Capsules swell in water, diffusion is enhanced, slow release
  - Boiled sweets which release flavour in the mouth

• **Temperature**
  - Core within a hard fat (eg leavening agent) that is released during baking

• **Pressure/Shear**
  - Carbonless paper (two colourless inks in microcapsules, capsule ruptured by pressure exerted by writing, mixed inks produce a colour)
  - Scratch and Sniff aromas in packaging

• **Changes in pH**
  - Release of bioactives as pH is changed from gastric to intestinal pH (eg due to change in charge of encapsulating material containing proteins or liposomes)

• **Enzyme action**
  - Degradation of starch based capsules with amylases
Microencapsulation for delivery of bioactives

Target delivery to GI tract

- Different sites of delivery desired for various health outcomes
- For Inflammatory gut diseases
  - Distal small intestine
  - Colon

Challenge – depending on target release site

- Protection against stomach acid & enzymes
- Protection against enzymes in small intestine
  - Amylases, Proteases, Lipases

Targeting release – Microencapsulation

Appropriate materials, formulation & process
Microencapsulation in the Food Industry
Traditional and emerging food industry

*Traditional food*

Food consumed to provide adequate nutrients
downarrow
Survival, satiety & food safety
downarrow
Well-being and health & Reducing disease risks
downarrow

*Functional food*

Foods must be safe, nutritious, appealing and affordable

What is the place for microencapsulation?
The Functional Food Revolution

• “Let thy food be thy medicine and thy medicine be thy food – Hippocrates 400BC”

• “He that takes medicine and neglects diet, wastes the skill of the physician“ - Chinese Proverb
Growing market for Nutraceuticals in Food

- **Global functional foods market revenue**
  - ~$175 billion for 2013
  - Expected to exceed $230 billion by 2015 with an annual average growth of 15%

  *Research and Markets 2013*

- **Global nutraceuticals ingredient market is expected to grow**
  - Estimate: From $23.8 billion in 2013 to $33.6 billion in 2018 with compound annual growth rate of 7.2%

  *Markets and Market 2014*

Growth is mainly driven by the growing demand for energy drinks and fortified dairy products

*Transparency Market Research 2014*
Traditional and Functional Food Development

Traditional Food Processing

- Conversion of raw material to edible, safe, wholesome & nutritious foods
  - Desirable physico-chemical properties, extended shelf-life
  - Desirable sensory properties and convenient

Processing of Functional Foods Adds Extra Dimensions to Traditional Food Processing

- Creation of functional bioactive component and appropriate delivery systems
  - Optimisation of functional component
  - Incorporation into food without compromising food quality
- Increased levels of complexity and monitoring

Microencapsulated Ingredients – Superior performance when incorporation of neat food ingredient compromised food quality
Food Ingredients and Bioactives

Food additives

• Food additives are ingredients added either during formulation or processing of food for a technological function
  – To improve the appeal and shelf life of the food

Bioactives

• Functional ingredients derived from natural food sources that benefit health
  – e.g. maintenance of health and well being, alleviating symptoms of illness, or prevention and treatment of disease

Microencapsulation – enables incorporation of ingredient and improves its functionality in a food application
Food Industry: Interests in microencapsulated Ingredients

Flavouring agents (e.g. sweeteners, seasonings, spices)
Acids, bases and buffers (e.g. citric acid, lactic acid, sodium bicarbonate)
Lipids (e.g. fish oils, milkfat, vegetable oils)
Enzymes and microorganisms (e.g. proteases, probiotic bacteria)
Artificial sweeteners (e.g. aspartame)
Antioxidants
Preservatives
Pigments and dyes
Essential oils
Minerals (e.g. calcium, iron, zinc)
Amino acids and peptides
Vitamins and pro-vitamins (e.g. vitamin A, carotene, vitamin K, vitamin C)

Novel solutions for improved delivery
Increasing interest in delivery of bioactives/nutraceuticals
<table>
<thead>
<tr>
<th>Food additive</th>
<th>Examples</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidulants</td>
<td>Various acids (e.g. citric, acetic, malic, fumaric acids)</td>
<td>To control pH of foods; lower pH of food to permit sterilization under less harsh conditions to improve food quality; contribute to taste and aroma of foods</td>
</tr>
<tr>
<td></td>
<td>δ-gluconolactone</td>
<td>Slow acid production in cultured dairy products for gel formation</td>
</tr>
<tr>
<td>Vitamins</td>
<td>Fat soluble vitamins (e.g. A, D, E, K), water soluble vitamins (B vitamins, folic acid, niacin, vitamin C)</td>
<td>Fortification of foods; providing a range of health benefits</td>
</tr>
<tr>
<td>Mineral salts</td>
<td>Ca and Fe salts</td>
<td>Fortification of foods for health benefits; Ca salts may also function as texturizing agents in certain applications</td>
</tr>
<tr>
<td>Antioxidants</td>
<td>Tocopherols, citric acid, ascorbyl palmitate, propyl gallate, thiodipropionates</td>
<td>Protecting unsaturated lipids from oxidation</td>
</tr>
<tr>
<td>Colorants</td>
<td>Carotene, annatto extract, anthocyanins, caramels, chlorophylls, synthetic food dyes</td>
<td>Imparting color to foods to improve appearance and appeal of foods</td>
</tr>
<tr>
<td>Emulsifiers</td>
<td>Low molecular weight surfactants (e.g. Tweens, phospholipids, mono- and di-acylglycerols,)</td>
<td>Lowering surface tension and stabilizing emulsions</td>
</tr>
<tr>
<td></td>
<td>High molecular weight emulsifiers (e.g. gum arabic, sugar beet pectin)</td>
<td>Stabilizing emulsions</td>
</tr>
<tr>
<td>Food additive</td>
<td>Examples</td>
<td>Functionality</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Enzymes</td>
<td>Various enzymes (e.g. glycosidases, pectinases, proteolytic enzymes, cellulases, lipases)</td>
<td>Transformation components in foods for specific functions (e.g. glycosidases for producing corn syrups, pectinases for facilitating extraction and clarification of juices, lipases for generating flavors in cheese)</td>
</tr>
<tr>
<td>Flavoring agents</td>
<td>Salt, citrus flavors, spicy flavors, umami tastants (e.g. monosodium glutamate), bitter tastants (e.g. quinine)</td>
<td>Enhancing flavor of various food products</td>
</tr>
<tr>
<td>Leavening agents</td>
<td>Sodium bicarbonate, ammonium bicarbonate</td>
<td>Producing carbon dioxide at baking temperatures for improved texture of baked goods</td>
</tr>
<tr>
<td>Thickening/Stabilizers</td>
<td>Various gums (e.g. agar, carrageenan, pectin,); starch</td>
<td>Stabilizing emulsions; imparting structure and texture to foods</td>
</tr>
<tr>
<td></td>
<td>Polyols</td>
<td>Humectant; binding water and maintaining texture; lowering water activity in intermediate-moisture foods</td>
</tr>
<tr>
<td>Antimicrobial agents</td>
<td>Various acids (e.g. citric, acetic, propionic, sorbic)</td>
<td>Antimicrobial activity against bacteria, mould and yeasts</td>
</tr>
<tr>
<td></td>
<td>Nitrates and nitrites</td>
<td>Inhibiting growth of microorganisms in meat products</td>
</tr>
<tr>
<td>Sequestrants</td>
<td>Ethylenediaminetetraacetic acid; polyphosphates</td>
<td>Chelating of metal ions; stabilizing foods against oxidation</td>
</tr>
<tr>
<td>Sweeteners</td>
<td>Aspartame, sulfonamides, sucralose</td>
<td>Non-nutritive low-calorie sweetener</td>
</tr>
<tr>
<td>Anticaking agents</td>
<td>Silicates of calcium or magnesium</td>
<td>Promoting free-flowing properties of granular and powdered foods</td>
</tr>
</tbody>
</table>
## Market Interest - Ingredients for health trends

<table>
<thead>
<tr>
<th>Weight Control</th>
<th>Body Sugar</th>
<th>Cardiovascular Health</th>
<th>Joint Health</th>
<th>Beauty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber</td>
<td>Herbs /Botanicals</td>
<td>Omega-3</td>
<td>Calcium</td>
<td>Herbs /Botanicals</td>
</tr>
<tr>
<td>Herbs /Botanicals</td>
<td>Low GI ingredients</td>
<td>Sterols</td>
<td>Glucosamine</td>
<td>Omega-3</td>
</tr>
<tr>
<td>Chromium</td>
<td>Fiber</td>
<td>CoQ10</td>
<td>Omega-3</td>
<td>Antioxidants</td>
</tr>
<tr>
<td>Protein</td>
<td>Inulin</td>
<td>Herbs /Botanicals</td>
<td>Herbs /Botanicals</td>
<td>CoQ10</td>
</tr>
<tr>
<td>Reduced fat &amp; sugar</td>
<td>Chromium</td>
<td>Antioxidants</td>
<td>Chondroitin</td>
<td>Green tea</td>
</tr>
</tbody>
</table>

Business Insights Survey 2008
## Market interest – Ingredients for Health Trends

<table>
<thead>
<tr>
<th>Anti-ageing</th>
<th>Digestive Health</th>
<th>Immunity</th>
<th>Cognitive Health</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbs /botanicals</td>
<td>Probiotics</td>
<td>Herbs /botanicals</td>
<td>Omega-3</td>
<td>Vitamins</td>
</tr>
<tr>
<td>Antioxidants</td>
<td>Herbs /botanicals</td>
<td>Probiotics</td>
<td>Herbs /botanicals</td>
<td>CoQ10</td>
</tr>
<tr>
<td>Omega-3</td>
<td>Enzymes</td>
<td>Antioxidants</td>
<td>Antioxidants</td>
<td>Herbs /botanicals</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>Fiber</td>
<td>Vitamin C</td>
<td>Ginger</td>
<td>Proteins</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>Omega-3</td>
<td>Beta-sitosterol</td>
<td>Lecithin</td>
<td>Guarana</td>
</tr>
</tbody>
</table>

Business Insights Survey 2008
## Selected Cores - Reason for Encapsulation

<table>
<thead>
<tr>
<th>Type of core</th>
<th>Examples</th>
<th>Potential benefit of encapsulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oils</td>
<td>Milkfat, omega-3 oils</td>
<td>Improved storage stability, target release</td>
</tr>
<tr>
<td>Flavours</td>
<td>Mint, orange oil</td>
<td>Preservation of flavours, controlled release in the mouth</td>
</tr>
<tr>
<td>Food additives</td>
<td>Leavening agents</td>
<td>Controlled release during baking</td>
</tr>
<tr>
<td>Minerals</td>
<td>Iron salts</td>
<td>Avoiding undesirable interactions (e.g. catalyzing fat oxidation), target delivery on ingestion</td>
</tr>
<tr>
<td>Phytonutrients</td>
<td>Flavanoids, polyphenols, tocopherols, phytosterols, carotenoids, carotene, lycopene, lutein</td>
<td>Protection of sensitive ingredients from the environment and interactions with the food matrix, target delivery on ingestion</td>
</tr>
<tr>
<td>Probiotics</td>
<td>Bifidobacteria, lactobacilli</td>
<td>Improved survival during storage, survival on exposure to stomach acids</td>
</tr>
</tbody>
</table>
Development of microencapsulated ingredients
# Microencapsulation: Science & Practice

## A Multidisciplinary Approach

<table>
<thead>
<tr>
<th>SCIENCE</th>
<th>CAPABILITY</th>
<th>ACTIVITY</th>
<th>Encapsulated product</th>
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</thead>
<tbody>
<tr>
<td>Chemistry, Microbiology</td>
<td>Chemistry, Material Science &amp; Engineering</td>
<td>Formulation science &amp; Chemistry</td>
<td>Engineering and Processing</td>
</tr>
<tr>
<td><strong>Core</strong></td>
<td><strong>Encapsulant Material</strong></td>
<td><strong>Formulation</strong></td>
<td><strong>Process</strong></td>
</tr>
<tr>
<td>Select/identify</td>
<td>Existing/New</td>
<td>Design formulations</td>
<td>Conventional/emerging</td>
</tr>
<tr>
<td>Characterise – physical &amp; chemical</td>
<td>Modification/Synthesis</td>
<td>Study of interfacial behaviour</td>
<td>Maintain/develop processing capability</td>
</tr>
<tr>
<td>Stability of materials</td>
<td>Triggers for release &amp; stability of formulation</td>
<td>Assess efficiency/consistency of process</td>
<td>Suitability for incorporation into foods/target delivery</td>
</tr>
<tr>
<td>Work with supplier/user</td>
<td>Establish cost/availability</td>
<td>Compare with competitors(existing products)</td>
<td>Align with industry capability</td>
</tr>
</tbody>
</table>

**ACTIVITY**
- Chemistry, Material Science & Engineering
- Formulation science & Chemistry
- Engineering and Processing

**CAPABILITY**
- Chemistry, Microbiology
- Chemistry, Material Science & Engineering
- Formulation science & Chemistry
- Engineering and Processing
- Chemistry, Biochemistry, Food technology, Nutrition

**SCIENCE**
- Chemistry, Microbiology
- Chemistry, Material Science & Engineering
- Formulation science & Chemistry
- Engineering and Processing
- Chemistry, Biochemistry, Food technology, Nutrition
### Important Issues | Action or Questions to ask
--- | ---
**Regulatory standard** | • Check the regulatory standards in each country for addition of bioactives.  
• Can the bioactive be added to the chosen food?  
• Are the ingredients used as encapsulant allowed in the chosen food?  
• What levels are required if there is to be a health claim?

**Food product application format** | • What is the format of the final product chosen?  
  - For a powder, blending applications require good control of particle size, moisture and bulk density  
  - For a liquid, then rehydration and redispersion behaviour of powdered encapsulated bioactives are important

**Protection and release characteristics** | • What processing stresses has the ingredient to survive during incorporation into the food?  
• Under what conditions or in response to what trigger is the bioactive released?
### Important Issues

<table>
<thead>
<tr>
<th>Important Issues</th>
<th>Action or Questions to ask</th>
</tr>
</thead>
</table>
| **Stage or point of addition**          | • Is the food manufacturing plant set up automated?  
• At what point during production will the ingredient be added?  
• Will the ingredient be added using an automated process or manually? |
| **Interaction with other ingredients**  | • Is there a need to avoid interaction of the bioactive with other ingredients in the final food during processing and storage?                          |
| **Final product characteristics**       | • What are the storage conditions and shelf life of the final food product?  
• What flavour characteristics are present in the food chosen?  
• Does the food product have a delicate flavour or strong flavour that can mask some undesirable taste and aroma? |
Selection of Formulation and Process

• **What is the active core?**
  - What are its inherent properties
  - What is the desired payload?

• **What are the materials allowed for the intended application?**
  - Check legal status

• **What are the processing capabilities available?**
  - What is the cost of the process and the formulation?
  - What is the amenability of the encapsulant formulation to be processed?

• **What is the desired size of the particle?**
  - This will dictate some of the processes used (eg homogenisation pressure use for formation of an emulsion)

• **What is the desired shelf life?**
  - Define the storage conditions (eg temperature, packaging, water activity)
## Process – General Considerations

<table>
<thead>
<tr>
<th>Method</th>
<th>Principle</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray drying</td>
<td>Core is dispersed into aqueous encapsulant solution and atomized into a drying chamber</td>
<td>Most commonly used method, cost-effective</td>
</tr>
<tr>
<td>Spray chilling</td>
<td>Core is dispersed into coating solution and sprayed into a cold environment to solidify the carrier material</td>
<td>Used for protection of water-soluble cores, also suitable for cores that are sensitive to temperature</td>
</tr>
<tr>
<td>Extrusion</td>
<td>Emulsion dispersion containing the core passed through a die at high temperature and pressure into a bath for solidification of the particle</td>
<td>Used primarily for encapsulation of flavours and volatile cores in glassy matrices</td>
</tr>
<tr>
<td>Fluidized bed coating</td>
<td>Particles are suspended in air and a coating is applied</td>
<td>Used for achieving finer control over release properties of the core</td>
</tr>
<tr>
<td>Inclusion complexation</td>
<td>An inclusion complex is formed between cyclodextrin and the core</td>
<td>Encapsulation of flavours and lipophilic nutrients</td>
</tr>
<tr>
<td>Coacervation</td>
<td>Coacervates are formed when two oppositely charged biopolymers associate and phase separate</td>
<td>Can entrap high loadings of cores, has been used in encapsulation of flavours and many nutrients</td>
</tr>
</tbody>
</table>
Nanoencapsulation
Nanotechnology

Emerging area of Science

- Science and Technology that deals with the Application, production and processing of materials with dimensions on the nano-scale
- Multi-disciplinary
  - Brings together chemists, physicists, biologists and engineers
- Disruptive and enabling technology
  - Enables radically new generation of existing products and processes
  - Displaces older technologies

**Creation of new and exciting materials**

**Significant impact on society**
Relevant length-scales and time-scales for food materials

Leser et al., IN Food colloids, biopolymers and materials (Eds Dickinson and van Vliet, 2003), pp3-13
Nanoencapsulation

• **Nanotechnology**
  - Creation, utilisation or manipulation of materials, devices or systems in the nanometre scale (<100 nm)

• **Nanoencapsulation**
  - Entrapping of active cores within a carrier material with dimensions in the nano-scale

• **Why nano?**
  - Claims that higher surface area results in higher nutritional value, requirement for lower does of additives and improved sensory properties
Nanoencapsulated ingredients

**Nanoemulsions**

- Active ingredient confined within a membrane
  - Membrane forming molecule, a co-emulsifier and a lipophilic material
- Small size for optical clarity
  - e.g. 20-100 nm nanoparticles - suitable for delivery into clear beverages
  - Formed with high kinetic energy
  - Large amounts of emulsifier required

**Hydrophobic nanospheres**

- e.g. Nanospheres encapsulated in pH- or moisture sensitive microspheres for improved flavour profile
Nanoencapsulation – Considerations for food applications

Consumer concerns

- Potential of unknown toxicity of nanoparticles
- Dry format – risk of inhalation and explosive properties

What should scientists consider

- The transparency of health, safety and environmental impacts
- Regulatory standards which ensure that precautions are taken in any commercialisation
- The introduction of food products arising out of nanotechnology into the market place requires education of the public and other interest groups
Conclusions

**Microencapsulation – at present**
- Increasingly being used to delivery food ingredients and bioactives
- Superior performance of encapsulated ingredients
  - Successful delivery of ingredients into foods
  - Potential for enhancing bioavailability of bioactive components

**Microencapsulation – into the future**
- Opportunities to grow as greater demands made on ingredient performance (food additives, nutraceuticals, supplements)
  - Different formats for delivery
- Increased interest in tailoring release
  - During processing
  - After ingestion

Tailor-made microencapsulated ingredients that are fit for purpose
Taking into account final food application and target delivery in body
Further Reading


Thank you

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