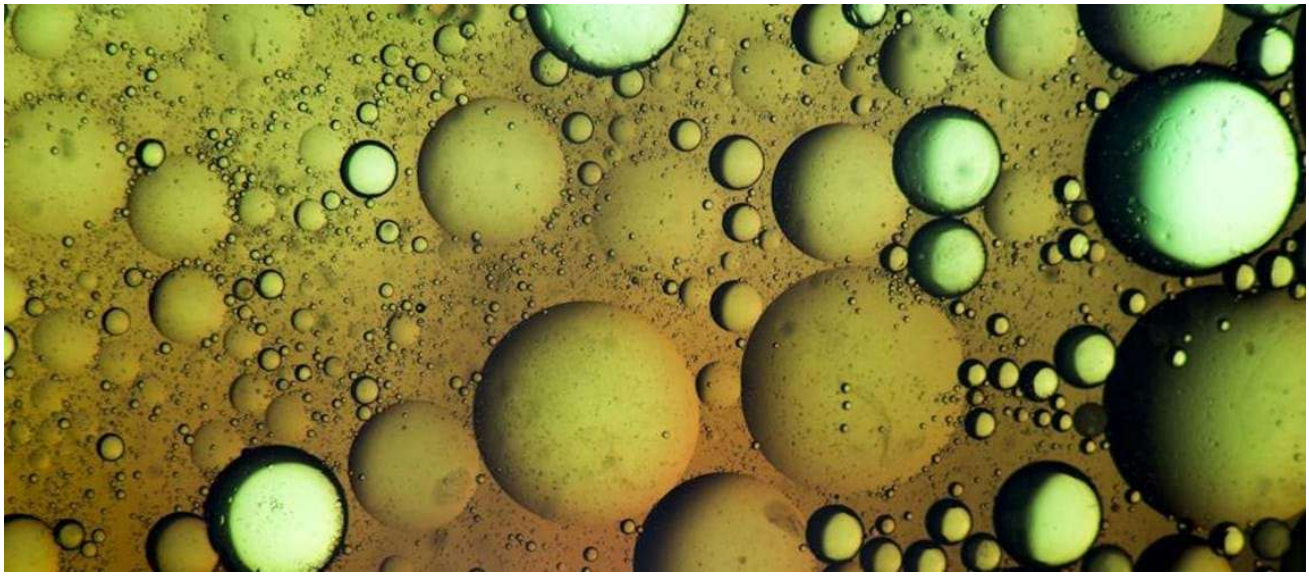

PHOODSEP: Challenges & innovation in Pharmaceutics and Novel food downstream processing

Organizing Institution:

Cellular Agriculture Manufacturing Hub (CARMA)

IChemE Fluid separation SIG

10th February 2026 at Bath Royal Literary and Scientific Institution, 16-18 Queen Square, Bath, BA1 2HN.

IChemE BIO-RAD iwt TECNIPLAST GROUP CARMA CELLULAR AGRICULTURE MANUFACTURING HUB

Dear Participants,

It is a pleasure to welcome you to this one-day conference '**PHOODSEP: Challenges & innovation in Pharmaceutics and Novel food downstream processing'** held on 10th February 20256 in Bath. This conference in organised by collaboration of CARMA-hub and IChemE fluid separation SIG.

The growing demand for sustainable and health-promoting novel foods (e.g., alternative protein, cultivated meat etc.), along with increasingly complex pharmaceutical products, has brought downstream processing (DSP) into the spotlight as a critical yet often underestimated component of bioprocess development. While upstream innovations often catalyse attention, downstream separation plays an equally crucial role in ensuring product quality, safety, scalability, and regulatory compliance.

This one-day symposium will provide a focused platform for researchers, industry experts, and regulatory stakeholders to discuss the current challenges, recent innovations, and future directions in downstream separation. The event will emphasize the importance of DSP in the successful commercialization of novel foods and biopharmaceuticals, especially in the face of evolving regulatory landscapes, sustainability requirements, and the need for cost-effective manufacturing processes.

Attendees will hear from leading experts in cellular agriculture, pharmaceutics, and novel food technologies. A panel discussion will bring together academic and industry voices from both the pharmaceutical and food sectors, fostering cross-disciplinary dialogue. The aim is to identify shared challenges and collaborative solutions that can accelerate progress in DSP across bioprocessing applications.

We hope that you will extend your network during the event, interact in the poster session and presentations, and with sponsors, and enjoy hearing about the latest innovations in the field of biotech downstream processing.

With best wishes,

Dr. -Ing Fatima Anjum,
Lead of the organising committee

ORGANISING COMMITTEE

Lucinda Brook

University of Bath

Dr. -Ing Fatima Anjum

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Dr. Madhurima Dutta

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Dr. Hannah Leese

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We are grateful to our sponsors Bio-Rad and IWT Tecniplast Group for their support.

Sponsors & Organising Institutions

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IWT Tecniplast Group

The Tecniplast Group has been at the forefront of the lab animal industry since 1949, designing, manufacturing and distributing equipment to laboratories around the world. Thanks to our in depth understanding of the needs of the modern animal facility, we offer the most comprehensive product portfolio: ranging from housing systems to laminar flow cabinets, aquatic solutions to washing equipment, automation to decontamination services, all tied together by logistics products, monitoring and analysis platforms.

CARMA: Cellular Agriculture Manufacturing Hub

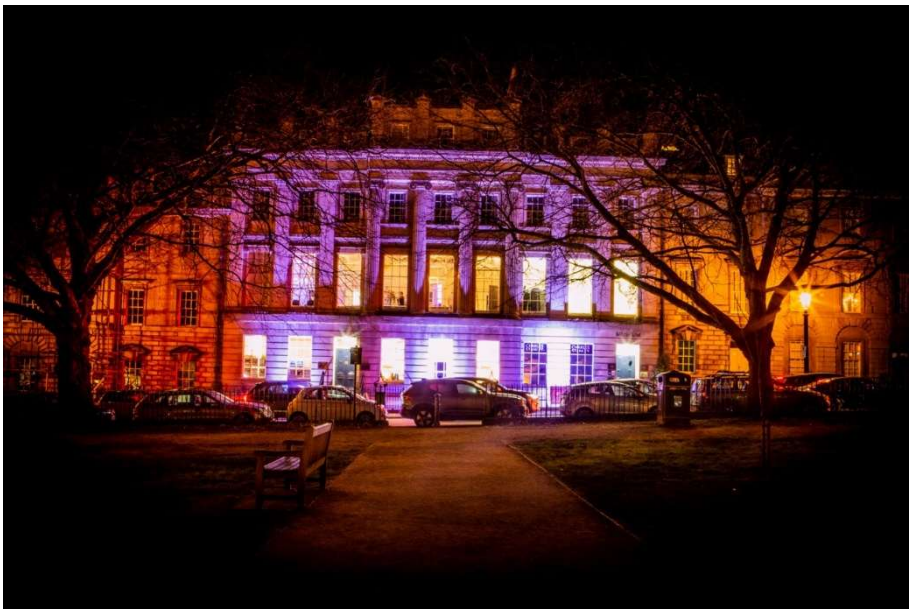
The EPSRC-funded Cellular Agriculture Manufacturing Hub 'CARMA' is working to transform food production. Our vision is for a just transition to environmentally, economically, and socially sustainable food systems. Our mission is the integration of transdisciplinary responsible approaches for novel cellular agriculture tools and technologies, into current food systems, to deliver sustainable food manufacturing in the UK and beyond.

IChemE's Fluid Separation SIG

IChemE's Fluid Separations Special Interest Group is concerned with the development, design, operation and control of fluid separation processes and equipment. The need to develop more efficient and economic separation technologies, including more complex, integrated and hybrid units, demands that we continue to develop and improve these technologies in both new designs and process revamps. Increasingly important are the issues of energy efficiency, sustainability, health, safety and environmental impact in the context of separations.

IChemE BIO-RAD IWT TECNIPLAST GROUP CARMA CELLULAR AGRICULTURE MANUFACTURING HUB

LOGISTICAL INFORMATION

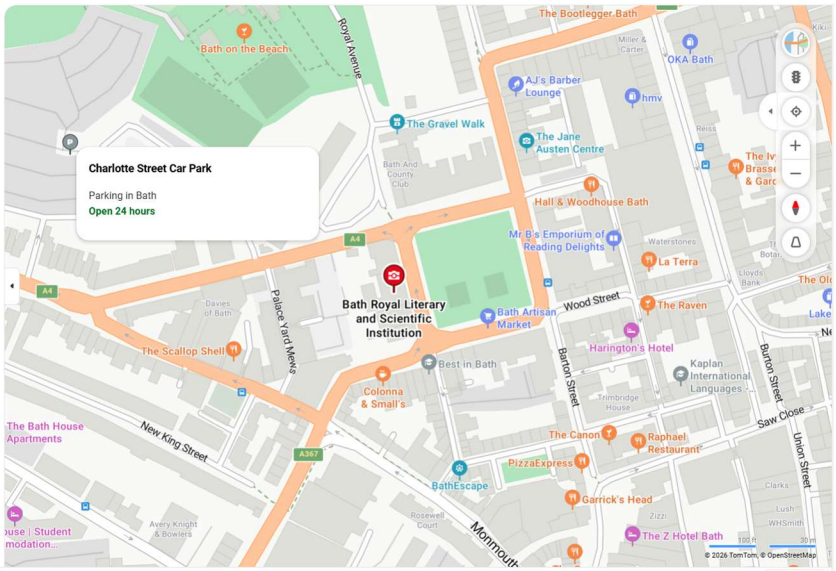


Timing

Tuesday 10th February 2026. Registration and Coffee from 9.00 am and the conference will finish at 5.00 pm.

Event Venue

Bath Royal Literary and Scientific Institution, 16-18 Queen Square, Bath, BA1 2HN.



BRLSI is 13 minutes (0.6 miles) walk from the Bath SPA railway station and Bath central bus station. Charlotte Street (long-stay) Car Park is the closest (0.2 miles and 4 min walk) from the venue.

Reception, Coffee/Tea breaks, Lunch and Sponsors' Exhibitions

The Duncan room on the first floor (next to the Elwin room) will host all networking, refreshments and sponsor stand desks. Both rooms are connected through a central door.

Conference presentations and posters

All presentations will take place in the Elwin room (1st floor) which can be access through the central door in Duncan room.

Photography/Filming

We kindly request you to not film the presentations to respect the confidentiality of the work. Please do not take any photos of the posters without presenter's consent.

CONFERENCE PROGRAMME

Time	Schedule
9:00-10:00	Registration & networking
10:00-10:10 10:10-10:30	**Welcome note - Prof. Davide Mattia & Dr. -Ing Fatima Anjum** **CARMA WP2 Update – Dr. Hannah Leese** Opportunities for Circularity and Nutrient Recovery in CARMA
10:30-11:00 11:00-11:20	**Keynote speaker: Dr. Andrea Rayat** Beyond Bottlenecks: Bringing Engineering Clarity to Today's Diverse Bioseparations Challenges **Invited speaker: Dr. Monika Tomecka (CEO Ufraction8)** Microfluidics for scalable downstream processing in industrial biotechnology
11:20-11:50 11:50-12:10	**Invited speaker: Prof. Jerry Heng** Downstream Processing of Proteins and Peptides via Crystallisation **Invited speaker: Ida Amura (Astrazeneca)** Downstream processing in pharmaceutical industry
12:10-12:20	**Invited speaker: Mirza Mohammad Mehdi (Bio-Rad Laboratories)** Chromatography resins solutions for the Food & Biopharmaceutical Industry
12:20-12:50	Lunch
12:50-14:00	Poster session
14:00-15:00 14:00-14:10 14:10-14:20 14:20-14:30 14:30-14:40 14:40-14:50 14:50-15:00	**Abstract / ESRs talks (10 min each)** **Ehsan Nourafkan:** Vibratory Tangential Flow Filtration for the Clarification and Fractionation of Yeast-Derived Protein Extracts as Animal-Free Media Components for Cultured Meat Applications **Isha Bade:** Crystallisation of Peptides Using Templating Strategies **Isa Senica:** Ultra Scale-Down Evaluation of Shear Effects During the Centrifugal Recovery of Cultivated Meat Cells **James Penkman:** Use of chemically modified polybenzimidazole (PBI) spiral wound modules (SWM) for downstream purification of oligonucleotides at high concentration in aqueous-organic feeds **Jing Zhang:** Spent Cell Culture Media Recovery for Cultivated Meat

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	Madhurima Dutta: From Pasture to Plate: Enhancing protein recovery from grass through combined mechanochemical extraction and downstream membrane processing
15:00-15:40	Coffee & Networking
15:40-16:30	**Panel discussion** Challenges in Biotech downstream processing and how we can support each other in advancing biotech DSP. **Chairs** **Prof. Marianne Ellis** **Prof. Davide Mattia** **Panellists** **Prof. Daniel Bracewell** **Dr. Nigel from cytiva** **Prof. Gary Lye**
16:30-17:00	ESRs prizes & Closing remarks

CARMA Update

Dr. Hannah Leese (CARMA WP2 (DSP) Lead)

This talk will highlight how CARMA's Work Package 2 is working towards a circular, resource-efficient future for cellular agriculture. At its core, the work focuses on **product purification and waste valorisation**, two critical steps for reducing environmental impact and increasing sustainability in biomanufacturing.

A major opportunity lies in transforming **spent media, and process waste streams** into valuable resources. CARMA is investigating how these streams can be treated, recycled, or fed back into upstream processes, closing loops, lowering resource demand, and enabling **nutrient recovery**.

Technologies for the multiple downstream challenges are being evaluated for their potential to support continuous, closed-loop bioprocessing. These strategies aim to remove and utilise inhibitors, enable media reuse, and minimise waste across the production lifecycle. We are also developing processes to valorise yeast-based bioproducts, where significant opportunities exist to reduce waste and enhance circularity. Yeasts are an increasingly important source of sustainable proteins and food-grade oils. Yeast-derived proteins provide promising substitutes for animal-based media components in mammalian cell-culture. Achieving selective, food-grade separation and recovery of these compounds is essential for developing sustainable processes that align with circular manufacturing principles.

CARMA's work in WP2 demonstrates how rethinking waste as a resource, and redesigning processes, creates tangible opportunities for circularity, nutrient recovery, and sustainable growth in the UK's emerging cellular agriculture sector.

Invited Speakers

Keynote Speaker: Dr. Andrea Rayat

Beyond Bottlenecks: Bringing Engineering Clarity to Today's Diverse Bioseparations Challenges

Bioseparations lie at the centre of producing high-quality biological therapeutics, yet their complexity is often reduced to the single label of "downstream processing" (DSP). In practice, DSP encompasses a wide range of fundamentally different operations: bioparticle separations, solid–liquid separations, and solute–solute separations; each governed by its own physical principles, performance limits, and engineering requirements. Treating DSP as a uniform activity can obscure these distinctions and reinforce the perception that it is inherently the bottleneck in bioprocessing.

This talk will explore whether DSP is truly the constraint many believe it to be, or whether this impression stems from a historical underinvestment in mechanistic understanding and characterisation. Key aspects of bioseparations will be examined, beginning with the renewed importance of bioparticle separation and the need to define more precisely what is being separated, and why. The role of process shear will be discussed, challenging the assumption that it is always detrimental and asking whether it may, in some contexts, be leveraged as a controllable parameter. The evolving impurity and product landscape will also be addressed, particularly as DNA, RNA, and viruses transition from contaminants to valuable products.

Crucially, improved engineering clarity enables us to design recovery and purification sequences that are fit-for-purpose for emerging product classes, including those in food biotechnology and advanced pharmaceuticals, where particle diversity and regulatory expectations are rapidly expanding. By quantifying bioprocess properties, forces, and interactions, we gain robust predictive insight, enabling smarter DSP design with fewer bottlenecks and greater confidence across sectors.

Biography

Andrea C.M.E. Rayat is an Associate Professor of Bioseparations and Downstream Processing at University College London. She obtained her Bachelor of Science in Chemical Engineering from the University of the Philippines, her Master of Science in Chemical Engineering and Biochemical Engineering (*cum laude*) from Delft University of Technology on the Netherlands and her PhD in Biochemical Engineering from UCL.

Her research portfolio spans antibodies, therapeutic vectors including lentiviral vectors, biopolymers, and complex particle systems relevant to food and biopharmaceutical manufacturing. Her work integrates ultra scale-down methodologies, the design of scale-down tools, mechanistic characterisation, and the engineering of unit operations to improve the predictability, robustness, and scalability of primary recovery operations and membrane-based separations. This has recently included advancing the bioprocessing of lentiviral vectors through influential studies on vector stability and shear robustness.

Her group operates at the interface of technology translation and knowledge exchange, attracting support from UKRI BBSRC, EPSRC Impact Acceleration, and Knowledge Transfer programmes, the latter earning her team an IChemE Global Award. She is passionate about optimal operation and recovery, particularly where these contribute to sustainable bioprocessing goals. This commitment is reflected in her roles as a session chair at the forthcoming Recovery of Biological Products Conference (Recovery XXI) and as chair of the 2025 ECI Single-Use Technologies conference, which highlighted an expanding range of DSP-focused presentations.

A current priority in her lab is the downstream processing of new product modalities and the evaluation of emerging technologies for continuous biomanufacture and process intensification. Across these areas, her work centres on developing engineering clarity that enhances predictability, robustness, and the smart design of next-generation downstream processes.

Dr. Monika Tomecka

Microfluidics for scalable downstream processing in industrial biotechnology

As bioprocesses for novel foods and advanced biopharmaceuticals scale in complexity and volume, downstream processing (DSP) has emerged as a critical bottleneck to commercialisation. Conventional separation technologies often struggle to deliver the scalability, cost-efficiency, and gentle handling required for sensitive biological products. Microfluidics offers a promising alternative, enabling continuous, label-free separations based on intrinsic physical properties.

This presentation introduces uFraction8, an inertial microfluidic platform developed to address key DSP challenges in cellular agriculture, pharmaceutics, and novel food bioprocessing. We outline the core principles of the technology and its translation from laboratory-scale concepts to robust industrial systems. Case studies demonstrate the deployment of uFraction8 equipment integrated with 10,000 L microalgae bioreactors, highlighting operation at industrially relevant throughputs and its contribution to sustainable biomass processing for novel food and feed applications.

In addition, recent data from mammalian cell processing will be presented, illustrating the platform's versatility and relevance to cellular agriculture and biopharmaceutical DSP. Together, these examples position microfluidics as a scalable, cross-disciplinary solution to emerging downstream processing challenges.

Biography

Monika Tomecka is a biomedical scientist, entrepreneur, and the Founder & CEO of uFraction8, a biotech engineering company she co-founded in 2017 to develop disruptive bio-separation and downstream technologies for scalable biomanufacturing. She holds a PhD in Biomedical Science from the University of Sheffield and has an academic background in biology, genetics and biomedical research, which informs her leadership of science-driven innovation.

At uFraction8, Monika leads fundraising, business strategy, and customer engagement to advance the company's microfluidics-based separation systems, which enable more efficient downstream processing with lower energy use and higher yield than traditional filters and centrifuges. This technology targets key markets such as microalgae, cellular agriculture and biopharmaceutical production, helping solve major downstream processing challenges in industrial biotechnology.

Under her leadership, uFraction8 has secured significant investment rounds, expanded its operations to include a subsidiary in Poland, and gained recognition for technological innovation and sustainable bioprocessing solutions. Monika is also recognized as a Cartier Women Initiative Science and Technology Fellow 2024, TOP 100 Europe's most influential women in the startup 2022, Top 10 of European Women Who Tech 2019, and she actively advocates for women in STEM and biotech entrepreneurship.

Prof. Dr. Jerry Heng

Downstream Processing of Proteins and Peptides via Crystallisation

The purification of high-molecular-weight modalities such as proteins and peptides for biopharmaceutical therapeutics continues to account for a significant proportion of drug development costs. Recent advances in optimising crystallisation conditions have substantially improved the scalability of protein and peptide crystallisation, making it an increasingly attractive isolation step due to its ability to deliver high purity while controlling particle size distribution, morphology, and polymorphism.

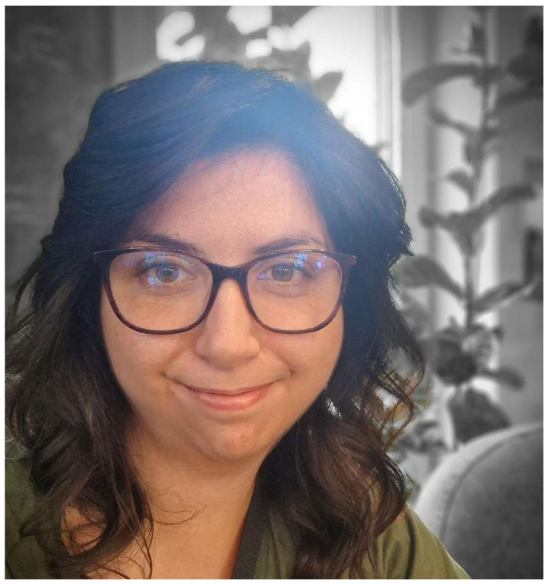
Crystallisation also offers pharmacokinetic advantages, including improved release control, enhanced bioavailability, and reduced impurity loading. This talk will highlight our recent efforts to control nucleation and crystallisation of complex macromolecules—including proteins such as monoclonal antibody (Anti-CD20), thaumatin, concanavalin A, and catalase, as well as homo-peptides—using 3D nanotemplates, soft templates, and systematic studies of short-chain peptide crystallisation. For peptides, we examine how chain length, sequence, and protecting groups influence solubility and crystallisability, using glycine homopeptides as model systems, and extend these studies to vancomycin and GnRH analogues, where intermolecular interactions and emerging secondary structure features play a critical role in crystallisation behaviour.

The work here. illustrate how these molecular features govern solubility and crystallisation behaviour of peptides. Overall, the talk provides insights into the challenges and opportunities of crystallisation as a purification unit operation for proteins and peptides.

Biography

Prof. Dr. Jerry Heng (JH) is currently a Professor in Particle Technology and Director of Undergraduate Studies at the Department of Chemical Engineering at Imperial College London. Jerry obtained his PhD in Chemical Engineering from Imperial College London (2006) and a B.Eng in Chemical Engineering from Universiti Teknologi Malaysia (2002). Jerry

research focuses on surfaces and interfaces of particulate materials. A current key research activity of his group is in the area of nucleation and crystal growth, with the aim of developing crystallisation as a separation strategy for the purification of biopharmaceuticals. The Heng Group is supported by UK and EU research councils and industry, publishing >170 journal papers and 10 book chapters and successfully supervised 30 PhD students. Jerry is a Fellow of the Royal Society of Chemistry and Editor-in-Chief for Chemical Engineering Research and Design and a Thematic Editor for Particuology.



Dr. Ida Amura

Transforming Pharmaceutical Downstream Processing: The Role of Membrane Technologie

The pharmaceutical industry faces mounting pressure to reduce environmental impact while maintaining product quality and regulatory compliance. Traditional API manufacturing processes are characterized by energy-intensive unit operations, multistep synthesis requiring extensive solvent use, and limited opportunities for material recovery—resulting in wasteful processes with significant environmental footprints. As part of AstraZeneca's commitment to embracing circular economy principles and delivering on sustainability targets, membrane separation technologies have emerged as a transformative approach to downstream processing. This presentation will showcase strategic implementation of membrane technologies—including organic solvent nanofiltration (OSN), pervaporation, and ultrafiltration. It will also discuss the practical challenges of implementing novel separation technologies in highly regulated environments.

Biography

Dr Ida Amura holds a master's degree in chemical sciences from the University of Sassari (Italy) and a PhD in Chemical Engineering from the University of Bath. She has been working at AstraZeneca since 2020 within the Process Engineering team in Chemical Development at the Macclesfield site. Ida works as scientific specialist in membrane technology, and she deals with advanced membrane separation processes in connection with sustainability, focusing particularly on non-aqueous, organic solvent-based separations, with applications ranging from API purification, metal recovery and solvent cleaning. Her work comprises membrane process design and experimental development from lab to pilot scale. Ida (co-)authored 8 peer-reviewed scientific publications and 1 book chapter. Since 2023 she also leads the process engineering sustainability strategy for chemical development. She is currently studying part-time for a MSc in Sustainability with the University of Cranfield.

Panel Discussion

Chairs

Prof. Dr. Marianne Ellis

Marianne Ellis, BEng, PhD, CEng, MIChemE, is a Professor of BioProcess & Tissue Engineering at the University of Bath. Her research is focused on bioprocess design for tissue engineering applications. Marianne is Director of CARMA. She started her career focused on the scale up of regenerative medicine and cell therapies, moved into non-animal technologies for in vitro models, and is now focused on cellular agriculture and in particular cultivated meat. Marianne is also co-founder and CTO of Cellular Agriculture Ltd.

Prof. Dr. Davide Mattia

Prof. Dr. Davide Mattia is a Professor of Chemical Engineering at the University of Bath, specialising in sustainable membrane manufacturing and advanced nanomaterials. His research focuses on greener, more efficient separation processes using 3D-printed membranes, green solvents and novel 2D materials. He is also Co-Investigator in the Sustainable Chemicals and Materials Manufacturing Hub. Mattia is the co-founder and Chief Technical Officer of Naturbeads, a spin-out developing biodegradable cellulose-based microbeads as alternatives to plastics. He has held several leadership roles at Bath and contributes widely to the membranes and materials science community.

Panellists

Prof. Dr. Gary Lye

Prof. Gary Lye is Director of the UCL East Manufacturing Futures Lab (MFL), Director of the EPSRC Centre for Doctoral Training (CDT) in Bioprocess Engineering Leadership and Co-Director of the EPSRC Cellular Agriculture Manufacturing Research Hub (CARMA) and the UK Medicines Manufacturing Skills Centre of Excellence (RESILIENCE). He was previously Head of the UCL Department of Biochemical Engineering from 2015 – 2023. He is Fellow of the Royal Academy of Engineering (FREng), a Fellow of the Institution of Chemical Engineers (FIChemE, CEng, CSci), a Senior Fellow of the Higher Education Academy (SFHEA) and recipient of the IChemE Donald Medal (2021).

Gary joined UCL in 1996 and was a founding member of the UCL Department of Biochemical Engineering in 1998. Prior to UCL he was a Lecturer in Chemical Engineering, University of Edinburgh (1995 - 1996) and a Research Fellow in Chemical Engineering, Imperial College London (1993 - 1995). Academic qualifications include a BSc in Biotechnology (1989) and a PhD in Biochemical Engineering (1992), both from the University of Reading.

Prof. Dr. Daniel Bracewell

Daniel G. Bracewell is Professor of Bioprocess Analysis at the UCL Department of Biochemical Engineering. He has made major contributions to fundamentally understanding the recovery of biological products. His research is focused on the manufacture of biological products that are of therapeutic, diagnostic and industrial value to society. Generating over £10 million in

research funds including collaborations with Thailand, India and the USA. He has authored more than 100 peer reviewed journal articles in the area to date and currently supervises 15 doctoral and postdoctoral projects, many of these studies are in collaboration with industry. One such project was the basis from which the spinout Puridify was created. It was acquired by GE Healthcare (now Cytiva) in 2017.

Dr. Nigel Jackson

Dr. Nigel Jackson is a principal engineer at Cytiva R&D. Since his PhD in biochemical engineering at University College London, Nigel Jackson has 20 years of experience in bioprocessing R&D at Cytiva as a filtration expert. Nigel has multiple publications and conference presentations increasing the understanding of virus filtration. He has directed this knowledge into helping develop robust and effective new filters and many other Cytiva products and applications. He is also currently a visiting lecturer in filtration at UCL.

ORAL ABSTRACT PRESENTATIONS

Vibratory Tangential Flow Filtration for the Clarification and Fractionation of Yeast-Derived Protein Extracts as Animal-Free Media Components for Cultured Meat Applications

Abstract

This research focuses on the downstream processing (DSP) of yeast-derived hydrolysates for use as animal-free hydrolysates (AFHs) in cultured meat applications. Although upstream processes, such as fermentation, have demonstrated significant enhancements in biomass productivity, DSP remains a major bottleneck for commercialisation of cellular agriculture products. Key DSP challenges include low recovery yields and scalability limitations that affect production efficiency and cost. In this study, hydrolysates of *Saccharomyces cerevisiae* (SC) baker's yeast were produced by disrupting yeast biomass using high-pressure homogenization (HPH), followed by alkaline hydrolysis of the protein extracts. The resulting yeast hydrolysate was then fractionated using a vibratory tangential flow filtration device (TFF, SANI Vibro-Lab35P), and the fractions evaluated for their potential as substitutes for animal-derived media components in mammalian cell cultures. The results showed that the average yeast cell size decreased from 5.7 µm to 3.8 µm after four cycles of HPH disruption at 400 bar. A protein extraction yield of 13.5 w/w% was obtained following alkaline hydrolysis of the disrupted biomass using 0.5 M sodium hydroxide at 45 °C for 2 hours. Furthermore, the yeast protein hydrolysate fractions (YPHF) within the 1-100 kDa molecular weight range successfully reduced the amount of expensive fetal bovine serum (FBS) required in cell culture experiments, whereas the unfractionated yeast extract exhibited cytotoxic effects on the cell culture. These initial results demonstrate the benefits of vibratory TFF technology and provide insights into future scale-up routes for cellular agriculture processes.

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Crystallisation of Peptides Using Templating Strategies

Abstract

Peptide therapeutics have emerged as a transformative class of drugs, offering high target specificity, potency, and favourable safety profiles, leading to a significant rise in their clinical demand [1]. Compared to traditional small-molecule drugs, peptides exhibit lower toxicity, better biocompatibility, and the ability to modulate complex biological interactions that small molecules often cannot address [2]. Despite these advantages, challenges persist in downstream processing, where conventional chromatographic purification struggles with scalability, cost-effectiveness, and separating closely related impurities due to peptides' structural complexity. In this context, peptide crystallisation offers a promising alternative, enabling simultaneous purification and isolation while improving product stability — a crucial step towards robust manufacturing pipelines. Crystallisation also plays a pivotal role in advancing oral peptide formulations, as crystalline forms can enhance bioavailability and control release profiles, addressing the long-standing challenge of peptide instability in the gastrointestinal tract [3].

In our studies, heterogeneous templates have shown significant potential in directing and accelerating peptide crystallisation, opening new pathways to overcome kinetic barriers and achieve high-purity crystalline products. Hard templates, such as functionalised porous silica, have been successfully employed to crystallise glycine and diglycine [4]–[6], while soft templates, like amino acids, have facilitated the crystallisation of insulin [7]. The predominant mechanism driving heterogeneous nucleation is functional group matching, where hydrogen bond complementarity between the hetero-surface and peptide enhances nucleation rates. Notably, reductions in induction times were observed when homopeptides, dipeptides, and tripeptides were crystallised in the presence of silica. Additionally, the presence of heteronucleants significantly increased the pre-exponential factor in nucleation kinetics, indicating a higher rate of cluster formation [4]. Successfully crystallising therapeutic peptides through templated strategies not only advances purification and formulation technologies but also unlocks new possibilities for the oral delivery of complex biologics.

Acknowledgments: The authors would like to thank Dr. Vivek Verma and Dr. Frederik Link for their valuable contributions to the published data on templated crystallisation of peptides. We also gratefully acknowledge Eli Lilly and Company for funding support and Dr. Emily J. Guinn for the insighful discussions.

References

[1] L. Wang *et al.*, *Signal Transduct. Target. Ther.*, vol. 7, no. 1, 2022
[2] M. Muttenthaler *et al.*, *Nat. Rev. Drug Discov.*, vol. 20, no. 4, pp. 309–325, 2021
[3] H. Zhang *et al.*, *RSC Chem. Biol.*, vol. 3, no. 1, pp. 18–31, 2022
[4] V. Verma *et al.*, *Faraday Discuss.*, vol. 235, pp. 199–218, 2021
[5] U. V. Shah *et al.*, *Curr. Opin. Chem. Eng.*, vol. 8, pp. 69–75, 2015
[6] V. Verma *et al.*, *Pharmaceutics*, vol. 15, no. 4, 2023
[7] F. J. Link *et al.*, *CrystEngComm*, vol. 23, no. 22, pp. 3951–3960, 2021

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Ultra Scale-Down Evaluation of Shear Effects During the Centrifugal Recovery of Cultivated Meat Cells

Abstract

Developing efficient and cost-effective bioprocesses for the manufacture of cultivated meat is paramount to achieving price parity with conventional meat. Process development is far cheaper and quicker to complete at bench scale, but this requires representative scale-down models of key bioprocess unit operations to be available. In this work, ultra-scale down (USD) technologies are used to rapidly evaluate the effects of shear on the recovery of mammalian cells through centrifugation. Baseline experiments were conducted with Chinese hamster ovary (CHO) cells to develop USD and cell quality analysis methods. Shear in the entry and exit zones of a disc stack centrifuge were simulated in a kompAs® USD shear device. The effects of shear were quantified by measuring total cell concentration, cell viability, particle size distribution, and lactate dehydrogenase (LDH) release. The cell death mechanism was investigated using flow cytometry.

Data from CHO cells indicate a significant impact of shear (energy dissipation rate of 5.3 x 10^5 W/kg based on a disc stack centrifuge) on total cell concentration, cell viability, particle size distribution, and LDH concentration across harvest cell densities of 1 – 12 x 10^6 cells mL^{-1}. In contrast, preliminary data in Water Buffalo adipose-derived stem cells (WB ASCs) and a benchmark C2C12 mouse myoblast cell line indicate no significant effect of shear at harvest cell densities of 1 x 10^6 cells mL^{-1}. Experiments are currently being undertaken to determine the levels of apoptotic and necrotic markers in response to shear, as well as shear effects on higher cell concentrations. Thus far, results suggest that shear effects may be greater on cell suspensions than adherent cells which tend to form clumps. However, serum in the culture medium may also play a shear-protective role. Further work will be done to replicate these initial results and to evaluate strength and viscoelastic properties of cultivated meat cells. USD methods will also be established to mimic other centrifuge designs.

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Use of chemically modified polybenzimidazole (PBI) spiral wound modules (SWM) for downstream purification of oligonucleotides at high concentration in aqueous-organic feeds

Abstract

Tangential Flow Filtration (TFF) is a widely used technique for oligonucleotide purification, enabling efficient removal of salts and solvent, while concentrating the target product. A limiting factor in the downstream processing of pharmaceutical materials is the increased breakthrough of desired solute and the increased osmotic pressure at high product concentrations. This significantly limits the maximum achievable concentration during TFF, with expensive lyophilisation required to meet the drug concentrations required for formulation operations.

To overcome these challenges, Exactmer has developed Exact-20^{TM} PBI membranes, for TFF in aqueous/organic solutions. These membranes are surface functionalised to overcome breakthrough at high concentrations and have been manufactured into spiral wound modules (SWM) which are stable at up to 30 bar transmembrane pressure (TMP) to overcome the osmotic pressure, which limits commercially available TFF cassettes. These modules were utilised to process increasing concentrations of a duplex oligonucleotide in an aqueous/organic solution, achieving rejections of over 99.85% at 300 mg mL^{-1}, whilst maintaining an effective flux of 10.0 L m^{-2} h^{-1} at 30 bar TMP. Further to this, these modules were tested in solvent up to 75% DMF to determine the stability of the membrane in oligonucleotide post-synthesis conjugation reaction mixtures. Exact-20^{TM} demonstrated exceptional solvent stability and delivered high rejection performance of over 99.9%, demonstrating DMF removal which cannot be achieved by any commercial TFF membrane.

This work demonstrates the potential of using Exact-20^{TM} SWM in downstream pharmaceutical processing, where increased pressures and solvent stable membrane can greatly improve final concentrations and reduce required membrane area.

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Spent Cell Culture Media Recovery for Cultivated Meat

Abstract

The emerging development of cultured meat has highlighted downstream processing as a critical yet underexplored barrier to industrial scale-up, encompassing efficient cell harvesting and the valorisation of by-products, particularly recovering underutilised components in spent cell culture media[1]. Cell media constitutes one of the main cost drivers in large-scale cultivated meat production[2]. Despite being routinely discarded, spent media retains a substantial proportion of essential nutrients. Its disposal is caused by the accumulation of cytotoxic metabolites, most notably lactate and ammonia, which inhibit cell proliferation[2]. Therefore, the selective removal of these metabolites presents a strategic opportunity to extend media usability, reduce production cost, and enhance environmental sustainability[2]. Additionally, recovered lactate and ammonia could be used as carbon and nitrogen feedstocks for microbial fermentation, aligning with circular bioeconomy principles .[3]

This research proposes a membrane-based separation approach to recovery spent cell culture media. The membrane filtration enables the selective removal of lactate and ammonia based on molecular size and physicochemical properties without introducing additional toxic chemical agents. The process aims to preserve the functional integrity of essential media constituents, including proteins, amino acids, and growth factors, thereby supporting the reuse of the recycled media with minimal performance loss for at least a second use.

Overall, this work aims to address the underdeveloped media reutilisation for cultivated meat production through effective nutrient recovery. Through selective membrane filtration for metabolite removal, the proposed approach aims to establish a scalable, cost-effective, and environmentally sustainable processing framework that will enhance the industrial feasibility of future cellular agriculture.

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From Pasture to Plate: Enhancing protein recovery from grass through combined mechanochemical extraction and downstream membrane processing

Abstract

According to the United Nations, the world population is projected to increase from 8.3 billion today to 9.6 billion by 2050 [1]. To feed the global population, food production needs to increase by 50-70% as per the reports of Food and Agriculture Organisation (FAO, 2017). However, current food production practices are responsible for one-third of total greenhouse gas emissions worldwide, with animal-based foods responsible for 60% of the total emissions [2]. The current food production processes are unsustainable; beef production alone generates 70 kg of CO_2 equivalent emissions per kilogram of meat produced, making it one of the most environmentally taxing protein sources available [3-5]. Despite already high production volumes, food insecurity persists. The Global Hunger Index remains high at 18.3, and the urgency to meet the UN SDG 2: Zero Hunger has never been greater. Hence, it is essential to shift to alternative food sources with a lower environmental impact to reduce the overall carbon footprint, while developing sustainable, high-valued food sources that meet global nutritional demands.

A promising and abundant source for this transition may lie in reimagining our existing landscapes. In the UK, 70% of land is agricultural, with 9.7 million hectares of permanent grassland. Grass, despite its abundance and ~8% crude protein content, remains underutilised due to its indigestible lignocellulosic structure [6]. Unlocking this vast, green reservoir requires a combination of upstream and downstream processing to transform it into an accessible, high-value food ingredient.

The “Pasture to Plate” project is working to unlock this potential by combining mechanochemical extraction [7] and membrane separation techniques to extract, purify and concentrate edible proteins. Water-soluble proteins were extracted from freeze dried grass using a twin screw extruder. The pressed grass extract was then further processed downstream in a tangential flow filtration system operated in semi-batch mode to concentrate the proteins. A 1.2-micron microfiltration membrane, at 1.5 bar transmembrane pressure and 14 l/h cross flow rate, was used to concentrate and retain the grass proteins. The retained proteins were further purified and concentrated with a three step diafiltration process. At the end of the diafiltration process, the clarified retentate was freeze-dried.

The resulting product achieved a crude protein concentration of approximately 54%, approaching the commercial benchmark of 60%. The crude protein is primarily composed of RubisCo along with other proteins. In terms of protein quality and functionality, grass proteins have a Protein Digestibility Corrected AA Score (PDCAAS) and Digestible Indispensable AA Score (DIAAS) of 0.83 and 0.87, respectively, which is quite comparable to pea protein isolate.

While promising, key challenges remain, including ways to increase the overall purity and functionality of the protein powder. This study highlights a viable path to valorise grass as a sustainable, high-value protein source, reducing reliance on environmentally intensive animal proteins and advancing the goal of sustainable food systems.

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Poster Presentations

Reflecting the role of protected fragments in the downstream processing: how protecting groups affect the solubility and crystallisation of alanine homopeptides

Abstract

Chromatography is recognised as a versatile downstream processing (DSP) technique, yet scale-limited, solvent-intensive and costly. To achieve the ultra-high purity for pharmaceuticals and foods, impurity removal becomes a demanding section accounting for >80% of the total production cost (Bracewell *et al.*, 2015). Crystallisation offers a sustainable alternative whose success relies on a thorough understanding of thermodynamic, kinetic and impurity profiles. Taking peptide manufacturing as an example, after Solid-Phase Peptide Synthesis (SPPS), unreacted N-terminus protected amino acids remaining in the crude product can be one of the main impurities. In this study, alanine homopeptides were selected as the model molecules, and an investigation into the effect of protecting groups (PG) on the solubility and nucleation kinetics could be leveraged to intensify DSP.

Aqueous solubilities of 8 compounds including alanine homopeptides (alanine to tetraalanine) and Boc, Cbz protected alanines and dialalnines were measured gravimetrically from 278.15 to 313.15 K. Generally, solubility decreases with an increase in peptide chain length and PG hydrophobicity. For example, at 313.15 K, the presence of Boc reduces Boc-Ala-Ala solubility to ~0.7% of Ala-Ala. The molecular-weight effect of PGs is weaker on dipeptides than on amino acids, highlighting a composition-dependent lever to position crystallisation windows. Interestingly, Ala-Ala exhibits a peculiar ultra-high retrograde solubility curve, which could be relevant to the inherent crystal packing and hydrogen bonding propensity.

Based on the solubility profiles, the nucleation kinetics of the aforementioned 8 compounds in water were studied by measuring metastable zone width (MSZW) and induction time at specific supersaturation ratios. Nucleation of protected fragments appears to be more stochastic than that of corresponding unprotected species. When the alkyl chain length reaches 3 or 4, nucleation cannot be observed after 96 hours. It is also intriguing to have seen the unexpected trends from MSZW experiments: quicker nucleation at a lower concentration of Cbz-Ala versus suppressed nucleation at a higher concentration of Boc-Ala. Other than enhancing the reliability of data by more repeats on the current DoE, for the species has not been crystallised, solvent selection, antisolvent and templated crystallisation will be considered to make the crystallisation feasible.

In summary, protecting groups have been confirmed to have a significant effect on the thermodynamic properties and nucleation kinetics of alanine homopeptides. The resultant differences in solubility and nucleation kinetics may guide for selecting PGs that not only deliver synthetic selectivity but also unlock robust, sustainable DSP.

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Single Pass Tangential Flow Filtration (SPTFF) for ContinuousConcentration: State of the Art and Current Models

Abstract

The switch to continuous bioprocessing has driven interest in the development of a continuous filtration operation. Single pass tangential flow filtration (SPTFF) is an alternative to traditional TFF. The core principle of SPTFF is the elimination of the TFF recycle loop, enabling the desired separation and concentration to be achieved in a single pass. Multiples membranes or cassettes are used to extend the filter length, while reduced feed flow rates increase residence time of material within the filter, promoting higher concentration factors. Given these characteristics, it is essential to optimise SPTFF process design by considering both the operating parameters and key equipment design elements such as configuration and overall length.

A deeper understanding of the critical operating parameters aGecting SPTFF performance oGers the opportunity for less reliance on large scale industrial testing. However, current SPTFF characterisation is limited to specific experimental studies rather than a broader framework of design principles. This work will present an overview of this new technology, focusing on (1) the current state of the art and (2) early modelling results to describe the hydrodynamics and mass transfer processes occurring within filtration modules.

Current published studies show that initial concentration, feed flow rate, transmembrane pressure (TMP), and filter configuration exert the greatest influence on SPTFF performance. Due to the longer characteristic length and flexible design architecture of SPTFF systems, volume decreases along the module leading to progressive pressure loss. This reduction in pressure diminishes the driving force in later stages. Consequently, SPTFF configurations must be optimised to minimise pressure drop while maintaining adequate feed fluxes across successive stages. Optimal system designs are therefore process-specific and remains an inherent challenge for SPTFF modelling.

The modelling approaches presented here incorporate the theories related to the osmotic pressure model, boundary layer model, and stagnant film theory, each capturing distinct resistance mechanisms to calculate local flux and overall concentration factors. This review of published experimental work, existing SPTFF models, and our new modelling analyses highlights key gaps in current understanding. These findings outline the next step in this research, which will be addressed through dedicated scale-down studies.

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Improving the Sustainability of Oligonucleotide Manufacturing through Solvent Reuse and Enzymatic Ligation

Abstract

Improving the sustainability of solid-phase oligonucleotide synthesis (SPOS) remains a significant challenge, particularly with respect to solvent reuse and downstream purification. At CPI, two complementary projects have been undertaken to address these issues. The first project (MELOS), carried out in collaboration with Exactmer and Queen Mary University, focused on the development and validation of a waste-collection and solvent-recycling strategy for SPOS, incorporating cross-flow membrane purification of waste streams and reuse of recovered acetonitrile. Oligonucleotides synthesized using recycled acetonitrile exhibited purity profiles comparable to those obtained with fresh solvent, demonstrating the effectiveness of the membrane-based recycling approach. The second project (OLLIE) aimed to reduce purification burden and associated yield losses in the manufacture of siRNA therapeutics. In this work, CPI, Almac and Biotoolomics are developing a novel siRNA synthesis platform based on enzymatic ligation of oligonucleotide fragments, offering the potential for more efficient and sustainable production.

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Affinity Chromatography Using Streptavidin Monoliths for Lentiviral Vector Capture: Selectivity and Impurity Clearance in Downstream Processing

Abstract

Downstream processing of lentiviral vectors (LVs) remains a major bottleneck due to low recoveries and long cycle times in conventional packed-bed operations. This work presents a single-use monolith affinity chromatography platform that leverages the high-specificity interaction between streptavidin and a cyclic biotin-mimetic peptide (cTag8) displayed on LVs envelopes, enabling selective capture under convective flow.

The purification mechanism relies on competitive affinity binding: cTag-modified LVs bind to immobilised streptavidin during loading, followed by gentle competitive elution using micromolar concentrations of biotin [1]. This approach avoids harsh conditions such as high salt or imidazole, preserving LV integrity and infectivity while leveraging the advantage of monolith columns to operate under high flowrates and linear velocities with minimal pressure drop, reducing residence time and improving process throughput. Engineered HEK239T packaging cells are central to this approach. These cells enable the of cTag8 on the CD8α stalk, allowing LVs to passively present cTag8 on the viral surfaces.

The current work evaluated the impact of various process conditions such as load capacity, operating temperature, flowrates and buffers. The process characterisation focused on step yields and impurity clearance, particularly double-stranded DNA (dsDNA) and host cell proteins (HCP). Complete capture of infectious particles was achieved, with ~99% dsDNA removal via the flowthrough and wash fractions, and approximately 98% HCP clearance in the elution fractions. Elution was achieved under mild conditions obtaining >75% overall recovery depending on elution buffer used, demonstrating a potential for optimised operations by fine tuning buffer selection. The recovery showed robust desorption without the risks associated with other affinity-based separation (e.g., in IMAC, there is a risk of the elution being harsh on the LVs, which can cause damage the viral vector envelope and decrease infectivity).

Further work on dynamic binding capacity studies are ongoing while the scalability of this purification strategy will be further assessed in a ten-fold scale up. This one-step affinity chromatography approach offers viral selectivity, efficient impurity removal and robust recovery, representing a critical advancement in downstream processing by potentially reducing the number of unit operations, simplifying the complex operations, and enabling a more scalable and cost-effective platform.

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