
CALIFORNIA

Abstract

Our unit members have made significant strides in their research projects and engaged in local outreach activities during FY2023. We published 15 peer-reviewed papers spanning microfluidics, 3D printing, rheology, and biotechnology. Actively disseminating our research, we delivered over 45 invited and contributed presentations, including posters, and participated in virtual and in-person professional society meetings throughout FY2023. In December, we co-hosted the IEEE-NANOMED 2023 conference at OIST, featuring 200+ well-known international speakers. Additionally, we organized 12 seminars led by globally recognized scientists covering topics from microfluidics to rheology and biotechnology.

In FY2023, our unit secured 7 prestigious fellowships and Kakenhi grants. Amy and Simon received Kakenhi-B for 'Canopy Elastic Turbulence', Simon already received Kakenhi-C for 'Large Amplitude Oscillatory Extension (LAOE)'. Vincenzo's project on 'Polymer Conformational History's Role in Polymeric Liquids', Kohei's research on 'Buoyancy-Induced Circulation in Microchannels' and Ricardo's study on 'Elastic Turbulence in Micro Canopy Flows' each received Kakenhi grants. Ben's 'Eleprep' project, developing an electrochemical-microfluidic biosensor for foodborne pathogens and Pranab's project on 'Surface wettability effects for microfluidic flows' also secured kakenhi funding.

We hosted 2 Ph.D. rotation students from OIST and welcomed 5 research interns from Toyohashi University of Technology, Chonnam National University, University of Cambridge, Maastricht University, and University of Twente and 1 visiting research from Tohoku University.

Personnel-wise, we welcomed 2 new postdocs: Dr. Davide Califano from the University of Bath, specializing in bio-based products like algae, and Dr. Steffen Recktenwald from Saarland University, focusing on rheology and microfluidics. Additionally, Dr. Kohei Abe joined us as a JSPS postdoc Fellow from Tokyo University of Agriculture and Technology (TUAT), and Prof. Pranab Mondal as a JSPS Invitational Fellow from IIT Guwahati.

1. Group Member

Prof. Amy Shen, Professor
Dr. Simon Haward, Group Leader
Dr. Vincenzo Calabrese, Postdoctoral Scholar
Dr. Ricardo Arturo Lopez de la Cruz, Postdoctoral Scholar
Dr. Murali Mohan Jaligam, Postdoctoral Scholar
Dr. Davide Califano, Postdoctoral Scholar (POC)
Dr. Kohei Abe (JSPS Postdoc Fellow)
Prof. Pranab K Mondal (JSPS Invitational Fellow)
Dr. Steffen Michael Recktenwald, Postdoctoral Scholar
Mr. Kazumi Toda-Peters, Lab Manager and Research Technician
Mr. Fabian Hillebrand, Graduate Student
Mr. Jiangming Wu, Graduate Student
Ms. Arisa Yokokoji, Graduate Student
Mr. Mauricio Andres Rios Maciel, Graduate Student
Ms. Hiromu Josha, Research Administrator

Alumni

Dr. Daniel Carlson, Postdoctoral Scholar
Dr. Tatiana Porto Dos Santos, Postdoctoral Scholar (external funding)
Dr. Stylianos Varchanis, Postdoctoral Scholar
Dr. Benjamin Heidt, Postdoctoral Scholar
Dr. Eliane Younes, Postdoctoral Scholar
Ms. Teresa Bosch Tamayo, Rotation Student
Ms. Tamara Iakimova, Rotation Student
Mr. Ryoma Suzuki, Research Intern
Mr. Yangyul Ju, Research Intern
Mr. Silvio Salvatore Bonni, Research Intern
Mr. Henry John London, Research Intern
Ms. Diana Susanne Andreoli, Research Intern
Mr. Shunsuke Kato, Visiting Researcher

2. Collaborations

Type of collaboration: Joint research
Researchers:
Professor Riccardo Funari, Scuola Superiore Sant'Anna, Italy
Professor Nikhil Bhalla, University of Ulster, UK
Professor Carlos Lopez, The Pennsylvania State University, USA
Professor Gareth McKinley, MIT, USA
Professor Ashis Sen, IIT, Madras, India
Professor Atsushi Matsumoto, University of Fukui, Japan
Professor Yuanyuan Guo, Tohoku University, Japan
Professor Yoichiroh Hosokawa and Yaxiaer Yalikun, Nara Institute of Science and Technology, Japan
Professors Paola Laurino and Marco Rosti, OIST, Japan

3. Activities and Findings

3.1 Viscoelastic instabilities and flow alignment in complex fluids

3.1.1 Rheological effects on purely-elastic flow asymmetries in the cross-slot geometry, Arisa Yokokoji, Stylianos Varchanis, Amy Q. Shen, Simon J. Haward, *Soft Matter* **20**: 152-166(2024)

We investigate the elastic flow instability in the cross-slot geometry. We employ a series of hydrolyzed polyacrylamide solutions of varying rheological properties to investigate how fluid elasticity and shear-thinning affect the onset and development of asymmetric flows in the cross-slot. Flow velocimetry is performed on each of the polymer solutions. It is used to assess the degree of flow asymmetry I in the cross-slot as a function of both Wi and a dimensionless parameter S quantifying the flow-rate-dependent extent of shear thinning. Typically, the flow field breaks symmetry beyond a critical Wi, but the magnitude of flow asymmetries is also found to be dependent on S. For a few specific polymer solutions, the flow field recovers symmetry above a second, higher critical Wi as S becomes small. The experimental results are summarized in a flow state diagram in Wi–S space, showing the relationship between flow asymmetry and fluid rheology. Finally, numerical simulations are performed using the linear simplified Phan–Thien–Tanner model to gain a deeper understanding of the effects of shear thinning. We demonstrate that the degree of both shear thinning and elasticity of the fluid, and their interplay are important factors controlling elastic instabilities in the cross-slot geometry.

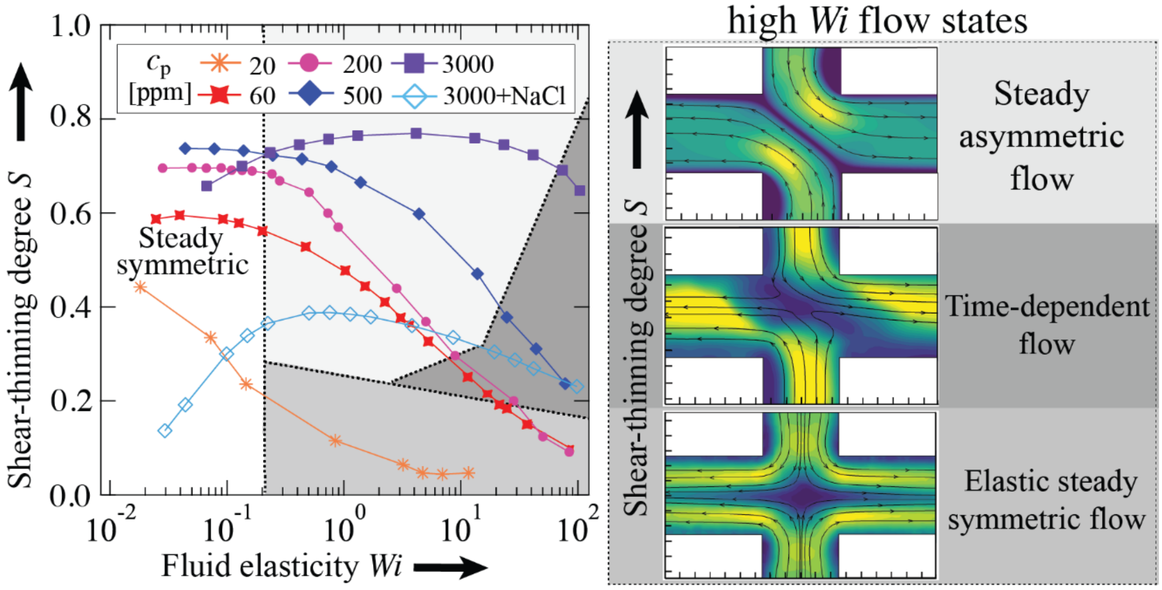


Figure 1: Flow state diagram with various combinations of Weissenberg number *Wi* and shear-thinning degree *S* by changing the polymer concentration (c_p = 20 ppm (orange), 60 ppm (red), 200 ppm (pink), 500 ppm (blue), 3000 ppm (purple), 3000 ppm with sodium chloride 0.5 mol L^{-1} (light-blue)). The color in the flow state diagram differentiates the flow states (white: steady symmetric (Newtonian-like) flow, light-gray: steady asymmetric flow, medium-gray: elastic steady symmetric flow, dark-gray: time-dependent flow). The representative flow states are shown on the right side: Steady asymmetric flow state (*Wi* = 4.2, *S* = 0.77), Time-dependent flow state (*Wi* = 29, *S* = 0.29), and elastic steady symmetric flow state (*Wi* = 19, *S* = 0.19).

3.1.2 Exploring multi-stability in three-dimensional viscoelastic flow around a free stagnation point. Daniel W. Carlson, Simon J. Haward, Amy Q. Shen. *Journal of Non-Newtonian Fluid Mechanics*, **323**, 105169 (2024).

Fluid elements passing near a stagnation point experience finite strain rates over long persistence times, and thus accumulate large strains. By the numerical optimization of a microfluidic 6-arm cross-slot geometry, recent works have harnessed this flow type as a tool for performing uniaxial and biaxial extensional rheometry (Haward et al., 2023). Here we use the microfluidic 'Optimized-shape Uniaxial and Biaxial Extensional Rheometer' (OUBER) geometry to probe an elastic flow instability which is sensitive to the alignment of the extensional flow. A three-dimensional symmetry-breaking instability occurring for flow of a dilute polymer solution in the OUBER geometry is studied experimentally by leveraging tomographic particle image velocimetry. Above a critical Weissenberg number, flow in uniaxial extension undergoes a supercritical pitchfork bifurcation to a multi-stable state. However, for biaxial extension (which is simply the kinematic inverse of uniaxial extension) the instability is strongly suppressed. In uniaxial extension, the multiple stable states align in an apparently random orientation as flow joining from four neighbouring inlet channels passes to one of the two opposing outlets; thus forming a mirrored asymmetry about the stagnation point. We relate the suppression of the instability in biaxial extension to the kinematic history of flow under the context of breaking the time-reversibility assumption.

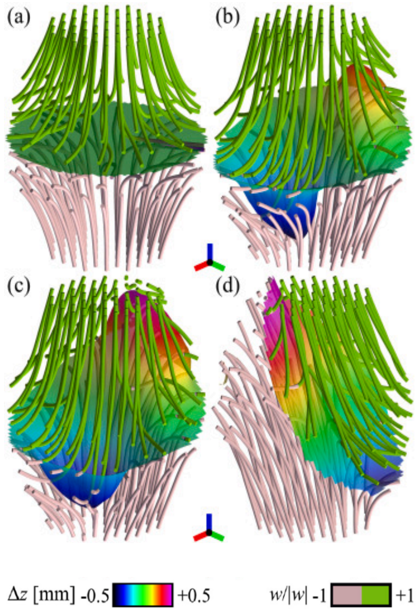


Figure 2: 3D streamlines coloured by w/|w| for uniaxial extensional flow at (a–d) 0.6, 3.6, 4.0, 16.4. The isosurface follows w = 0 and is coloured by Δz for contrast. All volumes are aligned to the reference coordinate triad in the centre.

3.1.3 Naturally derived colloidal rods in microfluidic flows, Vincenzo Calabrese, Amy Q. Shen, Simon J. Haward, *Biomicrofluidics*, **17**, 021301, (2023).

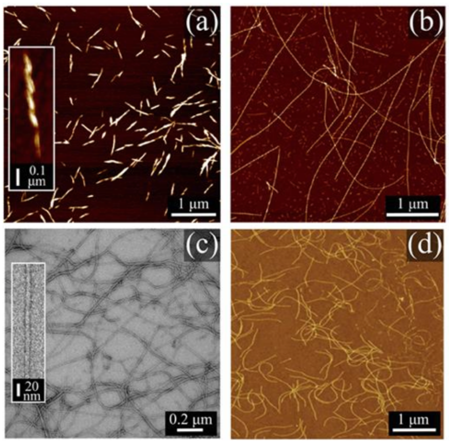


Figure 3: Images of representative naturally derived colloidal rods.

Naturally derived colloidal rods (CR) are promising building blocks for developing sustainable soft materials. Engineering new materials based on naturally derived CR requires an in-depth understanding of the structural dynamics and self-assembly of CR in dispersion under processing conditions. With the advancement of microfabrication techniques, many microfluidic platforms have been employed to study the structural dynamics of CR under flow. However, each microfluidic design has its pros and cons which need careful evaluation in order to fully meet the experimental goal and correctly interpret the data. We analyze recent results obtained from naturally derived CR and relevant rod-like macromolecules under microfluidic flows, with emphasis on the dynamical behavior in shear- and extensional-dominated flows. We highlight the key concepts required in order to assess and evaluate the results obtained from different CR and microfluidic platforms as a whole and to aid interconnections with neighboring fields. Finally, we identify and discuss areas of interest for future research directions.

3.1.4 Alignment–Rheology Relationship of Biosourced Rod-Like Colloids and Polymers under Flow, Marvin Detert, Tatian Porto Santos, Amy Q. Shen, Vincenzo Calabrese
Biomacromolecules, **24**, 3304-3312, (2023).

Fluids composed of biosourced rod-like colloids (RC) and rod-like polymers (RP) have been extensively studied due to various promising applications relying on their flow-induced orientation (e.g., fiber spinning). However, the relationship between RC and RP alignment and the resulting rheological properties is unclear due to experimental challenges. We investigate the alignment–rheology relationship for a variety of biosourced RC and RP, including cellulose-based particles, filamentous viruses, and xanthan gum, by simultaneous measurements of the shear viscosity and fluid anisotropy under rheometric shear flows. For each system, the RC and RP contribution to the fluid viscosity, captured by the specific viscosity η_{sp}, follows a universal trend with the extent of the RC and RP alignment independent of concentration. We further exploit this unique rheological-structural link to retrieve a dimensionless parameter (β) directly proportional to η_{sp} at zero shear rate ($\eta_{0,sp}$), a parameter often difficult to access from experimental rheometry for RC and RP with relatively long contour lengths. Our results highlight the unique link between the flow-induced structural and rheological changes occurring in RC and RP fluids. We envision that our findings will be relevant in building and testing microstructural constitutive models to predict the flow-induced structural and rheological evolution of fluids containing RC and RP.

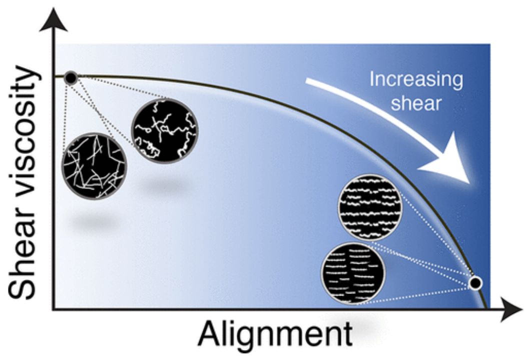


Figure 4: Cartoon describing the relationship between shear viscosity and alignment of rod-like colloids and polymers under shear flow.

3.2 Extensional rheometry and microfluidics

3.2.1 Extensional rheometry of mobile fluids. Part I: OUBER, an optimized uniaxial and biaxial extensional rheometer. Simon J. Haward, Francisco Pimenta, Stylianos Varchanis, Daniel W. Carlson, Kazumi Toda-Peters, Manuel A. Alves, Amy Q. Shen.
Journal of Rheology, **67** (5), 995-1009 (2023).

Numerical optimization of a "six-arm cross-slot" device yields several three-dimensional shapes of fluidic channels that impose close approximations to an ideal uniaxial (biaxial) stagnation point extensional flow under the constraints of having four inlets and two outlets (two inlets and four outlets) and for Newtonian creeping flow. One of the numerically designed geometries is considered suitable for fabrication at the microscale, and numerical simulations with the Oldroyd-B and Phan-Thien and Tanner models confirm that the optimal flow fields are observed in the geometry for both constant viscosity and shear thinning viscoelastic fluids. The geometry, named the optimized uniaxial and biaxial extensional rheometer (OUBER), is microfabricated with high precision by selective laser-induced etching of a fused-silica substrate. Employing a refractive index-matched viscous Newtonian fluid, microtomographic-particle image velocimetry enables the measurement of the flow field in a substantial volume around the stagnation point. The flow velocimetry, performed at low Reynolds number (<0.1), confirms the accurate imposition of the desired and predicted flows, with a pure extensional flow at an essentially uniform deformation rate being applied over a wide region around the stagnation point. In Part II of this paper [Haward et al., J. Rheol. **67**, 1011–1030 (2023)], pressure drop measurements in the OUBER geometry are used to assess the uniaxial and biaxial extensional rheometry of dilute polymeric solutions, in comparison to measurements made in planar extension using an optimized-shape cross-slot extensional rheometer [OSCER, Haward et al., Phys. Rev. Lett. **109**, 128301 (2012)].

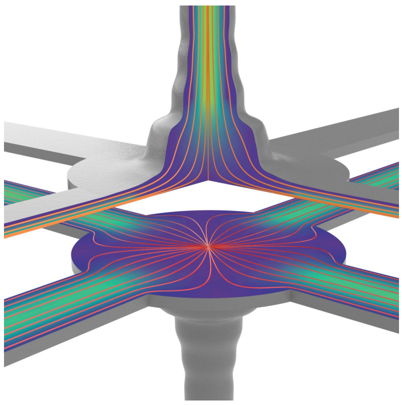


Figure 5: We describe the numerical optimization of a six-armed cross-slot geometry in order to generate homogeneous uniaxial and biaxial extensional flow fields. In the schematic representation of the resulting 'OUBER' geometry (left), color contours are normalized flow velocity magnitude and colored lines are streamlines.

3.2.2 Extensional rheometry of mobile fluids. Part II: Comparison between the uniaxial, planar and biaxial extensional rheology of polymer solutions using numerically-optimized stagnation point microfluidic geometries. Simon J. Haward, Stylianos Varchanis, Gareth H. McKinley, Manuel A. Alves, and Amy Q. Shen**,** *Journal of Rheology* **67**: 1011-1030 (2023)

Part I of this paper [Haward et al., J. Rheol. **67**, 995–1009 (2023)] presents a three dimensional microfluidic device (the optimized uniaxial and biaxial extensional rheometer, OUBER) for generating near-homogeneous uniaxial and biaxial elongational flows. Here, in Part II, the

OUBER device is employed to examine the uniaxial and biaxial extensional rheology of model dilute polymer solutions, compared with measurements made under planar extension in the optimized-shape cross-slot extensional rheometer [OSCER, Haward et al. Phys. Rev. Lett. **109**, 128301 (2012)]. In each case, micro-particle image velocimetry is used to measure the extension rate as a function of the imposed flow conditions, and excess pressure drop measurements enable estimation of the tensile stress difference generated in the fluid via a new analysis based on the macroscopic power balance for flow through each device. Based on this analysis, for the most dilute polymer sample tested, which is "ultradilute", the extensional viscosity is well described by Peterlin's finitely extensible nonlinear elastic dumbbell model. In this limit, the biaxial extensional viscosity at high Weissenberg numbers (Wi) is half that of the uniaxial and planar extensional viscosities. At higher polymer concentrations, although the fluids remain dilute, the experimental measurements deviate from the model predictions, which is attributed to the onset of intermolecular interactions as the polymer chains unravel in the extensional flows. Of practical significance (and fundamental interest), elastic instability occurs at a significantly lower Wi in uniaxial extensional flow than in either biaxial or planar extensional flow, thereby limiting the utility of this flow type for extensional viscosity measurement.

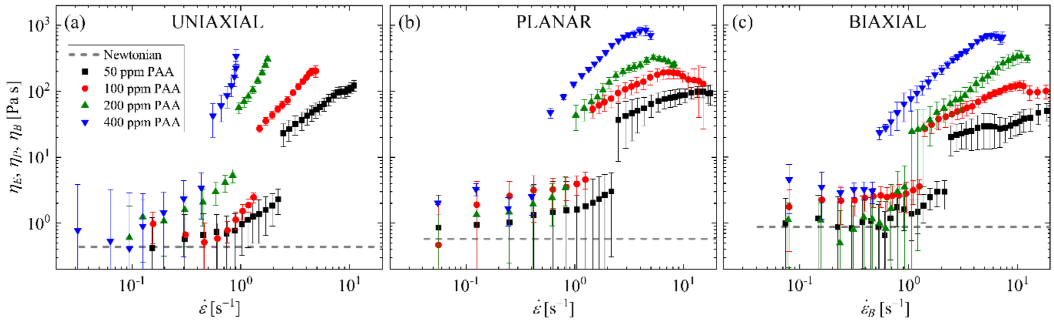


Figure 6: Extensional viscosity flow curves obtained for polyacrylamide (PAA) aqueous solutions under (a) uniaxial, (b) planar, and (c) biaxial extensional flow.

3.2.3 Extensibility governs the flow-induced alignment of polymers and rod-like colloids

Vincenzo Calabrese, Tatiana Porto Santos, Carlos G. Lopez, Minne Paul Lettinga, Simon J. Haward, Amy Q. Shen, *Physical Review Research* (Letter), **6**:1, L012042, (2024)

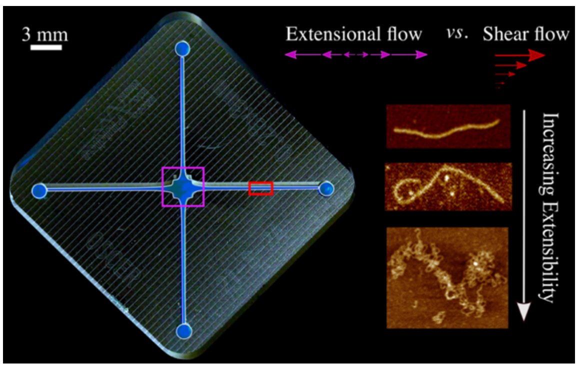


Figure 7: Schematic of the microfluidic device and typical polymers and rod-like colloids (PaRC) used in the study.

Polymers and rod-like colloids (PaRC) adopt a favorable orientation under sufficiently strong flows. However, how the flow kinematics affect the alignment of such nanostructures according to their extensibility remains unclear. By analyzing the shear- and extension-induced alignment of chemically and structurally different PaRC, we show that extensibility is a key determinant of the structural response to the imposed kinematics. We propose a unified description of the effectiveness of extensional flow, compared to shearing flow, at aligning PaRC of different extensibility.

3.3 Microfluidics and biotechnology

3.3.1 Twisted fiber microfluidics: a cutting-edge approach to 3D spiral devices.

Shunsuke Kato, Daniel W. Carlson, Amy Q. Shen, Yuanyuan Guo. *Microsystems & Nanoengineering*, **10**(1), 14 (2024).

The development of 3D spiral microfluidics has opened new avenues for leveraging inertial focusing to analyze small fluid volumes, thereby advancing research across chemical, physical, and biological disciplines. While traditional straight microchannels rely solely on inertial lift forces, the novel spiral geometry generates Dean drag forces, eliminating the necessity for external fields in fluid manipulation. Nevertheless, fabricating 3D spiral microfluidics remains a labor-intensive and costly endeavor, hindering its widespread adoption. Moreover, conventional lithographic methods primarily yield 2D planar devices, thereby limiting the selection of materials and geometrical configurations. To address these challenges, this work introduces a streamlined fabrication method for 3D spiral microfluidic devices, employing rotational force within a miniaturized thermal drawing process, termed as mini-rTDP. This innovation allows for rapid prototyping of twisted fiber-based microfluidics featuring versatility in material selection and heightened geometric intricacy. To validate the performance of these devices, we combined computational modeling with microtomographic particle image velocimetry (µTPIV) to comprehensively characterize the 3D flow dynamics. Our results corroborate the presence of a steady secondary flow, underscoring the effectiveness of our approach. Our 3D spiral microfluidics platform paves the way for exploring intricate microflow dynamics, with promising applications in areas such as drug delivery, diagnostics, and lab-on-a-chip systems.

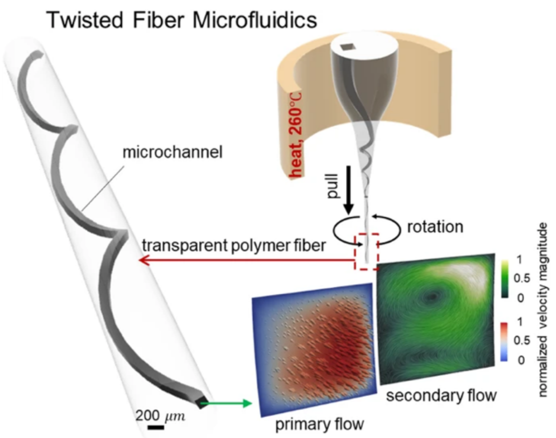


Figure 8: Introducing mini-rTDP: a streamlined method for fabricating 3D spiral microfluidic devices using rotational force in miniaturized thermal drawing. Computational

modeling and microtomographic particle image velocimetry (µTPIV) validate device performance by characterizing 3D flow dynamics.

3.3.2 Passive microfluidic devices for cell separation. Tianlong Zhang, Dino Di Carlo, Chwee Teck Lim, Tianyuan Zhou, Guizhong Tian, Tao Tang, Amy Q Shen, Weihua Li, Ming Li, Yang Yang, Keisuke Goda, Ruopeng Yan, Cheng Lei, Yoichiroh Hosokawa, Yaxiaer Yalikun. *Biotechnology Advances*, **71**, 108317 (2024).

Cell separation plays a crucial role in understanding cellular processes, disease mechanisms, and applications like tissue engineering and diagnostics. Microfluidic techniques have revolutionized this field through miniaturization, advanced fabrication, and diverse separation mechanisms. Passive microfluidic systems, which utilize channel structures and fluidic rheology without external forces, offer cost-effective scalability. This review explores various passive techniques such as filtration, sedimentation, and inertial microfluidics, among others, highlighting their applications, challenges, and future prospects in cell separation.

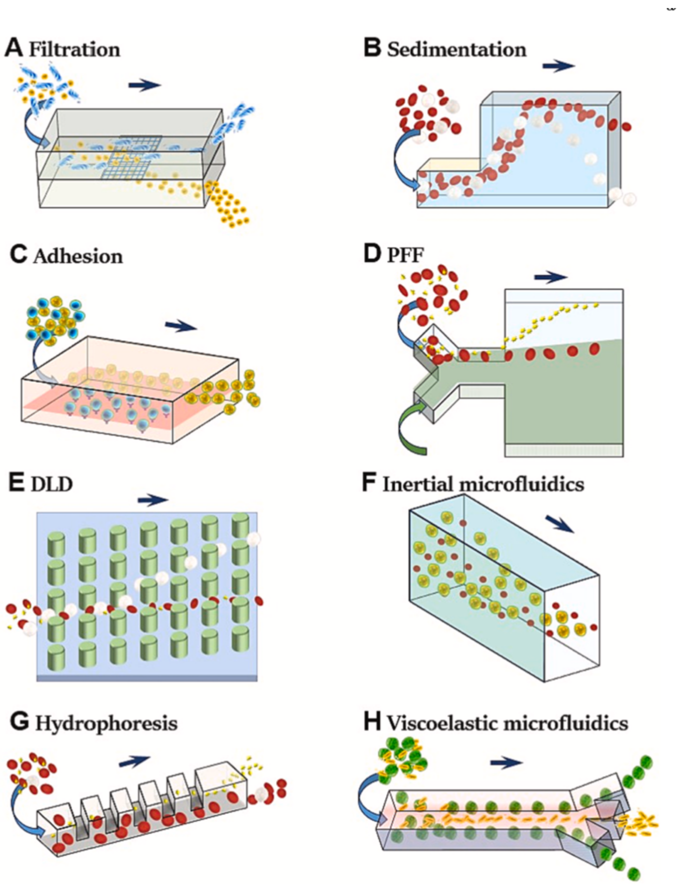


Figure 9: Overview of passive microfluidic cell separation techniques, including advancements, applications, and challenges in the field.

3.3.3 Surface-imprinted polymers based on 3D printing resin for selective bacteria detectionon. Tamara M. Iakimova, Benjamin Heidt, Amy Q. Shen, *Cell Reports Physical Science*, 101853, (2024).

Surface-imprinted polymers (SIPs) are biomimetic receptors that emulate the molecular recognition capabilities of antibodies but offer enhanced stability. Traditional contact imprinting for SIP fabrication is labor intensive and can produce inconsistent results due to the manual polymer synthesis. Laying the groundwork for future SIP imprinting with three-dimensional (3D) printers, our study pioneers the use of the Formlabs clear 3D printing resin for creating SIPs geared toward bacterial detection, thus eliminating the manual synthesis step. We produce SIPs using E. coli as a benchmark template bacterium, analyze their structure, and assess their rebinding capacity through fluorescence microscopy. To test cross-selectivity, SIPs for five other bacterial strains are produced and subsequently exposed to each, underscoring the SIPs' specific affinity for their original bacterial mold. Given its 3D printing suitability and the material's commercial availability, we envision the use of bacteria-binding imprints on intricate surfaces, bolstering biosensing applications in biotechnology, industry, and environmental monitoring.

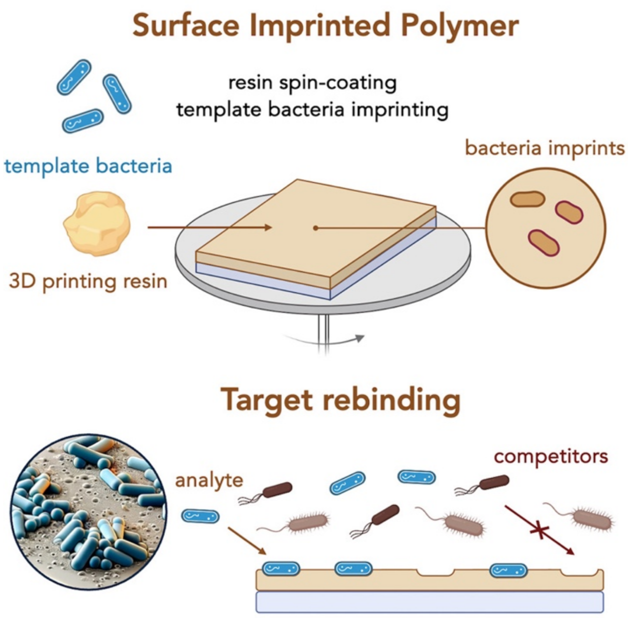


Figure 10: We present an approach for fabrication of surface-imprinted polymers (SIPs). These SIPs function as robust plastic antibodies with enhanced stability. This study utilizes 3D printing resin for streamlined SIP production, focusing on selective and sensitive bacterial detection, with applications in biosensing and biotechnology.

4. Publications

4.1 Journals

1. Tamara M. Iakimova, Benjamin Heidt, Amy Q. Shen, Surface-imprinted polymers based on 3D printing resin for selective bacteria detection, *Cell Reports Physical Science*, 101853, (2024). OPEN ACCESS
2. Vincenzo Calabrese, Tatiana Porto Santos, Carlos G. Lopez, Minne Paul Lettinga, Simon J. Haward, and Amy Q. Shen, Extensibility governs the flow-induced alignment of polymers and rod-like colloids, *Phys. Rev. Research,* 6, L012042, (2024). OPEN ACCESS
3. Shunsuke Kato, Daniel W. Carlson, Amy Q. Shen & Yuanyuan Guo, Twisted fiber microfluidics: a cutting-edge approach to 3D spiral devices, *Microsystems & Nanoengineering*, 10, 14 (2024). OPEN ACCESS
4. Tianlong Zhang, Dino Di Carlo, Chwee Teck Lim, Tianyuan Zhou, Guizhong Tian, Tao Tang, Amy Q. Shen, Weihua Li, Ming Li, Yang Yang, Keisuke Goda, Ruopeng Yan, Cheng Lei, Yoichiroh Hosokawa, Yaxiaer Yalikun, Passive microfluidic devices for cell separation, *Biotechnology Advances*, **71**, 108317, (2024). LINK
5. Kohei Abe, Patrick S. Atkinson, Chi S. Cheung, Haida Liang, Lucas Goehring, Susumu Inasawa, Dynamics of drying colloidal suspensions, measured by optical coherence tomography, *Soft Matter*, **20**, 2381-2393 (2024). LINK
6. Daniel W. Carlson, Amy Q. Shen, Simon J. Haward, Exploring multi-stability in three-dimensional viscoelastic flow around a free stagnation point, *Journal of Non-Newtonian Fluid Mechanics*, **323**, 105169, (2023). OPEN ACCESS
7. Haoyi Wang, Xinyi Yu, San To Chan, Guillaume Durey, Amy Q. Shen, and Jesse T. Ault, Vortex breakdown in the shear-driven flow in a rectangular cavity, *Physical Review Fluids*, **8**, 114701, (2023). LINK
8. Arisa Yokokoji, Stylianos Varchanis, Amy Q. Shen and Simon J. Haward, Rheological effects on purely-elastic flow asymmetries in the cross-slot geometry, *Soft Matter*, (2023). OPEN ACCESS
9. San To Chan, Stylianos Varchanis, Simon J. Haward, Amy Q. Shen, Perspective on edge fracture, *Journal of Rheology*, (2023). OPEN ACCESS
10. M. A. Kanso, V. Calabrese, Amy Q. Shen, Myong Chol Pak, A. J. Giacomin, Bacteriophage Pf1 complex viscosity, *Physics of Fluids*, 35, 073107, (2023). LINK
11. Simon J. Haward, Stylianos Varchanis, Gareth H. McKinley, Manuel A. Alves, and Amy Q. Shen, Extensional rheometry of mobile fluids. Part II: Comparison between the uniaxial, planar, and biaxial extensional rheology of dilute polymer solutions using numerically optimized stagnation point microfluidic devices, *Journal of Rheology*, (2023). OPEN ACCESS
12. Simon J. Haward, Francisco Pimenta, Stylianos Varchanis, Daniel W. Carlson, Kazumi Toda-Peters, Manuel A. Alves, and Amy Q. Shen, Extensional rheometry of mobile fluids. Part I: OUBER, an optimized uniaxial and biaxial extensional rheometer, *Journal of Rheology*, (2023). OPEN ACCESS
13. Marvin Detert, Tatiana Porto Santos, Amy Q. Shen, Vincenzo Calabrese, Alignment–Rheology Relationship of Biosourced Rod-Like Colloids and Polymers under Flow, *Biomacromolecules*, (2023). OPEN ACCESS

14. Vincenzo Calabrese, Amy Q. Shen, and Simon J. Haward, Naturally derived colloidal rods in microfluidic flows, *Biomicrofluidics* **17**, 021301 (2023). OPEN ACCESS
15. Kohei Abe, Susumu Inasawa, Position-dependent rates of film growth in drying colloidal suspensions on tilted air-water interfaces, *Physical Chemistry Chemical Physics*, **25**, 15647-15655 (2023). LINK

4.2 Oral and Poster Presentations

4.2.1 ORAL

1. Amy Q. Shen, Microfluidics and lab-on-a-chip devices for biosensing and disease diagnosis, Keynote, Biosensors 2023, Busan, Korea, June 2023
2. Amy Q. Shen, New opportunities to study population genetics and detect diseases by employing microfluidics and lab-on-a-chip devices, KIST, Korea, June 2023.
3. Amy Q. Shen, Microfluidics assisted platforms to detect disease and probe microbials for population genetics studies, Invited (online), The 2st Indian conference on Micro Nano Fluidics-From soft matter to bioengineering, September 2023.
4. Amy Q. Shen, New opportunities to study population genetics and detect diseases by employing lab-on-a-chip devices, KEYNOTE, SELECTBIO, Lab-on-a-Chip and Microfluidics Asia, Narita, Japan, October 2023
5. Amy Q. Shen, New opportunities to detect disease and probe microbials using lab-on-a-chip devices, Invited, The 22nd International Conference on Solid-State Sensors, Actuators and Microsystems, Kyoto, Japan, October 2023
6. Amy Q. Shen, Microfluidics and Lab-on-a-Chip Innovations: Pioneering Biophysics and Biotechnology Research, Plenary, Symposium on “HYPER-ADAPTABILITY", Nagoya, Japan, November 2023
7. Amy Q. Shen, Microfluidic assisted platforms to detect disease and probe microbials for population genetics studies, IEEE-NANOMED, Okinawa, Japan, December 2023.
8. SJ Haward, Geometric Effects on the Dynamics of Viscoelastic Porous Media Flows. Poole Group Meeting, Invited, University of Liverpool, Department of Engineering (May 26, 2023)
9. C de Blois, SJ Haward, AQ Shen, Canopy elastic turbulence: Spontaneous formation of waves in beds of slender microposts. Invited, Physical Review Fluids Journal Club (April 28, 2023)
10. SJ Haward, F Pimenta, S Varchanis, DW Carlson, K Toda-Peters, GH McKinley, MA Alves, AQ Shen, Extensional rheometry using numerically-optimized stagnation point microfluidic devices, 21st International Workshop on Numerical Methods for Non-Newtonian Flows (IWNMNNF), Loch Lomond, Scotland (May 29-June 1, 2023)
11. SJ Haward, F Pimenta, S Varchanis, DW Carlson, K Toda-Peters, GH McKinley, MA Alves, AQ Shen, Extensional rheometry in numerically-optimized stagnation point microfluidic devices, XIXth International Congress on Rheology (ICR), Athens, Greece (July 29-August 4, 2023).
12. SJ Haward, F Pimenta, S Varchanis, DW Carlson, K Toda-Peters, GH McKinley, MA Alves, AQ Shen, Extensional rheometry using numerically-optimized stagnation point microfluidic devices, 7th International Soft Matter Conference (ISMC), Osaka, Japan (September 4-8, 2023).
13. RA Lopez, SJ Haward, AQ Shen, Characterization of inertialess viscoelastic canopy flows, 7th ISMC, Osaka, Japan (September 4-8, 2023).

14. EY Chen, CA Browne, SJ Haward, DW Carlson, AQ Shen, SS Datta, Influence of geometric ordering on viscoelastic flow instabilities in 3D porous media, XIXth ICR, Athens, Greece (July 29-August 4, 2023).
15. V Calabrese, TP Santos, CG Lopez, MP Lettinga, SJ Haward, AQ Shen, A unified framework to describe shear- and extension-induced alignment of macromolecules of various flexibility, XIXth ICR, Athens, Greece (July 29-August 4, 2023).
16. S Varchanis, SJ Haward, AQ Shen, Viscoelastic fingering during the sedimentation of a sphere, XIXth ICR, Athens, Greece (July 29-August 4, 2023).
17. N Burshtein, AA Banaei, M Aulnette, SJ Haward, AQ Shen, A Lindner, Transport dynamics of spherical microparticles and fibers in inertio-elastic vortex flows, 21st IWNMNNF, Loch Lomond, Scotland (May 29-June 1, 2023).
18. A Yokokoji, S Varchanis, AQ Shen, SJ Haward, Rheological effects on purely-elastic flow asymmetries in the cross-slot geometry, 8th Pacific Rim Conference on Rheology (PRCR), Vancouver, Canada (May 15-19, 2023). ORAL:
19. F Hillebrand, S Varchanis, SJ Haward, AQ Shen, Flow of a wormlike micellar solution over a long cavity, 8th PRCR, Vancouver, Canada (May 15-19, 2023).
20. EY Chen, CA Browne, SJ Haward, DW Carlson, AQ Shen, SS Datta, Influence of geometric ordering on viscoelastic flow instabilities in 3D porous media, 76th American Physical Society Division of Fluid Dynamics (APS-DFD) meeting, Washington DC (19-21 Nov, 2023)
21. A Lindner, A Shen, S Haward, L Brandt, A Banaei, M Aulnette, N Burshtein, Transport dynamics of isotropic and anisotropic microparticles in inertio-elastic vortex flows, 76th APS-DFD meeting, Washington DC (19-21 Nov, 2023)
22. E Chen, S Haward, A Shen, S Datta, The flow thickens: predicting macroscopic flow resistance of viscoelastic fluid flow in porous media, American Physical Society (APS) March meeting, Minneapolis, MN (3-8 March 2024)
23. Keynote: S Varchanis, SJ Haward, CC Hopkins, J Tsamopoulos, AQ Shen, Evaluation of constitutive models for shear-banding wormlike micellar solutions in simple and complex flows. XIXth International Congress on Rheology (ICR), Athens, Greece (July 29-August 4, 2023)
24. S Varchanis, S Haward, A Shen, Viscoelastic fingering during the sedimentation of a sphere, APS March meeting, Minneapolis, MN (3-8 March 2024)
25. V Calabrese, TP Santos, CG Lopez, MP lettinga, SJ Haward, AQ Shen,A unified framework to describe shear- and extension-induced alignment of macromolecules of various flexibility, XIXth ICR, Athens, Greece (July 29-August 4, 2023).
26. RA Lopez de la Cruz, SJ Haward, AQ Shen, Characterization of inertialess viscoleastic canopy flows, The 7th International Soft Matter Conference (September 4 - 8,2023)
27. F Hillebrand, 8th Pacific Rim Conference on Rheology: "Flow of a wormlike micellar solution over a long cavity"
28. A.Yokokoji, S. Varchanis, A.Q. Shen, S.J. Haward, " Rheologicaleffects on purely-elastic flow asymmetries in the cross-slot geometry", 8 th PACIFIC RIM CONFERENCE ON RHEOLOGY", Vancouver (May 15-19, 2023)
29. K. Abe, P. S. Atkinson, C. S. Cheung, H. Liang, L. Goehring and S. Inasawa, "In-situ measurement of particle-concentration profiles in a drying suspension with optical coherence tomography", 13th Asian Coating Workshop (May 11 - 13, 2023, Taipei, Taiwan)"

4.2.2 POSTERS

1. SJ Haward, ST Chan, S Varchanis, AQ Shen, Edge fracture of thixotropic elastoviscoplastic liquid bridges, XIXth ICR, Athens, Greece (July 29-August 4, 2023).
2. SJ Haward, F Pimenta, S Varchanis, DW Carlson, K Toda-Peters, MA Alves, AQ Shen, Design and fabrication of an optimized "6-arm cross-slot" device, XIXth ICR, Athens, Greece (July 29-August 4, 2023).
3. SJ Haward, CC Hopkins, AQ Shen, Upstream wall vortices in viscoelastic flow past a cylinder, XIXth ICR, Athens, Greece (July 29-August 4, 2023).
4. V Calabrese, AQ Shen, SJ Haward, How do polymers stretch in capillary-driven extensional flows? Gordon Research Conference on Colloidal, Macromolecular and Polyelectrolyte Solutions, Ventura, CA (11-16 Feb, 2024)
5. V Calabrese, TP Santos, CG Lopez, MP lettinga, SJ Haward, AQ Shen, Extensibility governs the flow-induced alignment of polymers and rod-like colloids. Gordon Research Conference on Colloidal, Macromolecular and Polyelectrolyte Solutions, Ventura, CA (11-16 Feb, 2024)
6. V Calabrese, TP Santos, CG Lopez, MP lettinga, SJ Haward, AQ Shen, A unified framework to describe shear- and extension-induced alignment of macromolecules of various flexibility. 7th ISMC, Osaka, Japan (September 4-8, 2023)
7. EY Chen, CA Browne, R Huang, C Zheng, SJ Haward, DW Carlson, AQ Shen, SS Datta, Elastic flow instabilities in structurally-complex 3D porous media: linking pore-scale behaviour to macroscopic flow resistance, XIXth ICR, Athens, Greece (July 29-August 4, 2023).
8. RA Lopez, SJ Haward, AQ Shen, Characterization of inertialess viscoelastic canopy flows, XIXth ICR, Athens, Greece (July 29-August 4, 2023).
9. S Varchanis, V Calabrese, ST Chan, SJ Haward, AQ Shen, Modeling and simulations of thixotropic elastoviscoplastic fluids, XIXth ICR, Athens, Greece (July 29-August 4, 2023).
10. MS Abdelgaward, SJ Haward, AQ Shen, ME Rosti, Tuning extensional behavior of elastoviscoplastic fluids with polymer additives, XIXth ICR, Athens, Greece (July 29-August 4, 2023).
11. EY Chen, CA Browne, R Huang, C Zheng, SJ Haward, DW Carlson, AQ Shen, SS Datta, Elastic flow instabilities in structurally-complex 3D porous media: linking pore-scale behaviour to macroscopic flow resistance, Gordon Research Conference (GRC) on Colloidal, Macromolecular and Polyelectrolyte Solutions, Ventura, CA (11-16 Feb, 2024)
12. V Calabrese, TP Santos, CG Lopez, MP lettinga, SJ Haward, AQ Shen, A unified framework to describe shear- and extension-induced alignment of macromolecules of various flexibility. 7th ISMC, Osaka, Japan (September 4-8, 2023)
13. V Calabrese, TP Santos, CG Lopez, MP lettinga, SJ Haward, AQ Shen, Extensibility governs the flow-induced alignment of polymers and rod-like colloids. Gordon Research Conference on Colloidal, Macromolecular and Polyelectrolyte Solutions, Ventura, CA (11-16 Feb, 2024)
14. V Calabrese, AQ Shen, SJ Haward, How do polymers stretch in capillary-driven extensional flows? Gordon Research Conference on Colloidal, Macromolecular and Polyelectrolyte Solutions, Ventura, CA (11-16 Feb, 2024)
15. RA Lopez de la Cruz, SJ Haward, AQ Shen, Characterization of inertialess viscoelastic canopy flows, XIXth ICR, Athens, Greece (July 29-August 4, 2023).
16. V. Mazzaracchio, M. Rios Maciel, T. Porto Santos, K. Toda-Peters, A. Q. Shen, "Duplex electrochemical microfluidic sensor for COVID-19 antibody detection:

natural versus vaccine-induced humoral response. BIOSENSORS 2023, Busan, South Korea. (June 5-8, 2023)

5. Other Specific Achievements

5.1 Grants and Fellowships

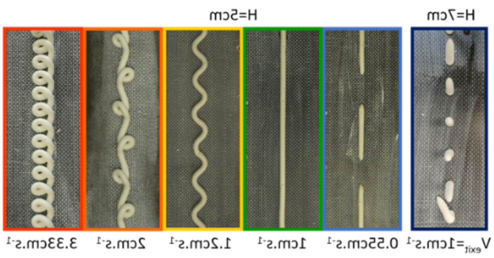
1. Amy Shen and Simon Haward received Kakenhi-B for 'Canopy Elastic Turbulence'.
2. Simon Haward received Kakenhi-C for 'Large Amplitude Oscillatory Extension (LAOE)'.
3. Vincenzo Calabrese received Kakenhi for 'Polymer Conformational History's Role in Polymeric Liquids'.
4. Kohei Abe received Kakenhi for 'Buoyancy-Induced Circulation in Microchannels'.
5. Ricardo Arturo Lopez de la Cruz received Kakenhi for 'Elastic Turbulence in Micro Canopy Flows'.
6. Benjamin Heidt received Kakenhi for 'Eleprep' project, developing an electrochemical-microfluidic biosensor for foodborne pathogens.
7. Pranab Mondal received Kakenhi for ‘Surface wettability effects for microfluidic flows’.

5.2 Awards

1. Stylianos Varchanis, Simon J. Haward, and Amy Q. Shen, 2022 Walters Prize at the XIXth International Congress on Rheology (ICR2023), in Greece
2. Kohei Abe, Gold Medal Presentation at 13th Asian Coating Workshop, Korea
3. Arisa Yokokoji, Mauricio Rios, Best Project Award at the POC project at OIST

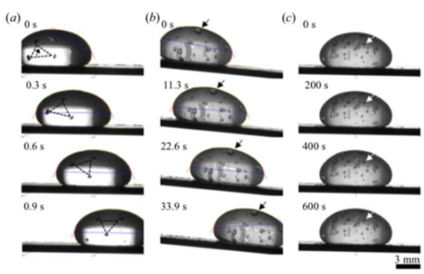
6. Seminars and Events

6.1.1 Seminars



1. Dr. Anatole Geffrault

- Date: April 25, 2023
- Time: 3:00-3:30pm
- Seminar title: Shape of deposits and flow mechanisms in 3D printing of yield stress fluids
- Website: https://navier-lab.fr/en/phd-postdocs/



2. Dr. Minyoung Kim (In-person)

- Date: May 9, 2023
- Time: 11:00-11:30am
- Seminar title: Dynamics of a viscoplastic drop on a superhydrophobic surface

3. Prof. Patrick Anderson (In-person)

- Date: August 24, 2023
- Time: 10:00-11:00am
- Seminar title: Applied and computational rheology advances from extrusion to additive manufacturing

4. Mr. Hossein Rahmani (In-person)

- Date: August 30, 2023
- Time: 10:00-11:00am
- Seminar title: Complex viscoplastic flows in superhydrophobic channels

5. Dr. Matthew A. Wade (In-person)

- Date: September 19, 2023
- Time: 03:00-04:00pm
- Seminar title: Molecular Scale Properties of Complex Molecules from Bulk, Microscale, and Scattering Measurements
- Jülich Centre for Neutron Science (JCNS), Forschungszentrum Jülich GmbH

6. Prof. Doojin Lee (In-person)

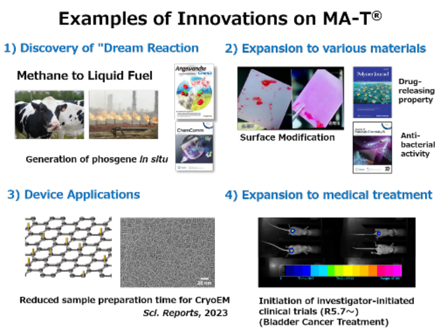
- Date: December 14, 2023
- Time: 10:00-11:00am
- Seminar title: The Role of Rheology in Improving Electrospinning and Li-ion Battery Slurry Coating Techniques

7. Prof. Zhenying Wang (In-person)

- Date: January 11, 2024
- Time: 03:00-04:00pm
- Seminar title: Spreading Law of Evaporative Droplets

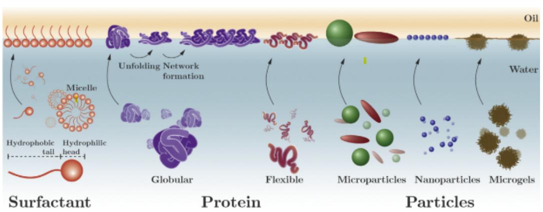
8. Dr. Mark Sullivan (In-person)

- Date: January 16, 2024
- Time: 03:00-04:00pm
- Seminar title: Synthetic Recognition Materials: Mimicking Nature's Antibodies



9. Prof. Tsuyoshi Inoue (In-person)

- Date: February 2, 2024
- Time: 03:00-04:00pm
- Seminar title: MA-T®: A liquid with the potential to make a significant contribution to the SDGs



10. Prof. Peter Fischer (In-person)

- Date: February 6, 2024
- Time: 03:00-04:00pm
- Seminar title: Role of the hydrophobic phase on interfacial phenomena of surfactants, proteins, and particles at fluid interfaces

6.1.2 Soft Matter Lecture

1. Prof. Xuehua Zhang (In-person)

- Date: January 11, 2024
- Time: 03:00-04:00pm
- Seminar title: Spontaneous Detachment of Reacting Drops

2. Prof. Rachel Segalman (In-person)

- Date: March 25, 2024
- Time: 02:00-03:00pm
- Seminar title: Using bioinspired polypeptoids to understand how chain shape influences self-assembly and water dynamics

6.2 Events

IEEE-NANOMED 2023

- Date: December 5-8, 2023
- Venue: OIST Auditorium
- Co-organizer: Prof. Amy Shen

7. Outreach activities

7.1 Science-expo at Okinawa Zoo and Museum (沖縄こどもの国)

- Part of the PCD project (won Best Project Award)
- Members: Arisa Yokokoji, Mauricio Rios etc.
- Description: On February 3th and 4th 2024, an interactive science expo was carried out at the Okinawa Zoo and Museum, where there was showcased different technologies including microfabrication through 3D printers. The kids were exposed to different haptic illusions carried out in home-made 3D printed devices as well as animal textures created by the same means. The devices converted sounds from the Okinawan forest's animals into vibrations that the participants could feel, the 3D printed textures were for the participants to observe the detail that is obtainable through this technology as well as a method for kids to 'touch' things that otherwise would be dangerous (shark skin, puffer fish, snake bones, etc). This activity was awarded with the Best Project Award.

7.1 Science Festival at OIST

- Date: November 11th, 2024
- Members: Kazumi Toda-Peters, Vincenzo Calabrese, Ricardo Arturo Lopez de la Cruz, Davide Califano, Eliane Younes, Jiangming Wu, Arisa Yokokoji, Mauricio Rios, Tamara Iakimova, Ryoma Suzuki
- The booth title "Let's do chemistry in the kitchen!- Race boats and make some bubble tea with magic of chemistry!"

7.3 OIST Science Challenge 2024

- Hands-on activity
- Date: February 20th, 2024
- Members: Arisa Yokokoji, Teresa Bosch, Mauricio Rios
- Description: Carried out a chemical experiment for undergrad/graduate students that came to OIST as part of the annual Science challenge. Four students were guided in order to obtain the concentration of sugar present in commercial beverages. The students from different backgrounds were taught to build a calibration curve, design experiments and analyze the data.