Preparation and Characterization of an Oral Vaccine Formulation Using Electrosprayed Chitosan Microparticles

Chitosan particles loaded with the antigen ovalbumin (OVA) and the adjuvant Quil-A were produced by electrospray, using mixtures of water/ethanol/acetic acid as a solvent. Three different chitosans designed as HMC+70, HMC+85, and HMC+90 (called as 705010, 855010, and 905010) were tested and its efficacy to be used in oral vaccine delivery applications was investigated. The morphology, size, and zeta potential of the produced particles were investigated, together with the encapsulation efficiency and release of OVA from the three chitosan formulations. Moreover, the mucoadhesion and cytotoxicity of the chitosan microparticles was examined. All the three formulations OVA and Quil-A were in the micrometer size range and had a positive zeta potential between 46 and 75 mV. Furthermore, all the three formulations displayed encapsulation efficiencies above 80% and the release of OVA over a period of 80 h was observed to be between 38 and 47%. None of the developed formulations exhibited high mucoadhesive properties, either cytotoxicity. The formulation prepared with HMC+70, OVA, and Quil-A had the highest stability within 2 h in buffer solution, as measured by dynamic light scattering. The electrosprayed formulation consisting of HMC+70 with OVA and Quil-A showed to be the most promising as an oral vaccine system.
Biopolymers for the Nano-microencapsulation of Bioactive Ingredients by Electrohydrodynamic Processing

Electrohydrodynamic processing, including electrospinning and electrospraying, is an emerging technique for the encapsulation of bioactive ingredients (e.g. omega-3, vitamins, antioxidants, probiotics) with interest for the functional food industry. This chapter presents the fundamentals of electrohydrodynamic processes for the production of nano-microstructures (fibers or capsules) loaded with bioactive compounds. Particularly, it focuses on the properties as well as electrospinning and electrospray processing of food-grade polymers. The physicochemical characteristics of the resulting nano-microencapsulates will also be discussed. Electrospun and electrospray food-grade polymers include biopolymers such as proteins (e.g. zein, gelatin, whey, casein, amaranth, soy, egg and fish protein) and polysaccharides (e.g. pullulan, dextran, chitosan, starch, alginate, cellulose, cyclodextrin, xanthan gum), as well as blends of biopolymers with biocompatible synthetic polymers (e.g. poly-vinyl alcohol).

General information
State: Published
Organisations: National Food Institute, Research Group for Bioactives – Analysis and Application, Research Group for Nano-Bio Science
Contributors: García Moreno, P. J., Mendes, A. C. L., Jacobsen, C., Chronakis, I. S.
Pages: 447-479
Publication date: 2018

Host publication information
Title of host publication: Polymers for Food Applications
Publisher: Springer
Editor: T. J. G.
ISBN (Print): 978-3-319-94624-5
ISBN (Electronic): 978-3-319-94625-2
Development of electrospayed mucoadhesive chitosan microparticles

The efficacy of chitosan (CS) to be used as drug delivery carrier has previously been reported. However, limited work has been pursued to produce stable and mucoadhesive CS electrospayed particles for oral drug delivery, which is the aim of this study. Various CS types with different molecular weight (MW), degree of deacetylation (DD), and degree of polymerization (DP) were assessed. In addition, the effect of the solvent composition was also investigated. Results showed that stable CS electrospayed particles can be produced by dissolving 3% w/v of low MW CS in mixtures of aqueous acetic acid and ethanol (50/50% v/v). The stable CS particles displayed diameters of approximately 1 μm as determined by dynamic light scattering. The zeta potential of these particles was found to be approximately 40 mV confirming the mucoadhesion properties of these CS electrospayed particles and its potential to be used as drug delivery carrier.

General information
State: Published
Organisations: National Food Institute, Research Group for Nano-Bio Science, Department of Micro- and Nanotechnology, Nanoprobes, University of Münster
Contributors: Moreno, J. A. S., Mendes, A. C., Stephansen, K., Engwer, C., Goycoolea, F. M., Boisen, A., Nielsen, L. H., Chronakis, I. S.
Pages: 240-247
Publication date: 2018
Peer-reviewed: Yes

Publication information
Journal: Carbohydrate Polymers
Volume: 190
ISSN (Print): 0144-8617
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 5.58 SJR 1.428 SNIP 1.733
Web of Science (2017): Impact factor 5.158
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 5.15 SJR 1.419 SNIP 1.75
Web of Science (2016): Impact factor 4.811
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 4.86 SJR 1.44 SNIP 1.819
Web of Science (2015): Impact factor 4.219
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 4.69 SJR 1.587 SNIP 1.955
Web of Science (2014): Impact factor 4.074
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 4.39 SJR 1.346 SNIP 1.945
Web of Science (2013): Impact factor 3.916
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.93 SJR 1.394 SNIP 2.025
Web of Science (2012): Impact factor 3.479
Electrospun Xanthan gum-Chitosan nanofibers as delivery carrier of hydrophobic bioactives
Viscoelastic gels of xanthan gum-chitosan(X-Ch) were electrospun to produce nanofibers, stable in aqueous media, for the encapsulation and release of curcumin (Cu). After 120h, the nanofibers released lower amount of curcumin (~20%) at pH 2.2 comparatively to the release in neutral media (~50%), suggesting that X-Ch nanofibers could be used as a carrier for the encapsulation of hydrophobic bioactive compounds with long-term pH-stimulated release properties.

General information
State: Published
Organisations: National Food Institute, Research Group for Nano-Bio Science, Danish National Metrology Institute
Contributors: Shekarforoush, E., Ajalloueian, F., Zeng, G., Mendes, A. C. L., Chronakis, I. S.
Pages: 322-326
Publication date: 2018
Peer-reviewed: Yes

Publication information
Journal: Materials Letters
Volume: 228
ISSN (Print): 0167-577X
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
In vitro permeability enhancement of curcumin across Caco-2 cells monolayers using electrospun xanthan-chitosan nanofibers

Xanthan-Chitosan (X-Ch) polysaccharides nanofibers were prepared using electrospinning processing as an encapsulation and delivery system of curcumin (Cu). The X-Ch-Cu nanofibers remained stable in aqueous HBSS medium at pH 6.5 and pH 7.4, mainly due to the ability of oppositely charged xanthan-chitosan polyelectrolytes to form ionically associated electrospun nanofibers. The xanthan-chitosan-curcumin nanofibers were incubated with Caco-2 cells, and the cell viability, transepithelial transport and permeability properties across cell monolayers were investigated. After 24h of incubation, the exposure of Caco-2 cell monolayers to X-Ch-Cu nanofibers resulted in a cell viability of ~80%. A 3.4-fold increase of curcumin permeability was observed when the polyphenol was loaded into X-Ch nanofibers, compared to the free curcumin. This increased in vitro transepithelial permeation of curcumin without compromising cellular viability was induced by interactions upon contact between the nanofibers and the Caco-2 cells, leading to the opening of the tight junctions. The results obtained revealed that X-Ch nanofibers can be used for oral delivery applications of poorly water-soluble compounds at the gastrointestinal tract.

General information
State: Accepted/In press
Organisations: National Food Institute, Research Group for Nano-Bio Science
Contributors: Faralli, A., Shekarforoush, E., Ajalloueian, F., Mendes, A. C. L., Chronakis, I. S.
Publication date: 2018
Peer-reviewed: Yes

Publication information
Journal: Carbohydrate Polymers
ISSN (Print): 0144-8617
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 5.58 SJR 1.428 SNIP 1.733
Web of Science (2017): Impact factor 5.158
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 5.15 SJR 1.419 SNIP 1.75
Web of Science (2016): Impact factor 4.811
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 4.86 SJR 1.44 SNIP 1.819
Web of Science (2015): Impact factor 4.219
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 4.69 SJR 1.587 SNIP 1.955
Web of Science (2014): Impact factor 4.074
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 4.39 SJR 1.346 SNIP 1.945
Web of Science (2013): Impact factor 3.916
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.93 SJR 1.394 SNIP 2.025
Web of Science (2012): Impact factor 3.479
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Mineralization of gellan gum hydrogels with calcium and magnesium carbonates by alternate soaking in solutions of calcium/magnesium and carbonate ion solutions

Mineralization of hydrogels is desirable prior to applications in bone regeneration. CaCO3 is a widely used bone regeneration material and Mg, when used as a component of calcium phosphate biomaterials, has promoted bone-forming cell adhesion and proliferation and bone regeneration. In this study, gellan gum (GG) hydrogels were mineralized with carbonates containing different amounts of calcium (Ca) and magnesium (Mg) by alternate soaking in, firstly, a calcium and/or magnesium ion solution and, secondly, a carbonate ion solution. This alternate soaking cycle was repeated five times. Five different calcium and/or magnesium ion solutions, containing different molar ratios of Ca to Mg ranging from Mg-free to Ca-free were compared. Carbonate mineral formed in all sample groups subjected to the Ca:Mg elemental ratio in the carbonate mineral formed was higher than in the respective mineralizing solution. Mineral formed in the absence of Mg was predominantly CaCO3 in the form of a mixture of calcite and vaterite. Increasing the Mg content in the mineral formed led to the formation of magnesian calcite, decreased the total amount of the mineral formed and its crystallinity. Hydrogel mineralization and increasing Mg content in mineral formed did not obviously improve proliferation of MC3T3-E1 osteoblast-like cells or differentiation after 7 days.
Morphological, Mechanical and Mucoadhesive Properties of Electrospun Chitosan/Phospholipid Hybrid Nanofibers

This study aimed to develop hybrid electrospun chitosan–phospholipid nanofibers and investigate the effect of phospholipid (P) content and chitosans (Ch) molecular weights (Mw) and degree of acetylation (DA), on the morphological, mechanical and mucoadhesive properties of the nanofibers. Electrospun Ch/P nanofibers exhibited a smooth and uniform surface with average diameters ranging from 300 to 1000 nm, as observed by scanning electron microscopy (SEM). The average diameter of the nanofibers was observed to increase with the increase of the Mw and degree of deacetylation of Ch, and phospholipid content. The elastic and adhesive properties of the nanofibers were determined by atomic force microscopy, and displayed higher values for higher Mw and lower DA Ch used. The elastic modulus of electrospun Ch/P hybrid fibers determined for the different conditions tested was found to be in the range of 500 and 1400 MPa. Furthermore, electrospun Ch/P nanofibers displayed mucoadhesive properties expressed by the work of adhesion calculated after the compression of the nanofibers against a section of pig small intestine. Our results showed...
that the increase in phospholipid content and DA of Ch decrease the work of adhesion, while the increase of Mw resulted in slightly higher work of adhesion of the nanofibers.

**General information**

State: Published
Organisations: National Food Institute, Research Group for Nano-Bio Science, Department of Micro- and Nanotechnology, Nanoprobes, Aarhus University, Lancaster University
Number of pages: 16
Publication date: 2018
Peer-reviewed: Yes

**Publication information**

Journal: International Journal of Molecular Sciences
Volume: 19
Issue number: 8
Article number: 2266
ISSN (Print): 1661-6596
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.86 SJR 1.26 SNIP 1.124
Web of Science (2017): Impact factor 3.687
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.73 SJR 1.235 SNIP 1.15
Web of Science (2016): Impact factor 3.226
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 3.37 SJR 1.157 SNIP 1.118
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 3.06 SJR 0.991 SNIP 1.143
Web of Science (2014): Impact factor 2.862
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.83 SJR 0.769 SNIP 1.103
Web of Science (2013): Impact factor 2.339
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.86 SJR 0.77 SNIP 1.195
Web of Science (2012): Impact factor 2.464
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.95 SJR 0.787 SNIP 1.172
Web of Science (2011): Impact factor 2.598
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.659 SNIP 0.905
Web of Science (2010): Impact factor 2.279
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.358 SNIP 0.63
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.305 SNIP 0.395
Scopus rating (2007): SJR 0.262 SNIP 0.434
Phytase-mediated enzymatic mineralization of chitosan-enriched hydrogels

Hydrogels mineralized with calcium phosphate (CaP) are increasingly popular bone regeneration biomaterials. Mineralization can be achieved by phosphatase enzyme incorporation and incubation in calcium glycerophosphate (CaGP). Gellan gum (GG) hydrogels containing the enzyme phytase and chitosan oligomer were mineralized in CaGP solution and characterized with human osteoblast-like MG63 cells and adipose tissue-derived stem cells (ADSC). Phytase induced CaP formation. Chitosan concentration determined mineralization extent and hydrogel mechanical reinforcement. Phytase-induced mineralization promoted MG63 adhesion and proliferation, especially in the presence of chitosan, and was non-toxic to MG63 cells (with and without chitosan). ADSC adhesion and proliferation was poor without mineralization. Chitosan did not affect ADSC osteogenic differentiation.
Use of Electrohydrodynamic Processing for Encapsulation of Sensitive Bioactive Compounds and Applications in Food

The use of vitamins, polyphenolic antioxidants, omega-3 polyunsaturated fatty acids (PUFAs), and probiotics for the fortification of foods is increasing. However, these bioactive compounds have low stability and need to be protected to avoid deterioration in the food system itself or in the gastrointestinal tract. For that purpose, efficient encapsulation of the compounds may be required. Spray drying is one of the most commonly used encapsulation techniques in the food industry, but it uses high temperature, which can lead to decomposition of the bioactive compounds. Recently, alternative technologies such as electrospraying and electrospinning have received increasing attention. This review presents the principles of electrohydrodynamic processes for the production of nano-microstructures (NMSs) containing bioactive compounds. It provides an overview of the current use of this technology for encapsulation of bioactive compounds and discusses the future potential of the technology. Finally, the review discusses advanced microscopy techniques to study the morphology of NMSs.

General information
Bioinspired, biomimetic, double-enzymatic mineralization of hydrogels for bone regeneration with calcium carbonate

Hydrogels are popular materials for tissue regeneration. Incorporation of biologically active substances, e.g. enzymes, is straightforward. Hydrogel mineralization is desirable for bone regeneration. Here, hydrogels of Gellan Gum (GG), a biocompatible polysaccharide, were mineralized biomimetically with CaCO₃ using a double enzymatic approach. The enzymes urease (U) and carbonic anhydrase (CA) were incorporated in GG hydrogels. Hydrogels were incubated in a mineralization solution containing U substrate (urea) and calcium ions. U converts urea to ammonia (which raises pH) and CO₂. CA catalyses the reaction of CO₂ with water to form HCO₃⁻, which undergoes deprotonation to form CO₃²⁻, which react with Ca²⁺ to form insoluble CaCO₃. All hydrogels containing U+CA were mineralized more with calcite and stiffer than hydrogels containing U. Mineralization with calcite promoted proliferation and spreading of osteoblast-like cells.
Electrospinning of food proteins and polysaccharides

Nano-microfibrous structures of biopolymers with a wide range of compositions, morphologies, mechanical properties and bioactivities could be developed using electrospinning technology. This review focuses on the processing, properties, functionalization and potential applications of electrospun biopolymers. Biopolymers include proteins (gelatin, collagen, elastin, silk, soy zein, gliadin, hordein, amaranth, casein, wheat, whey, marine sources proteins), and polysaccharides (chitosan, starch, alginate, cellulose and cellulose derivatives, pullulan, dextran, cyclodextrins).

General information
State: Published
Organisations: National Food Institute, Research Group for Nano-Bio Science
Contributors: Mendes, A. C. L., Boutrup Stephansen, K., Chronakis, I. S.
Pages: 53-68
Publication date: 2017
Peer-reviewed: Yes

Publication information
Journal: Food Hydrocolloids
Volume: 68
ISSN (Print): 0268-005X
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 5.25 SJR 1.991 SNIP 1.892
Web of Science (2017): Impact factor 5.089
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.1 SJR 2.03 SNIP 2.045
Web of Science (2016): Impact factor 4.747
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.53 SJR 1.802 SNIP 1.924
Web of Science (2015): Impact factor 3.858
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.21 SJR 2.232 SNIP 2.554
Web of Science (2014): Impact factor 4.09
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.81 SJR 2.098 SNIP 2.256
Web of Science (2013): Impact factor 4.28
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.69 SJR 1.837 SNIP 2.06
Web of Science (2012): Impact factor 3.494
ISI indexed (2012): ISI indexed yes
Electrospinning of Xanthan Polysaccharide

Electrospun pure xanthan polysaccharide nanofibers are prepared using formic acid as a solvent. Morphological studies by scanning electron microscopy show that uniform fibers with average diameters ranging from 128 ± 36.7 to 240 ± 80.7 nm are formed depending on the polysaccharide concentration (0.5 to 2.5 wt/vol%). The correlation between the concentration and the rheological properties of xanthan solutions, with the morphology of the nanofibers is investigated. At the polysaccharide concentrations where nanofiber formation is observed, an increase of the elastic modulus and first normal stress differences is observed. The typical "weak gel-like" and thixotropic properties known for aqueous xanthan solutions, are not observed for the xanthan solutions in formic acid. The Fourier transform infrared spectroscopic and circular dichroism studies verify that an esterification reaction takes place, where formic acid reacts with the pyruvic acid groups of xanthan. Hence, formate groups neutralize the pyruvic charges which in turn stabilize the helical conformation of xanthan. The results obtained from size-exclusion chromatography reveal a small difference in the molecular weight of the polysaccharide when dissolved in distilled water or in formic acid.

General information
State: Published
Organisations: National Food Institute, Research Group for Nano-Bio Science, Center for Nanostructured Graphene, Department of Micro- and Nanotechnology, Self-Organized Nanoporous Materials
Contributors: Shekarforoush, E., Faralli, A., Ndoni, S., Mendes, A. C. L., Chronakis, I. S.
Number of pages: 11
Publication date: 2017
Peer-reviewed: Yes

Publication information
Journal: Macromolecular Materials & Engineering
Volume: 302
Issue number: 8
ISSN (Print): 1438-7492
Ratings:

BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.71 SJR 0.755 SNIP 0.945
Web of Science (2017): Impact factor 2.69
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.01 SJR 0.905 SNIP 0.972
Web of Science (2016): Impact factor 2.863
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.88 SJR 0.847 SNIP 1.072
Web of Science (2015): Impact factor 2.834
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.81 SJR 1.009 SNIP 1.294
Web of Science (2014): Impact factor 2.661
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.66 SJR 0.956 SNIP 1.24
Web of Science (2013): Impact factor 2.781
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.34 SJR 0.963 SNIP 1.181
Web of Science (2012): Impact factor 2.338
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.18 SJR 0.972 SNIP 1.058
Web of Science (2011): Impact factor 1.986
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.922 SNIP 0.916
Web of Science (2010): Impact factor 1.916
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.072 SNIP 0.992
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.952 SNIP 0.942
Scopus rating (2007): SJR 0.819 SNIP 0.854
Scopus rating (2006): SJR 0.939 SNIP 1.155
Scopus rating (2005): SJR 0.948 SNIP 0.943
Scopus rating (2004): SJR 0.818 SNIP 0.915
Scopus rating (2003): SJR 0.981 SNIP 1.083
Scopus rating (2002): SJR 0.557 SNIP 0.67
Scopus rating (2001): SJR 0.622 SNIP 0.77
Scopus rating (2000): SJR 0.473 SNIP 0.578
Scopus rating (1999): SJR 0.464 SNIP 0.675

Original language: English

DOIs:
10.1002/mame.201700067
Source: PublicationPreSubmission
Source-ID: 131268882
Research output: Research - peer-review › Journal article – Annual report year: 2017
Electrospun Phospholipid Fibers as Micro-Encapsulation and Antioxidant Matrices

Electrospun phospholipid (asolectin) microfibers were investigated as antioxidants and encapsulation matrices for curcumin and vanillin. These phospholipid microfibers exhibited antioxidant properties which increased after the encapsulation of both curcumin and vanillin. The total antioxidant capacity (TAC) and the total phenolic content (TPC) of curcumin/phospholipid and vanillin/phospholipid microfibers remained stable over time at different temperatures (refrigerated, ambient) and pressures (vacuum, ambient). ¹H-NMR confirmed the chemical stability of both encapsulated curcumin and vanillin within phospholipid fibers. Release studies in aqueous media revealed that the phenolic bioactives were released mainly due to swelling of the phospholipid fiber matrix over time. The above studies confirm the efficacy of electrospun phospholipid microfibers as encapsulation and antioxidant systems.

General information
State: Published
Organisations: National Food Institute, Research Group for Nano-Bio Science, Department of Chemistry, Organic Chemistry
Contributors: Shekarforoush, E., Mendes, A. C. L., Baj, V., Beeren, S. R., Chronakis, I. S.
Number of pages: 16
Publication date: 2017
Peer-reviewed: Yes

Publication information
Journal: Molecules
Volume: 22
Issue number: 10
Article number: 1708
ISSN (Print): 1420-3049
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.27 SJR 0.855 SNIP 1.146
Web of Science (2017): Impact factor 3.098
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.09 SJR 0.825 SNIP 1.257
Web of Science (2016): Impact factor 2.861
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.65 SJR 0.57 SNIP 1.164
Web of Science (2015): Impact factor 2.465
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.62 SJR 0.738 SNIP 1.3
Web of Science (2014): Impact factor 2.416
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.61 SJR 0.719 SNIP 1.268
Web of Science (2013): Impact factor 2.095
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.87 SJR 0.792 SNIP 1.363
Web of Science (2012): Impact factor 2.428
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.54 SJR 0.72 SNIP 1.119
Web of Science (2011): Impact factor 2.386
Electrospun Polymer Fiber Lasers for Applications in Vapor Sensing

A sensing approach based on laser emission from polymer fiber networks is presented. Poly(methyl methacrylate) (PMMA) fibers doped with a laser dye are fabricated by electrospinning. They form random loop resonators, which show laser emission upon optical pumping. The shift of the spectral position of the narrow lasing modes upon uptake of alcohol vapors (model vapors are methanol and ethanol) serves as sensor signal. Thus, the high sensitivity related to the spectral line shifts of cavity-based transducers can be combined with the fiber’s large surface to volume ratio. The resulting optical sensors feature excellent sensing performance due to the large overlap (more than 80%) of light field and transducer. The shift of the laser modes results from the swelling of the polymer when exposed to solvent vapors. Due to distinctly different diffusion coefficients in polymers, the uptake dynamics reflected in the transient shift of the lasing peaks can be used to discriminate ethanol and methanol vapor in mixtures of them. The sensing mechanism is expected to be applicable to other solvent vapors that cause polymer swelling.

General information

State: Published
Organisations: Department of Micro- and Nanotechnology, National Food Institute, Research Group for Nano-Bio Science, Center for Nanostructured Graphene, Optofluidics, Karlsruhe Institute of Technology
Number of pages: 5
Publication date: 2017
Peer-reviewed: Yes

Publication information

Journal: Advanced Optical Materials
Volume: 5
Issue number: 17
Article number: 1700248
ISSN (Print): 2195-1071
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
Electrostatic Self-Assembly of Polysaccharides into Nanofibers

In this study, the anionic polysaccharide Xanthan gum (X) was mixed with positively charged Chitosan oligomers (ChO), and used as building blocks, to generate novel nanofibers by electrostatic self-assembly in aqueous conditions. Different concentrations, ionic strength and order of mixing of both components were tested and observed to affect the diameter, which ranged from 100 to 500 nm, and morphology of the self-assembled nanofibers. The release of diclofenac, as model drug, from self-assembled xanthan-chitosan nanofibers was demonstrated, suggesting that these nanostructures can be used in applications within life sciences such as drug delivery.
Enzymatic, urease-mediated mineralization of gellan gum hydrogel with calcium carbonate, magnesium-enriched calcium carbonate and magnesium carbonate for bone regeneration applications

Mineralization of hydrogel biomaterials is considered desirable to improve their suitability as materials for bone regeneration. Calcium carbonate (CaCO₃) has been successfully applied as a bone regeneration material, but hydrogel-CaCO₃ composites have received less attention. Magnesium (Mg) has been used as a component of calcium phosphate biomaterials to stimulate bone-forming cell adhesion and proliferation and bone regeneration in vivo, but its effect as a component of carbonate-based biomaterials remains uninvestigated. In the present study, gellan gum (GG) hydrogels were mineralized enzymatically with CaCO₃, Mg-enriched CaCO₃ and magnesium carbonate to generate composite biomaterials for bone regeneration. Hydrogels loaded with the enzyme urease were mineralized by incubation in mineralization media containing urea and different ratios of calcium and magnesium ions. Increasing the magnesium concentration decreased mineral crystallinity. At low magnesium concentrations calcite was formed, while at higher concentrations magnesian calcite was formed. Hydromagnesite (Mg₅(CO₃)₄(OH)₂.4H₂O) formed at high magnesium concentration in the absence of calcium. The amount of mineral formed and compressive strength decreased with...
increasing magnesium concentration in the mineralization medium. The calcium:magnesium elemental ratio in the mineral formed was higher than in the respective mineralization media. Mineralization of hydrogels with calcite or magnesian calcite promoted adhesion and growth of osteoblast-like cells. Hydrogels mineralized with hydromagnesite displayed higher cytotoxicity. In conclusion, enzymatic mineralization of GG hydrogels with CaCO3 in the form of calcite successfully reinforced hydrogels and promoted osteoblast-like cell adhesion and growth, but magnesium enrichment had no definitive positive effect. Copyright © 2017 John Wiley & Sons, Ltd.
Hybrid hydrogels by the co-assembly of chitosan with phospholipids

**General information**
State: Published
Organisations: National Food Institute, Research Group for Nano-Bio Science, Westfälische Wilhelms-Universität Münster
Contributors: Shekarforoush, E., Mendes, A. C. L., Engwer, C., Goycoolea, F., Chronakis, I. S.
Number of pages: 1
Publication date: 2017
Peer-reviewed: Yes
Event: Abstract from The Annual European Rheology Conference (AERC2017), Copenhagen, Denmark.
Electronic versions:
Elham_Abstract_.pdf

Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2017

The electrospinning of xanthan gum: from solution to nanofiber formation

**General information**
State: Published
Organisations: National Food Institute, Research Group for Nano-Bio Science
Contributors: Shekarforoush, E., Mendes, A. C. L., Chronakis, I. S.
Pages: 235-235
Publication date: 2017

**Host publication information**
Title of host publication: ANNIC 2017 - Book of abstracts
Place of publication: Rome, Italy
Article number: 632
Electronic versions:
ANNIC2017_Book_Of_Abstrac. pdf
Source: PublicationPreSubmission
Source-ID: 139478679

Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

Chitosan/Phospholipids Hybrid Nanofibers and Hydrogels for Life Sciences Applications

**General information**
State: Published
Organisations: National Food Institute, Research Group for Nano-Bio Science
Contributors: Mendes, A. C. L., Shekarforoush, E., Sevilla Moreno, J. A., Chronakis, I. S.
Number of pages: 1
Publication date: 2016
Peer-reviewed: Yes
URLs:
http://www.sustain.dtu.dk/

**Bibliographical note**
Sustain Abstract H-8
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Co-assembly of chitosan and phospholipids into hybrid hydrogels
Novel hybrid hydrogels were formed by adding chitosan (Ch) to phospholipids (P) self-assembled particles in lactic acid. The effect of the phospholipid concentration on the hydrogel properties was investigated and was observed to affect the rate of hydrogel formation and viscoelastic properties. A lower concentration of phospholipids (0.5% wt/v) in the mixture, facilitates faster network formation as observed by Dynamic Light Scattering, with lower elastic modulus than the hydrogels formed with higher phospholipid content. The nano-porous structure of Ch/P hydrogels, with a diameter of
260±20 nm, as observed by cryo-scanning electron microscopy, facilitated the penetration of water and swelling. Cell studies revealed suitable biocompatibility of the Ch/P hydrogels that can be used within life sciences applications.
**Electrospinning of Chitosan-Xanthan Nanofibers**

Electrospun chitosan-xanthan gum nanofibers were produced and the correlation between the rheological properties of chitosan-xanthan solutions and electrospinability were investigated at different xanthan gum concentrations. Uniform chitosan-xanthan nanofibers with diameters ranging from 382±182 to 842±296 nm were developed based on the chitosan-xanthan gum content. Overall chitosan-xanthan gum solutions exhibited shear thinning behavior for all the concentrations tested, which tended to increase with the increase of concentration of xanthan. Furthermore the electrical conductivity of the chitosan-xanthan solutions was observed to increase with the increase of xanthan gum concentrations. We can conclude that the optimal electrospinning process is directed by the apparent viscosity properties and the electrical conductivity of the chitosan-xanthan solutions. We are currently investigating the utilisation of these electrospun chitosan-xanthan nanofibers as a carrier for bioactive compounds.

**General information**

State: Published
Organisations: National Food Institute, Research Group for Nano-Bio Science
Contributors: Shekarforoush, E., Mendes, A. C. L., Chronakis, I. S.
Number of pages: 1
Publication date: 2016
Peer-reviewed: Yes

**Bibliographical note**

Sustain Abstract H-7
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2016

**Enzymatic, urease-mediated mineralization of gellan gum hydrogel with calcium carbonate, magnesium-enriched calcium carbonate and magnesium carbonate for bone regeneration applications**

Introduction: Mineralization of hydrogel biomaterials is considered desirable to improve their suitability as materials for bone regeneration[1],[2]. Hydrogels have been most commonly mineralized with calcium phosphate (CaP), but hydrogel-CaCO3 composites have received less attention. Magnesium (Mg) has been added to CaP to stimulate cell adhesion and proliferation and bone regeneration in vivo, but its effect as a component of carbonate-based biomaterials remains uninvestigated. In this study, gellan gum (GG) hydrogels were mineralized enzymatically with (CaCO3), Mg-enriched CaCO3 and magnesium carbonate to generate composite biomaterials for bone regeneration. GG is an inexpensive, biotechnologically produced anionic polysaccharide, from which hydrogels for cartilage regeneration have been formed by crosslinking with divalent ions[3].

Methods: GG hydrogels were loaded with the enzyme urease by incubation in 5% (w/v) urease solution and mineralized for 5 days in five different media denoted as UA, UB, UC, UD and UE, which contained urea (0.17 M) and different concentrations of CaCl2 and MgCl2 (270:0, 202.5:67.5, 135:135, 67.5:202.5 and 0:250, respectively (mmol dm-3)). Discs were autoclaved and subjected to physiochemical, mechanical and cell biological characterization.

Results: FTIR, SEM, TGA and XRD analysis revealed that increasing magnesium concentration decreased mineral crystallinity. At low magnesium concentrations calcite was formed, while at higher concentrations magnesium calcite was formed. Hydromagnesite formed at high magnesium concentration in the absence of calcium. Amount of mineral formed and compressive strength decreased with increasing magnesium concentration in the mineralization medium. ICP analysis revealed that Ca:Mg elemental ratio in the mineral formed was higher than in the respective mineralization media. Mineralization of hydrogels promoted adhesion and growth of osteoblast-like cells, which were supported best on mineralized hydrogels containing no or little magnesium. Hydrogels mineralized with hydromagnesite displayed higher
cytotoxicity.

Discussion: Enzymatic mineralization of GG hydrogels with CaCO3 in the form of calcite successfully reinforced hydrogels and promoted osteoblast-like cell adhesion and growth, but Mg enrichment had no positive effect. This is in contrast with other studies reporting that incorporation of Mg into GG mineralized with CaP promotes cell adhesion and proliferation[4].

Conclusion: Sample groups UA and UB seem to be the most promising due to the superior amount of mineral formed and cell adhesion and proliferation.

Hybrid electrospun chitosan-phospholipids nanofibers for transdermal drug delivery
Chitosan (Ch) polysaccharide was mixed with phospholipids (P) to generate electrospun hybrid nanofibers intended to be used as platforms for transdermal drug delivery. Ch/P nanofibers exhibited average diameters ranging from 248 +/- 94 nm to 600 +/- 201 nm, depending on the amount of phospholipids used. Fourier Transformed Infra-Red (FTIR) spectroscopy and Dynamic Light Scattering (DLS) data suggested the occurrence of electrostatic interactions between amine groups of chitosan with the phospholipid counterparts. The nanofibers were shown to be stable for at least 7 days in Phosphate Buffer Saline (PBS) solution. Cytotoxicity studies (WST-1 and LDH assays) demonstrated that the hybrid nanofibers have suitable biocompatibility. Fluorescence microscopy, also suggested that L929 cells seeded on top of the CH/P hybrid have similar metabolic activity comparatively to the cells seeded on tissue culture plate (control). The release of curcumin, diclofenac and vitamin B12, as model drugs, from Ch/P hybrid nanofibers was investigated, demonstrating their potential utilization as a transdermal drug delivery system.
Web of Science (2017): Impact factor 3.862
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.24 SJR 1.323 SNIP 1.386
Web of Science (2016): Impact factor 3.649
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 4.2 SJR 1.298 SNIP 1.45
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 4.13 SJR 1.347 SNIP 1.551
Web of Science (2014): Impact factor 3.65
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 4.17 SJR 1.377 SNIP 1.605
Web of Science (2013): Impact factor 3.785
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 4.1 SJR 1.552 SNIP 1.637
Web of Science (2012): Impact factor 3.458
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 4.01 SJR 1.493 SNIP 1.619
Web of Science (2011): Impact factor 3.35
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.574 SNIP 1.608
Web of Science (2010): Impact factor 3.607
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.399 SNIP 1.53
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.227 SNIP 1.575
Scopus rating (2007): SJR 1.186 SNIP 1.527
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.995 SNIP 1.398
Scopus rating (2005): SJR 1.043 SNIP 1.589
Scopus rating (2004): SJR 1.045 SNIP 1.464
Scopus rating (2003): SJR 0.981 SNIP 1.355
Scopus rating (2002): SJR 0.793 SNIP 1.265
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.74 SNIP 1.047
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.703 SNIP 1.05
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.616 SNIP 0.978
Original language: English
Keywords: Electrospinning, Nanofibers, Transdermal drug delivery, Chitosan, Phospholipids, Pharmaceutical Science
DOIs:
10.1016/j.ijpharm.2016.06.016
Optical sensors from electrohydrodynamic jetted polymer fiber resonators
Electrohydrodynamic jetting is used to manufacture dye-doped polymer fiber resonators. We present comb-like laser emission from different polymer/dye combinations and report the use of these structures as sensitive detection of ethanol and methanol.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Optofluidics, National Food Institute, Research Group for Nano-Bio Science, Center for Nanostructured Graphene, Karlsruhe Institute of Technology
Number of pages: 2
Publication date: 2016

Host publication information
Title of host publication: CLEO: Applications and Technology 2016
Place of publication: San Jose, California United States
Publisher: OSA Publishing
Article number: JTu5A.146
DOIs: 10.1364/CLEO_AT.2016.JTu5A.146

Bibliographical note
Source: PublicationPreSubmission
Source-ID: 127114515
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2016

Effects of electrospun chitosan wrapping for dry-ageing of beef, as studied by microbiological, physicochemical and low-field nuclear magnetic resonance analysis
The effects of using electrospun chitosan fibres as a wrapping material for dry-ageing beef was studied and compared to traditional dry-ageing and wet-ageing of beef for up to 21 days. The chitosan treatment showed improved results in terms of yield, reduction of microbial counts, yeasts and moulds, and lighter appearance compared to traditional dry-ageing. Weight and trimming losses were minimal in the wet-ageing beef. However, significant growth of lactic acid bacteria was observed in this group. Transverse relaxation times indicated a lower degree of muscle denaturation during ageing in the chitosan dry-ageing beef compared to the traditional dry-ageing meat. A principal component analysis furthermore indicated that 60.6% of the variation between samples and ageing treatments could be described by differences in the water content and distribution in the muscle. The study showed that electrospun chitosan fibre mats have potential as a wrapping material for improved quality during dry-ageing of beef.

General information
State: Published
Organisations: National Food Institute, Division of Industrial Food Research, University of Copenhagen
Contributors: Guðjónsdóttir, M., Gacutan, M. D., Mendes, A. C. L., Chronakis, I. S., Jespersen, L., Karlsson, A. H.
Number of pages: 9
Pages: 167-175
Publication date: 2015
Peer-reviewed: Yes

Publication information
Journal: Food Chemistry
Volume: 184
ISSN (Print): 0308-8146
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 5.19 SJR 1.793 SNIP 2.109
Web of Science (2017): Impact factor 4.946
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.85 SJR 1.731 SNIP 2.095
Web of Science (2016): Impact factor 4.529
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.31 SJR 1.582 SNIP 1.946
Web of Science (2015): Impact factor 4.052
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.92 SJR 1.557 SNIP 2.01
Web of Science (2014): Impact factor 3.391
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.87 SJR 1.554 SNIP 2.056
Web of Science (2013): Impact factor 3.259
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.98 SJR 1.762 SNIP 2.342
Web of Science (2012): Impact factor 3.334
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.17 SJR 1.911 SNIP 2.383
Web of Science (2011): Impact factor 3.655
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.981 SNIP 2.253
Web of Science (2010): Impact factor 3.458
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.789 SNIP 2.023
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.47 SNIP 1.706
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.475 SNIP 2.087
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.028 SNIP 1.526
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.077 SNIP 1.438
Scopus rating (2003): SJR 0.876 SNIP 1.248
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.966 SNIP 1.235
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.785 SNIP 0.975
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.588 SNIP 0.961
Highly functionalized nano-microstructures for Bioengineering

Nanomechanics of electrospun phospholipid fiber
Electrospun asolectin phospholipid fibers were prepared using isooctane as a solvent and had an average diameter of 6.1 +/- 2.7 μm. Their mechanical properties were evaluated by nanoindentation using Atomic Force Microscopy, and their elastic modulus was found to be approximately 17.2 +/- 1 MPa. At a cycle of piezo expansion-retraction (loading-unloading) of a silicon tip on a fiber, relatively high adhesion was observed during unloading. It is proposed that this was primarily due to molecular rearrangements at the utmost layers of the fiber caused by the indentation of the hydrophilic tip. The phospholipid fibers were shown to be stable in ambient conditions, preserving the modulus of elasticity up to 24 h. (c) 2015 AIP Publishing LLC.
Device, method and system for preparing microcapsules

The invention discloses a novel device for the formation of microcapsules based on micro-droplet generation inside silicone tubing, which is punctured with a blunt-ended syringe needle vertically (1). The device uses droplet generation by vertical injection of hydrophilic polymer/cell mixture into hydrophobic oil flow, which is horizontally maintained in the silicone tubing. The injection of polymer/cell mixture into a stream of mineral oil results in the generation of spherical droplet and in the formation of a water-in-oil emulsion due to the immiscibility of the two phases. Subsequently, the microdroplets in oil phase are converted into stable microcapsules by gelation in a separate chamber which is loaded with ionic cross-linking solution at physiological ionic strength and pH. The utility of the microcapsules generated by the device of present invention is virtually unlimited in the fields of regenerative medicine, controlled delivery of growth factor or drug

Enzyme Prodrug Therapy Engineered into Biomaterials

In this work, enzyme-prodrug therapy (EPT) is engineered into hydrogel biomaterials to achieve localized synthesis of the drugs and their delivery to the adhering cells. The use of EPT in the context of drug delivery mediated by biomaterials significantly empowers the latter in that the same hydrogel is used to successfully synthesize several drugs with dissimilar structures and therapeutic effects. The concentration of the synthesized drugs is conveniently controlled by the concentration of the administered prodrugs. Using prodrugs for two therapeutic agents allows their synthesis and delivery with independent control over the concentration and the time of administration of each of the drugs. Using these tools, sequential delivery of drugs for anti-inflammatory and anti-proliferative activity is accomplished whereby the synthesis of drugs is mediated by the same enzyme-functionalized hydrogel. The use of EPT to perform combination therapy mediated by an implantable biomaterial is also reported. Taken together, these results contribute significantly to the development of flexible and highly powerful tools of substrate-mediated drug delivery with applications in the design of therapeutic implants and tissue engineering.

General information
State: Published
Organisations: National Food Institute, Division of Industrial Food Research
Contributors: Azevedo, P. D. S. S., Baran, E. T., Mendes, A. C. L., Reis, R. L. G. D.
Publication date: 2014

General information
State: Published
Organisations: Aarhus University
Contributors: Mendes, A. C. L., Zelikin, A. N.
Co-Assembled and Microfabricated Bioactive Membranes

The fabrication of hierarchical and bioactive self-supporting membranes, which integrate physical and biomolecular elements, using a single-step process that combines molecular self-assembly with soft lithography is reported. A positively charged multidomain peptide (with or without the cell-adhesive sequence arginine-glycine-aspartic acid-serine (RGDS)) self-assembles with hyaluronic acid (HA), an anionic biopolymer. Optimization of the assembling conditions enables the realization of membranes with well-controlled and easily tunable features at multiple size scales including peptide sequence, building-block co-assembly, membrane thickness, bioactive epitope availability, and topographical pattern morphology. Membrane structure, morphology, and bioactivity are investigated according to temperature, assembly time,
and variations in the experimental setup. Furthermore, to evaluate the physical and biomolecular signaling of the self-assembled microfabricated membranes, rat mesenchymal stem cells are cultured on membranes exhibiting various densities of RGDS and different topographical patterns. Cell adhesion, spreading, and morphology are significantly affected by the surface topographical patterns and the different concentrations of RGDS. The versatility of the combined bottom-up and top-down fabrication processes described may permit the development of hierarchical macrostructures with precise biomolecular and physical properties and the opportunity to fine tune them with spatiotemporal control.

General information
State: Published
Organisations: University of Minho
Contributors: Mendes, A. C. L., Smith, K. H., Tejeda-Montes, E., Engel, E., Reis, R. L., Azevedo, H. S., Mata, A.
Number of pages: 9
Pages: 430-438
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: Advanced Functional Materials
Volume: 23
Issue number: 4
ISSN (Print): 1616-301X
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 12.51
Web of Science (2017): Impact factor 13.325
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 11.56
Web of Science (2016): Impact factor 12.124
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 11.93
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 11.32
Web of Science (2014): Impact factor 11.805
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 10.6
Web of Science (2013): Impact factor 10.439
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 10.41
Web of Science (2012): Impact factor 9.765
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 9.47
Web of Science (2011): Impact factor 10.179
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Web of Science (2010): Impact factor 8.508
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Fabrication of phospholipid-xanthan microcapsules by combining microfluidics with self-assembly

We report the synthesis of an amphiphilic polysaccharide, a phospholipid (1,2-dioleoyl-sn-glycerophosphoethanolamine, DOPE) conjugated with the anionic xanthan gum, and its ability to spontaneously self-assemble under mild aqueous conditions. This work also aimed to apply a microfluidic platform that can precisely fabricate microsized and monodispersed capsules for cell encapsulation. Stable hollow capsular structures were obtained by the generation of homogeneous spherical droplets of the self-assembled polymer in the microfluidic device through the formation of a water-in-oil emulsion, followed by the stabilization of the polymer aggregates in a separate collection vessel containing phosphate-buffered saline (physiological ionic strength and pH). The properties (size, morphology, permeability) and performance (stability) of the obtained microcapsules were studied, as well their ability to support the viability, function and proliferation of encapsulated cells. ATDC5 cells were encapsulated within the capsules and shown to remain viable, evidencing increased cellular metabolic activity over 21 days of in vitro culture. By combining microfluidic droplet generation and self-assembly of xanthan-DOPE, we were able to fabricate microcapsules that provided an adequate environment for cells to survive and proliferate. (C) 2013 Acta Materialia Inc. Published by Elsevier Ltd. All rights reserved.
Self-assembly in nature: using the principles of nature to create complex nanobiomaterials

Self-assembly is a ubiquitous process in biology where it plays numerous important roles and underlies the formation of a wide variety of complex biological structures. Over the past two decades, materials scientists have aspired to exploit nature's assembly principles to create artificial materials, with hierarchical structures and tailored properties, for the fabrication of functional devices. Toward this goal, both biological and synthetic building blocks have been subject of extensive research in self-assembly. In fact, molecular self-assembly is becoming increasingly important for the fabrication of biomaterials because it offers a great platform for constructing materials with high level of precision and complexity, integrating order and dynamics, to achieve functions such as stimuli-responsiveness, adaptation, recognition, transport, and catalysis. The importance of peptide self-assembling building blocks has been recognized in the last years, as demonstrated by the literature available on the topic. The simple structure of peptides, as well as their facile synthesis, makes peptides an excellent family of structural units for the bottom-up fabrication of complex nanobiomaterials. Additionally, peptides offer a great diversity of biochemical (specificity, intrinsic bioactivity, biodegradability) and physical (small size, conformation) properties to form self-assembled structures with different molecular configurations. The motivation of this review is to provide an overview on the design principles for peptide self-assembly and to illustrate how these principles have been applied to manipulate their self-assembly across the scales. Applications of self-assembling peptides as nanobiomaterials, including carriers for drug delivery, hydrogels for cell culture and tissue repair are also described. (C) 2013 Wiley Periodicals, Inc.
Degradation studies of hydrophilic, partially degradable and bioactive cements (HDBCs) incorporating chemically modified starch

The degradation rate in Hydrophilic, Degradable and Bioactive Cements (HDBCs) containing starch/cellulose acetate blends (SCA) is still low. In order to increase degradation, higher amounts of starch are required to exceed the percolation threshold. In this work, gelatinization, acetylation and methacrylation of corn starch were performed and assessed as candidates to replace SCA in HDBCs. Formulations containing methacrylated starch were prepared with different molar ratios of 2-hydroxyethyl methacrylate and methyl methacrylate in the liquid component and the amount of residual monomer released into water was evaluated. The concentration of reducing sugars, percentage of weight loss and
morphologic analyses after degradation all confirmed increased degradation of HDBC with alpha-amylase, with the appearance of pores and voids from enzymatic action. Methacrylated starch therefore is a better alternative to be used as the solid component of HDBC then SCA, since it leads to the formation of cements with a lower release of toxic monomers and more prone to hydrolytic degradation while keeping the other advantages of HDBCs.
Encapsulation and Survival of a Chondrocyte Cell Line within Xanthan Gum Derivative

A chemical derivative of xanthan gum polysaccharide is investigated as a new artificial matrix for the encapsulation of chondrocytic cells. Toward this goal, a novel micro-droplet generator is developed to produce microcapsules. Microcapsules with an average diameter of 500 μm, smooth surface, and homogeneous size distribution are obtained. ATDC5 cells encapsulated in carboxymethyl xanthan (CMX) microcapsules remain viable and are observed to proliferate for prolonged culture periods with enhanced metabolic activity. Furthermore, retention of the chondrogenic phenotype is exhibited by the cells within CMX, suggesting the ability of this material to be applied in cell-delivery therapies.

General information
State: Published
Organisations: University of Minho
Contributors: Mendes, A. C. L., Baran, E. T., Pereira, R. C., Azevedo, H. S., Reis, R. L.
Number of pages: 10
Pages: 350-359
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: Macromolecular Bioscience
Volume: 12
Issue number: 3
ISSN (Print): 1616-5187
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.24 SJR 1.017 SNIP 0.776
Web of Science (2017): Impact factor 3.392
Microfluidic Fabrication of Self-Assembled Peptide-Polysaccharide Microcapsules as 3D Environments for Cell Culture

We report a mild cell encapsulation method based on self-assembly and microfluidics technology. Xanthan gum, an anionic polysaccharide, was used to trigger the self-assembly of a positively charged multidomain peptide. The self-assembly resulted in the formation of a nanofibrous matrix and using a microfluidic device, microcapsules with homogeneous size were fabricated. The properties and performance of xanthan-peptide microcapsules were optimized by changing peptide/polysaccharide ratio and their effects on the microcapsule permeability and mechanical stability were analyzed. The effect of microcapsule formulation on viability and proliferation of encapsulated chondrocytic (ATDC5) cells was also investigated. The encapsulated cells were metabolically active, showing an increased viability and proliferation over 21 days of in vitro culture, demonstrating the long-term stability of the self-assembled microcapsules and their ability to support and enhance the survival of encapsulated cells over a prolonged time. Self-assembling materials combined with microfluidics demonstrated to be an innovative approach in the fabrication of cytotocompatible matrix for cell microencapsulation and delivery.

General information
State: Published
Organisations: University of Minho
Number of pages: 10
Pages: 4039-4048
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: Biomacromolecules
Volume: 13
Issue number: 12
ISSN (Print): 1525-7797
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 5.89 SJR 1.95 SNIP 1.339
Web of Science (2017): Impact factor 5.738
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.74 SJR 1.98 SNIP 1.323
Web of Science (2016): Impact factor 5.246
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.05 SJR 2.105 SNIP 1.434
Web of Science (2015): Impact factor 5.583
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.38 SJR 2.207 SNIP 1.642
Web of Science (2014): Impact factor 5.75
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 6.07 SJR 2.09 SNIP 1.593
Web of Science (2013): Impact factor 5.788
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 5.72 SJR 2.316 SNIP 1.661
Web of Science (2012): Impact factor 5.371
Hydrophobized polysaccharides have emerged as a promising strategy in the biomedical field due to the versatility to design functional structures through the spontaneous self-assembly in cell-friendly conditions. Based on this concept, xanthan, a bacterial extracellular polysaccharide with potential as encapsulating matrix, was conjugated with hydrophobic palmitoyl groups to obtain an amphiphilic system able to form capsules by self-assembly processes. The conjugation of xanthan was performed at different xanthan/palmitoyl chloride ratios and Fourier transformed infrared, H-1 nuclear magnetic resonance spectroscopies, as well as wide angle X-ray diffraction, differential scanning calorimetry were performed to characterize the obtained conjugates. The results showed that the increase in the hydrophobic reactant promoted higher hydrophobic interaction and consequently higher molecular organization. At certain palmitoyl concentrations and through a proper balance between charge repulsion and hydrophobic interaction, the amphiphilic molecules self-assembled into stable capsular hollow structures in the presence of physiological ion concentration and pH. Poly-L-lysine coated microcapsules with an average diameter of 576.6 +/- 74 μm and homogenous size distribution were obtained. The morphology revealed by scanning electron microscopy showed microcapsules with two distinct layers. The ability of palmitoyl-xanthan microcapsules to sustain viability and proliferation of encapsulated cells was confirmed by AlamarBlue and DNA assays. These findings suggest the application of palmitoyl-xanthan microcapsules as a potential material for cell encapsulation in cell-based therapies.
Hepatic UDP-glucose $^{13}$C isotopomers from [U-$^{13}$C]glucose: A simple analysis by $^{13}$C NMR of urinary menthol glucuronide

Menthol glucuronide was isolated from the urine of a healthy-70-kg female subject following ingestion of 400 mg of peppermint oil and 6 g of 99% [U-$^{13}$C]glucose. Glucuronide C-13-excess enrichment levels were 4-6% and thus provided high signal-to-noise ratios (SNRs) for confident assignment of C-13-C-13 Spin-coupled multiplet components within each C-13 resonance by C-13 NMR. The [U-$^{13}$C]glucuronide isotopomer derived via direct pathway conversion of [U-$^{13}$C]glucose to [U-$^{13}$C] UDP-glucose was resolved from [1,2,3-$^{13}$C]- and [1,2-$^{13}$C(2)] glucuronide isomers derived via Cori cycle or indirect pathway metabolism of [U-$^{13}$C]glucose. In a second study, a group of four overnight-fasted patients (63 +/- 10 kg) with severe heart failure were given peppermint oil and infused with [U-$^{13}$C]glucose for 4 hr (14 mg/kg prime, 0.12 mg/kg/min constant infusion) resulting in a steady-state plasma [U-$^{13}$C]glucose enrichment of 4.6% +/- 0.6%. Menthol glucuronide was harvested and glucuronide C-13-isotopomers were analyzed by C-13 NMR. [U-$^{13}$C]glucuronide enrichment was 0.6% +/- 0.1%, and the sum of [1,2,3-$^{13}$C]- and [1,2-$^{13}$C(2)] glucuronide enrichments was 0.9% +/- 0.2%. From these data, flux of plasma glucose to hepatic UDPG was estimated to be 15% +/- 4% that of endogenous glucose production (EGP), and the Cori cycle accounted for at least 32% +/- 10% of GP.

General information

State: Published
Organisations: University of Coimbra
Number of pages: 5
Pages: 1121-1125
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Magnetic Resonance in Medicine
Volume: 56
Issue number: 5
ISSN (Print): 0740-3194
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.77 SJR 1.89 SNIP 1.411
Web of Science (2017): Impact factor 4.082
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
NMR Derivatives for Quantification of 2H and 13C - Enrichment of Human Glucuronide from Metabolic Tracers

Quantification of 2H and 13C enrichment distributions in human urinary glucuronide following ingestion of 2H2O and 13C gluconeogenic tracers was achieved by NMR spectroscopy of the 1,2-O-isopropylidene a-D-glucofuranurono-6,3-lactone and 5-O-acetyl-1,2-O-isopropylidene-a-D-glucofuranurono-6,3-lactone derivatives. The derivatization process is simple and can be applied to any glucuronide species. The derivatives are highly soluble in acetonitrile and generate well-resolved and narrow 2H and 13C NMR signals. The 1,2-O-isopropylidene-a-D-glucofuranurono-6,3-lactone derivative provided resolution of the six glucuronide 13C signals and numerous 13C isotopomer populations through one- and two-bond 13C-13C-coupling, while the 5-O-acetyl-1,2-Isopropylidene-a-D-glucofuranurono-6,3-lactone derivative provided complete resolution of the 2H NMR signals for the five glucuronide hydrogens. The isopropylidene methyl signals were also resolved and provided an internal 2H enrichment standard following the acetonation of glucuronolactone with deuterated acetone.

General information

State: Published
Organisations: University of Coimbra, Pediatrics Hospital of Coimbra, University Hospital of Coimbra
Pages: 203-217
Publication date: 2006
Peer-reviewed: Yes

Publication information

Journal: Journal of Carbohydrate Chemistry
Volume: 25
ISSN (Print): 0732-8303
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.86 SJR 0.344 SNIP 0.362
Web of Science (2017): Impact factor 0.629
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.87 SJR 0.389 SNIP 0.378
Web of Science (2016): Impact factor 0.671
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1 SJR 0.482 SNIP 0.425
Web of Science (2015): Impact factor 0.738
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.16 SJR 0.517 SNIP 0.571
Web of Science (2014): Impact factor 1.417
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.02 SJR 0.486 SNIP 0.445
Web of Science (2013): Impact factor 1.183
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 0.7 SJR 0.342 SNIP 0.434
Web of Science (2012): Impact factor 0.847
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 0.84 SJR 0.415 SNIP 0.387
Web of Science (2011): Impact factor 0.631
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.441 SNIP 0.606
Web of Science (2010): Impact factor 1.055
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.576 SNIP 0.592
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.528 SNIP 0.608
Scopus rating (2007): SJR 0.436 SNIP 0.37
Scopus rating (2006): SJR 0.413 SNIP 0.562
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.36 SNIP 0.439
Scopus rating (2004): SJR 0.39 SNIP 0.478
Scopus rating (2003): SJR 0.404 SNIP 0.559
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.551 SNIP 0.629
Scopus rating (2001): SJR 0.514 SNIP 0.57
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.531 SNIP 0.588
Scopus rating (1999): SJR 0.526 SNIP 0.665
Original language: English
DOIs:
10.1080/07328300600732840
Source: PublicationPreSubmission
Source-ID: 92386327
Research output: Research - peer-review • Journal article – Annual report year: 2006

Projects:

PROBIO: PROBIO - Bioencapsulation of Bioingredients
Chronakis, I. S., Project Manager, National Food Institute, Research Group for Nano-Bio Science
Mendes, A. C. L., Project Participant, National Food Institute, Research Group for Nano-Bio Science
Sevilla Moreno, J. A., Project Participant, National Food Institute, Research Group for Nano-Bio Science
Stubbe, P. R., Project Participant, National Food Institute, Research Group for Food Production Engineering
Bang-Berthelsen, I., Project Manager, National Food Institute
01/01/2018 → 01/01/2022
Keywords: Food, Health, Materials technology, encapsulation, Probiotika
Project: Research

Functional Biopolymer Nanostructures for Bioengineering Applications
Shekarforoush, E., PhD Student, National Food Institute
Chronakis, I. S., Main Supervisor, National Food Institute
Mendes, A. C. L., Supervisor, National Food Institute
Mohammadifar, M. A., Examiner, National Food Institute
Douglas, T. E. L., Examiner
Yang, M., Examiner
Privatist
01/02/2015 → 20/06/2018
Award relations: Functional Biopolymer Nanostructures for Bioengineering Applications
Project: PhD

**Functional Biopolymer Nanostructures for Bioengineering Applications**
Shekarforoush, E., Project Participant, National Food Institute, Research Group for Nano-Bio Science
Chronakis, I. S., Main Supervisor, National Food Institute, Research Group for Nano-Bio Science
Mendes, A. C. L., Supervisor, National Food Institute, Research Group for Nano-Bio Science
01/02/2015 → 31/01/2018
Project: Research

**FENAMI: Functional Electrospun Nanostructures and Microstructures for Food and Bioengineering Applications**
The objectives of this project is to generate the scientific and technological basis to: (i) develop new nano-microcarrier systems for bioactive compounds using electrospun nano-microstructures for their immobilization, (ii) develop new nano-microdelivery systems utilizing enzyme functionality and molecular imprinted polymers for controlled delivery/release of bioactives, (iii) study the structural and functional properties of nano-microstructures (NMS) as novel components of food and bioengineered products, (iv) evaluate their bioavailability and degradation/digestion in-vitro and in-vivo. The overall aim is to create new functional systems that have a potential usage in foods/healthy foods, as nutritional supplements, as pharmaceutical products and for a range of other bioengineering applications. The project’s ambition is also to contribute to research training in research institutes and industrial companies as well as education of industrial employees. We expect that the obtained knowledge will strengthen the Danish industry’s potential to emerging nano-microtechnologies and technologies of bioactives.
Chronakis, I. S., Project Manager, National Food Institute, Division of Industrial Food Research
Meyer, A. S., Project Participant, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Qvortrup, K., Project Participant, University of Copenhagen
Ye, L., Project Participant, University of Lund, Pure and Applied Biochemistry
Goycoolea, F., Project Participant, Westphalian Wilhelm's University of Münster, Institute for Plant Biology and Biotechnology
Nielsen, K. A., Project Participant, Fertin A/S
Jessen, F., Project Participant, National Food Institute, Division of Industrial Food Research
Boutrup Stephanse, K., Project Participant, National Food Institute, Division of Industrial Food Research
Jørgensen, L., Project Participant, National Food Institute, Division of Industrial Food Research
Mendes, A. C. L., Project Participant, National Food Institute, Division of Industrial Food Research
Danish Research Council/Programme Commission for "Sundhed, Fødevarer og Velfærd": DKK14,866,637.00
01/05/2011 → 31/10/2015
Collaborators: Westphalian Wilhelm's University of Münster, Institute for Plant Biology and Biotechnology, University of Lund, Pure and Applied Biochemistry, University of Copenhagen, Fertin A/S
Award relations: Functional Electrospun Nanostructures and Microstructures for Food and Bioengineering Applications
Project: Research

**Activities:**

**The electrospinning of xanthan gum: from solution to nanofiber formation**
Period: 18 Oct 2017 → 20 Oct 2017
Elhamalsadat Shekarforoush (Guest lecturer)
Adele Faralli (Guest lecturer)
Ana Carina Loureiro Mendes (Guest lecturer)
Ioannis S. Chronakis (Guest lecturer)
National Food Institute

Research Group for Nano-Bio Science
Degree of recognition: International
Documents:
ANNIC2017_Book_Of_Abstracts

**Related event**

**Applied NANOTECHNOLOGY and NANOSCIENCE International Conference**
18/10/2017 → 20/10/2017
Activity: Talks and presentations › Conference presentations
Hybrid hydrogels by the co-assembly of chitosan with phospholipids
Period: 3 Apr 2017 → 6 Apr 2017
Elhamalsadat Shekarforoush (Guest lecturer)
Ana Carina Loureiro Mendes (Guest lecturer)
Christoph Engwer (Other)
Francisco Goycoolea (Other)
Ioannis S. Chronakis (Guest lecturer)

National Food Institute
Research Group for Nano-Bio Science
Degree of recognition: International
Documents:
Elham Abstract-

Related event

The Annual European Rheology Conference (AERC2017)
03/04/2017 → 06/04/2017
Copenhagen, Denmark
Activity: Talks and presentations › Conference presentations

The Fiber Society 2016
Ana Carina Loureiro Mendes (Speaker)

National Food Institute
Research Group for Nano-Bio Science

Related event

The Fiber Society 2016 : Fall Meeting and Technical Conference
10/10/2016 → 12/11/2016
Ithaca, United States
Activity: Talks and presentations › Conference presentations

Nanotec2016
Period: 26 Sep 2016 → 27 Sep 2016
Ana Carina Loureiro Mendes (Speaker)
National Food Institute
Research Group for Nano-Bio Science

Related event
Nanotec2016: International Conference on Nanotechnology Applications
26/09/2016 → 27/10/2016
Valencia, Spain
Activity: Talks and presentations › Conference presentations

COST MP1206- Electrospinning of Chitosan
Period: 2 Sep 2015 → 4 Sep 2015
Ana Carina Loureiro Mendes (Invited speaker)

National Food Institute
Research Group for Nano-Bio Science

Related event
COST MP1206 – Workshop: Electrospinning of Chitosan
02/09/2015 → 04/09/2015
Munster, Germany
Activity: Talks and presentations › Conference presentations

International Conference of the European Chitin Society
Period: 30 Aug 2015 → 2 Sep 2015
Ana Carina Loureiro Mendes (Participant)

National Food Institute
Research Group for Nano-Bio Science

Description
Poster Presentation

Related event
International Conference of the European Chitin Society
30/08/2015 → 02/09/2015
Münster, Germany
Activity: Attending an event › Participating in or organising a conference

FENAMI Project Course : Advances in Bioinspired Nanomaterials and Approaches in Life Sciences
Period: 17 Nov 2014 → 21 Nov 2014
Ana Carina Loureiro Mendes (Lecturer)

National Food Institute
Research Group for Nano-Bio Science

Related event
FENAMI Project Course : Advances in Bioinspired Nanomaterials and Approaches in Life Sciences
17/11/2015 → 21/11/2016
Münster, Germany
Activity: Talks and presentations › Conference presentations