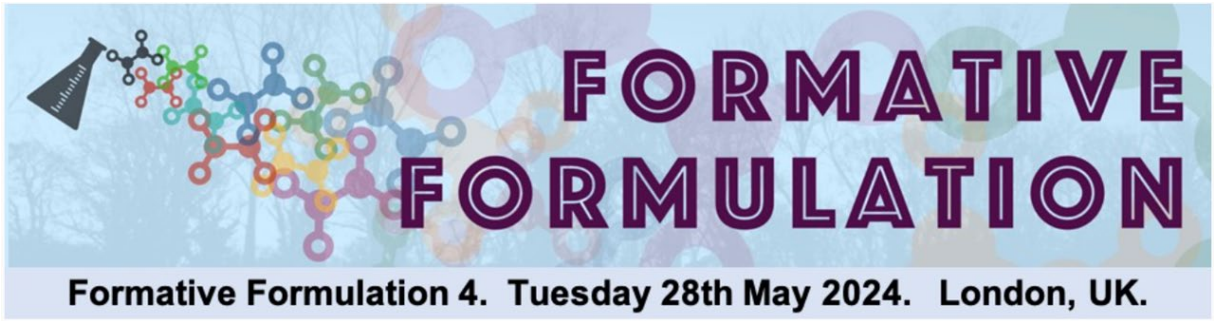
RSC INTEREST GROUP
FORMULATION SCIENCE
& TECHNOLOGY



@RSC_FSTG

RSC_FSTG

#formativeformulation4
#earlycareerresearchers

RSC INTEREST GROUP
FORMULATION SCIENCE
& TECHNOLOGY

Conference Booklet

Welcome to Formative Formulation 4

This is a 1-day scientific and networking event organised by the Formulation Science & Technology (FST) interest group of the Royal Society of Chemistry (RSC) to support early career researchers (ECRs). RSC-FST is the leading scientific organisation dedicated to product formulation and acts as a community for the exchange of knowledge in formulation in its broadest sense. As a charitable organisation, it works for the benefits of its members and to further the awareness of formulation science. It fosters the advancement of formulation science across many scientific disciplines and industrial applications, including pharmaceuticals, cosmetics, foods and detergents. It is a point of focus for all industrialists and academics engaged in the practice of formulation science. The RSC-FST organises many events during the year for the benefit of its members, including conferences, training days, and networking events. This year we have moved to a virtual platform for dissemination. This has allowed for a wider global reach – please take advantage to network with the formulation community from across the world during the meeting.

Formative Formulation 4 is forum to enhance our community of Early Career Formulation Scientists from industry, academia and beyond with exciting invited talks and a broad range of contributed oral and poster presentations. It offers a friendly environment for ECRs to develop their presentation skills as well as meet peers, as well as hearing about different career journeys and experiences.

Organising committee

Dr Denise Li, University of Edinburgh

Dr Vivian Christogianni, Arda Biomaterials

RSC INTEREST GROUP FORMULATION SCIENCE & TECHNOLOGY

Programme

09:00-09:45	**Registration**	
09:50-10:00	Welcome and	networking task - Denise
10:00-10:45	Invited Speaker Dr Thomas Curwen	**Watching Paint Dry and Other Adventures in Formulation Industries**
10:45-11:00	Orlaith Skelton	**Sustainable Formulations: Cellulose Based Colloid-nematic Gels**
11:00-11:15	Grace M. Lawler	**Advancing topical formulations: Comprehensive characterisation and effectiveness testing for a novel antifungal**
11:15-11:30	Raj Tadi	**Changes in interfacial colloid interactions and the effects on emulsion evolution**
11:30-12:30	Coffee break &	poster session
12:30-13:15	Invited speaker Dr Louise Anderson	**Be Curious**
13:15-14:00	Lunch &	Networking
14:00-14:45	Invited speaker Prof Gleb Yakubov	**Formulating Functional Dietary Fibre for Designing Nutritionally Superior Foods**
14:45-15:00	Shima Nezamipour	**Particle and fluid manipulation using nonlinear effects of soft boundaries**
15:00-15:15	Dr Tom Whitehead	**Fewer, faster, better: unlocking formulation efficiency with Adaptive Experimental Design**
15:15-15:30	Dr Anders Aufderhorst-Roberts	**Rheodialysis - An New Approach for Changing Chemical Environments during Rheological Testing**
15:30-16:00	Coffee break &	poster session
16:00-16:45	Invited speaker Dr Robert Bowles	**Careers from formulation science**
16:45-17:00	Networking	debrief and awards - Denise and Vivian

Abstracts

Invited speakers

Thomas Curwen

Tom Curwen is Principal Scientist (Food Materials Science) at Mondelēz International. Mondelēz International's purpose is to empower people to snack right and is the home of global snacking brands like Cadbury and Oreo. As a Food Materials Scientist, Tom's role is to apply physical chemistry and soft-matter physics to enable the development and production of sustainable, consumer-desired, wellbeing snacks.

Tom holds an undergraduate degree in Natural Sciences, majoring in Chemistry, from the University of Birmingham, and a DPhil in Physical Chemistry, on the Kinetics of Surfactant Adsorption, from the University of Oxford. Since gaining his doctorate in 2006, Tom has worked in a range of different Industry R&D roles in the field of suspension formulations. Working first for Syngenta (Agrochemicals), then AkzoNobel (Paints and Coatings) before moving to his current role at Mondelēz (Chocolate & Bakery).

Louise Anderson

Louise Anderson is a Materials Scientist and Chemist, and currently Research Director at Notpla, developing sustainable seaweed alternatives to traditional packaging materials. She is a Chartered Chemist with a PhD in Materials Science (Queen Mary University of London) and a Master's degree in Chemistry from University Collect London (MChem). Louise started her career as a Research Portfolio Manager with EPSRC (now UKRI) before moving into the start-up world to develop waterproof coatings for electronics with Semblant (now HZO,Inc). Louise was previously Head of R&D at THE UNSEEN creating the world's first prismatic colour hair dye with Henkel (Schwarzkopf Professional). Louise joined Notpla in 2021 with the ambition to harness nature for the creation of truly sustainable packaging products.

Gleb Yakubov

Professor Gleb Yakubov conducted his postgraduate research at the University of Mainz and the Max Planck Institute for Polymer Research in Germany, earning his PhD in physical chemistry with a focus on colloidal probe AFM force spectroscopy. Before assuming an academic position at the University of Nottingham, Gleb served as a Senior Research Fellow in the School of Chemical Engineering at The University of Queensland in Australia. Prior to that, he accumulated eight years of experience in industrial R&D roles at one of the UK-based global fast-moving consumer goods companies. His primary expertise lies in applying principles of colloidal, soft matter, and polymer science to address challenges in food research, digestive health, and biomolecular technology.

Professor Yakubov leads the Soft Matter Biomaterials and Biointerfaces research team, equipped with instrumental capabilities ranging from macroscopic (rotational rheometry) to microscale (soft contact tribology, CaBER) and nanoscale characterization techniques (biofluidic microscopy), as well as a suite of structural and molecular hydrodynamic techniques which include analytical ultracentrifugation, SEC-MALS, HPAEC-PAD, low field NMR, wide-angle X-Ray scattering, dynamic vapour sorption, and static and dynamic light scattering.

Robert Bowles Ph.D. MRSC, RCDP

After an early career in marine biotechnology, Robert moved out of the lab, gaining five years' experience in sales and marketing of educational software to schools. He joined the Royal Society of Chemistry seventeen years ago, and has managed a programme of their successful education and careers projects.

As a qualified careers adviser, he currently works in the Royal Society of Chemistry's Career Management team; offering careers advice directly to their membership and the wider chemistry community.

www.rsc.org/careers

Oral Abstracts

Sustainable Formulations: Cellulose Based Colloid-nematic Gels

Ó. Skelton[1], *T. A. Wood*[1],

[1]*University of Edinburgh, School of Physics and Astronomy, Edinburgh, United Kingdom*

Corresponding author: O.Skelton@sms.ed.ac.uk

Stiff, yet highly thinning, viscoelastic gels can be formed upon mixing colloids with homeotropic (normal) alignment into a nematic liquid crystalline medium [1]. This is due to the entangled network of defect lines that percolate throughout the sample. Cellulose nematic phases can be created from biorenewable ingredients obtained from wood and seaweed.

In this work, the rheological properties of the colloid-nematic composite are explored. While the nematogen concentration has little to no effect on the composite, we show that rheological properties are greatly impacted by colloid volume fraction. We also show broad linear viscoelastic regions, suggesting high stability of the composite gels.

References

[1] T. A. Wood, J. S. Lintuvuori, A. B. Schofield, D. Marenduzzo and W. C. K. Poon Science

2011, 334, 79-83. DOI:10.1126/science.1209997

Advancing topical formulations: Comprehensive characterisation and effectiveness testing for a novel antifungal.

Grace M. Lawler[a] , Carmel C. Kealey[b] , Damien B. Brady[c] , James J. Roche[d]
[abd] Technological University of the Shannon (Athlone Campus) Westmeath, Ireland

[d] South East Technological University, Carlow, Ireland

A proprietary modified coconut oil formulation (MCO) has revealed notable antifungal efficacy against *Trichophyton rubrum*, an opportunistic pathogenic fungus affecting both the integumentary system and the nails. Process analytical measurements are providing insights into the specific properties of the oil, contributing to the broader understanding of its potential as a therapeutic agent and aiding the identification of its mechanism of action.

MCO's critical quality attributes undergo physiochemical, thermo-analytical, spectroscopic and chromatographic assessment. Efficacy is assessed via *in vitro* microbiological assays, enabling comprehension of antifungal properties, including dose extrapolation and fungicidal kinetics.

Physiochemical analysis has divulged distinctions between initial virgin coconut oil (VCO) and its modified counterpart. Attributable to altered colligative properties, both bomb calorimetry and differential scanning calorimetry effectively confirm the modification and thermodynamically differentiate the stages of manufacture. Infrared carbonyl stretching affirms characteristic modified variations within the 1700-1750 cm^{-1} region. The related Raman spectroscopy yields further subtle differences and correlates spectral data with compositional profile as determined using gas chromatographic FAMEs analysis. Calibrated experiments using lower-chained fatty acids (C8-C12) demonstrate notable inhibitory effects against the fungus. Batches of MCO consistently exhibit robust antifungal activity across *in vitro* bioassays, additionally outperforming a market-leading commercial product.

Reflecting the need to control the properties of naturally derived ingredients, validation of the coconut oil modification process through identification of its key effective components, holds promise as a potent contender for the antifungal market.

Changes in interfacial colloid interactions and the effects on emulsion evolution

Raj Tadi[1], Beth Green[2], Tom Curwen[2], Paul Clegg[1],

[1]University of Edinburgh, School of Physics and Astronomy, Edinburgh, United Kingdom

[2]Mondelēz International, Reading Science Centre, Whiteknights Campus, Pepper Lane, Reading, RG6 6LA, UK

Corresponding author: raj.tadi@ed.ac.uk

Pickering emulsions are stabilised by colloidal particles that offer many advantages over their surfactant-stabilised counterparts. This includes long term stability, biocompatibility, and enhanced functionality. As a result, they have gained attention across diverse sectors including cosmetics, material science, and food. As colloids are often considered irreversibly adsorbed at the interface, this gives rise to significant interfacial properties that play a role in emulsion stability. Interfacial properties are affected by not only the characteristics of the colloids used but also how they interact with each other.

In this work, changes to the colloid interactions, and resulting effects on a model water-in-oil emulsion system undergoing compositional ripening, are explored. We show that the addition of solvent to the continuous phase can alter the rheological properties of the interface, and end fate of the emulsions. In addition, we show that changes in the type of steric stabilisation used can vary the emulsion behaviour, from buckling to colloids diffusing off the interface.

Particle and fluid manipulation using nonlinear effects of soft boundaries

Sh. Nezamipour*; A. Najafi
Department of Physics, Institute for Advanced Studies in Basic Sciences (IASBS), Zanjan 45137- 66731, Iran
shimanezami@gmail.com

The manipulation of particles and fluids within microfluidic devices is of critical importance. It allows for exact control over biochemical environments, thus paving the way for advancements in various fields such as point-of-care diagnostics, drug discovery, and cellular biology. Soft boundaries, such as elastic membranes and fluid-fluid interfaces, are common in biological systems and microfluidic devices.The deformation of such boundaries introduces complexity to the system, presenting both challenges and opportunities1 .They lead to significant nonlinear effects, including lateral migration2 and lift forces3 , in low Reynolds number regimes. Prior research has indicated that the horizontal oscillation of a microparticle near a deformable fluid/fluid interface results in a net downward flow4. However, the presence of non-linearity implies that the superposition principle may not be applicable. As a result, a particle moving at an angle of θ relative to the horizon, with a velocity of $Up=cos(\theta)\hat{x}$+sin$(\theta)\hat{z}$, will experience a hydrodynamic force not necessarily equivalent to the sum of the forces in parallel and perpendicular modes. In this study, we semi-analytically calculated this hydrodynamic force for a tilted path. We demonstrated that by adjusting the angle of the particle path, we can generate fluid flows in any desired direction. This method enables us to create dye trajectories of any shape, thereby introducing a novel, noninvasive, and contactless approach to particle manipulation. This approach can be implemented using optical or acoustic tweezers.

Keywords: Flow; Particle transport; Interface; Nonlinearity; Reciprocal motion.

References:

1. Trouilloud, R., Tony, S. Y., Hosoi, A. E., & Lauga, E. (2008). *Physical review letters, 101*, 048102.
2. Rallabandi, B., Oppenheimer, N., Ben Zion, M. Y., & Stone, H. A. (2018). *Nature Physics, 14*, 1211-1215.
3. Zhang, Z., Bertin, V., Arshad, M., Raphael, E., Salez, T., & Maali, A. (2020). *Physical review letters, 124*, 054502.
4. Nezamipour, S., & Najafi, A. (2021). *Scientific Reports, 11*, 15041.

Fewer, faster, better: unlocking formulation efficiency with Adaptive Experimental Design

Dr Tom Whitehead

Artificial intelligence is on top of the hype cycle, but where can it make a tangible difference to the current world of formulation science? A fully automated future of robotic equipment autonomously carrying out experiments might one day arrive, but in the meantime there are concrete differences that machine learning is already making to the daily life of chemists, integrating into standard R&D approaches.

We will explore the way Adaptive Experimental Design, powered by machine learning, extracts the maximum value from every lab experiment, minimising the overall number of experiments that need to be carried out and hence reducing the time to go from today's knowledge to an optimal solution. We will examine case studies of the successful application of Adaptive Experimental Design in live projects, identifying the key trends that enabled the realisation of these benefits.

In particular we will cover a case study of ink formulation at Domino Printing Sciences, where the reformulation of existing products to remove reclassified ingredients was accelerated using Adaptive Experimental Design. We will also cover some of the challenges that companies experience when applying machine learning for formulation development and how leading organizations overcome these challenges.

Using machine learning to accelerate existing R&D approaches enables chemists to deliver better, more sustainable products faster – and all seamlessly integrated into current workflows.

Rheodialysis - An New Approach for Changing Chemical Environments during Rheological Testing

Anders Aufderhorst-Roberts

Centre for Materials Physics, Department of Physics, University of Durham, Durham, UK

Corresponding author:a.aufderhorst-roberts@durham.ac.uk

Across formulation science, many soft structured materials are highly sensitive both to mechanical forces and changes in chemical environment. Examples include hydrogels that re-polymerise under strain[1], biopolymer capsules whose size depends on shear[2] and living materials such as blood clots that degrade upon removal of tension.[3] In each case there is a common theme mechanical forces and chemical stimuli act not individually, but in synergy.

In this presentation I will discuss a technique known as rheodialysis, which extends the capabilities of standard rheology by incorporating a customised flow cell with a porous membrane into a parallel plate rheometer.[4] We have shown that this approach allows a sample's chemical environment to be exchanged, while simultaneously probing its mechanical properties. I will demonstrate experimental results that apply this technique to alginate biopolymer hydrogels assembled through diffusion of calcium ions. By probing alginate hydrogels at different plate separations, we shown that the resulting hydrogels have different properties owing to the slow diffusion calcium ions through the incipient gel network. We also show that the fractal dimension of these hydrogels varies with the distance from the source of ion diffusion and we model this process using reaction diffusion models. I will also present some results on extending the rheodialysis technique to microrheology, by using microfluidic flow chambers with embedded microspheres that report the local mechanics of the sample through passive brownian motion. We have successfully applied this technique to samples constructed from protein filament hydrogels and have shown that their assembly pathway, as controlled by ion diffusion, has a significant influence on their mechanical properties.

These techniques have broad applications across food science, biological science and soft matter physics and I will also outline some of the potential applications that are currently being pursued.

References

[1] Matsuda, T., Kawakami, R., Namba, R., Nakajima, T., & Gong, J. P. (2019). Science,

363(6426), 504-508.

[2] Farr´es, I. F., & Norton, I. T. (2014). Food Hydrocolloids, 40, 76-84.

[3] Weisel, J. W., & Litvinov, R. I. (2017), 405-456.

[4] Inman, J.S., Smith, A., Aufderhorst-Roberts, A. (2023) Rheology Bulletin, 64 (3), 74-79

Poster Abstracts

Self-assembly of small molecule fragrances and biosurfactants in micelles

Joyce Lemmer

This is a study that assesses the self-assembly behaviours of biosurfactants in the presence of small-molecule fragrances.

Fragrances are important ingredients in a wide range of surfactant-based home and personal care products. These small molecules can alter the physical properties of surfactants, such as their phase behaviour, surface tension and viscosity, and thus the final formulations' performance and stability1. So far, a variety of fragrance molecules with differing degrees of solubility and hydrophobicity have been studied, focusing on their solubilisation in surfactant systems, the localisation of the fragrance molecule within the surfactant micelle, and the impact of these molecules on surfactant phase behaviour2.

The growing demand for biodegradable products has resulted in an increasing need for bio-sourced surfactants. Produced as secondary metabolites by microorganisms, biosurfactants offer many advantages over their synthetic counterparts: reduced toxicity, enhanced biodegradability, and higher efficacy. Primary examples of these biosurfactants include glycolipids, more specifically rhamnolipids and sophorolipids3. The self-assembly of glycolipids is well understood, but little is known about their behaviour in the presence of fragrance additives.

This study focuses on characterising dilute solutions of glycolipids and fragrances, utilising advanced characterisation techniques such as small angle X-ray scattering (SAXS), diffusion ordered spectroscopy (DOSY), surface tension, conductivity and rheological studies. These methods are used to develop a model to predict how biosurfactants and fragrances assemble in solution, and to compare their fundamental properties, i.e. the variation in surfactant packing parameter, the micro and nanostructure of the formulations, and their compatibility with other formulation ingredients to ultimately understand and thus evaluate their properties for use in future cleaning products.

References

(1) Fischer, E. et al. (2009). *Journal of Surfactants and Detergents*, 2009, 12, 73-84.

(2) Fan, Y. et al. (2016). *Soft Matter*, 2016, 12, 219-227.

(3) Nagtode, V. et al. (2023). ACS Omega, 2023, 8 (13), 11674-11699.

Formulation development of nanostructured lipid carriers for oral aquatic vaccine

delivery

Jojo Rodrigues1,2, Conor O'Hara1, Daniel Sedough-Abbasian1, Maria Roméria da Silva3,

Jener Zuanon4, Tiago Mendes3,2, Sheiliza Carmali1

1 School of Pharmacy, Queen's University Belfast, Belfast UK

2 Department of Microbiology, Federal University of Viçosa, Minas Gerais, Brazil

3 Department of Biochemistry and Molecular Biology, Federal University of Viçosa, Minas Gerais, Brazil

4 Department of Animal Biology, , Federal University of Viçosa, Minas Gerais, Brazil

Introduction: The widespread presence of pathogens in the aquaculture industry and scarcity of effective oral vaccines has become a challenge to the fish community and a risk to human health.1 Despite an increase in available oral vaccines for fish, these are often subperforming due to antigen degradation, highly tolerogenic gut environment and inferior vaccine formulation. Derived from oil-in-water nanoemulsions, nanostructured lipid carriers (NLCs) present an attractive strategy for vaccine delivery due to their antigen protection and adjuvant characteristics. Moreover, NLCs can protect proteins from harsh conditions of the gastro-intestinal tract, enhance transmucosal transport and provide controlled release, making them ideal for oral administration.2 Here, we report on the formulation development of nanostructured lipid carriers for oral aquatic vaccine delivery.

Methods: Precirol ATO 5 (PATO), labrafac PG (LaPG) and Tween 80 (T80) were used as the solid lipid, oil, and surfactant, respectively. Solid lipid to oil concentrations were varied from 90-70%, and surfactant concentrations of 2, 5 or 10% were used. Blank NLCs were prepared using high-pressure homogenization. Solid and liquid lipid were heated for 10 min at 70 °C. Separately, an aqueous solution of T80 was heated at the same temperature and time. After this time, both lipid and aqueous solutions were combined, and mixed at 6500/24000 rpm for 3 min at 70 °C before cooling for 10 min in an ice bath. Nanoparticle size, dispersity and zeta potential were measured against varying processing parameters (homogenising time, power, lipid composition and percentage of surfactant. Measurements were completed at 25 °C in triplicate (Zetasizer Nano).

Results: Particle size, dispersity, and zeta potential measurements of ATO/LaPG/T80 ternary mixtures showed that formulation ratios influenced significantly NLCs structural properties. Surfactant concentration showed a pronounced effect on particle size, with 10% T80 forming particle sizes < 200 nm albeit with high dispersity values. Surfactant concentration also impacted surface charge, with higher T80 concentration leading to less negative nanoparticles. Optimized NLCs (~ 100 nm in size and PDI < 0.3) were obtained with 5% T80 at all lipid ratios tested.

Conclusions: NLC formulations suitable for oral aquatic vaccines were developed using high-pressure homogenization. Formulation composition and processing methods were optimized to develop NLCs with good uniformity and a particle size

suitable for oral administration. Further research, including encapsulation studies and in vitro stability testing under environmental and physiological conditions is currently on-going to evaluate the potential application of NLCs for aquatic vaccines.

References:

1 *Aquac Int.* 31(2): 867–891 (**2023**)

2 *Adv Drug Deliv. Rev* 182, 114097 (**2022**)

Spray drying and formulation of nut-based dairy alternatives

Xin Tian Lee

Dairy alternatives have received a significant market growth in the past few years. However, there are limited research done on formulating nut-based dairy alternatives in the powder format, with most research focused on formulating other dairy alternatives in the liquid form. In this project, spray drying is used as a thermal processing technique to convert liquid to powder by moisture removal from atomized liquid droplets.

The formulation of nut-based non-dairy creamer is challenging because as with most dairy alternatives, they tend to have a thin mouthfeel due to addition of water needed for extraction. This results in the lack of creaminess which would typically require the addition of oils or additives for thickening. Aside from the lack of mouthfeel, the large proportion of fats in contrast to other nutrient components in the nuts poses a hurdle to emulsion stability affecting spray drying in terms of powder yield and powder properties. Non-optimized spray drying and formulation result in poor powder dissolution and flowability which is crucial in powdered products.

In this poster, we report some findings from the formulation and spray drying optimization of nut-based non-dairy alternatives.

Software toolkits for *in silico* screening of polymer excipients used in small molecule formulation and drug delivery.

Hannah Turney[1], Micaela Matta[1]

[1]King's College London – Department of Chemistry

The use of polymers as excipients in small molecule pharmaceutical formulations is an established approach for the controlled delivery of drugs. However, designing safe and effective formulations is resource-intensive and delays product delivery to the clinic, primarily due to the sensitivity of polymer substructure to delivery properties.

Molecular simulations are a powerful approach to enable *in silico* workflows for a range of chemistries. Advances in simulation tools, such as dedicated molecular dynamics force fields, have eased their computational demand. Limitations remain in the regular employment of these tools to model polymer excipients, including scaling to larger systems and molecule versatility.

We are using advanced molecular dynamics techniques and global modelling initiatives to create a robust *in silico* polymer methodology. By taking advantage of existing open-source software, and sharing any resulting tools developed, we aim to maintain transparency and promote collaboration with all methods and data generation.

This will enable fast, accurate and reproducible profiling of polymers in the context of drug formulation design, via the high throughput determination of kinetic parameters that predict their suitability for productive drug delivery.

How does synergy play a role in the mechanics of a double-network hydrogels?

Vinay Kopnar*, Adam O'Connell#, Dr. Natasha Shirshova**, Dr. Anders Aufderhorst-Roberts*

* Department of Physics, Durham University,

Reckitt, United Kingdom,

** Department of Engineering, Durham University

Composite materials are found almost everywhere in nature. The synergistic effect of collagen which is good at absorbing and dissipating energy but is highly inextensible, and elastin which is extensible but very poor at dissipating energy help tendons in our body transfer force from muscles to bone structure. Double-network (DN) hydrogel is a soft and tough material consisting of two inter-penetrating polymer networks having contrasting properties[1]. It provides a way for us to design sustainable soft materials that can use the same synergistic effect for various applications. However, due to limited rheological studies, the fundamental understanding of the non-linear mechanics of double-network hydrogels is still lacking which prevents the design of materials for advanced practical applications.

Through this poster, we demonstrate how individual networks play out their role in determining the non-linear properties of a DN hydrogel. We illustrate a way to disrupt links between the two networks and thus, present the synergistic effect caused by these links on the linear properties as well as the failure mechanics of the DN hydrogel. Simultaneously, we present how Large Amplitude Oscillatory Shear (LAOS) rheology[2] could help in studying non-linear characteristics of such composite materials.

References:

1. Gong, J. P., Katsuyama, Y., Kurokawa, T., & Osada, Y. (2003). Double-Network Hydrogels with Extremely High Mechanical Strength. In Advanced Materials (Vol. 15, Issue 14, pp. 1155–1158). Wiley. https://doi.org/10.1002/adma.200304907

2. Ewoldt, R. H., Hosoi, A. E., & McKinley, G. H. (2008). New measures for characterizing nonlinear viscoelasticity in large amplitude oscillatory shear. In Journal of Rheology (Vol. 52, Issue 6, pp. 1427–1458). Society of Rheology. https://doi.org/10.1122/1.2970095

Lyophilised wafer dressings loaded with biosurfactant based niosomes for potential chronic wound healing

Olufunke A. Akiyode[1] and Joshua Boateng[1*]
[1]CK Group Richmond House, Walkern Rd, Stevenage SG1 3QP
[1]Faculty of Engineering and Science, University of Greenwich, Medway, Kent, UK ME4 4TB
*Correspondence: Professor Joshua Boateng (j.s.boateng@gre.ac.uk).

Keywords: Biosurfactants, niosomes, wound dressings and ulcer

Introduction: Bioactive dressings incorporating antimicrobial agents (such as silver, iodine, and honey), have set a precedent for introducing advanced biosurfactant based wound dressings. Microbial biosurfactants (BSs) are broad spectrum secondary metabolites superior to synthetic surfactants in terms of low toxicity, biodegradability and stability, but the high cost of manufacturing green ecologically friendly BSs are higher. Niosomes are drug delivery vesicles composed mainly of hydrated non-ionic surfactants. The aim of this research is to investigate the therapeutic properties of niosome based BSs wound dressings that could outweigh residual production costs of BSs and create a route to market. The incorporation of niosome based BSs dressings is a novel concept.

Materials and methods: K-carrageenan and sodium alginate are naturally derived linear anionic polysaccharide polymers which due to their biocompatibility, biodegradability, immunogenicity and non-toxicity were selected for the formulation of 23 viscoelastic composite gels and lyophilised into semisolid matrixes known as wafers. These wafers were analysed with a combination of physico-chemical, mechanical and bio-analytical techniques to optimise conditions for selected excipients and bio-materials during pre-formulation and formulation development. Free and BSs based multi-lamellar niosomes were designed using thin film hydration technique and incorporated into selected optimised bioactive composite gels lyophilised into wafers.

Results: There was an increase in the mechanical strength of niosome based BSs wafers in comparison to BSs only based wafers. Further, the incorporation of a charge inducer into the niosomes affected the mechanical and bio-analytical properties in comparison to wafer loaded niosomes without the charge inducer. Additionally, the BLK and BSs loaded niosomes were not visible on the surface and pore walls of the lyophilised wafer matrix indicating they were well incorporated within the wafer matrix. Both BLK and BSs niosome loaded wafers showed the characteristic functional groups of their lyophilised wafer matrix. XRD diffractograms showed amorphous patterns in both BLK and BSs loaded niosomes incorporated into wafers.

Conclusion: The formulation of BSs loaded niosomes in lyophilised composite polymeric wafers was successfully achieved. The incorporation of a charge inducer during niosome formation helped to improve porous structures in the formulated wafers. This helped to enhance mechanical strength which is expected to improve ease of hydration of composite wafers. Overall, the composite wafers containing BSs based niosomes loaded into wafers in this study, showed improved mechanical and comparable bioanalytical properties in comparison to the reference composite polymer systems and can be potentially used for highly exuding wounds such as chronic ulcers.

Formulating cellulose nanocrystal Pickering emulsions and their impact on lipid digestion

Lin Zhang[1], Balazs Bajka[2], Cecile Dreiss[1]

[1] Institute of Pharmaceutical Science, King's College London, London, SE1 9NH, UK

[2] Department of Nutritional Sciences, King's College London, London, SE1 9NH, UK

lin.zhang@kcl.ac.uk

Understanding the process of lipid digestion and absorption and using effective ways to control it is paramount for the development of food formulation strategies to address the obesity crisis.

Aim: To develop and characterise Pickering emulsions stabilised by cellulose nanocrystals (CNCs) or combined with other polysaccharides, including methyl cellulose (MC) and chitosan (CS), to regulate lipid digestion, using simulated *in vitro* digestion.

Methods: CNCs alone, or in combination with MC or CS were used to generate Pickering emulsions. CNCs were characterised by atomic force microscopy (AFM), dynamic light scattering (DLS), and emulsions by laser diffraction and fluorescence microscopy. The pH-stat method was used to measure free fatty acids (FFA) release.

Results: CNCs were rod-like (length = 81.9±0.3 nm) and a negative ζ-potential (-53 mV). All formulations generated stable emulsions, however emulsions utilising CNCs alone demonstrated significant instability in the simulated intestinal environment. The combination of CNC with MC or CS resulted in greater stability and reduced FFA release *in vitro*.

Conclusion: CNCs can be used to stabilise Pickering emulsions alone. Utilising CNCs, in combination with polysaccharides with different physico-chemical properties, has potential to generate novel food emulsion systems for improved regulation of lipid digestion.

List of Delegates

Names, affiliations and contact details for those that agreed on registration are below, alphabetical by surname.

First name	Last name	Affiliation	Contact email
Funke	Akiyode	CK Group	olufunke_akiyode@yahoo.co.uk
Louise	Anderson	Notpla	annlouiseanderson1@gmail.com
Anders	Aufderhorst-Roberts	University of Durham	vnsm67@durham.ac.uk
Oscar	Berger	Arda Biomaterials	oscar@arda.bio
Joe	Bradley	University of Edinburgh	Joe.Bradley@ed.ac.uk
Naomi	Brown	University of Edinburgh	naomi.brown@ed.ac.uk
Vivian	Christogianni	Arda Biomaterials Ltd	v.christogianni@gmail.com
Thomas	Curwen	Mondelez International	thomas.curwen@mdlz.com
Vinay	Kopnar	Durham University	vinay.h.kopnar@durham.ac.uk
Grace	Lawler	Technological University of the Shannon Midlands Athlone Campus	A00243040@student.tus.ie
Xin Tian	Lee	Singapore Institute of Technology	xintian.lee@singaporetech.edu.sg
Denise	Li	University of Edinburgh	denise.li@ei.ed.ac.uk
Dillon	McGurty	Unilever	dillon.mcgurty@unilever.com
Jojo	Rodrigues	Queen's University Belfast	j.dasilvarodrigues@qub.ac.uk
Holly	Shirley-Rush	Oxeco	hollyshirleyrush@yahoo.co.uk
Orlaith	Skelton	University of Edinburgh	s2135342@ed.ac.uk
Raj	Tadi	University of Edinburgh	raj.tadi@ed.ac.uk
Tom	Whitehead	Intellegens	tom@intellegens.com

Future Events

Formula XII 2025
Sustainable formulations: New strategies for innovation and performance prediction
16-18 June 2025, Sofia , Bulgaria

To hear more about our upcoming events and find out more about our Formulation and Science Technology Group visit our website https://www.formulation.org.uk

Thank you for attending Formative Formulation 4