Nano food
augmenting nature

Prof. Lorenzo Pastrana

International Iberian Nanotechnology Laboratory

INL – The international Hub for food nanotechnology

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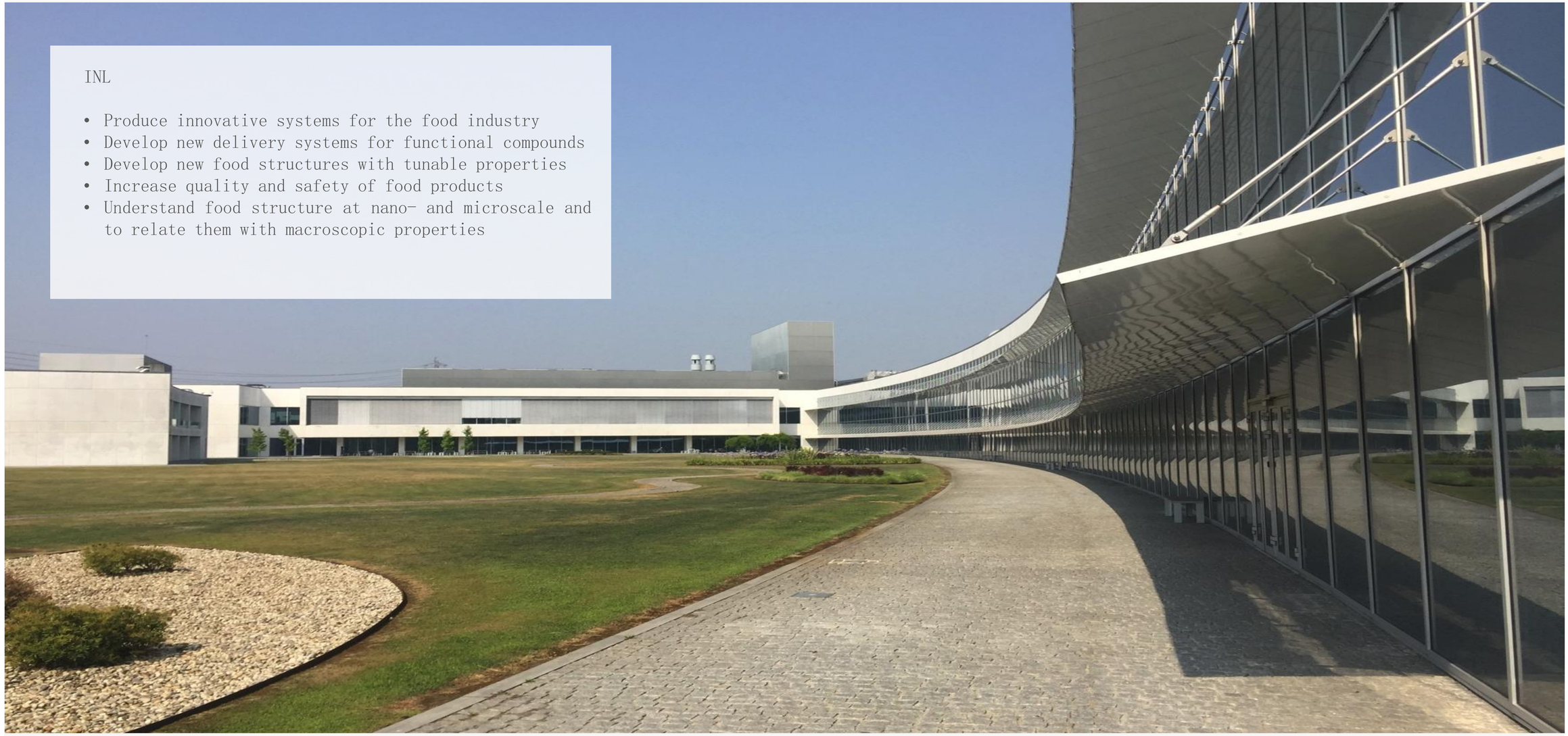


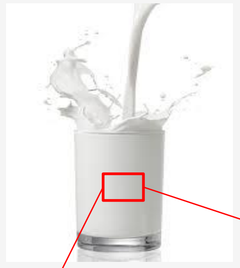
INL

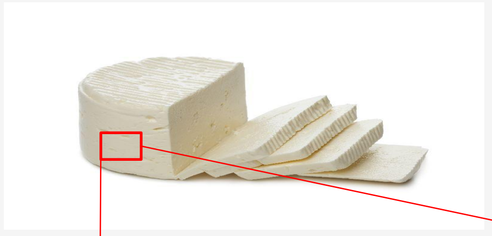
- Produce innovative systems for the food industry
- Develop new delivery systems for functional compounds
- Develop new food structures with tunable properties
- Increase quality and safety of food products
- Understand food structure at nano- and microscale and to relate them with macroscopic properties

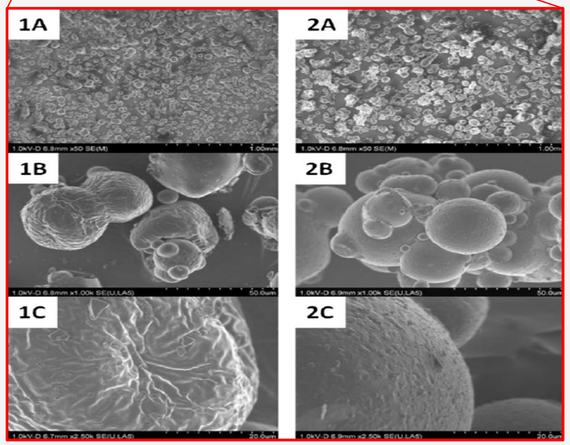
The natural Bio-Nano-Factory

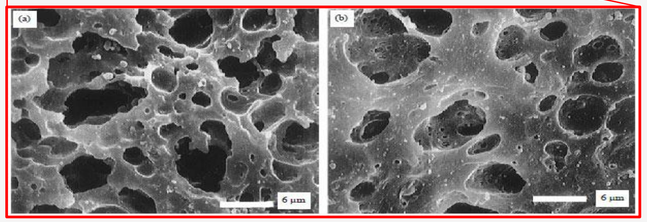
The Nanoscale in Foods

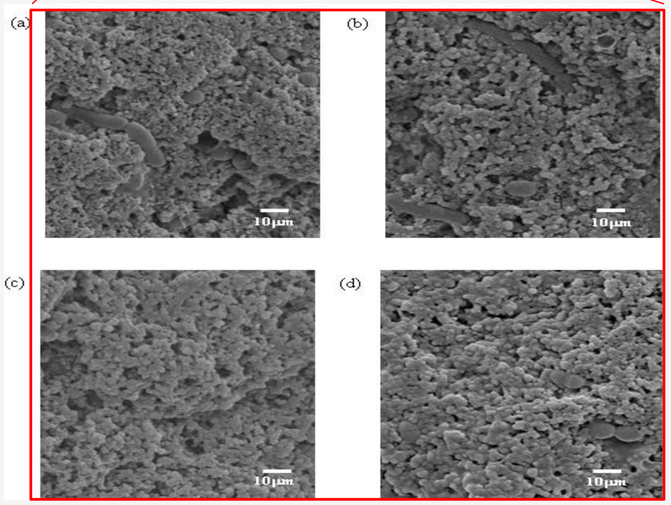
The Nanoscale in Foods

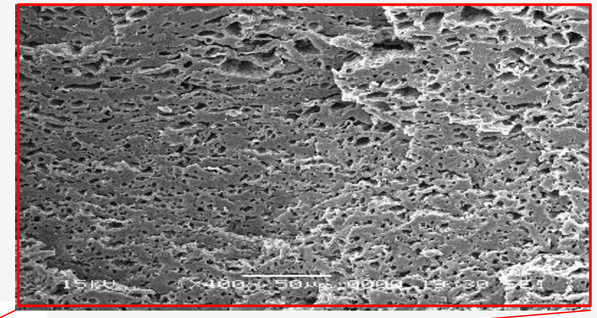


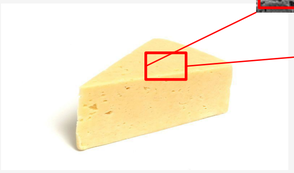












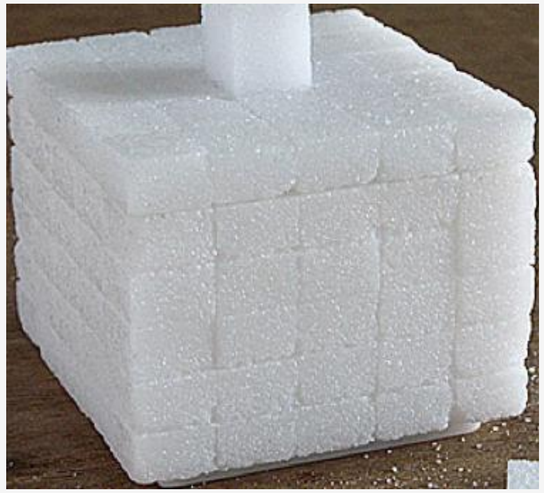
Size matters

1 cm

6 cm^2

1 cm^3

1 mm



60 cm^2

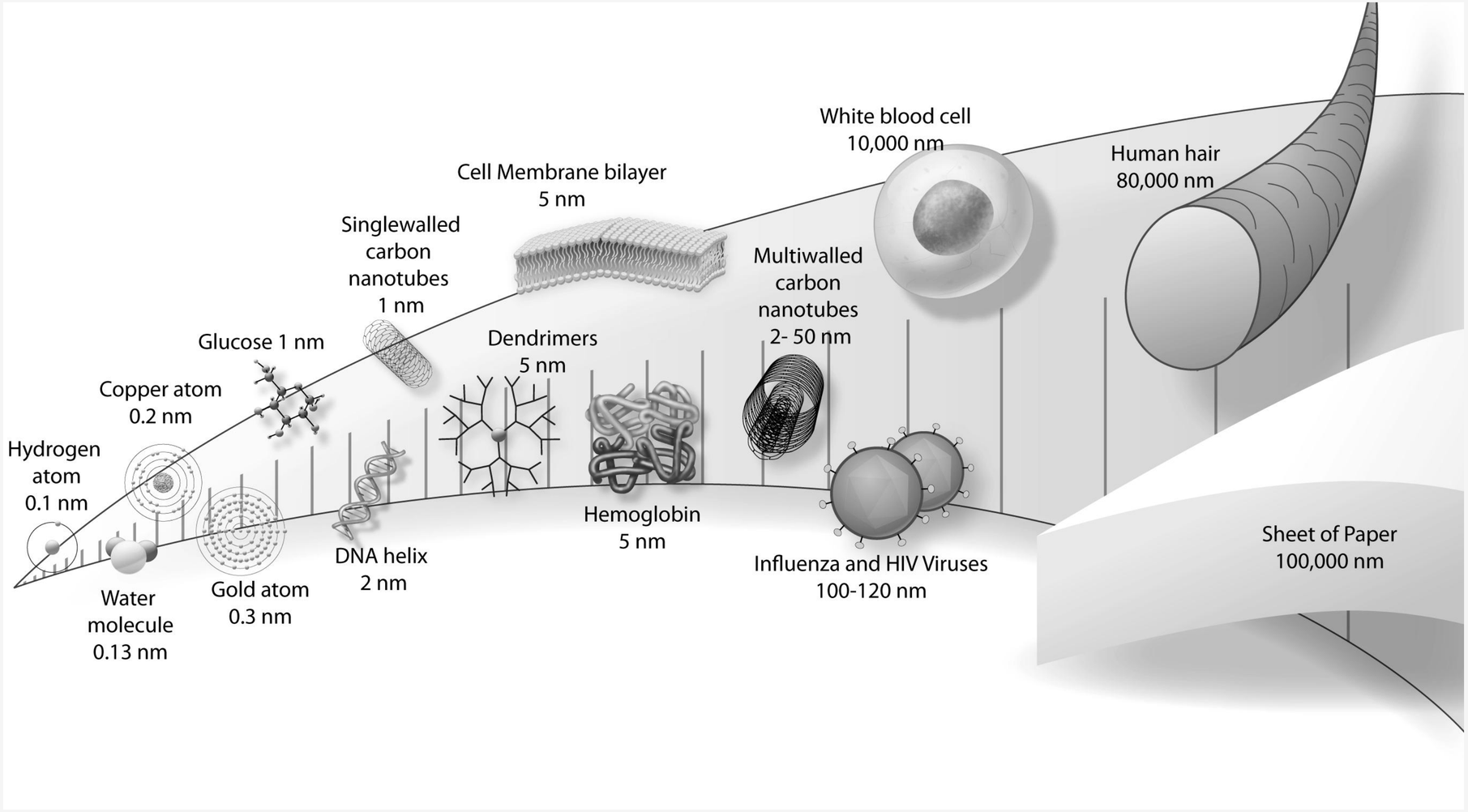
1 cm^3

1 nm

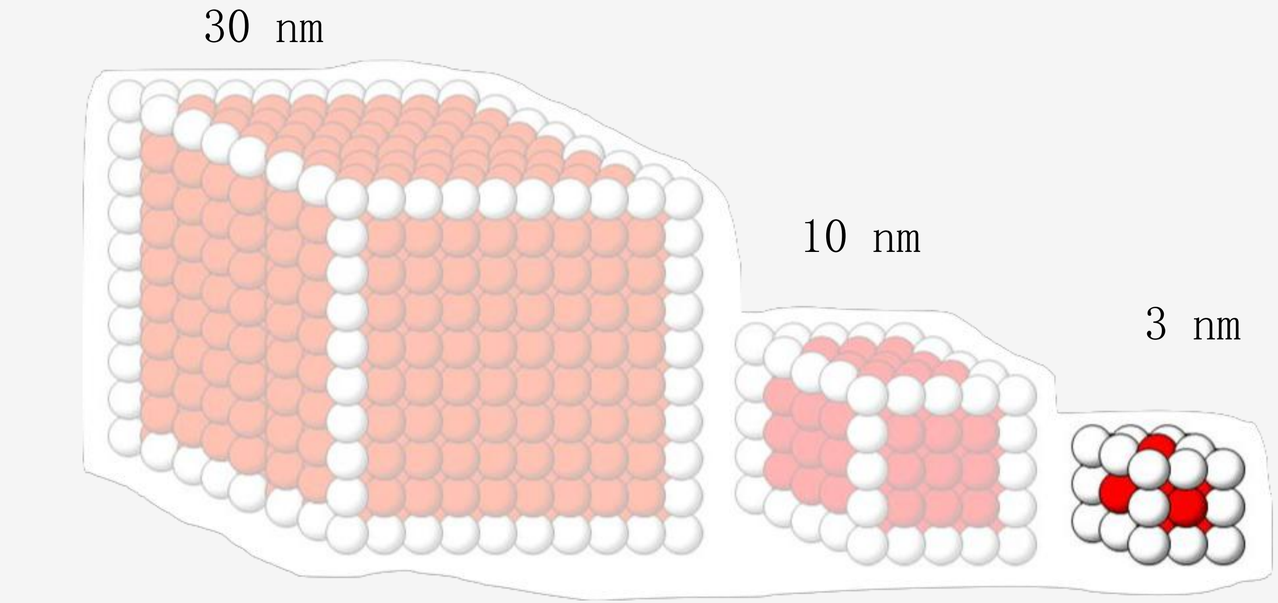
60000000 cm^2

1 cm^3

The Nanoscale



The importance of Nano



The enhancement of many properties depends on the atoms on surface: chemical reactivity, color, material strength

INL – The international Hub for food nanotechnology

Healthier Food
Food 3D-Printing

Active,
Edible and
Smart Packaging
Safety 4.0

Authenticity
New experiences

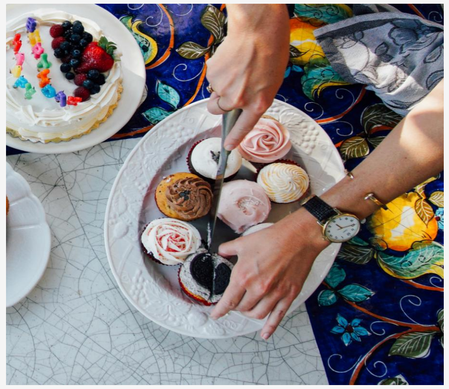
INL - The international Hub for food nanotechnology

Healthier Food
Food 3D-Printing

Personalization

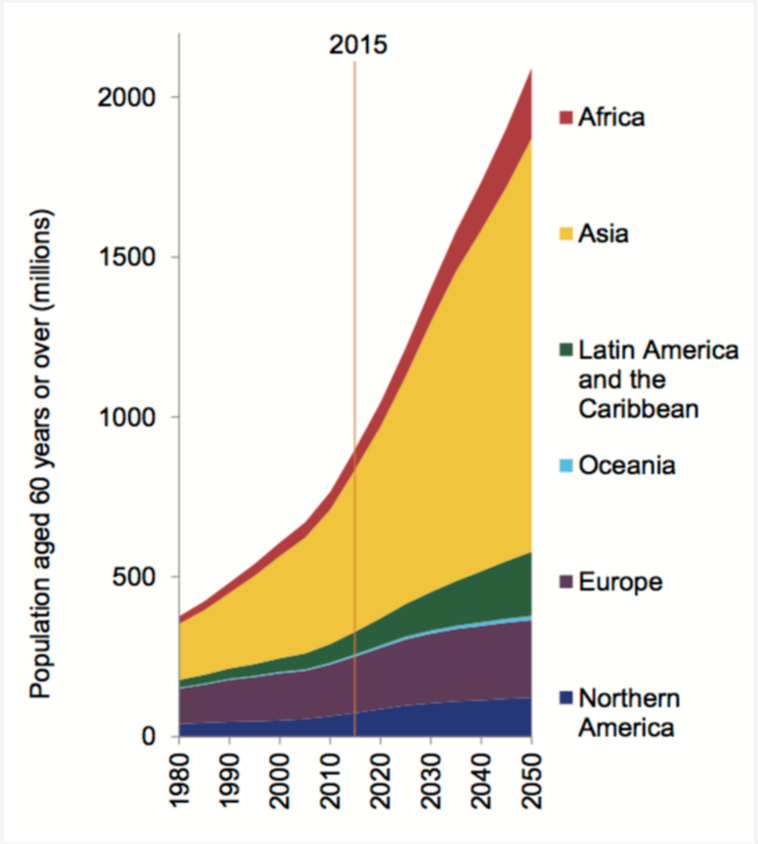






Food plays a variety of roles in peoples' lives

Big Challenges for the XXI Century



2030	
Country or area	Percentage aged 60 years or over
Martinique	38.5
Japan	37.3
Italy	36.6
Germany	36.1
Portugal	34.7
China, Hong Kong SAR	33.6
Spain	33.5
Greece	33.2
Slovenia	32.7
Austria	32.4

Population growth and Ageing are incresing fast

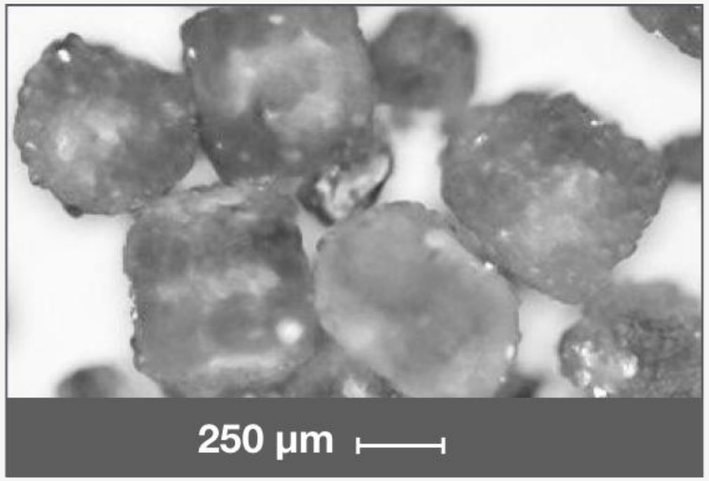
Less is More: Nano Sized Salt and Sugar

- 1.56 billion people worldwide will have hypertension by the year 2025
- It is expected to have 642 million people living with diabetes worldwide by 2040

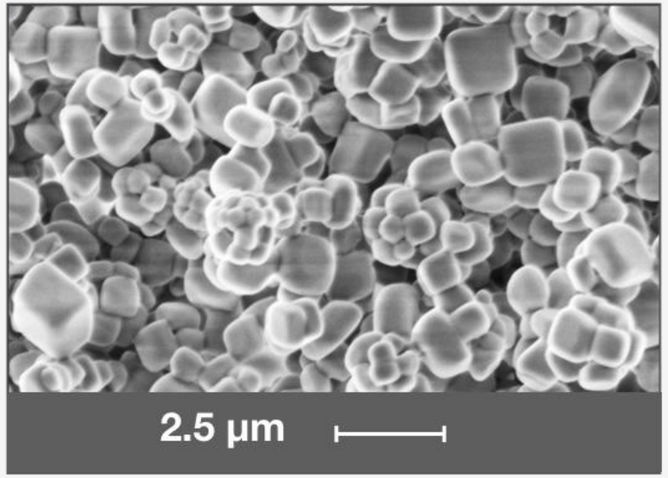
Sodium-rich diets are a leading cause of hypertension, and a reduction on salt intake is advised
(WHO - http://www.who.int/elena/titles/sodium_cvd_adults/en/)

Less is More: Nano Sized Salt and Sugar

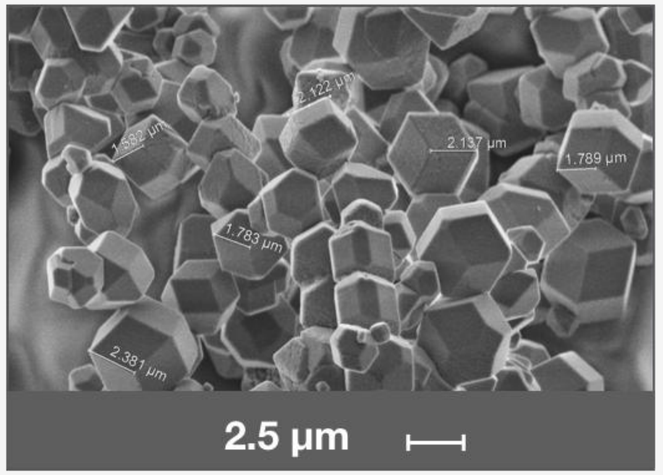
We have technologies suitable for producing salt particles in the range of 1-2 µm



A. Regular fine commercial salt (Sigma Aldrich)



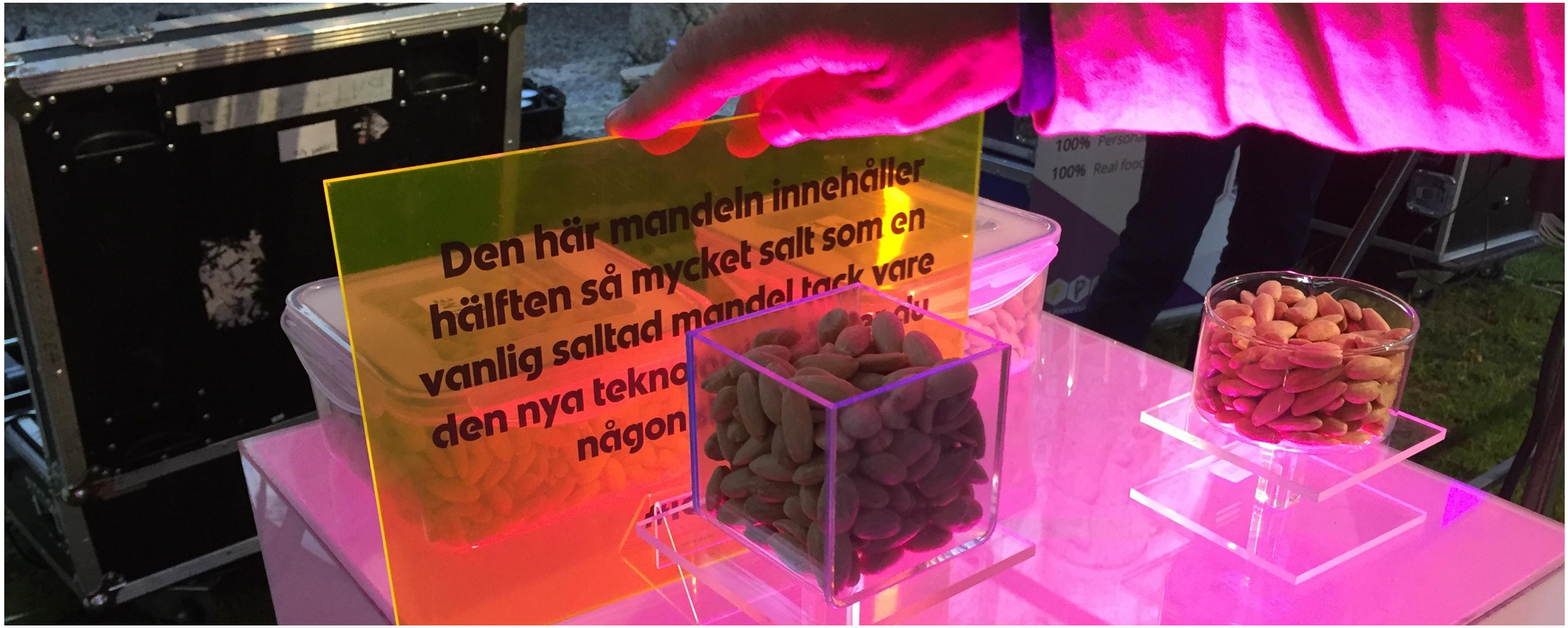
B. MicroSalt Formulation 1



C. MicroSalt Formulation 2

It is posible to reduce 50% amount of salt keeping the salty taste

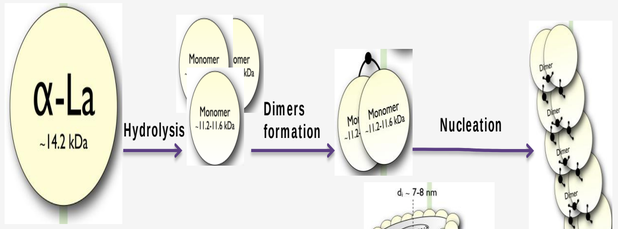
A proof of concept in Sweden, Summer 2017…

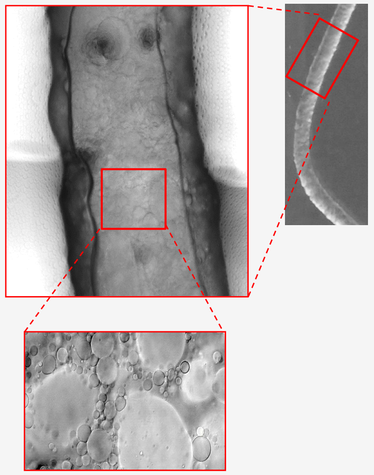


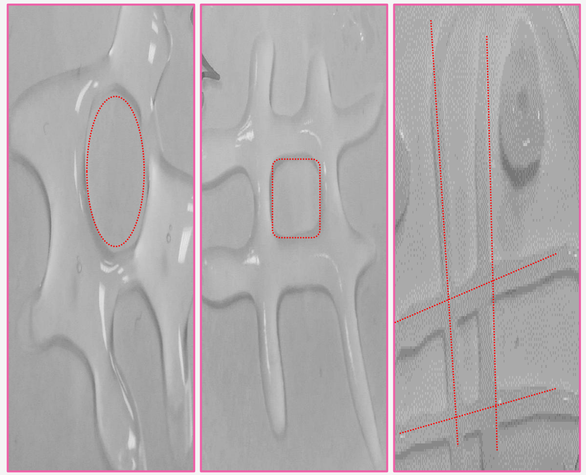
Healthier nanoengineered Almonds with the same taste than regular snacks

Swalloging difficulties (Dysphagia) and 3D Printed Food

- 45% seniors have symptoms of dysphagia
- Soluble proteins such as whey protein can be structured to obtain nanotubes
- Design meals for easy swallowing in dysphagia patients by using be printable proteins

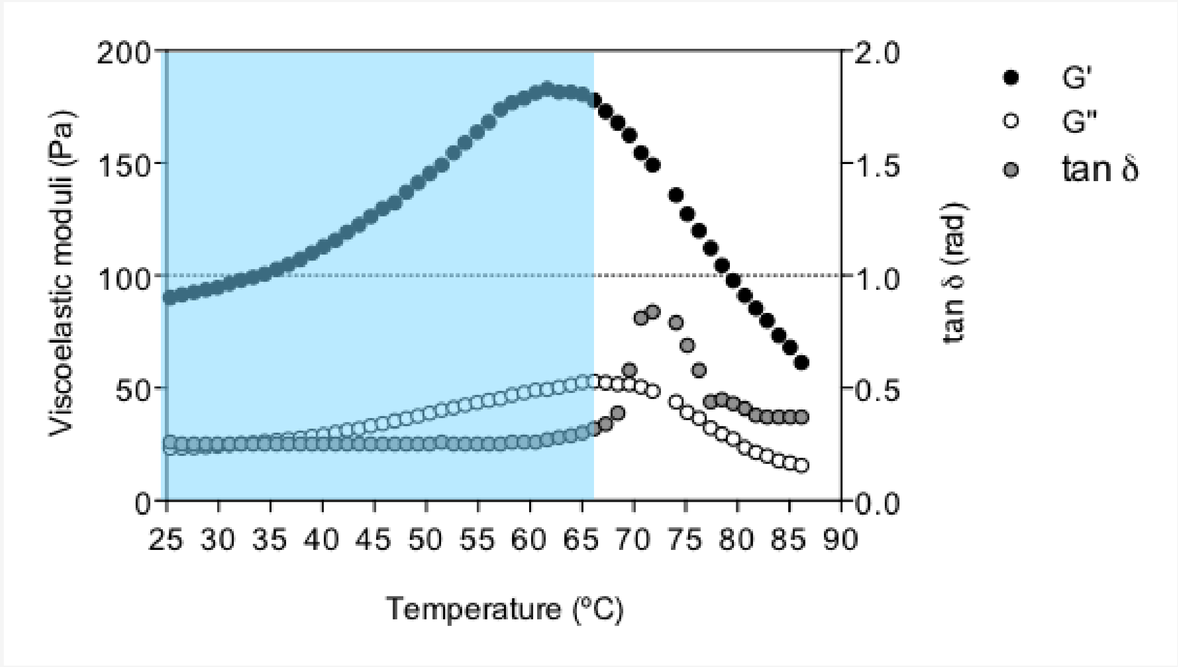






Tailor made rheological properties

- RS600 Haake rheometer
- Parallel-plate geometry (20 mm diameter and 1 mm gap)
- 20 ºC, rest for 15 min
- 20-90 ºC, 1ºC/min
- Shear strain (γ) = 1%
- Angular frequency (ω) = 1 Hz (6.28 rad s^{-1})



↑ T (25-66 ºC) → ↑ Hydrophobic interactions
↑ electrostatic desolvation → ↑ salt-bridge stability → ↑ Gel stiffness

Functional Foods

- Malnutrition can affect 50% of the frailest elderly population

- Direct incorporation of micronutrients to the biscuit mass is not compatible with fabrication process and yield unacceptable quality and sensorial biscuits

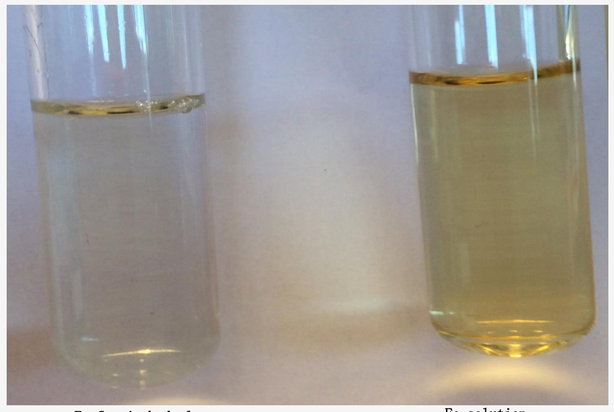
Control without Fe

Formulation with Fe

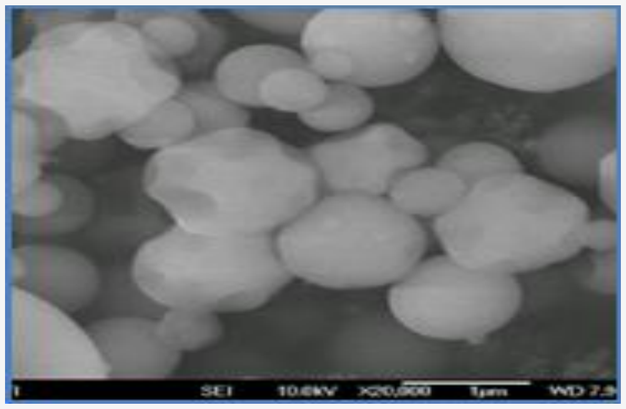
Nano-encapsulation of micronutrients

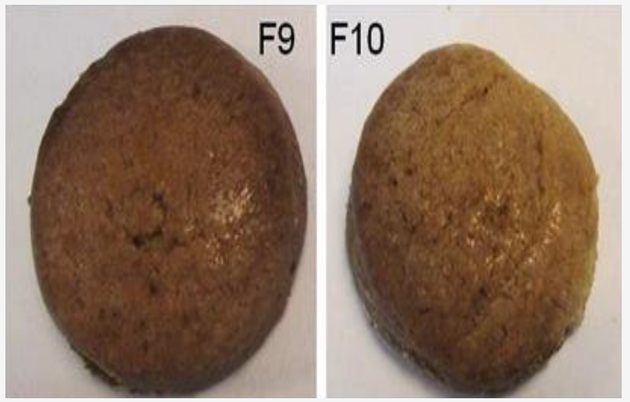
- Fe, Ca and Se must be encapsulated to prevent their degradation, reduction of bioavailability

- Encapsulation of iron is technologically compatible and mask offlavours



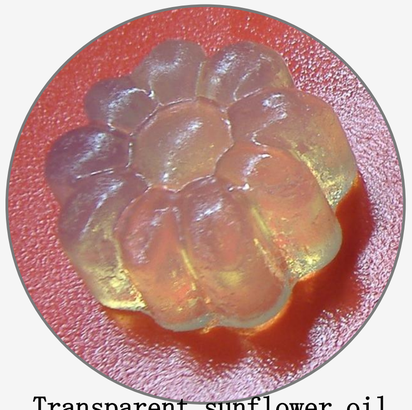
Fe-Casein hydrolysate Fe solution



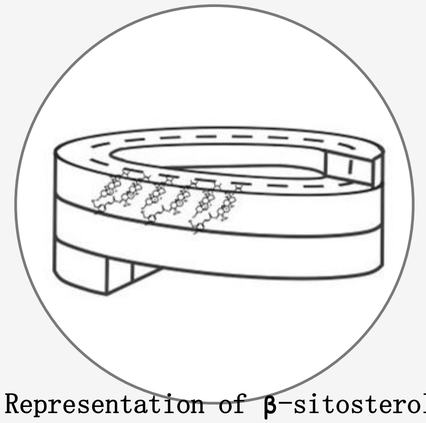


Nanostructured Oleogels

- Oleogels can be produced with different appearance (opaque or transparent), hardness and melting profile
- Solid fats such as lard or butter can be replaced by oleogels with a healthier fatty acid profile.
- Vegetable oils can be structured to provide new sensory experiences.



Transparent sunflower oil oleogel structured with β-sitosterol and γ-oryzanol (Rogers et al., 2014, Int J Gastron and Food Sci, 2:22-31)



Representation of β-sitosterol and γ-oryzanol nanotubes (diameter of ~10 nm) (Rogers et al., 2014, Int J Gastron and Food Sci, 2:22-31)

Regular chocolate (left) and Heat Resistant Chocolate (right) at 40 °C. HRC was structured with ethyl cellulose (Stortz et al., 2013, Food Res Int, 51:797-803)

Functional Foods

FODIAC

Food for Diabetic And Cognition

Bioactive compounds (polyphenols and flavones) from fruit wastes and wastage

DEVELOPMENT
Bioactivity

INGREDIENT

- Extraction
- Encapsulation

FEASIBILITY
implementation

FOOD

- Processing
- Formulation

ASSESSMENT

DIET

- In vitro
- Clinical trials

Antidiabetic and cognitive functional food and diets for elderlies

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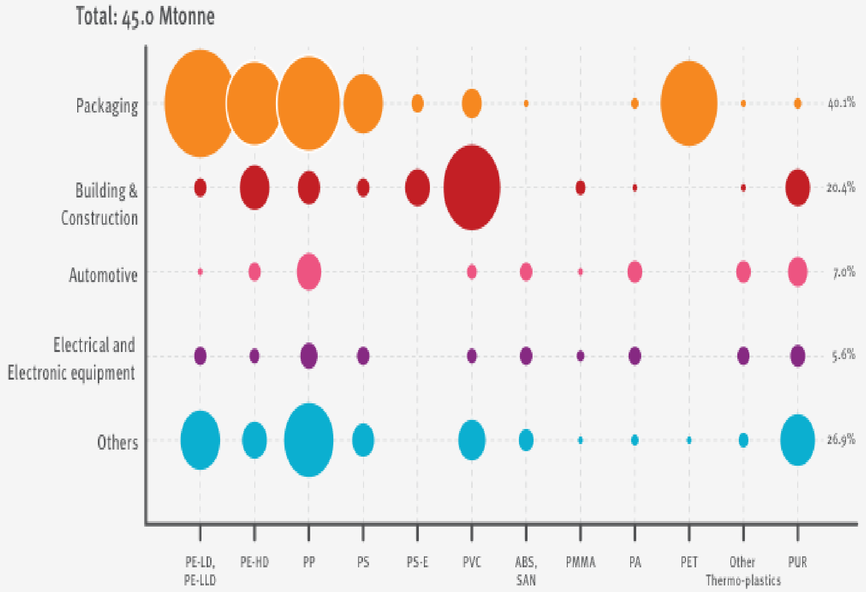
Active,
Edible and
Smart Packaging
Safety 4.0

Replacing petrol based plastics

270 million tons of non-biodegradable/non-compostable plastics are produced annually

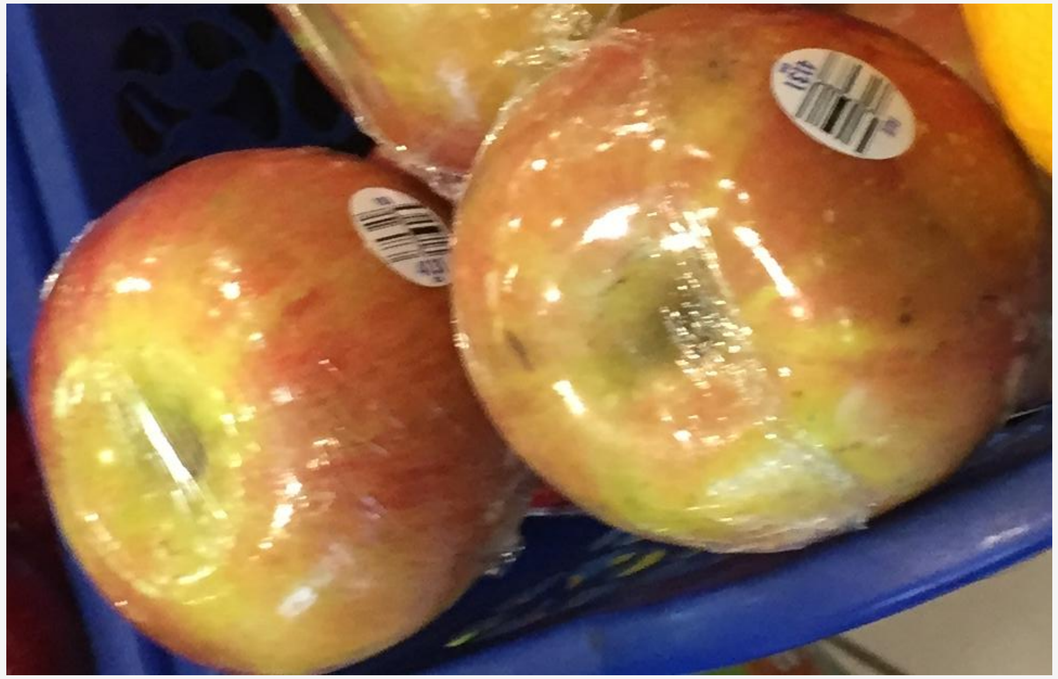
Packaging industry is the main user of synthetic plastics



(1) www.plasticseurope.org; (2) http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home; (3) http://www.clal.it/en/index.php

Active and Edible Packaging

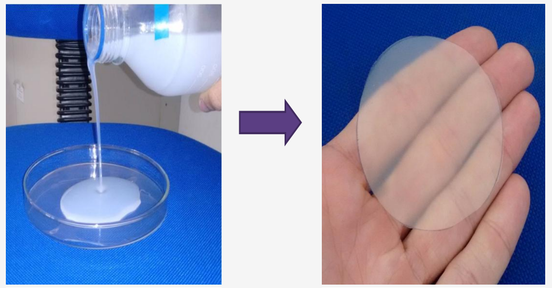
What aple do you prefer?



Antioxidant and Antimicrobial edible coatings…

Based on blends of natural biodegradable food grade biopolymers

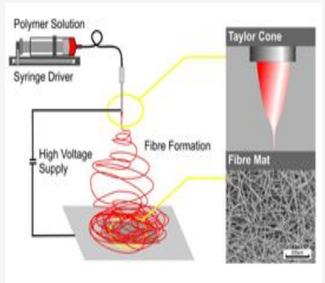
Made with bacterial cellulose, natural waxes, protein hydrolisates or polyphenols extracts

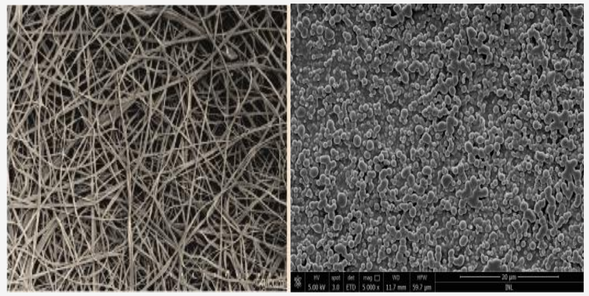


TEMPO-OXIDIZED BACTERIAL CELLULOSE SUSPENSION (CBNF)

ANTIOXIDANT FILM FROM CBNF AND PEPTIDES

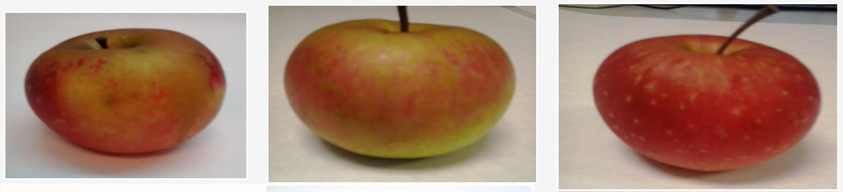
Layer-by-Layer Electrospinning





No treated | Candelilla wax coating | Candelilla wax + PPE coating

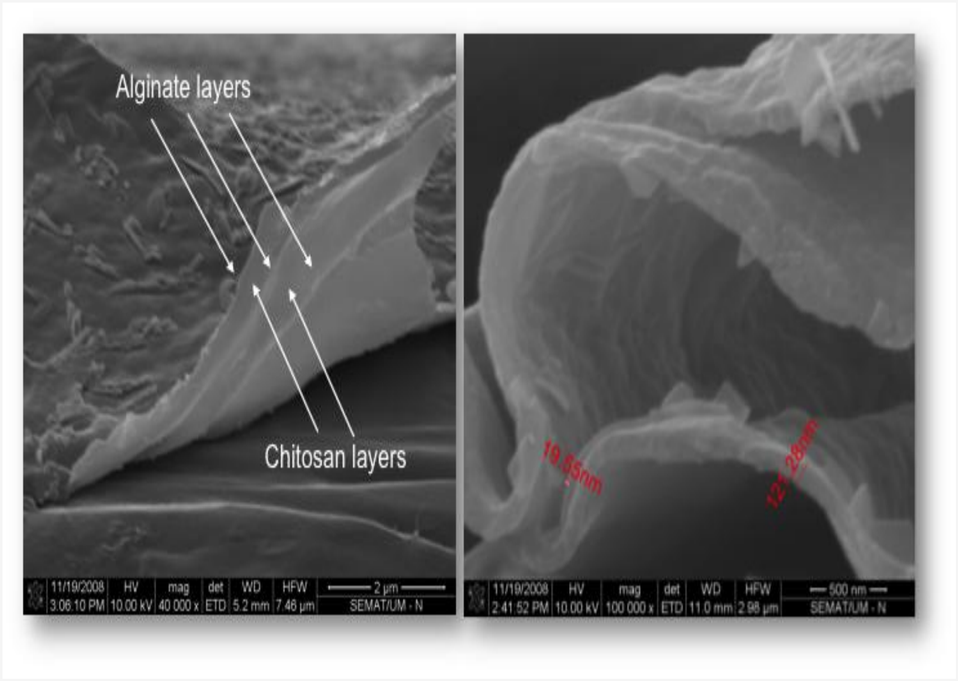
Initial



Stored:
8 weeks (5°C/90%RH)
2 weeks (25°C/90%RH

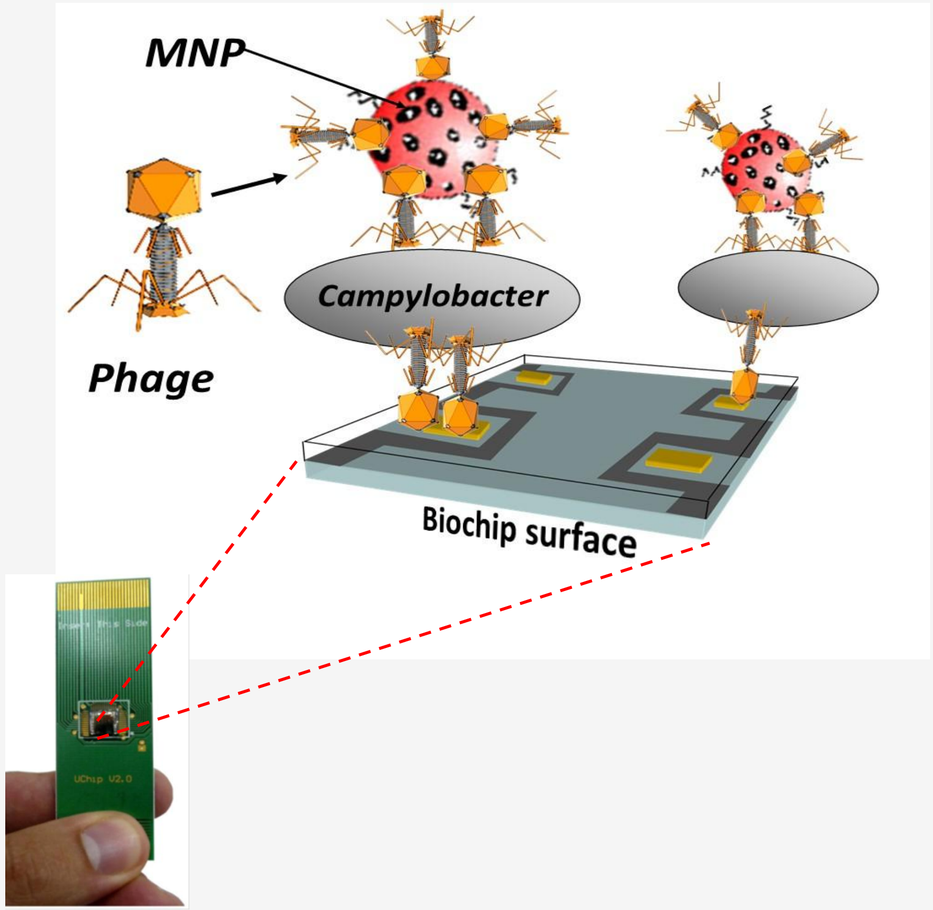
...and films

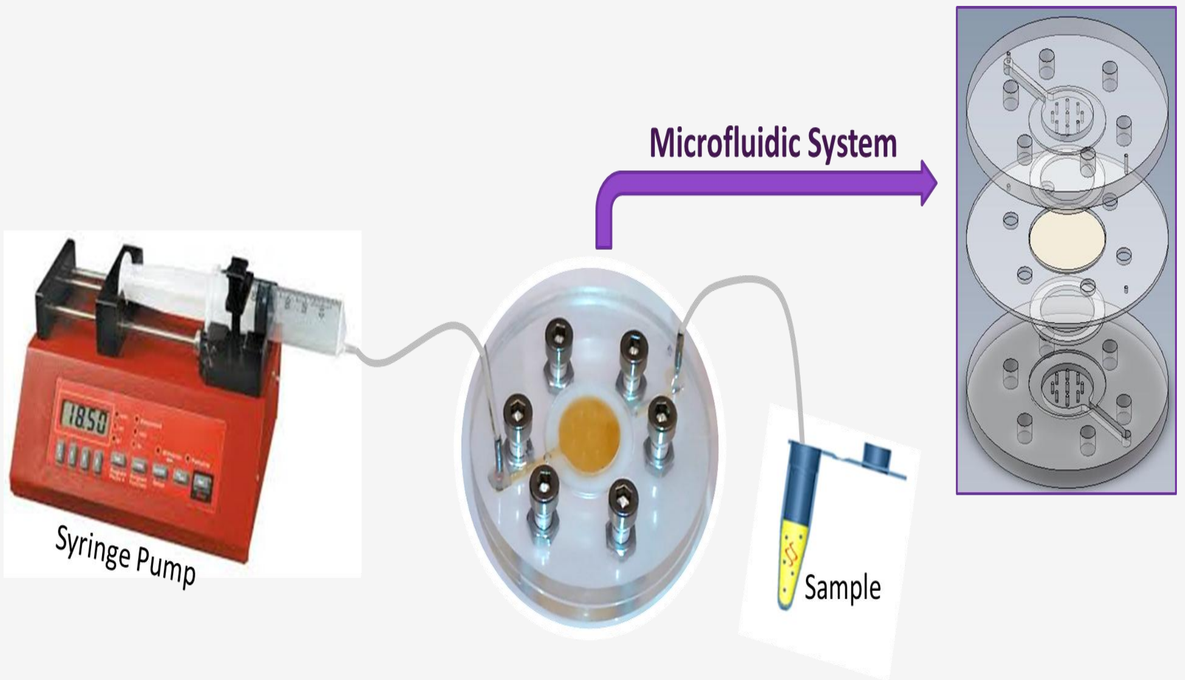
Aginate-Chitosan active films



Smart packaging

Sensors for food safety and authenticity





Anticounterfeiting

Blockchain adapted edible packaging

Integrated, repeating watermark embedded in the edible packaging material making it technically and economically challenging to duplicate

Electron beam induced photoluminiscence

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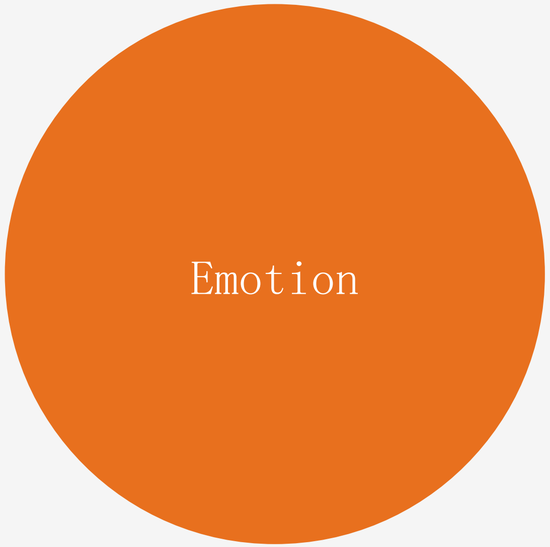
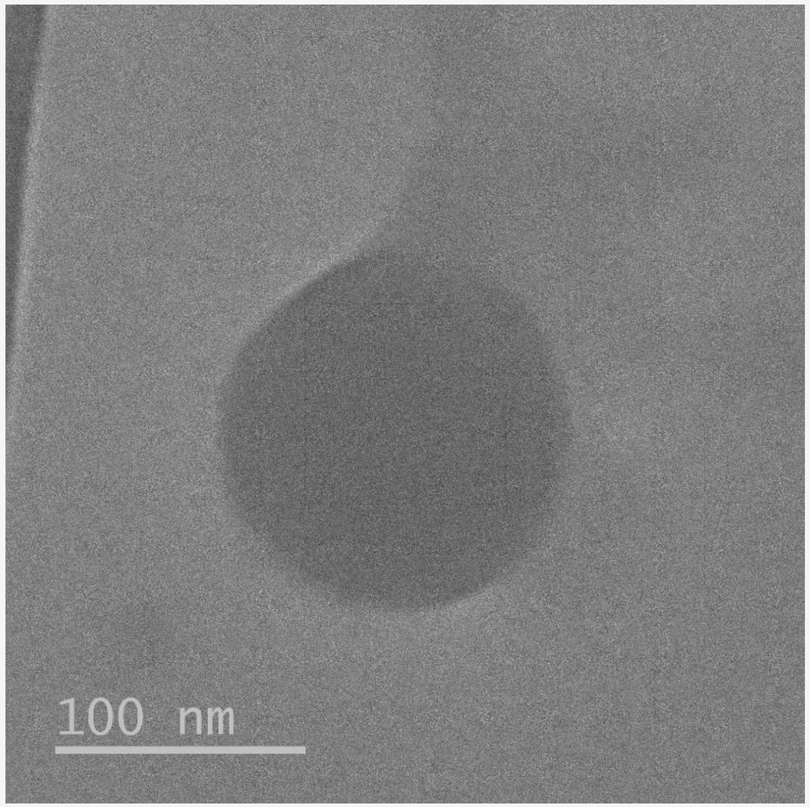


Authenticity
New experiences

Foams

Intensely coloured edible foams - Nano enabled solution

Encapsulating colorants in protein nanoparticles (coated with surfactants) and using these loaded particles for creating Pickering foams. The anchoring of the particles onto the air-water interface results in accumulation of the colorants in the foam phase.

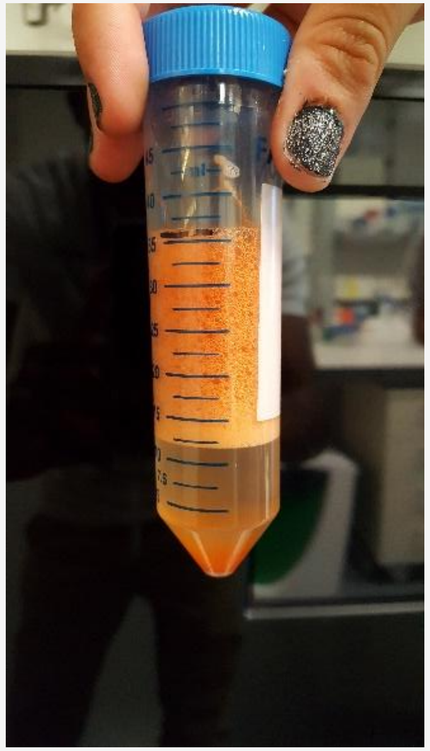


Stabilized coloured edible foams

FDC blue coloured foam stabilized by sucrose ester alone.

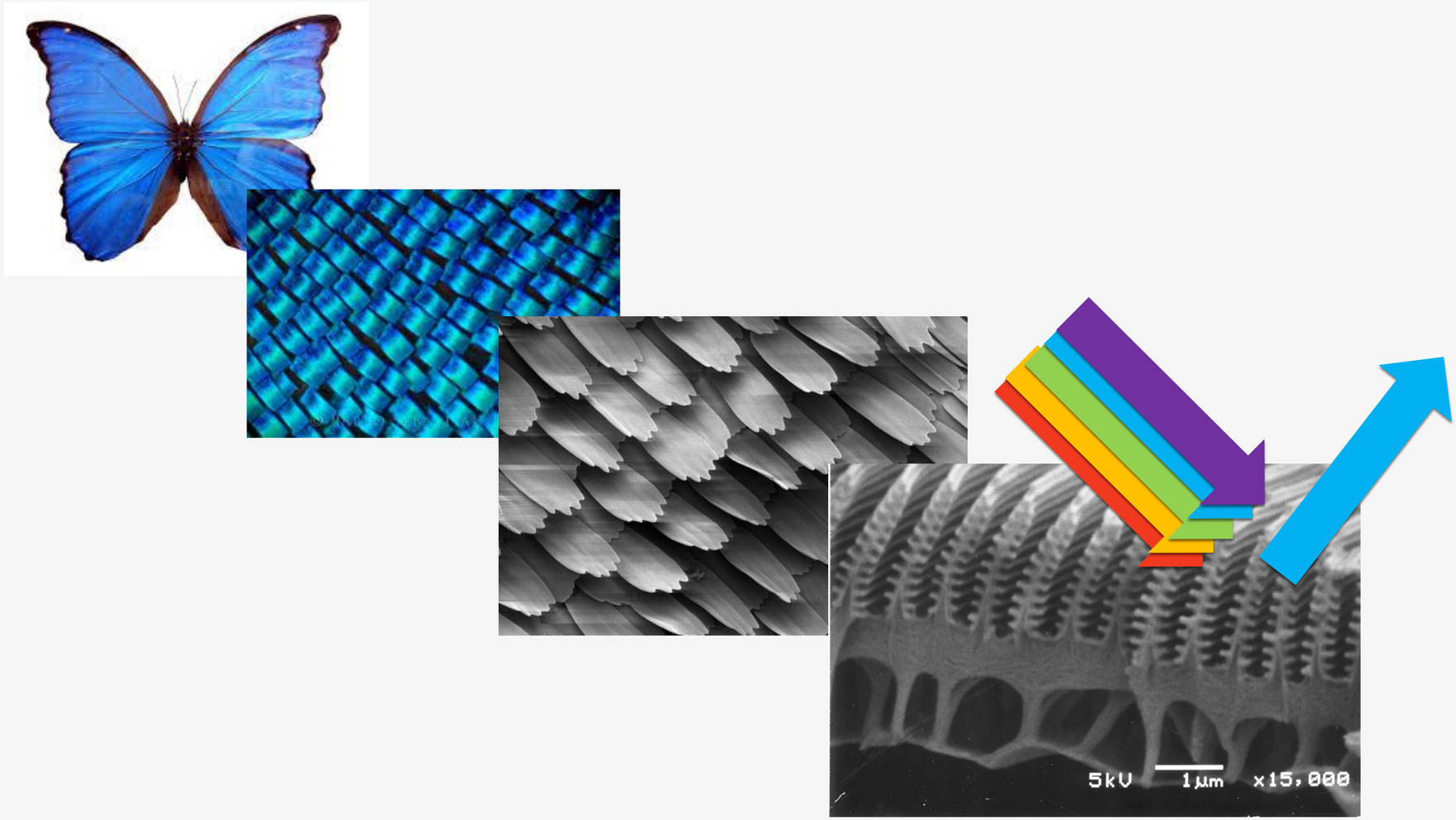
Pickering stabilized foam using color loaded zein particles as stabilizers.

β-carotene

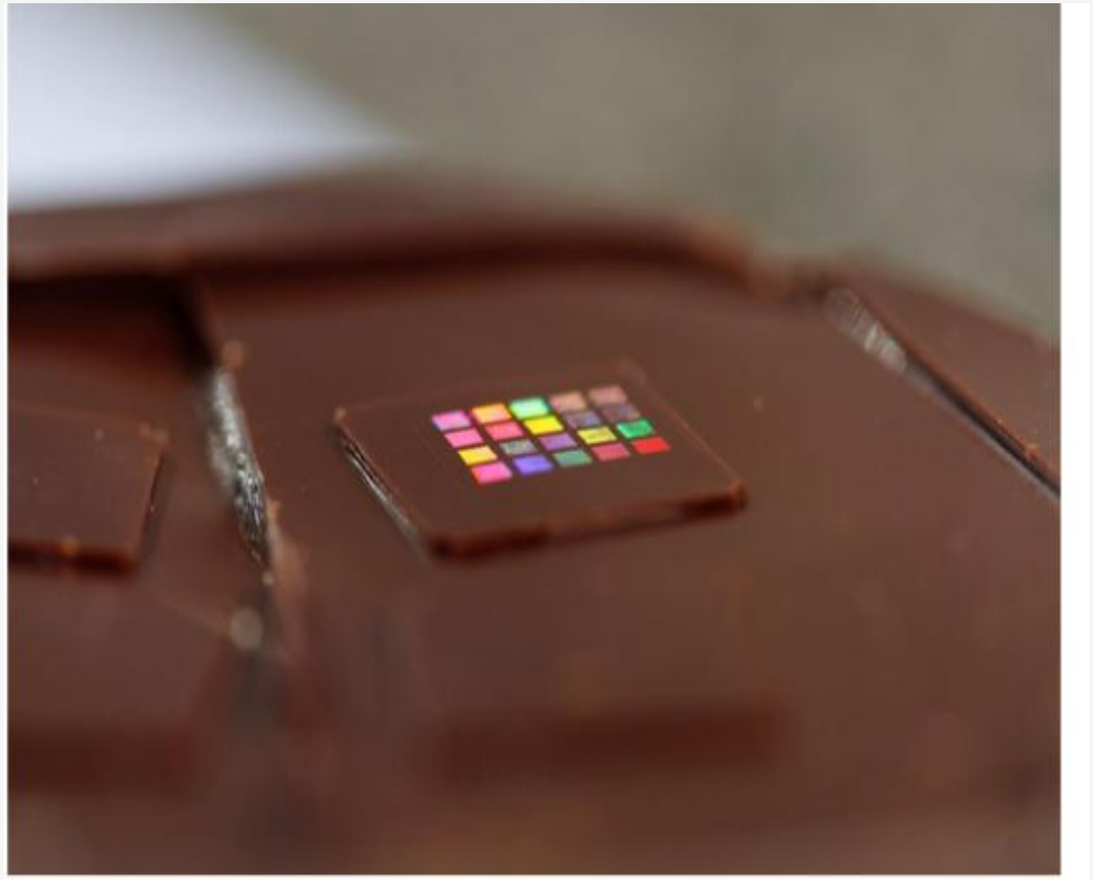


Notice the drainage of colur in the serum phase.

Structural Color



Structural Color



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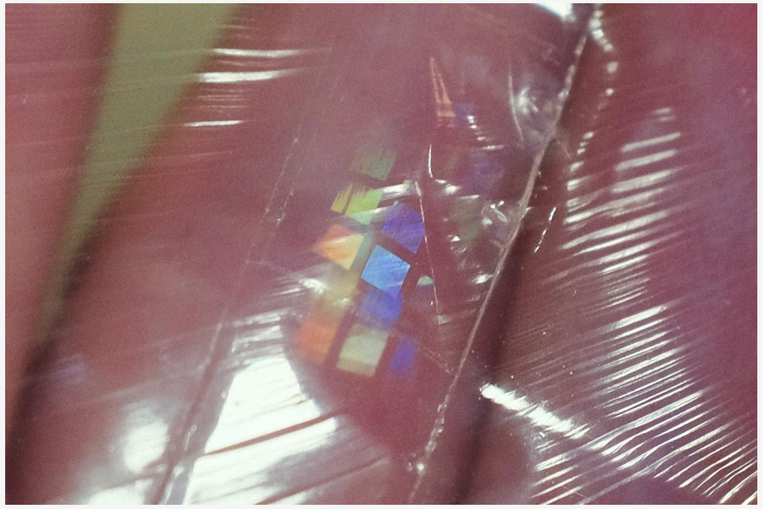

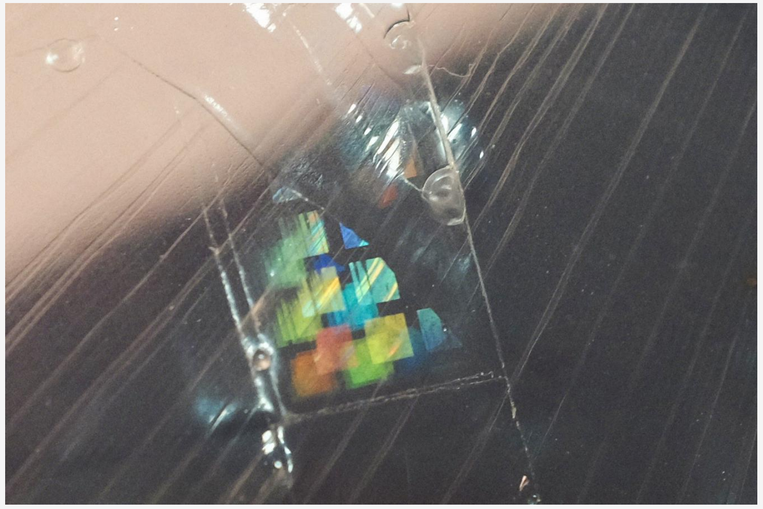

The Food NanoTeam at INL

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