

An hourglass with blue particles falling from the top bulb to the bottom bulb. The particles are small and spherical, creating a dense stream in the narrow neck of the hourglass.

ESPCI SOFT MATTER DAYS 2ND EDITION

JUNE 26TH - 27TH, 2017
GIF-SUR-YVETTE

This Internal meeting is intended to provide the opportunity to present and discuss our research activities on soft matter.

Registration until April 15th at
<https://smd2017.sciencesconf.org>

Organizing committee:
N. Bremond, C. Monteux, R. Nicolaÿ,
E. Reyssat, S. Rogue, T. Salez

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ESPCI SOFT MATTER DAYS

June 26th and 27th, 2017, Gif-sur-Yvette

Monday, June 26th

9h00-9h30 **Welcome and Registration**

9h30-9h40 **Introduction**

9h40-10h45 **Talk Session (A1-A5) [Session Chair: Ramiro Godoy-Diana]**

- **Alba Marcellan** (SIMM) *Thermoresponsive toughening in phase-separated gels under isochoric conditions*
- **Marine Borocco** (PMMH) *Two liquids competing on a glass substrate*
- **Alban Sauret** (Saint-Gobain) *Accretion Dynamics on Wet Granular Materials*
- **Filippo Caschera** (Gulliver) *Cell-free synthesis of artificial cell models combining soft matter and biochemical experiments*
- **Rémi Carminati** (Langevin) *Light scattering from correlated disordered materials*

10h45-11h15 **Coffee Break/Poster Session**

11h15-12h20 **Talk Session (A6-A10) [Session Chair: Ramiro Godoy-Diana]**

- **Wafa Bouhlel** (CBI) *Bubble spreading on superaerophilic surfaces Collagen I Matrix capsules for parallelized 3D cell culture*
- **Olivier Dauchot** (Gulliver) *Active vs. passive hard disks against a membrane : mechanical pressure and instability*
- **Armelle Gas** (PMMH) *Dynamics on lubricant impregnated surfaces*
- **François Bargain** (MMC) *Structural and thermal study of the relaxor ferroelectric phase in VDF-based electroactive polymers*
- **Pierre Chantelot** (PMMH) *Drop trampoline*

12h20-13h45 **Lunch**

13h45-15h00 **Poster Session**

15h00-16h15 **Talk Session (B1-B6) [Session Chair: Etienne Barthel]**

- **Mathilde Reyssat** (Gulliver) *Membranes and capsules made through interfacial H-bond polymer complexation*
- **Alice Boursier** (SIMM) *Cold compression of zirconia granules, role of the binder*
- **Coralie Teulère** (MMC) *Synthesis of bottlebrush polymers by telomerization*
- **Yanan Liu** (PMMH) *The dynamics of flexible actin filaments in shear flow*
- **Gustavo Gimenes** (Gulliver) *From flow to fracture in colloidal gels*
- **Martyna Goral** (PMMH) *Hydrodynamics of lateral strike in aquatic snakes*

16h15-16h45	Coffee Break/Poster Session
16h45-18h00	Talk Session (B7-B12) [Session Chair: Etienne Barthel] <ul style="list-style-type: none"> - Vincent Démercy (Gulliver) <i>Correlations in intersecting populations: from electrolytes to pedestrians</i> - Maddalena Mattiello (MMC) <i>How do particles softness and attractive interactions affect the structure and dynamics of colloidal glasses?</i> - Daniel Beilharz (PMMH) <i>How menisci negotiate micropillars?</i> - Charles Barrand (SIMM) <i>Elastomeric foams from high internal phase emulsion: a complex structure</i> - Maxence Arutkin (Gulliver) <i>Cooperative strings and glassy interfaces</i> - Marine Daïeff (PMMH) <i>Deformation and shape of flexible, microscale helices in viscous flows</i>
18h00-19h00	Free Time
19h00-23h00	Dinner

Tuesday, June 27th

9h30-10h45	Talk Session (C1-C6) [Session Chair: Teresa Lopez-Leon] <ul style="list-style-type: none"> - Marc Fermigier (PMMH) <i>Sliding on a fluid</i> - Guillaume Gines (Gulliver) <i>Isothermal compartmentalized digital detection of microRNA</i> - Abdulwahed Shglabow (CBI) <i>A new approach to microencapsulation active material free of surfactant and control delivery</i> - Mickael Pruvost (SIMM) <i>Materials with variable permittivity for vibrational energy harvesting</i> - Cesare Cejas (Gulliver) <i>Colloidal particle deposition kinetics in microchannels at high ionic strengths</i> - Jérémie Lacombe (MMC) <i>Supramolecular polyethylenes: synthesis, characterization and properties</i>
10h45-11h15	Coffee Break/Poster Session
11h15-12h30	Talk Session (C7-C12) [Session Chair: Teresa Lopez-Leon] <ul style="list-style-type: none"> - Guillaume Chatté (SIMM) <i>Pairwise frictional profile between particles determines discontinuous shear thickening transition in non-colloidal suspensions</i> - Marie Tani (PMMH) <i>Elastocapillary adhesion of a soft shell on a rigid sphere</i> - Kunyun He (Gulliver) <i>Metastability in nematic liquid crystal shells</i> - Raphaël Michel (MMC) <i>Adhesion of hydrogel films to living tissues</i> - Ambre Bouillant (PMMH) <i>Leidenfrost drops are intrinsically self-propelled !</i> - Laurent Geffroy (SIMM) <i>Early stage of large ribosomal subunit assembly in E.coli: a single molecule study</i>

12h30-13h45	Lunch
13h45-14h30	Poster Session
14h30-15h35	Talk Session (D1-D5) [Session Chair: Emilie Verneuil] <ul style="list-style-type: none"> - Matteo Ciccotti (SIMM) <i>Large strain viscoelastic dissipation during interfacial rupture in laminated glass</i> - Guillaume Briand (Gulliver) <i>Crystallization of self-propelled hard-discs : a new scenario</i> - Mathieu de la Motte Saint Pierre (CBI) <i>Digital microfluidics for growing unculturable micro-organisms</i> - Ludovic Keiser (PMMH) <i>Dynamics of confined droplets in a rough medium</i> - Pavel Yazhgur (Gulliver) <i>Self-assembling photonic materials</i>
15h35-16h05	Coffee Break/Poster Session
16h05-16h10	Presentation of Best Poster Award
16h10-17h15	Talk Session (D6-D10) [Session Chair: Emilie Verneuil] <ul style="list-style-type: none"> - Panagiotis Karagiannopoulos (PMMH) <i>Intéraction intrus élastique-milieu granulaire</i> - Trystan Domenech (MMC) <i>Synthesis of vitrimers from high-density polyethylene via reactive melt processing</i> - Jessica Delavoipière (SIMM) <i>Poroelastic indentation of mechanically confined hydrogel layers</i> - Joshua McGraw (Gulliver) <i>Friction at the interface between a solid self-assembled monolayers and liquid polymers or solid metal nanotips</i> - Vincent Cognet (PMMH) <i>Improving wind turbines starting with flexible blades</i>
17h15	End of the Soft Matter Days

Note: talks last 10 minutes + 2 minutes for discussion

A. MONDAY @ 9h40-10h45 / 11h15-12h15

A1. Thermoresponsive toughening in phase-separated gels under Isochoric Conditions

Hui Guo, Cécile Mussault, Nicolas Sanson, Dominique Hourdet, Alba Marcellan

Soft Matter Sciences and Engineering (SIMM), ESPCI Paris - CNRS - UPMC, France

The phase transition of covalently cross-linked gels entails a drastic volume-change that makes it difficult to reveal the role of phase transition on the mechanical toughening independently of the polymer concentration effect. To clear up this ambiguity, recently we designed [1] covalently cross-linked gels that phase-separate at constant macroscopic volume and quite high level of hydration, i.e. typically more than 80 wt% water. By exploring original network topologies, we demonstrated the remarkable asset that may represent the phase-separation process for the gel design displaying responsive advanced mechanical properties: excellent fatigue resistance, full recovery and more interestingly remarkable fracture properties. Beyond the achieved high values of fracture energies (1000 J m⁻²) for gels with relatively high hydration level, the gel fracture patterns have highlighted a systematic crack bifurcation, as commonly observed in natural rubbers but unreported so far in gels.

[1] H. Guo, N. Sanson, D. Hourdet, A. Marcellan, *Advanced Materials*, 28, 5857 (2016).

A2. Two liquids competing on a glass substrate

Marine Borocco,^{1,2} David Quéré,^{1,2} Christophe Clanet,^{1,2} Charlotte Pellet,³ Jean-René Authelin³

1 Physique et Mécanique des Milieux Hétérogènes (PMMH), ESPCI Paris - CNRS, France

2 Laboratoire d'hydrodynamique (LadHyX) - Polytechnique - X, France

3 Sanofi-Aventis R&D, SANOFI Recherche, France

When washing dishes, we usually find it much more difficult to properly clean a plastic bowl than a porcelain one. The plastic surface feels greasier than the porcelain, which is due to the affinity of the considered substrates with the liquids in presence (water or grease). Plastic has more affinity with grease than water, unlike porcelain. This differential wetting can be measured through the contact angle between the three coexisting phases: solid, water, and oil.

While the study of solid-liquid-gas contact angles motivated numerous experiments, the similar solid-liquid-liquid systems are far less studied. For our experiments, we filled glass capillary tubes with silicone oil, and injected a water drop in the oil, in a geometry similar to the one Hoffman used in his classical work. The liquid phases are then pushed forward at a small velocity, allowing us to measure the effects of dynamics on the advancing and receding contact angles.

Surprisingly, we discovered that changing the time t during which the glass had been in contact with silicone oil only resulted in extreme variations of the measured contact angles. This is interpreted as a chemical effect, caused by the bonding of a few OH-terminated chains, present in the bulk silicone oil, with the glass substrate. Since these chains are only present as impurities in a mostly CH₃-terminated oil, the bonding reaction's kinetics is slow, yet irreversible. As t gets larger, so does the advancing contact angle of water chasing oil from the glass. The affinity of the glass substrate for silicone oil eventually becomes so high that the aqueous phase is not in contact with glass anymore. We quantified the variations of the advancing and receding contact angles of a water droplet in silicone oil as a function of the imposed speed, oil viscosity and composition, and aging parameter.

A.3 Accretion Dynamics on Wet Granular Materials

Guillaume Saingier, [Alban Sauret](#), Pierre Jop

Saint-Gobain Recherche, Aubervilliers, France

Surface du Verre et Interfaces, UMR 125 CNRS/Saint-Gobain, 39 Quai Lucien Lefranc, F-93303 Aubervilliers, Cedex, France

Wet granular aggregates are common precursors of construction materials, food, and health care products. The physical mechanisms involved in the mixing of dry grains with a wet substrate are not well understood and difficult to control. Here, we study experimentally the accretion of dry grains on a wet granular substrate by measuring the growth dynamics of the wet aggregate. We show that this aggregate is fully saturated and its cohesion is ensured by the capillary depression at the air-liquid interface. The growth dynamics is controlled by the liquid fraction at the surface of the aggregate and exhibits two regimes. In the viscous regime, the growth dynamics is limited by the capillary-driven flow of liquid through the granular packing to the surface of the aggregate. In the capture regime, the capture probability depends on the availability of the liquid at the saturated interface, which is controlled by the hydrostatic depression in the material. We propose a model that rationalize our observations and captures both dynamics based on the evolution of the capture probability with the hydrostatic depression.

A4. Cell-free synthesis of artificial cell models combining soft matter and biochemical experiments

[Filippo Caschera](#)

Gulliver, ESPCI Paris - CNRS, France

The synthesis of artificial cells consists of the integration of three main modules or subsystems: container, metabolism and information. I will present results on different types of containers that I have studied as models to build artificial cells based on oil droplets, fatty acid vesicles and liposomes. First, I will show an oil droplet system out-of-equilibrium undergoing fusion and fission dynamics in iterative manner. Then, I will present results on fusion of oppositely charged liposomes, which I have further implemented to activate compartmentalized gene expression. Remarkably, fusion and fission dynamics are necessary to design a life-cycle supporting evolution of artificial cells. Recently, in order to achieve better system control and design, I have developed methods to prepare high yielding cell-free expression systems for in vitro protein synthesis, and compartmentalized ribosome synthesis, self-assembly and translation. Looking forward, I aim to integrate the components of artificial cell applying high-throughput screening methods and machine learning algorithms. My highest goal is to build a life-like system that can show open-ended evolution, and then find useful applications in biotechnology. I believe this will be possible combining computer algorithms with soft-matter and biochemical experiments.

A5. Light scattering from correlated disordered materials

Rémi Carminati

Institut Langevin, ESPCI Paris, France

Light scattering and transport in disordered media has been extensively studied. The possibility to study coherent scattering in optics (speckles) has provided a tool for basic studies in mesoscopic physics. On the applied side, methods and techniques have been developed for sensing and imaging in complex media using diffuse light. These techniques are widely used to probe soft-matter and biological tissues.

The existence of short-range and/or long-range spatial correlations in the disorder has been very often overlooked. We will describe recent results illustrating the influence of correlations, including the formation of subwavelength speckle patterns [1,2] or the depolarization of light by multiple scattering [3]. In the specific case of hyperuniform disorder, we will show that materials that are both transparent and optically dense can be designed [4]. On the way to the fabrication of photonic materials with a controlled degree of order, soft-matter bottom up approaches might offer promising solutions.

I am indebted to R. Pierrat, O. Leseur, Y. De Wilde, V. Krachmalnicoff, K. Vynck and A. Dogariu with whom this work has been done.

[1] A. Dogariu and R. Carminati, Phys. Rep. 559, 1 (2015)

[2] V. Parigi et al., Opt. Express 24, 7019 (2016)

[3] K. Vynck, R. Pierrat and R. Carminati, Phys. Rev. A 94, 033851 (2016)

[4] O. Leseur, R. Pierrat and R. Carminati, Optica 3, 763 (2016)

A6. Collagen I matrix capsules for parallelized 3D cell culture

Wafa Bouhlel, Nicolas Bremond

Laboratoire des Colloïdes et Matériaux Divisés (LCMD), ESPCI Paris - CNRS, France

The ongoing development of three-dimensional cell culture techniques enable us to better recapitulate in-vivo conditions which are needed for recovering the proper cellular function as compared to standard cell culture methods. Despite numerous strategies of 3D cell culture, a standardized method that would allow high throughput screening, easy manipulation of the micro-tissues having controlled and reproducible features is a field of intense investigations. Sub-millimeter liquid core hydrogel capsules developed recently in our laboratory constitute a relevant tool for 3-D cell culture. The method relies on a co-extrusion step in air followed by a sol-gel transition of the shell in a gelling bath. The hydrogel shell offers a physical barrier to the cells against mechanical stress during their manipulation. Moreover, it provides a semi-permeable membrane for nutrients, gas and drugs diffusion. On the other side, cells cannot escape nor enter into the capsules. The production of these individual compartments at a high rate allows high throughput screening applications.

Among different types of cells, epithelial cells require an extracellular matrix as a supporting environment to express its primary proper characteristics: adhesion and spreading. These behaviours will be mainly dictated by chemical composition and mechanical properties of the scaffold. To better mimic natural environment, we implemented collagen I matrix in the core of the capsules. However, the formation of such capsules that require the use of different colloidal dispersions is not straightforward since the co-extrusion may undergo viscoelastic instabilities. Thanks to a clearer understanding of the underlying hydrodynamic phenomena that occur in a co-flow between two fluids with different physicochemical and viscoelastic properties, we are able to make collagen core capsules.

These results are very promising and will be used to encapsulate cholangiocytes. We expect that the collagen matrix in the core will allow the apicobasal epithelial polarity establishment to form cystes

A7. Active vs. passive hard disks against a membrane: mechanical pressure and instability

Olivier Dauchot

EC2M, Laboratoire Gulliver, ESPCI Paris - CNRS, France

At equilibrium, whether global or local, the mechanical, hydrodynamic and thermodynamic pressures are all equal quantities, which inherit each other their mutual properties. In particular equilibrium pressure is a state variable, which only depends on the bulk properties of the fluid. For active systems, it is intensively debated whether some form of pressure could be considered as a state variable, hence obeying an equation of state (EOS). Probing the mechanical pressure exerted on a wall, it was shown that the existence of an EOS strongly depends on the details of the dynamics and in general does not hold. Different conclusions were obtained when considering the virial pressure defined in the bulk of an active suspension. Whether these debated results hold for more realistic system remains anyhow unclear. On the experimental side, no direct measurement of mechanical quantities have been reported.

Here, we experimentally study the mechanical pressure exerted by a set of respectively passive isotropic and self-propelled polar disks onto two different flexible unidimensional membranes. In the case of the isotropic disks, the mechanical pressure, inferred from the shape of the membrane, is identical for both membranes and follows the equilibrium equation of state of hard disks. On the contrary, for the self-propelled disks, the mechanical pressure strongly depends on the membrane in use and is thus not a state variable. We further observe an instability of the membrane akin to the one predicted theoretically for Active Brownian Particles against a soft wall.

A8. Dynamics on lubricant impregnated surfaces

Armelle Gas,^{1,2} Christophe Clanet,^{1,2} David Quéré^{1,2}

1 Physique et Mécanique des Milieux Hétérogènes (PMMH), ESPCI Paris - CNRS, France

2 Laboratoire d'hydrodynamique (LadHyX) - Polytechnique - X, France

Trapping a thin film in the roughness of materials creates surfaces that are partially solid and partially liquid, referred to as a lubricant-impregnated surface. Those surfaces have recently raised a great interest for their promising industrial applications. Indeed, they proved to drastically reduce the adhesion of a broad range of liquids, leading to enhance mobility, and strong anti-biofouling, anti-icing and anti-fogging properties.

In our talk we focus on the dynamics of liquids on such surfaces. Through simple experiments (drops going down an incline surface or confined in a Hele-Shaw cell, dewetting of a thin film), we study friction and slip in a systematic way. By varying the viscosity of both the lubricant and the deposited liquid by decades, we show the existence of three main source of viscous dissipation that are successively discussed.

A9. Structural and thermal study of the relaxor ferroelectric phase in VDF-based electroactive polymers

François Bargain,¹ Pierre Panine,² Fabrice Domingues Dos Santos,³ Sylvie Tence-Girault¹

¹ Matière Molle et Chimie (MMC), ESPCI Paris - CNRS, France

² XENOCS

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The increasing industrial interest for printed organic electronics these last years has led to the increasing development of VDF-based electroactive polymers for numerous energy-related applications (sensors, actuators, capacitors). Among them, poly(VDF-*co*-TrFE), (CH₂-CF₂)₇₀-(CHF-CF₂)₃₀, copolymers are known to exhibit ferroelectric and piezoelectric properties, whereas poly(VDF-*ter*-TrFE-*ter*-CTFE) terpolymers, (CH₂-CF₂)₆₀-(CHF-CF₂)₃₀-(CF₂-CFCl)₁₀, present relaxor ferroelectric and electrostrictive properties with high dielectric constant ($\epsilon' \sim 30$ -50) and high deformation under electric field ($\sim 7\%$). [1] These remarkable electroactive properties near 25 °C are closely related to the semi-crystalline organization of polymer chains: the Ferroelectric (FE) phase or the Relaxor Ferroelectric (RFE) phase, respectively. The FE phase and the Curie transition (FE to Paraelectric (PE) phase) are now well understood in copolymers, [2] whereas the structural nature of the RFE phase and its related thermal transition to the PE phase still remains unclear in terpolymers. [3]

A thermal SAXS-WAXS study (Nano-InXider, Xenocs) correlated to DSC, DMA and dielectric spectroscopy techniques were performed on terpolymers films to investigate the role of CTFE termonomer units in the semi-crystalline structure and the thermal behavior of the RFE phase. The incorporation of CTFE units within the crystalline structure was shown to promote the RFE phase. A reversible RFE to PE transition was found to occur in a narrow [0°C, 40°C] temperature range. However, depending on their size and chemical nature, other termonomer units, like 1324ze (CHF-CH(CF₃)), [4] can be excluded from the FE crystalline structure, preserving ferroelectric properties and Curie transition.

[1] Q. Li; Q. Wang *Macromol. Chem. Phys.* **2016**, *217*, 1228.

[2] F. Bargain; P. Panine; F. Domingues Dos Santos; S. Tencé-Girault *Polymer* **2016**, *105*, 144.

[3] L. Yang *et al. Macromolecules* **2014**, *47*, 8119.

[4] F. Bargain *et al. Macromolecules* **2017**, *50*, 3313.

A10. Drop trampoline

Pierre Chantelot,^{1,2} Martin Coux,^{1,2} Christophe Clanet,^{1,2} David Quéré^{1,2}

¹ Physique et Mécanique des Milieux Hétérogènes (PMMH), ESPCI Paris - CNRS, France

² Laboratoire d'hydrodynamique (LadHyX) - Polytechnique - X, France

Superhydrophobic substrates inspired from the lotus leaf have the ability to reflect impacting water drops. They do so very efficiently and contact lasts typically 10 ms for millimetric droplets. Yet unlike a lotus leaf most synthetic substrates are rigid. Focusing on the interplay between substrate flexibility and liquid repellency might allow us to understand the dynamic properties of natural surfaces.

Previous work on flexible superhydrophobic beams has highlighted superhydrophobicity enhancement and contact time reduction by up to a factor 2 for water drop impacts. In our experiment, we perform liquid marbles (a model for nonwetting drops), impacts onto thin ($\sim 10 \mu\text{m}$) stretched circular PDMS membranes.

The bouncing mechanism is drastically modified compared to that on a rigid substrate: the marble is shot upwards as it is spread in a disk shape. The contact time can be tuned by adjusting the fundamental frequency of the membrane and reduced by a factor 4.5 compared to a rigid substrate. We show that bouncing is driven by inertia and by the substrate dynamics and that the rebound mechanism also explains why viscous drops (that would not bounce off a rigid surface) can be repelled.

B. MONDAY @ 15h00-16h15 / 16h45-18h10

B1. Membranes and capsules made through interfacial H-bond polymer complexation

Mathilde Reyssat,¹ Julien Dupré De Baubigny,^{1,2} Corentin Trégouët,^{1,2} Thomas Salez,¹ Nadège Pantoustier,² Patrick Perrin,² Cécile Monteux²

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² Soft Matter Sciences and Engineering (SIMM), ESPCI Paris - CNRS - UPMC, France

Biocompatible microencapsulation is of widespread interest for the targeted delivery of active species in fields such as pharmaceuticals, cosmetics and agro-chemistry. Capsules obtained by the self-assembly of polymers at interfaces enable the combination of responsiveness to stimuli, biocompatibility and scaled up production. We have recently developed different methods to produce membranes at oil-water interfaces, based on H-bond complexations of polymers. These membranes can be assembled on drops of various sizes from the micrometer scale using microfluidics or rotor-stator emulsification up to the millimeter scale using the pendant drop geometry. We have developed different tools to characterize the mechanical properties of such membranes, using microfluidics or interfacial rheology. These membranes, which can be easily self assembled and dissolved by changing the pH, are very promising for applications.

B2. Cold compression of zirconia granules, role of the binder

Alice Boursier,^{1,2} Laurence Talini,¹ François Lequeux,¹ Christian Fretigny¹

¹ Soft Matter Sciences and Engineering (SIMM), ESPCI Paris - CNRS - UPMC, France

² Saint-Gobain Centre de Recherches et d'Etudes Européen (CREE), Cavaillon, France

The step of compression before sintering is critical for the mechanical properties of materials like metals or ceramics, whose zirconia belongs to. The “green body's” density in particular is an essential parameter that determines the post-sintering porosity and strength of the material; the density's homogeneity is also crucial since density gradients lead to the formation of fractures in the sintered body; the green body's strength is also essential to ensure a successful demolding step.

In our case the shaping of zirconia materials is made by compressing zirconia granules, with a typical diameter of 100µm, made by the spray-drying process. During this industrial process, it is well known that the addition of a binder increases the mechanical properties of compressed green bodies and can either improve or worsen their density. Understanding the repartition of binders in granules is an important key to understand how its content and nature can strongly affect zirconia granules compression. Indeed different approaches to explain those observations can be used: the role of the binder inside spray-dried granules and its influence on granules' behavior under compression; the role of the binder at granules' surface that influences friction between granules and thus impacts the microstructure of the granular material; the role of the binder in the friction between the mold and the spray-dried granules which is detrimental for the demolding step. Our aim is finally to understand how binders influence the compression of zirconia granules in order to develop a formulation that ensures an optimum with the best green strength, homogeneity and density possible.

First results have highlighted that two main parameters explain the impact of binders in green strength and density: the adsorption of binders on zirconia nanoparticles and the binders' mechanical properties, that can be, in a first approach, characterized by their glass transition temperature.

B3. Synthesis of comb and bottlebrush polymers by telomerization

Coralie Teulère, Renaud Nicolay

Matière Molle et Chimie (MMC), ESPCI Paris - CNRS, France

Comb polymers and molecular brushes are very attractive for many applications including rheological modifiers [1], colloidal stabilizations [2] or supersoft elastomers [3] to name a few. However, the synthesis of these sophisticated architectures is rather complex and requires tedious deprotection-functionalization sequences and/or metal catalysts.[4] In an attempt to simplify the synthesis of comb and bottlebrush polymers, the Soft Matter and Chemistry laboratory has recently developed a versatile and robust methodology that allows preparing these objects by radical polymerization.

The method developed relies on the use of polymer carrying pending thiol side groups [5] that are used to initiate the growth of polymer side chains via chain transfer reactions. With this approach, neither complicated functionalization steps nor metal catalysts are required. To exemplify the versatility of the methodology, molecular brushes with different grafting densities and several chain lengths have been prepared. In addition, the nature of the pending side chains can be easily tuned, as exemplified with methacrylate, acrylate and acrylamide brushes.

1. S. Lee, N.D. Spencer, *Science* **2008**, 319, 575.
 2. Y. Li, J. Zou, B.P. Das, M. Tsianou, C. Cheng, *Macromolecules* **2012**, 45, 4623.
 3. T. Pakula, Y. Zhang, K. Matyjaszewski, H-I. Lee, H. Boerner, S. Qin, G.C. Berry, *Polymer* **2006**, 47, 7198.
 4. K. L. Beers, S. G. Gaynor, K. Matyjaszewski, S.S. Sheiko, M. Möller, *Macromolecules* **1998**, 31, 9413.
 5. R. Nicolay *Macromolecules* **2011**, 45, 821.
-

B4. The dynamics of flexible actin filaments in shear flow

Yanan Liu, Olivia Du Roure, Anke Lindner

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The rheological properties of complex fluids made of particles in a suspended fluid depend on the behavior of microscopic particles in flow. A first step to understand this link is to investigate the individual particle dynamics in different flow geometries. A rigid rod will perform so-called Jeffery orbits, however when the rigid rod becomes flexible and Brownian, the behavior in terms of deformation and rotation is still to be fully understood. We chose here to address this situation by studying experimentally the behavior of flexible polymers. We use actin filament and combine fluorescent labeling techniques, microfluidic devices and an automated stage to carry out controlled systematical experiments and statistical analysis. By increasing either the shear rate or the length of filaments, we subsequently observe tumbling, buckling, and bending under flow as shown in the figure. The evolution and transition of these typical dynamics are governed by elasto-viscous number, comparing viscous forces to elastic restoring force. We are also interested in the effect of Brownian fluctuation of changing individual dynamics of filaments.

B5. From flow to fracture in colloidal gels

Gustavo Estevam Gimenes,¹ Elisabeth Bouchaud^{1,2}

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Fracture of colloidal gels is an important issue in a number of fundamental and applied problems. However, its direct observation is complicated by the experimental challenges of gripping and imposing a

controlled load on a very soft material and the complexity of viscoelastic processes inducing large deformations.

To this end, we use two experimental setups previously developed for the study of biopolymer gels to investigate the mechanical response of synthetic hectorite clay Laponite RD gels and an analogous colloidal system composed of Ludox TM-50 silica nanoparticles. The first device consists in a Hele-Shaw-like cell with a built-in notch. By connecting a hole over the notch to a water syringe pump, a flow rate controlled crack is initiated. The second consists of a closed, rigid chamber where the gel sample is surrounded by an immiscible oil. By sucking the oil out of the chamber, a rate of displacement proportional to its flow rate is imposed to the oil-gel interfaces, and a mode I crack appears at a notch. Both setups are fabricated using microfluidic stickers technology.

A wide range of behaviors can be observed in these systems as a function of the solid concentration and ionic strength, from a fluid which flows under load to an elastic solid which breaks. The crack opening displacement is obtained from its shape in the tip vicinity, while the displacement field is determined using Digital Image Correlation. In this plane stress configuration, it allows for the determination of the stress intensity factor and the energy release rate. Also, birefringence in nematic phases of Laponite can be used: observations are carried out through crossed linear and circular polarizers. By comparing the results of various compositions and cracks propagation velocities, we can have insight into the dissipative mechanisms and fracture properties of colloidal gels.

B6. Hydrodynamics of lateral strike in aquatic snakes

Martyna Goral

1 Physique et Mécanique des Milieux Hétérogènes (PMMH), ESPCI Paris - CNRS, France

Aquatic snakes have to circumvent strong hydrodynamic constraints during prey capture underwater. However, unlike most of other aquatic predators, they did not develop a specific adaptation to predation in this media. But surprisingly, more than 200 species of snakes eat aquatic preys as fish, crustaceans or some amphibians. We have demonstrated in recent work that the head shape of aquatic snakes has converged. However, the functional advantage of this shape does not appear to be as straightforward as we thought. Indeed, by measuring the force applied on the head during frontal strike, their head shape does not seem optimized as expected. However, we only tested for a frontal strike but some of these aquatic snakes show a different behavioral strategy which is a lateral strike. The hydrodynamics of this strike is of great interest to understand how shape is related with strategy used. I will show and explain the experiment reproducing a lateral strike using different 3D printed models of snakeheads. I will also present the results from measurements of hydrodynamic constraints associated. The aim is to assess whether some shapes could be more efficient with one of the two strategies.

B7. Correlations in intersecting populations: from electrolytes to pedestrians

Vincent Démery

Gulliver, ESPCI Paris - CNRS, France

How do pedestrians organize in an intersecting flow, e.g. in a hallway when the two halves of the population aim at opposite directions? Do people walking in the same direction form lanes? These questions can be answered by looking at the correlations between the two populations. The same situation is encountered in an electrolyte under an external electric field. Here, the correlations allow one to compute the conductivity of the electrolyte, which has important consequences for the applications. I will present the tools introduced to quantify the organization in these systems, and a theoretical calculation of the correlations. Finally, I will discuss the large distance behavior and its dependence on the various parameters of the models.

B8. How do particles softness and attractive interactions affect the structure and dynamics of colloidal glasses?

Maddalena Mattiello, Michel Cloitre

Matière Molle et Chimie (MMC), ESPCI Paris - CNRS, France

Soft glasses encompass a broad class of dispersions made of soft and deformable particles arranged at high volume fraction: emulsion droplets, colloidal microgels, star polymers, copolymer micelles. These materials are known to share generic dynamic properties intermediate between solid and liquid, which make them extremely popular in applications. However, the phase diagram, the nature of the yielding transition, and the dynamical properties appear to be strongly dependent of the local architecture of the particles and their interactions.[1]

In this communication we address the question of how the interplay between particle elasticity and specific interactions control the phase diagram and the rheology of soft microgels. To explore this issue we use a novel class of associative particles obtained by decorating the surface of the polyelectrolyte microgels with functional hydrophobic macromonomers. The macromonomers have a controlled architecture and composition allowing a fine tuning of the interactions. The phase diagram, the linear rheology and the flow properties are entirely modified. We will discuss in details the unique phenomena that take place in relation with the strength of the interactions.

[1] D. Vlassopoulos, M. Cloitre, *Curr. Opin. Coll. Interf. Sci.* **2014**, *19*, 561

B9. How menisci negotiate micropillars?

Daniel Beilharz,^{1,2} Evan Spruijt,³ Christophe Clanet,^{1,2} David Quéré^{1,2}

1 Physique et Mécanique des Milieux Hétérogènes (PMMH), ESPCI Paris - CNRS, France

2 Laboratoire d'hydrodynamique (LadHyX) - Polytechnique - X, France

3 Institute for Molecules and Materials, Radboud University, The Netherlands

Wetting liquids trapped inside microtextures have recently attracted attention due to their slipperiness for both insects and liquids. To create such a liquid-infused surface, a wetting liquid has to spread on a textured surface by propagating from one surface feature to the next. How this complex microscopic motion of the meniscus results in simple global dynamics remains poorly understood.

We analyze the complete dynamics of meniscus propagation in micropillar arrays from direct microscopic observations. It was shown that while the silicone oil fills the gap between two micropillars (z-direction) it simultaneously sweeps towards the next pillar (x-direction). We explain both processes of filling z and sweeping x and show how this local negotiation to the next micropillar accommodates to global Lucas-Washburn dynamics.

B10. Elastomeric foams from High Internal Phase Emulsion: a complex structure

Charles Barrand

Soft Matter Sciences and Engineering (SIMM), ESPCI Paris - CNRS - UPMC, France

Thanks to the wide range of properties, foams are used in a lot of application's areas: thermal isolation (low thermal conductivity), packaging (ability to absorb impacts), and buoyancy (lightness). What do you think that make you feel so good when you sleep? Foam inside your mattress!

In foams, relationship between microstructure (voids size, interconnections area and wall thickness) and mechanical properties are still not precisely defined.

The goal of this topic is to understand this relationship. In our special case materials are based on methacrylate monomers [1] to get elastomeric foams with low Tg. They are synthesized using emulsions technique. We are in the special case of highly concentrated emulsion (internal phase is up to 74% of the total volume), called HIPEs [2] (High Internal Phase Emulsions) in order to get opened interconnected foams. A first part of formulation is needed to provide a wide range of structure. Then, steps of structural and mechanical characterizations on polyHIPEs [3] (foams from HIPE) should help us to get a better compression of the part of each component and to find the desired link between structure and mechanical properties.

B11. Cooperative strings and glassy interfaces

Maxence Arutkin

Gulliver, ESPCI Paris - CNRS, France

We present a minimal theory of glass formation based on the ideas of molecular crowding and string-like cooperative rearrangements. In the bulk case, we obtain a scaling expression for the number of particles taking part in cooperative strings as a function of density, and we recover the Adam-Gibbs description of glassy dynamics. Then, by including thermal dilatation, the Vogel-Fulcher-Tammann relation is derived. Moreover, the random and string-like characters of the cooperative rearrangements permit the prediction of a temperature-dependent expression for the cooperative length of bulk relaxation. This theoretical picture enables the exploration of the influence of sample boundaries, in various geometries where the system size becomes comparable to the bulk cooperative length, such as thin supported films and nanoparticles made of polymers.

B12. Deformation and shape of flexible, microscale helices in viscous flows

Marine Daïeff,¹ Jonathan Pham,² Alfred Crosby,² Alexander Morozov,³ Olivia Du Roure,¹ Anke Lindner¹

¹ Physique et Mécanique des Milieux Hétérogènes (PMMH), ESPCI Paris - CNRS, France

² University of Massachusetts (UMASS), United States

³ University of Edinburgh, United Kingdom

Studying the interactions of microscopic helices with fluids is important because of its relevance to both fundamental science and technological applications, such as swimming microrobots or microflow sensors. Helically shaped flagella are also exploited by swimming microorganisms to move through their surrounding fluids. Here we take advantage of the spontaneous formation of micro-helices when straight ribbons detach from a substrate to study experimentally these helix-fluid interactions. The size of the ribbons is typically microscopic for the width and nanoscopic for the thickness.

Using this system, we plan to study two different situations: the deformation of anchored helices under flow and the coupling between deformation and transport of freely transported helices. First we have studied anchored helices in Newtonian fluids describing the overall shape of the helix and the viscous frictional properties. In order to mimic the natural environment of motile micro-organisms, we currently extend our research by studying the impact of non-Newtonian fluid properties on the mechanics of helix-fluid interactions. In parallel we focus on reducing the size of the diameter and on controlling the length of the helices, a necessary condition to study freely transported helices.

The overall goal of this study is to design perfectly controlled microscopic model systems to study fundamental questions related to the interactions of complex microscopic objects with viscous flows.

C. TUESDAY @ 9h30-10h45 / 11h15-12h30

C1. Sliding on a fluid

Marc Fermigier, Anaïs Gauthier, Jean-Baptiste Thomazo, Etienne Reyssat

Physique et Mécanique des Milieux Hétérogènes (PMMH), ESPCI Paris - CNRS, France

In a water slide, a thin layer of water lubricates the contact between the solid surface and the person moving down the tube. The characteristics of the water slides in amusement parks are determined semi empirically to provide a safe ride to users. We have performed laboratory experiments on model systems made of small solid cylinders either moving down a water film on an inclined plane, or levitating on air film on a rotating horizontal disk. We interpret these experiments by analyzing the lubrication flow underneath the cylinder and we show that the balance of forces and torques determines the thickness of the lubrication layer and the speed of motion.

C2. Isothermal Compartmentalized Digital Detection of microRNA

Guillaume Gines,¹ Roberta Menezes,² Neha Mehanpuria,¹ Kaori Nara,¹ Valérie Taly,² Yannick Rondelez¹

¹ Soft Matter Sciences and Engineering (SIMM), ESPCI Paris - CNRS - UPMC, France

² Université Paris V - Paris Descartes, France

MicroRNA are endogenous non coding RNA. Discovered 20 years ago, they have been found to play a key role in the post-transcriptional regulation of genes expression. Over 60 % of the human genome may be targeted by such biomolecules. MicroRNA are rapidly emerging as biomarkers with great potential: firstly, because dysregulation in their physiological levels has been linked to a wide range of diseases, including all types of cancer, as well as to resistance to chemo and radiotherapy. Secondly, they are stably present in the blood stream and can be detected from formalin-treated or frozen tissues as well as from minimally invasive liquid biopsies (i.e. blood, urine). Finally, since they are nucleic acids with known sequences, they are amenable to rational and rapid design of generic detection tests. However, miRNAs are short sequences and diluted ribonucleic targets, and thus are not ideally adapted to existing detection methods based on quantitative PCR.

Inspired by molecular programming principles, we developed a background-free isothermal amplification technology dedicated to microRNA detection and quantification. This method relies on the rational design of DNA circuits made of short synthetic DNA strands each achieving a specific function (target capture and conversion, amplification, leak-absorption, or reporting). The circuit is interpreted by a set of purified enzymes that catalyze signal amplification from microRNA sequences inputs. This system has proven to be efficient for the direct microRNA detection from plasma or serum.

We adapted this isothermal amplification method to a digital format: the assay now consists in preparing a sample with the DNA circuit, enzymatic processor, and partitioning the mixture into millions of picoliter-size identical compartments- so that the targets are distributed according to Poisson law. After signal amplification, each target-containing compartment exhibits a positive fluorescence signal. This technology allows the absolute quantification of microRNA from various biological samples.

C3. A new approach to microencapsulation active material free of surfactant and control delivery

Abdulwahed Shglabow

Laboratoire des Colloïdes et Matériaux Divisés (LCMD), ESPCI Paris - CNRS, France

Microcapsules are widely used now in different applications to encapsulate active material because it have high volatility or high reactivity for example in industry to produce plastic moulded into a specific mould such as a wind turbine, car chasis, aeroplane wings and also in petroleum production to encapsulate some additive to increase the efficiency of this product for example the lubricant as additive for motor oil and in cosmetic industry to encapsulate fragrance and some vitamin for the skin like vitamin C for anti-Aging & brighter skin,

The previous procedures have low production, low efficiency of encapsulation and there is leak from these capsules and also the low efficiency of releases.

My goal is broduce microcapsules with low cost, and high level of production for example pilot production ~ 500 kg / day with size controlled made from different active material and polymer shell dispersed in aqueous or oil phase without free of surfactant, to reach complete protection and to be able to trigger the release of the encapsulated material at the right time in the right place and in the right form by different mechanisms of release for example pH response capsules, Temperature response capsules, Ultrasonic response capsules, Osmotique pressure response capsules.

My procedure is based on emulsification by shearing the different phase free of surfactant but having favorably interfacial energy and favorably viscosity ratio.

C4. Materials with variable permittivity for vibrational energy harvesting

Mickael Pruvost,¹ Annie Colin,¹ Cécile Monteux,¹ Philippe Poulin²

¹ Soft Matter Sciences and Engineering (SIMM), ESPCI Paris - CNRS - UPMC, France

² Centre de recherches Paul Pascal (CRPP), Pessac, France

The Internet of Things (IoT) aims at connecting everyday physical objects into the Internet without any human interaction. Eliminate the batteries and the wires for providing electrical power to these objects is a key to success for IoT. To overcome this problem, a promising route is harvesting mechanical energy from ambient vibrations. One way to convert mechanical energy into electrical power is to use variable capacitors. A recent approach is the use of polymers loaded with conductive particles as a variable dielectric layer. It is necessary to finely control the morphology of the inner network formed by the particles within an elastic polymer. The aim of the present work is the development of near percolated reduced graphene oxide (r-GO) or carbon black (BC) network within an elastic polymer matrix. Two novel emulsions formulations routes are employed to achieve a fine control over the structure of the materials. First, r-GO solution is dispersed in the continuous phase of an O/W PDMS emulsion. The r-GO platelets are segregated after water removal between the PDMS droplets and can form near percolated networks controlled by the emulsion droplets. In the second route, droplets of a BC solution are dispersed in a PDMS matrix. After water removal, BC is confined in the intern surface of pores. We have studied the dielectric properties of these two types of nanocomposites at rest and under deformation. In the high filler concentration situation, the values of the permittivity are giant. The power harvestable with the composites has been measured but remains still low (nW) because of high value of conductivity (higher than 10^{-7} S/m). But, the high values of piezoresistivity measured in the high filler concentration situation, open the road to use these materials for stress or strain sensor applications considering their giant responses to mechanical deformations.

C5. Colloidal particle deposition kinetics in microchannels at high ionic strengths

Cesare Cejas,¹ Fabrice Monti,¹ Marine Truchet,¹ Jean-Pierre Burnouf,² Patrick Tabeling¹

¹ MMN, Laboratoire Gulliver, ESPCI Paris - CNRS, France

² SANOFI Recherche, France

We use microfluidics to inject a fluid suspension and analyze the deposition of weakly Brownian particles in a straight channel at small Reynolds numbers and at high ionic strengths. Under these conditions, electrostatic interactions are neglected and particle-wall van der Waals interactions describe the deposition mechanism on microchannel walls. We calculate the deposition profiles and kinetics for a wide range of physical parameters and confirm agreement between theory and numerical Langevin simulations as well as experimental results. We demonstrate a universal dimensionless deposition function described by contributions from advection-diffusion transport and adhesion forces denoted by the value of the Hamaker constant. The Hamaker constant quantifies the order of magnitude of interaction forces between two surfaces and is traditionally measured using Atomic Force Microscopy. Though precise under vacuum, it is, however, rather inexact under aqueous conditions due to inherent difficulties linked to particle manipulation. We demonstrate that this microfluidics-based particle deposition technique enables us to measure the Hamaker constant of a large quantity of particles under aqueous conditions, a task that would be a challenge to perform using standard AFM.

C6. Supramolecular polyethylenes: synthesis, characterization and properties

Jérémie Lacombe, Corinne Soulié-Ziakovic

Matière Molle et Chimie (MMC), ESPCI Paris - CNRS, France

Polyethylene (PE) chains capped with hetero-complementary groups thymine (Thy) or 2,6-diaminotriazine (DAT) were targeted by a combination of Catalyzed Chain Growth Polymerization of ethylene and post-modification reactions. Low-molar mass (1000-2000 g/mol) supramolecular PE carrying Thy or DAT at one or both chain ends (PE-Thy, PE-DAT, Thy-PE-Thy, DAT-PE-DAT) were obtained with high functionalities (> 90%).

These materials were studied by thermal analyses and SAXS measurements. They feature lamellar morphologies which arise from the microphase separation of the polar end-groups and the non-polar chains induced by dispersion forces. When end-groups are not crystallizable (eg DAT), the PE crystallinity (62%) is not affected. On the contrary, association of Thy pairs crystallize in planes at high temperature (180°C) and induce a strong confinement of PE chains resulting in a significant decrease of PE crystallinity (17%). As observed with homologous Thy functionalized poly(propylene glycol) (PPG), mesoscopic organizations can be driven by the crystallization of associated Thy pairs. Yet, contrary to the PPG systems, supramolecular PE with non crystallizable DAT units are also ordered. This results from the fact that the clusterization of the H-bonding units is frozen by the PE crystallization during cooling. Finally, we studied the mechanical properties of these low-molar mass supramolecular PE and in particular the impact of the mesoscopic organizations.

C7. Pairwise frictional profile between particles determines discontinuous shear thickening transition in non-colloidal suspensions

Jean Comtet,¹ Guillaume Chatté,² Antoine Niguès,¹ Lydéric Bocquet,¹ Alessandro Siria,¹ Annie Colin²

¹ Laboratoire de Physique Statistique de l'ENS (LPS), ENS - UPMC - Université Paris Diderot, France

² Soft Matter Sciences and Engineering (SIMM), ESPCI Paris - CNRS - UPMC, France

The process by which sheared suspensions go through a dramatic change in viscosity is known as discontinuous shear thickening. Although well-characterized on the macroscale, the microscopic mechanisms at play in this transition are still poorly understood. Here, by developing new experimental procedures based on quartz-tuning fork Atomic Force Microscopy, we measure the pairwise frictional profile between approaching pairs of PVC and cornstarch particles in solvent. We report a clear transition from a low-friction regime, where pairs of particles support a finite normal load while interacting purely hydrodynamically to a high-friction regime characterized by hard repulsive contact between the particles and sliding friction. Critically, we show that the normal stress needed to enter the frictional regime at nanoscale matches the critical stress at which shear thickening occurs for macroscopic suspensions. Our experiments bridge nano and macroscales, and provide long needed demonstration of the role of frictional forces in discontinuous shear thickening.

C8. Elastocapillary adhesion of a soft shell on a rigid sphere

Marie Tani, Hadrien Bense, Maïka Saint Jean, Benoît Roman, Etienne Reyssat, José Bico

Physique et Mécanique des Milieux Hétérogènes (PMMH), ESPCI Paris - CNRS, France

Curiously, soft contact lenses have almost the same curvature while the shape of patients eyes differ from one to another. Within which limit do soft lenses accommodate a mismatch in curvature? To address this question, we designed a model experiment where a thin elastomeric shell is deposited on a rigid sphere of different radius of curvature and coated with a wetting liquid. We measured the maximum size of the sphere that ensures a perfect matching. This size is well described by a scaling law which generalizes a previous work from Hure et al. [1] and compares capillary adhesion with the stretching energy induced by the change in Gaussian curvature. Beyond this maximal size, various contact patterns are observed, such as star-shaped bubbles or blisters.

[1] J. Hure, B. Roman, and J. Bico, *Phys. Rev. Lett.* **2011**, *106*, 174301

C9. Metastability in nematic liquid crystal shells

Kunyun He,¹ Ye Zhou,² Juan J. De Pablo,² Alberto Fernandez-Nieves,³ Teresa Lopez-Leon¹

¹ Gulliver, ESPCI Paris - CNRS, France

² University of Chicago, United States

³ Georgia Institute of Technology (GATECH), United States

Confining a nematic to a spherical geometry inevitably yields topological defects. For example, nematic liquid crystals, constrained to lie parallel to the interface of a drop, possess two surface defects, called boojums. When a nematic is confined to a shell geometry, i. e. between two spherical surfaces, a number of different defect structures results from an interesting interplay between topological constraints and energy minimization.[1,2] Recent experimental results on nematic shells suggest that the existence of energy barriers, which separate one defect configuration from the others, can play a determinant role in

stabilising metastable structures.[3,4] In this work, we show the existence of metastability in nematic shells. By imposing an external osmotic pressure, we change the shell average thickness to reach situations that are energetically unfavorable. We observe two different transition routes along the process. Remarkably, we observe a dramatic transition in which the inner droplet is expelled from the shell when a critical average thickness is reached. We find that the critical average thickness depends on the osmotic pressure of the outer phase.

[1] V. Vitelli, D. R. Nelson, *Phys Rev. E* **2006**, 74

[2] Fernández-Nieves, A., Vitelli, V. *et al.*, *Phys. Rev. Lett.* **2007**, 99

[3] Lopez-Leon, T., Koning, V. *et al.*, *Nature Phys.* **2011**, 7

[4] V. Koning, T. Lopez-Leon, *et al.*, *Phys Rev. E* **2016**, 94

C10. Adhesion of Hydrogel Films to Living Tissues

Raphaël Michel, Laurent Corté

Matière Molle et Chimie (MMC), ESPCI Paris - CNRS, France

Centre des Matériaux (MAT), MINES ParisTech, France

Hydrogel films are particularly interesting as substrates or membranes for medical applications such as drug delivery, cell therapy, wound dressing and hemostasis.[1] Their adhesive properties are often central to these applications where an intimate contact with living tissues is required. Yet, the microscopic and quantitative phenomena governing this adhesion are still little understood.

In that context, we devise an in vitro experiment based on a 90° peel test to measure the adhesion of model PEG hydrogel films onto porcine liver. Using this technique, we compare the influence of various parameters (contact pressure, contact duration, tissue hydration, hydrogel swelling ratio, etc.) on the adhesive properties of the films. Combining these results with swelling measurements and microscopic observations, we show that the adhesion between hydrogel films and tissues is strongly governed by the transport and distribution of fluid across the interface.

Building on this knowledge, we investigate how the presence of nanoparticles at the hydrogel-tissue interface can enhance this adhesion as recently discovered by Leibler and coworkers.[2]

This study provides valuable guides to design adhesive films relevant for clinical practice.

[1]. M. Mehdizadeh, J. Yang, *Macromol. Biosci.* **2013**, 13, 271.

[2]. a) A. Meddahi-Pelle, A. Legrand, A. Marcellan, L. Louedec, D. Letourneur, L. Leibler, *Angew. Chem. Int. Edit.* **2014**, 53, 6369; b) S. Rose, A. PrevotEAU, P. Elziere, D. Hourdet, A. Marcellan, L. Leibler, *Nature* **2014**, 505, 382.

C11. Leidenfrost drops are intrinsically self-propelled !

Ambre Bouillant, Timothée Mouterde, Philippe Bourriane, Christophe Clanet, David Quéré

1 Laboratoire d'hydrodynamique (LadHyX) - Polytechnique - X, France

2 Physique et Mécanique des Milieux Hétérogènes (PMMH), ESPCI Paris - CNRS, France

When a drop is brought close to a surface significantly hotter than the fluid's boiling point, an insulating vapor layer forms and prevents the liquid from wetting the surface. In this so-called Leidenfrost effect, the absence of solid/liquid contact provides a unique mobility for these kinds of soft hovercrafts.

We carry out experiment where we held drops above a hot plate using needles. As the drop evaporates, it detaches from the needle, and accelerates: it propels forward. Looking at the quadratic-like trajectories of levitating drops on silicon wafer heated at $T = 350^{\circ}\text{C}$, we measure the constant acceleration for various drop radius. We report the existence of two regimes: for large drops, drop acceleration plateaus to typically 1 mm/s^2 , whereas below a critical radius, drop acceleration increases significantly and reaches typical values of a hundred mm/s^2 , that were not reported before to the best of our knowledge. We intend to understand the existence of these two regimes of propulsion.

Over drop evaporation, viscous entrainment by the vapor beneath the drop and thermocapillary instabilities may induce dynamics inside the drop. The flow should be axisymmetrical, which was confirmed by PIV measurements. However, we observe a break in the internal motion symmetry below a critical radius R_c , which coincides with the radius below which drops are remarkably accelerated. The drop starts to roll which propels it forward in the rolling intended direction, explaining the surprisingly high value of the acceleration. As the break in symmetry is non-deterministic, Leidenfrost drops self-propel isotropically.

We perform interference-imaging experiments to bring to light the bottom interface geometry. The liquid-vapor interface beneath the drop is deformed in an asymmetric fashion and tilted of an angle of a few mrad, introducing a horizontal component of the force that holds drops in levitation which generates propulsion.

C12. Early stage of large ribosomal subunit assembly in E.coli: a single molecule study

Laurent Geffroy,¹ Thierry Bizebard,² Ulrich Bockelmann¹

1 Nanobiophysics, ESPCI Paris - CNRS, France

2 Expression Génétique Microbienne, CNRS - Université Paris 7, France

Ribosome assembly is still poorly understood in spite of many efforts. In vitro reconstitution studies have shown that this process is highly cooperative and starts with the binding of a few ribosomal (r-) proteins to rRNA, but how these early binders act is unknown. This work focuses on the initial phase of the assembly of the large subunit of the E. coli ribosome, which involves 23S rRNA, five r-proteins and assembly helper proteins.

We prepared a 79 nucleotide-long region of 23S rRNA encompassing the binding sites of the early binders L24 and L4 (these proteins were supplied by the group of Takuya Ueda, University of Tokyo). Force signals are measured in a DNA/RNA dumbbell configuration using a dual-beam trap. We measure upon unwinding the rRNA fragment without added protein, or in the presence of either L4 or L24 or both. Without protein, the rRNA fragment unfolds by a sequence of steps that involve three distinct intermediates. With L4 and/or L24, the same intermediates are observed but they unfold at significantly higher forces. For instance, the most probable unfolding force of the second intermediate, is 10.7, 13.3, 14.9 and 16.4 pN, without protein or in the presence of L4, L24 or both, respectively. We localise the binding sites of the two r-proteins on rRNA within ± 5 nucleotides and observe pronounced cooperativity in their binding. We conclude that L4 and L24 act in concert to mechanically stabilise this region of 23S rRNA.

D. TUESDAY @ 14h30-15h45 / 16h15-17h15

D1. Large strain viscoelastic dissipation during interfacial rupture in laminated glass

Matteo Ciccotti,¹ Paul Elziere,¹ Etienne Barthel,¹ Costantino Creton,¹ Cecile Dalle-Ferrier²

¹ Soft Matter Sciences and Engineering (SIMM), ESPCI Paris - CNRS - UPMC, France

² Saint-Gobain Recherche, Aubervilliers, France

In the dynamic rupture of laminated glass, it is essential to maximize energy dissipation. To investigate the mechanisms of energy dissipation, we have experimentally studied the delamination and stretching of a polymeric viscoelastic interlayer sandwiched between glass plates. We find that there is a velocity and temperature domain in which delamination fronts propagate in a steady state manner. At lower velocities, fronts are unstable, while at higher velocities, the polymer ruptures. Studying the influence of the interlayer thickness, we have shown that the macroscopic work of fracture during the delamination of the interlayer can be divided in two main components: (1) a near crack work of fracture which is related to the interfacial rupture and to the polymer deformation in the crack vicinity. (2) A bulk stretching work, which relates to the stretching of the interlayer behind the delamination front. Digital image correlation measurements showed that the characteristic length scale over which this stretching occurs is of the order of the interlayer thickness. Finally, an estimate of the bulk stretching work was provided, based on a simple uniaxial tensile test.

D2. Crystallization of self-propelled hard-discs: a new scenario

Guillaume Briand, Olivier Dauchot

EC2M, Laboratoire Gulliver, ESPCI Paris - CNRS, France

At low density, assemblies of self propelled particles are prone to a number of novel collective behaviors, which are specific to these intrinsically out-of-equilibrium systems. The high density phases of active matter have been much less studied. Either the density screens the activity and the liquid freezes according to equilibrium scenarii or activity dominates and new phases are prone to develop is an open question of major importance. Here we experimentally tackle this issue in the specific case of vibrated polar hard disks which are a model of self-propelled particle. We show that increasing density the quasi-continuous crystallization of equilibrium disks is replaced by a specifically active scenario. Clusters of dense hexagonally-ordered packed discs spontaneously form, melt, split and merge leading to a highly intermittent and heterogeneous dynamics. No coarsening is observed. Increasing further the density, the clusters span a finite fraction of the system size and the structure becomes similar to that of a polycrystal. However the system is never frozen: the clusters permanently melt from place to place forming droplets of active liquid which rapidly propagate across the system. This state of affair remains up to the highest possible packing fraction questioning the stability of the crystal for active discs.

D3. Digital microfluidics for growing unculturable micro-organisms

Mathieu De La Motte Saint Pierre, Jean Baudry

Laboratoire des Colloïdes et Matériaux Divisés (LCMD), ESPCI Paris - CNRS, France

Micro-organisms that are not yet culturable represent roughly 95% of the microbial population. Tapping into this vast diversity will allow us to comprehend our natural environment and it can also be a way of discovering new antibiotics. The usual approach to culturing a micro-organism is to dilute the environmental sample many times in a synthetic media until a pure culture of said micro-organism is obtained. However with this method the complexity of the natural medium that makes the growth possible of the overwhelming majority is lost.

The aim of our project is to use droplet based microfluidics to study and grow soil micro-organisms that are not yet culturable. Micro-droplets are used as microreactors and inside them we are recreating micro-habitats that can be found in the natural environment by encapsulating entire communities from the soil. The size of droplets enables communication between micro-organisms unlike in bulk solution.

After incubation, droplets can be observed in the form of a monolayer inside a glass chamber to study the result of interactions. Droplets can also be broken to sequence the micro-organisms that have grown inside.

Preliminary results show that interactions at this level may promote growth and that some micro-organisms from the soil can only be cultured inside the droplets.

D4. Dynamics of confined droplets in a rough medium

Ludovic Keiser, Armelle Gas, José Bico, Etienne Reyssat

Physique et Mécanique des Milieux Hétérogènes (PMMH), ESPCI Paris - CNRS, France

The dynamics of confined droplets has been extensively studied during the last decades, in the footsteps of the fast development of digital microfluidics. In the field of oil recovery, numerous phenomena lead to the emulsification of petroleum while transported across a reservoir, e.g. viscous fingering or snap-off. The understanding of the peculiar dynamics of confined droplets and emulsions is thus of crucial importance.

In this study, we focus on the dynamics of viscous and non-wetting droplets of oil confined in a vertical Hele-Shaw cell filled with a less viscous surfactant solution. The oil droplets are denser than the aqueous solution and move at constant speed driven by gravity. The surfactant solution completely wets the walls, and a thin lubrication film separates the oil drops from the walls. For a cell with smooth walls, two main dynamical regimes are characterized as the gap between the walls is varied. Viscous dissipation is found to dominate either in the droplet or in the lubrication film. A sharp transition between both regimes is observed and successfully captured by asymptotic models.

For a cell with rough walls, that transition is found to be dramatically altered. We show that drops are generally much slower in a rough Hele-Shaw cell, in comparison with a similar smooth cell. Building up on the seminal work of Seiwert et al. (JFM 2011) on film deposition by dip coating on a rough surface, we shed light on non-trivial friction processes resulting from the interplay of viscous dissipation at the front of the drop, in the lubrication film and in the bulk of the drop.

D5. Self-Assembling Photonic Materials

Pavel Yazhgur,¹ Joshua Ricouvier,¹ Romain Pierrat,² Rémi Carminati,² Patrick Tabeling¹

1 Laboratoire Microfluidique, MEMS, Nanostructures (MMN), ESPCI Paris - CNRS, France

2 Institut Langevin, ESPCI Paris, France

We explore the possibilities of fabricating photonic materials using the self-organisation of soft matter at the optical wave lengthscale. Hyperuniform materials,[1] being disordered systems with suppressed long-scale fluctuations have been demonstrated to exhibit potential applications for disordered photonic materials production.[2] In our project we study a jammed packing of oil droplets in water. The droplets are produced in a PDMS microfluidic chip and directly assembled in a microfluidic channel. By varying the fluid pressures we manage to sharply control the droplet production and thereby govern the structural properties of the obtained material. The pseudo-2D (a monolayer of droplets) are investigated. Our results show that at appropriate experimental conditions droplets self-organize in hyperuniform patterns. Our electromagnetic simulations also show that the obtained material can be transparent while staying optically dense. As far as we know, the proposed material is one of the first examples of experimentally made hyperuniform materials. We hope that our studies will help to establish a new way of disordered photonic materials production.

[1] S. Torquato, F. H. Stillinger, *Physical Review E* **2003**, 68, 041113.

[2] W. Man, M. Florescu, E. P. Williamson, Y. He, S. R. Hashemizad, B. Y. Leung, P. J. Steinhardt. *Proc. Natl. Acad. Sci. U.S.A.* **2013**, 110, 15886.

D6. Interaction intrus élastique-milieu granulaire

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Dans le cadre du stage M2, on étudie expérimentalement et numériquement le cas d'interaction fluide/structure entre une fibre élastique et un milieu granulaire. Différents cas de sollicitations de l'intrus sont prises en compte et la déformée pour chaque type de chargement est représenté numériquement. Des paramètres géométriques et matériels sont examinés sur cette étude afin de bien déterminer leur rôle et leur impact sur le basculement de la tige. Les différents régimes observés pendant le déroulement de l'expérience sont interprétés en focalisant surtout sur la régime de basculement de la tige sans prendre en compte la phase initiale de l'expérience durant laquelle la tige reste droite et la phase finale durant laquelle on observe des effets types avalanche. Les comparaisons de comptabilité et concordance des simulations numériques avec les expérimentales concernent la déformée de la tige, la déflexion maximale du bout de la tige et l'angle de l'encastrement avec la position droite initiale.

D7. Synthesis of vitrimers from high-density polyethylene via reactive melt processing

Trystan Domenech, Max Röttger, Rob van der Weegen, Antoine Breuillac, Renaud Nicolaÿ, Ludwik Leibler

Matière Molle et Chimie (MMC), ESPCI Paris - CNRS, France

Combining the processability of thermoplastics with the mechanical properties and chemical resistance of thermosets into a single material has been long sought after in polymer science. Such a material came to life in 2011 with the invention of vitrimers, which are permanent organic networks capable of flow, shaping and self-healing at high temperatures through associative covalent exchange reactions. The concept of vitrimer is highly attractive since it provides a new way to improve the properties and

recyclability of polymers, and could benefit from new synthetic routes that involve industrially-produced precursors. Here, we extend the vitrimer library to widely produced polymers. This new approach is based on two main findings: the metathesis of dioxaborolanes, and its implementation into high-density polyethylene (HDPE) thermoplastic backbone. Vitrimers are synthesized in two steps: functionalization of HDPE backbone with pendent dioxaborolane groups, and metathesis-based crosslinking through the addition of a bis-functional dioxaborolane. Both steps are conducted through reactive melt processing. We obtain insoluble materials that can be extruded and compression molded several times at high temperature. The dioxaborolane metathesis reaction is fast and does not require the use of catalysts in order to process or recycle these materials. The resulting vitrimers show improved chemical resistance, high temperature dimensional stability and environmental stress cracking resistance compared to their thermoplastics precursors. At the same time, they remain easily reprocessable and recyclable, as opposed to non-dynamically crosslinked materials.

D8. Poroelastic Indentation of Mechanically Confined Hydrogel Layers

Jessica Delavoipière, Yvette Tran, Emilie Verneuil, Antoine Chateauinois

Soft Matter Sciences and Engineering (SIMM), ESPCI Paris - CNRS - UPMC, France

We report on the poroelastic indentation response of thin hydrogel films geometrically confined within contacts with rigid spherical probes. Grafted networks differing in their glass transition temperature in the dried state were considered. Time-dependent changes in the indentation depth under a constant applied load were monitored over time as a function of the film thickness and of the radius of curvature of the probe using optical interferometry. The results are analysed within the framework of an approximate contact model derived within the limits of confined contact geometries. From this approach, scaling laws for the characteristic poroelastic time and the equilibrium depth are obtained. We show that this model adequately describes the poroelastic indentation behavior of the hydrogel films as far as the glass transition of the water plasticized network is not lowered below room temperature.

D9. Friction at the interface between a solid self-assembled monolayers and liquid polymers or solid metal nanotips

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Gulliver, ESPCI Paris - CNRS, France

The friction between a solid and a liquid was historically assumed to be so large that fluid molecules in contact with a solid boundary were stuck. Thus, the classical no-slip boundary condition was applied. With the advent of micro- and nano-fluidics in the last decades, however, this boundary condition has been observed to fail in many instances. Particularly, as will be discussed here, a slip boundary condition is observed when unentangled polystyrene (PS) dewets from a hydrophobic, alkylsilane self-assembled monolayer (SAM). This boundary condition can furthermore be tuned over an order of magnitude by subtly changing the SAM, indicating that the friction between solid and liquid is highly sensitive to atomic level details. We have also investigated the friction between these same SAMs and a solid metal tip of nanoscopic dimensions. Remarkably, this apparent solid/solid friction is velocity dependent over two orders of magnitude in the velocity, and can be described in terms of a distribution nanocontacts with very weak stiffness compared to the expected one for metal/solid contacts.

D10. Improving wind turbines starting with flexible blades

Vincent Cognet, Sylvain Courrech Du Pont, Benjamin Thiria

Physique et Mécanique des Milieux Hétérogènes (PMMH), ESPCI Paris - CNRS, France

Wind turbines benefit from decades of technological developments and are currently close to the Betz limit of maximal efficiency. However the starting of these turbines is still a challenging issue. Optimizing for high efficiency and having an early start leads to contradictory calibrations of the turbine. At startup the angle of attack of the wind on the blade is much higher than 45 degrees. Increasing the fluid torque around the rotor in order to lower the starting wind velocity means increasing the pitch angle. Conversely, high efficiencies are characterized by low pitch angles.

Concerning small wind turbines, nearly all have neither engine for starting nor variable pitch angle because it is not cost effective. In addition they are often located near places of energy consumption and do not experience optimal wind conditions. Thus in these areas of low and unstationnary wind velocities, it is vital to have a low starting velocity and a fast transitional regime, to avoid frequent and long "idling periods" or down periods.

A solution to that issue is to replace active flaps by passive variable pitch angles using chordwise flexible blades. This idea is inspired by studies on fish swimming, insect flight and plants reconfiguration. Flexibility of insects wings is a way to redirect the aerodynamic force and to increase the thrust. In the same line of thought, reconfiguration reduces the drag force on plants.

We explore experimentally and theoretically how flexible blades improve starting performance of a wind turbine without damaging the efficiency in operation. The criteria to evaluate the starting of the turbine are the starting wind velocity and the initial acceleration. Experiments show that a moderate blade flexibility improves significantly the starting performance of the turbine. We discuss these results in details, pointing out the scaling laws at stake for moderate blade flexibilities.

POSTERS

Adsorption of high molecular weight polyacrylamide on siliceous materials

Jennifer Fusier, Jean-Baptiste D'Espinoze De Lacaille, Nicolas Sanson, Francois Lequeux, Hela Bessaies-Bey

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Polymers are used in a large range of applications, including petroleum industries in oil recovery systems. They are used to obtain high viscous fluids injected in rock containing oil. On production well, injection of such fluids leads to loss of injectivity. Different assumptions could explain this behavior; one of them is the adsorption of high molecular weight polymers on the surface of rocks reducing the permeability of the porous media. Our work focuses on the understanding and characterization of the adsorption of polyacrylamide on siliceous materials. Polymers with narrow molecular weight distribution have been specially synthesized for this study with several sizes and charges.

Firstly the adsorption of polyacrylamide onto several siliceous surfaces has been investigated with total organic carbon measurements. It confirmed that the adsorption of neutral polyacrylamide and partially hydrolyzed polyacrylamide require the presence of aluminum groups at surface of particles.

Besides the competition of adsorption between different molecular weight neutral and negatively charged polyacrylamide has been studied by Size Exclusion Chromatography. It evidences that adsorption is always in favor of the highest molecular weight even with delayed addition.

We are also interested in measuring the thickness of adsorbed polymer at surface of siliceous materials by interferometry technique. The properties of solution such as the ionic strength and the concentration of polymers is varied. The dynamic of competition between polymers and the impact of layer thickness is also explored. Moreover these experiments are correlated to pressure measurements during injection experiments on sintered siliceous materials.

Dynamic covalent polymers as viscosity modifiers

Thibault Derouineau, Nga Nguyen, Renaud Nicolaÿ, Ludwik Leibler

Matière Molle et Chimie (MMC), ESPCI Paris - CNRS, France

It is still a challenge in many industrial applications, e.g. cosmetics, inks, adhesives, lubricants, paintings, etc., to control the rheological properties of organic formulations. Here, we describe a new approach to control the viscosity of organic solutions as a function of temperature. For that purpose, two functional monomers were synthesized and copolymerized separately by reversible addition-fragmentation chain transfer (RAFT) polymerization to prepare two sets of complementary random copolymers. The polymers were designed to display temperature dependant solvent affinity in mineral oils, while the functional monomers were chosen to enable fast dynamic covalent exchanges without the need for any catalyst. Rheological studies of the linear viscoelasticity and flow behavior as a function of temperature were performed to exemplify the efficiency of this system to control the viscosity of organic solutions. Thanks to the reversible association of the copolymers by boronic ester transesterification, these formulations exhibit a significant increase of the relative viscosity at high temperatures. The rheological behavior of the formulations is also fully reversible and reproducible over several warming-cooling cycles. Temperature sensitivity and viscosity change can be managed by changing the composition, the molecular weight and the functionality of the copolymers.

Adhesion of unvulcanized polar elastomers

Valentine Hervio

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Elastomers are used in several industrial applications (such as tires, seals etc) for their good properties of reversible elasticity and mechanical strength. Most of them are unsaturated and apolar polymers (to provide water impermeability), and their adhesion (and autohesion) properties have been widely studied. An experimental set-up has been developed in order to characterize the adhesion properties of different materials: the probe-tack. It consists in bringing together the two surfaces under a fixed compressive pressure and contact time, and measuring the force then needed to separate them at a fixed separation rate. The analysis of the results gives indications regarding the debonding mechanisms and the adhesive properties of the material.

Hamed and al identified several process and material parameters having a great influence on the autohesion properties for apolar rubbers such as contact time, debonding speed, temperature, elastomers' molar mass, and the material's thickness and roughness.

In order to exhibit high tack properties, the rubbers need to fulfill three main conditions: the two surfaces must come into intimate molecular contact; some inter-diffusion of polymer chains across the interface must occur and the material must show good breaking strength properties in its uncrosslinked state.

During our study, we focus on the adhesion of unvulcanized polar rubbers, for fuel tanks applications and aim at identifying the parameters influencing the adhesion of such polar soft materials. For this sake, we need to understand the physical and chemical mechanisms occurring at the interface when bringing these types of materials together. The influence of the concentration of polar groups and their orientation on the interdiffusion of the polymer chains, as well as the effect of fillers (especially the tackifying resin) need to be studied.

Takeoff, flight and landing of self-jumping micro-droplets

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Nanotextured superhydrophobic surfaces may self-remove condensing water: growing droplets coalesce and the release of excess of surface energy can result in the departure of the merging drop. Considering that surface energy is converted into kinetic energy, the jumping velocity U of the merged drop behaves like the inertio-capillary velocity and scales as $r^{(-1/2)}$. It has been reported that droplets with radius greater than $10\ \mu\text{m}$ can depart from the substrate. Below this critical radius, internal viscous dissipation might impede the motion. However, recent studies have proved that jumping can occur for much smaller droplets radii, down to $500\ \text{nm}$, which was also confirmed numerically. Through experimental work, we investigate the coalescence-induced jumping phenomenon on a silicon surface patterned with an array of nanocones. Our experiment consists in simultaneously filming the coalescence of two growing droplets from above and the jumping motion of the resulting droplet from aside. We measure the jumping velocity U of droplets with radius between $1\ \mu\text{m}$ and $1\ \text{mm}$.

We show that the capillary-inertial scaling law governs jumping down to $5\ \mu\text{m}$ until the velocity decreases with decreasing radius until $1\ \mu\text{m}$. We identify the possible origin of the dissipation causing this decrease and show that internal viscous dissipation plays a significant role, unlike friction and adhesion. Balancing inertia, surface tension and viscous dissipation gives a prediction that matches quite well experimental data. Then, we characterize the flight of small droplets ($r < 20\ \mu\text{m}$) that is governed by air viscosity. We finally understand what prevents those drops from bouncing when they come back on the substrate.

Direct observation of remarkable nanoparticle evolution during aqueous dissolution of polymer/drug particles

Ralm Ricarte

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Amorphous solid dispersions (SDs), metastable blends of an active pharmaceutical ingredient and a polymer excipient, can significantly enhance the aqueous solubility of hydrophobic drugs, but the mechanism is not well understood. To resolve this ambiguity, we explored the dissolution of hydroxypropyl methylcellulose acetate succinate (HPMCAS) SDs in phosphate buffered saline (PBS). Light scattering measurements of HPMCAS solutions showed the polymer forms a mixture of ~10 and ~100 nm sized structures (assigned to linear and covalently coupled polymer chains, respectively) in both PBS and tetrahydrofuran. The measurements also demonstrated that PBS is a poor solvent for HPMCAS at and below 37 °C, suggesting the solvent induces the polymer to associate with itself or other hydrophobic species in solution. In vitro dissolution of HPMCAS SDs – containing either phenytoin or probucol as the encapsulated hydrophobic drug – in PBS was studied using a combination of cryogenic transmission electron microscopy (both bright-field imaging and electron diffraction) and small-angle X-ray scattering. These tools revealed that HPMCAS and drug form <100 nm amorphous nanoparticles in solution. A direct correlation between the SD dissolution profiles and nanostructure evolution was uncovered for both drugs, implying that a significant portion of the drug measured in the supernatant during the dissolution assay is retained in the form of nanoparticles. Drug identity, loading, and targeted concentration influenced nanoparticle size, shape, and lifespan. These discoveries confirm that persistent nanostructures are important for enhancing drug supersaturation during SD dissolution.

Synthesis of vitrimers from high-density polyethylene via reactive melt processing

Antoine Breuillac, Trystan Domenech, Max Röttger, Rob van der Weegen, Renaud Nicolaÿ, Ludwik Leibler

Matière Molle et Chimie (MMC), ESPCI Paris - CNRS, France

Combining the processability of thermoplastics with the mechanical properties and chemical resistance of thermosets into a single material has been long sought after in polymer science. Such a material came to life in 2011 with the invention of vitrimers, which are permanent organic networks capable of flow, shaping and self-healing at high temperatures through associative covalent exchange reactions. The concept of vitrimer is highly attractive since it provides a new way to improve the properties and recyclability of polymers, and could benefit from new synthetic routes that involve industrially-produced precursors. Here, we extend the vitrimer library to widely produced polymers. This new approach is based on two main findings: the metathesis of dioxaborolanes, and its implementation into high-density polyethylene (HDPE) thermoplastic backbone. Vitrimers are synthesized in two steps: functionalization of HDPE backbone with pendent dioxaborolane groups, and metathesis-based crosslinking through the addition of a bis-functional dioxaborolane. Both steps are conducted through reactive melt processing. We obtain insoluble materials that can be extruded and compression molded several times at high temperature. The dioxaborolane metathesis reaction is fast and does not require the use of catalysts in order to process or recycle these materials. The resulting vitrimers show improved chemical resistance, high temperature dimensional stability and environmental stress cracking resistance compared to their thermoplastics precursors. At the same time, they remain easily reprocessable and recyclable, as opposed to non-dynamically crosslinked materials.

Synthesis of nanostructured latexes via mini-emulsion polymerization in aqueous media, leading to water-resistant, hydrophobic films

Maïssa Farroux, Corinne Soulié-Ziakovic

Matière Molle et Chimie (MMC), ESPCI Paris - CNRS, France

Nanostructured latexes synthesized by mini-emulsion polymerization enable the easy preparation of waterproof, hydrophobic films with good mechanical properties. Films are formed by water evaporation under ambient conditions without the use of coalescing aids (organic solvent), which might impact the film formation and properties and have environmental consequences. We demonstrate that lipophilic additives such as UV-filters can be encapsulated in the core-shell. Depending on the nature of the additive and the stage it is incorporated during the multi-steps latex synthesis, films with different specificities and properties can be obtained. Finally, it is possible to tune the mechanical behavior of the films by wisely choosing the monomers constituting the core and the shell of the latex and their ratio.

Soap bubble: a curvature sensor of wet surfaces

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Physique et Mécanique des Milieux Hétérogènes (PMMH), ESPCI Paris - CNRS, France

A hemispherical soap bubble on a curved substrate spontaneously moves toward the most concave regions. By doing so, it minimizes the surface area of the soap film, which is the driving mechanism. To understand the velocity of the bubble, we first study the friction forces opposing the motion in the case of a bubble moving along an inclined plane under gravity. On the long term, we will study the geometry-driven motion of bubbles on model surfaces with specific shapes.

Dynamics of 2D bubbles in a Hele-Shaw cell

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Droplet-based microfluidics is a growing field often requiring an accurate synchronization for automated systems. The question we address is the prediction of a bubble velocity pushed by a surrounding liquid set at a fixed mean velocity. Our understanding of the dynamics of travelling bubbles or droplets in confined geometries has been steadily refined since the pioneering work of Taylor and Saffman, who derived analytically the velocity of a quasi-2D bubble using depth-averaged Hele-Shaw equations [Q. J. Mech. Appl. Math. 12, 265 (1959)]. All the refined reported models, which take into account the dissipation at the meniscus, are 2D [Cantat., Phys. Fluids 25, 031303 (2013)]. However, predicting accurately bubble velocity calls for a full knowledge of the dissipation mechanisms at play, which requires determining the full 3D profile of a traveling bubble, mostly close to the walls. The experimental set up is a microfluidic system in which bubbles flow in fluorinated oil (FC-40) in a Hele-Shaw geometry in a total wetting case, i.e. there is a lubrication film of fluorinated oil between the bubble and the wall. We reported recently an experimental characterization of the lubrication film thickness with an accuracy of 2 nm using RICM [Huerre et al., Phys. Rev. Lett. 115, 064501 (2015)]. In the present work, the bubble

velocity is measured in order to link the film topography to the bubble velocity. We show that Taylor and Saffman model over-estimates the bubble velocity. In the present work, we propose a model that takes into account both the viscous dissipation in the menisci and the 3D topography of the lubrication film. Remarkably, this model allows recovering the experimental bubble velocity without any fitting parameter.

Droplet generation with quasi 2D flow

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The development of digital microfluidics has attracted considerable interest towards generation of highly monodisperse microdroplets. T-junction and axisymmetric step emulsification devices have become an essential element of most of microfluidic chips. Despite its importance, theoretical analysis of droplet formation in such devices is still incomplete due to complexity of physics involved. We focused on droplet generation for two examples of quasi-2D flows. The effect of various experimental parameters, such as channel geometry, flow rates, surface tension and fluid viscosities, was thoroughly investigated. Our results show that the experimental system exhibits various distinct regimes (squeezing, dripping and jetting regimes) and point out the effect of confinement on the transitions. Quasi-2D flow equations allow us to perform numerical simulations and to compare them with experimental results.

The Microflusa project receives funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 664823.

Capillary Descent

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Capillary rise is a remarkable and historical phenomenon which can be observed after contacting a surface of water with a small capillary tube. The liquid generally rises spontaneously against gravity going up typically to several centimeters. The mechanism driving the liquid has been studied for more than 500 years and it is of course well understood: capillary rise occurs because the liquid wets the tube. We choose to invert this system by playing with the surface properties of the tube. To do so, we coat its inner wall with an aerophilic material so that it is now air that 'wets' the tube. Hence, after filling such a tube with a liquid and placing it into a liquid pool, we can observe a capillary 'descent' when the tube is brought at the surface of the bath.

By tracking the position of meniscus along the descent, we can follow the temporal evolution of the interface. We observe at first a linear regime, followed by the relaxation to the equilibrium position. Hence inverting water and air produces new kinds of dynamics (here a constant velocity for the interface instead of a diffusion-like dynamics), which we analyze and discuss.

Tanner vs. Marangoni: who spreads the fastest?

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Thirty-eight years ago, Tanner studied the spreading of droplets on solid surfaces. The radius of a spreading droplet was found to scale with time to the power 1/10, which can be understood by writing that the dynamics of spreading is governed by a gradient of Laplace pressure.

Hereby, we show that spreading of a liquid droplet can be accelerated as follows: First, a thin liquid film of surface tension γ_+ is coated on a solid surface. Then, a droplet of a second miscible liquid with a lower surface tension γ_- is deposited on the coated surface. Figure 1a gives the radius of the spreading droplet as a function of time. Initially, spreading follows Tanner's law; but an unexpected regime promptly appears, with the following scaling: $r \sim t^{1/4}$. This fast spreading regime is attributed to the presence of a gradient of surface tension. This Marangoni spreading is accompanied by instabilities close to the spreading contact line, as shown in Figure 1b.

To give an example of application: Let us consider a 4-millimeters race of spreading droplets (under the volume category of half a microliter): The Marangoni-driven candidate would cross the finish line after 5 minutes, whereas it would take more than 2 hours for the one running for Tanner's team.

Optical characterization of titanium dioxide dispersion for sun protection

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In the make-up field, the visual qualification is often more determining than physical quantification. However, in order to optimize the formulation process and enable innovation, it is sometimes essential to understand visual characteristics. Then, the origin of microscopic phenomena of scattering and absorption, more or less desired, has to be understood and linked to macroscopic observations. The approach of this work consists in simplifying the complex systems - generally emulsions and/or dispersions - to identify the optical influence of each ingredient in the final product. As a first step, a simple dispersion of colloidal titanium dioxide in oil is considered. The optical properties of this system depend on the contrast of refractive indices, the size and the concentration of the particles, according to Mie scattering theory. Size has been measured with dynamic light scattering. The optical repartition of light between transmittance, reflectance, absorption and scattering has been measured thanks to an integrating sphere. Yet, it is currently difficult to measure high refractive indices of particles because of multiple scattering. A specific set-up, similar to an Abbe-type refractometer, has been developed. The experimental measurements are compared to Mie scattering theory in order to predict the behaviour of the particles and to apply it to sun protection by titanium dioxide particles at nanometric scale.

Early stage of large ribosomal subunit assembly in E.coli: a single molecule study

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Ribosome assembly is still poorly understood in spite of many efforts. In vitro reconstitution studies have shown that this process is highly cooperative and starts with the binding of a few ribosomal (r-) proteins to rRNA, but how these early binders act is unknown. This work focuses on the initial phase of the assembly of the large subunit of the E. coli ribosome, which involves 23S rRNA, five r-proteins and assembly helper proteins.

We prepared a 79 nucleotide-long region of 23S rRNA encompassing the binding sites of the early binders L24 and L4 (these proteins were supplied by the group of Takuya Ueda, University of Tokyo). Force signals are measured in a DNA/RNA dumbbell configuration using a dual-beam trap. We measure upon unwinding the rRNA fragment without added protein, or in the presence of either L4 or L24 or both. Without protein, the rRNA fragment unfolds by a sequence of steps that involve three distinct intermediates. With L4 and/or L24, the same intermediates are observed but they unfold at significantly higher forces. For instance, the most probable unfolding force of the second intermediate, is 10.7, 13.3, 14.9 and 16.4 pN, without protein or in the presence of L4, L24 or both, respectively. We localise the binding sites of the two r-proteins on rRNA within ± 5 nucleotides and observe pronounced cooperativity in their binding. We conclude that L4 and L24 act in concert to mechanically stabilise this region of 23S rRNA.

Boundary conditions control the onset of elastic turbulence in a curved microchannel

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The control of the onset of elastic instabilities in visco-elastic flows is of great industrial importance. In curvilinear flows, the elastic instability is governed by a balance between normal stresses in the fluid and the curvature of the streamlines. The critical flow rate for the onset of the instabilities in those curved channels is well established as a function of the fluid parameters and flow geometry.

We focus on the boundary conditions as a possible means of tuning this onset, and explore more specifically the influence of boundary compliance. We fabricate PDMS micro-channels of controlled curvature by using standard soft lithography techniques: standard (ie rigid) channels are obtained by bonding the PDMS to a glass slide; compliant channels with the same geometry are produced by bonding the PDMS onto a layer of soft PDMS gel deposited on a glass slide. In both types of channels, we measure the critical shear rate for the onset of the instability in the flow of visco-elastic polymeric solutions.

Surprisingly, we observe that the critical shear rate for the onset of the instability is lowered by the presence of the compliant gel layer. This result is robust when the radius of curvature of the channels is varied. Such gel layers have been experimentally shown to delay the onset of elastic instabilities in other geometries (torsional flow between parallel plates). However, for a planar Couette flow, the effect of the coupling with a soft boundary on the flow of a visco-elastic liquid has been theoretically shown to be either stabilizing or destabilizing depending on the fluid and solid relaxation times and the thickness of the solid layer. Our results thus provide a first insight on the complexity of this coupling in curved visco-elastic flows.

Organic nanocomposites hydrogels: thermo-toughening induced by phase separation

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By covalently crosslinking water-soluble polymers, soft elastic materials with defined shape can be designed displaying very interesting swelling and sieving properties. They are involved in many applications such as superabsorbents or contact lenses. However, an important issue is that these elastic materials are generally brittle.

An interesting way investigated to reinforce the mechanical properties of hydrogels is to introduce physical interactions into a hydrophilic covalent 3D-network.[1] To this extent, thermoresponsive polymers, leading to hydrophobic interactions and H-bonds, have been used to design original networks where physical interactions can be switched “on/off” by temperature.[2] Such innovative hydrogels, designed with a 3D hydrophilic network grafted with macromolecular side-chains exhibiting a Lower Critical Solution Temperature (LCST) in aqueous media (or reverse topology), have shown a dramatic and reversible enhancement of their mechanical properties upon heating. This reinforcement is attributed to the thermoresponsive polymer phase separation while the water-soluble macromolecular counterpart allows the hydrogel to keep its volume integrity.[3]

Based on this strategy, hydrogels made from two polymers exhibiting opposite thermoresponsive behaviors, LCST and UCST (Upper Critical Solution Temperature), were designed. These hydrogels demonstrate a reversible double thermo-responsive phase transition thereby modifying their swelling, rheological and mechanical properties. These novel schizophrenic hydrogels pave the way of thermoresponsive hydrogels use on a broad range of temperature. Modifications of hydrogels topology, performed by changing thermoresponsive polymer grafts molar mass while keeping the same hydrophilic covalent network, were also investigated to better understand the structure/properties relationships of these new hydrogels with temperature.

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Spray-dried collagen for injecting dense collagen scaffolds with tunable mechanical properties

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Type I collagen is an abundant protein produced by all mammals. Present in all soft and hard body tissues (skin, bones, cartilage, tendon, etc.), collagen provides tunable mechanical strength and elasticity according to the desired function. The collagen matrix therefore supplies a major structure that prevents the human body from collapsing under mechanical solicitation.

The collagen molecule is soluble at acidic pH and self-assembles to form fibrils at physiological pH. Both states (molecule and fibril) have lyotropic properties: when concentration increases, collagen behaves like a liquid crystal. Body tissues are actually formed by different patterns of self-assembled collagen fibrils. Amid such structures, cholesteric collagen phases are particularly relevant in living tissues such as dermis or tendon. Insufficient local collagen concentration or failure to organize collagen fibrils in the required architectures impacts dramatically tissue functionality and is behind numerous pathologies.

Thus there exists a large range of possible applications for biomimetic and injectable collagen-based

materials - especially in filling tissue defects (e.g. wrinkles) and maxillo-facial surgery, among other conditions. Biomimetic collagen scaffolds imply high collagen concentration so that the biomaterial can be integrated by the body. However, when collagen concentration increases, its viscosity increases beyond the injectability threshold.

How to combine biomimetism and injectability of 100% collagen-based hydrogels?

Here we propose to synthesize dense collagen beads by spray-drying an acidic collagen solution. After injection into the targeted defect, collagen molecules will self-assemble to reproduce the characteristic features of the tissue under physiological conditions. The aim of this study is to link collagen concentration, injectability, gel morphology and mechanical properties post-fibrillogenesis. Biomimetic collagen scaffolds with tissue-like mechanical properties will be tested *in vitro* then *in vivo*. In the long term, we aim at creating a library of biomimetic and injectable collagen hydrogels, enabling targeted body tissue repair via minimally invasive procedures.

Mechanophores for the detection of stress in soft materials

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Macroscopic toughness is strongly related to the ability of materials to transfer forces away from a broken bond to a large number of neighboring bonds. In mechanochemistry, the detection of bond forces and bond breakage can be done with mechanophores, which are polymers responsive (color change) to mechanical stimulus. Spiropyran (SP) as a mechanophore is incorporated into multiple network elastomers acting as cross-linker. SP can be activated into a merocyanine (MC) isomer under various loading conditions and generate changes in optical signals. Analyzing the optical signals of MC allows to reconstruct the spatial distribution of molecular forces in soft materials.

Micro mechanics of bio-based binders for insulation glass wool

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Insulation glass wool consists of an assembly of glass fibers with micrometric diameter (typically 1 μm to 10 μm) arranged into a structure similar to wool. To ensure adequate mechanical stiffness of glass wool panels, a binder (= a highly crosslinked polymer) is also incorporated to create permanent joints between fibers. In order to meet growing environmental concerns, new bio-based binders have been recently developed at Saint-Gobain. However, the new glass wool panels suffer from a loss of mechanical stiffness upon ageing which is detrimental for the ease of installation. This behaviour is attributed to the moisture sensitivity of the new binder. However, the correlation between binder microscopic joints mechanics and the macroscopic stiffness of glass wool panels is still unclear and impedes the optimization of the industrial product. Our work aims at understanding this relationship and consists in a multiscale approach:

1. At the microscopic scale, characterizing the mechanical properties of different binders upon ageing.
2. At the macroscopic scale, establishing the relationship between the binder micro mechanics and the macroscopic properties of the glass wool panels.

Up to now, this study has been focused on the binder characterization which is based on three micro mechanical tests: micro pillar compression, tensile test on micrometer-thick beams and substrate curvature measurement.

New bio-inspired Type I collagen-based materials for tissue engineering: from mineralized to transparent tissue substitutes

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This research work is based on a bio-inspired approach where “the living” is at the heart of the process of elaboration. The tailored-process is simplified and innovative. Depending on the target tissue (bone substitutes or cornea implant), hybrid or organic materials are implantable. By adjusting the concentration and mode of type I collagen' concentration used, biomaterials can form hierarchical architectures similar to those described in biological tissues in vivo. It is now well-known that collagen exhibits lyotropic properties in vitro. This protein forms crystal-liquid phases under certain conditions of concentration and pH. The collagen molecule consists in a triple helix which organized to form fibrils approximately 100 nm in diameter and several microns in length (cela dépend du tissu). When the precipitation of fibrils is performed under diluted conditions, a loose fibrillary gel is obtained; conversely, working at a high concentration gives access to the dense collagen matrices. Moreover, mixing this protein with biomineral ion precursors typically ($\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$, NaH_2PO_4 and NaHCO_3) leads to the mineralization of the collagen. Through the control of the chemical and physicochemical features, we are able to finely tune the structural and functional properties of these collagen-based materials from an acido-soluble state to a dense one building. The custom-made materials mimic the extracellular matrices' structure of some targeted dense connective tissues, namely corneal-inspired transparent collagen matrices and compact bone-inspired mineralized collagen matrices. The elaboration process of these different types of biomimetic collagen matrices as well as the structural, optical and mechanical characterizations are presented in the poster.

New bioreactors and milifluidic systems for sampling electroactive bacteria

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In 2012, 80% of the energy production in the world comes from fossil energy which includes gas, fuel or coal. However, those resources are polluting and limited while the humanity has a greater need for them. At the same time, we can use biomass as an alternative way to create clean energy. Optimizing this process is nowadays an attractive challenge. At the LCMD laboratory we are interested in *Geobacter sulfurreducens* anaerobic respiration. Because *Geobacter* enable the electron transfer between organic matter and its environment [Bond, D. R. & Lovley, D. R. *Appl. Environ. Microbiol.* 69, 1548–1555 (2003)], we have developed a core/shell bead that contain bacteria, surrounded by a conductive hydrogel membrane. When this bead is placed in a medium depleted in oxygen and rich in nutrient, bacteria can grow and form an electroactive biofilm [Reguera, G. et al. *Appl. Environ. Microbiol.* 72, 7345–7348 (2006)]. We will use this bead as an electrode in order to probe the electrical current provided by the bacterial colony. Since it is possible to make numerous beads in a very short time, this system can be parallelized with sub-cultures obtained from one initial sample. The next step of this project will be consequently the development of a milifluidic system that makes such kind of measure possible. Finally, it will allow us to select the most efficient lineage. Probing biodiversity is, in this manner, a key point to better extract energy inside the biomass.

Synthesis and mechanics of novel double network elastomers

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Recent studies in hydrogels and elastomers have shown that simple elastic networks can be significantly reinforced mechanically (in stiffness and toughness) by embedding them into an extensible elastic matrix that does not macrophase separate with the network.[1,2] In this configuration the well-crosslinked elastic network is swollen in successive steps into monomer, which is subsequently polymerized. The resulting composite material contains a minority volume fraction of prestretched polymer which is percolating through the material, and a majority component of stretchable and sparsely crosslinked polymer.

The enhancement has been attributed to the possibility of breaking the bonds in the bulk of the more crosslinked and highly stretched minority network while avoiding crack propagation through the less crosslinked and unstretched majority network.[3] In other words the stiff network would act as a reinforcement, providing stiffness and the soft network would provide extensibility.

All the materials tested so far are isotropic and the stiff network is continuous and percolating. Yet this fabrication method is not very practical to industrialize. Therefore, we currently explore new strategies to apply this general concept to different classes of materials than simple elastomers or gels.

(1) Gong, J. p.; Katsuyama, Y.; Kurokawa, T.; Osada, Y. *Adv. Mater.* 2003, 15 (14), 1155–1158.

(2) Ducrot, E.; Chen, Y.; Bulters, M.; Sijbesma, R. P.; Creton, C. *Science* 2014, 344 (6180), 186–189.

(3) Brown, H. R. *Macromolecules* 2007, 40 (10), 3815–3818.

Spreading of complex fluids for cosmetics

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Most cosmetics are complex fluids (i.e. emulsions, solid dispersions, gels). Their unusual mechanical response has a profound effect on the efficiency of the cosmetic product and the consumer feelings during application. It is essential to understand the response of spreading of these materials in order to optimize their composition. Scientifically, numerous parameters must be taken into account to simulate the vivo spreading with vitro experiments. The quality of the formulations is driven by their rheological properties at rest, but also by the variations of these properties while spreading. These are directly connected to the drying effect (evaporation of the water contained in the sample) and to the microstructure modifications occurring via the spreading shear. However, these physicochemical phenomena are still not well understood. In this study, we develop an innovative system allowing to simulate the spreading of a formulation on the skin and to examine the microstructure of the deposit formed during the spreading motion and overtime at rest. We use a Blade-Coating approach consisting of a U-shaped blade to simulate back and forth motions similar to the spreading of a formulation using a human finger. The shape of the blade upon touching the substrate indicates the applied force during spreading. Flow diagrams are built depending on rheological properties of the formulations (i.e. yield stress, viscosity ...), spreading velocity, and applied force. The thickness of the deposited layer is measured using the fluorescence of added dyes. Both force, velocity, and yield stress are found to be critical parameters in the formation of a liquid film on the skin.

Structure and properties of hydrogels having permanent and transient crosslinks

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Hydrogels are polymer networks swollen in water and their solid-like and liquid-like properties attract academic and industrial interests. Thanks to their high water content and biocompatibility, hydrogels are good candidates for biomedical applications such as tissue engineering, artificial cartilage, vessels, and prosthetic joints, etc. However simple chemically crosslinked hydrogels are typically fragile and not suitable for industrial applications requiring a certain mechanical toughness.

Various mechanically reinforced hydrogels have been reported in these last 10 years, and one of the successful strategies relies on the introduction of two types of crosslinking points, permanent (covalent) and transient and reversible (non-covalent). During the deformation of the gel, when the transient bonds break, they dissipate strain energy and redistribute local forces, preventing the irreversible rupture of the permanent bonds.

Although the dynamics of physical and chemical gels are well understood, new questions arise when the two cross-links coexist, such as the dissipation mechanisms, which is a prerequisite to understand their large deformation and fracture properties.

To answer these questions, we have developed a dual crosslink gel having a chemical network (Poly (acrylamide-co-1-vinylimidazole) crosslinked by methylenebisacrylamide and a physical network (the coordination bonds between 1-vinylimidazole and transition metal ions). We performed uniaxial stretching experiments with the same initial strain rate of 0.06s^{-1} to characterize the nonlinear (large strain) behavior of the dual cross-linked gels with Ni^{2+} , the tensile stress-strain curves showed a dramatic increase in stiffness as well as in toughness. We have carried out systematic fracture experiments in a single edge notch geometry over a range of stretch rates ($0.0003\text{-}0.3\text{s}^{-1}$), we found that the initiation fracture energy increase monotonously with strain rate and the crack propagates in a controlled way at a velocity nearly proportional to the stretch rate.

Fracture of interpenetrated networks: from bond scission to macroscopic fracture

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Soft but tough materials are of great interest for engineering applications and in life sciences. Bulk cohesion of a soft and tough material is ensured by chemical bonds [1]. Molecular detection of bond scissions is a key parameter to understand this failure mechanism. The bond scission can be detected by incorporating mechanically activable molecules into polymer network architectures. Mechanochemistry corresponds to the use of mechanical energy to generate chemical and physical property changes. Molecules undergoing reactions in response to mechanical forces are called mechanophores. Some of them change their spectral absorption properties, inducing a change in color or become fluorescent under loading. Taking advantages of recent advances in mechanochemistry, we aim to enhance the understanding of fracture mechanisms at the molecular scale and more precisely to study quantitatively the opening and propagation of a crack. According to the work done by E. Ducrot [2], the use of a dioxetane cross-linker enables bond breakage detection. By recording light emission during crack propagation, this method would link fracture at macroscopic scale to bond scission at the nanoscale.

We prepare multiple network elastomers – Single SN, Double DN or Triple TN Networks – as model soft and tough materials to introduce a controlled fraction of breakable bonds. The dioxetane mechanoluminescent cross-linker is relevant to achieve dynamic information during crack propagation.

We will also incorporate another mechanophore cross-linker which can provide post-mortem bond breaking mapping based on the fluorescence quenching phenomenon.

[1] C. Creton; M. Ciccotti, *Rep. Prog. Phys.*, **2016**, 79, 046601

[2] E. Ducrot; Y. Chen; M. Bulters; R.P. Sijbesma; C. Creton *Science* **2014**, 344, 186.

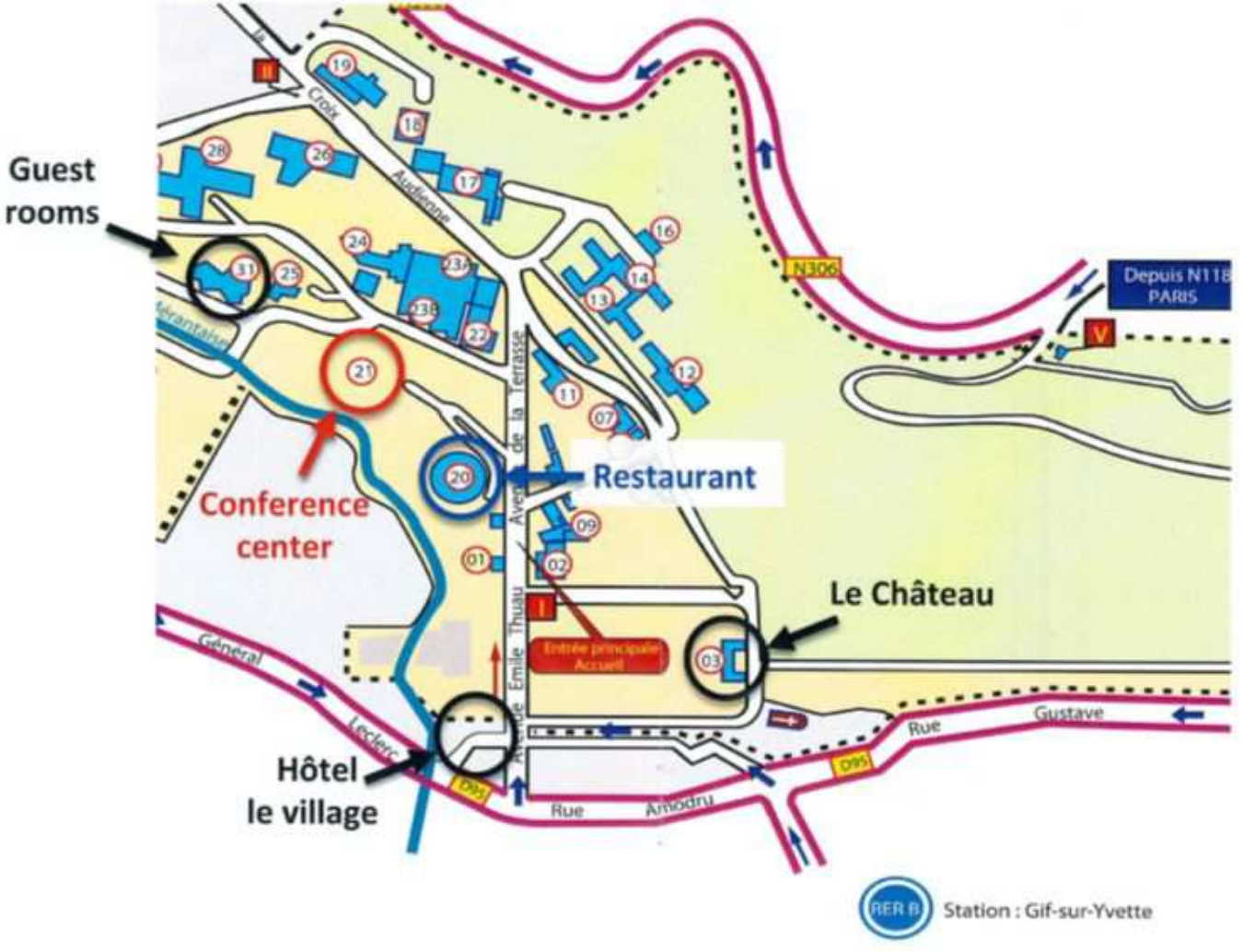
Experimental study of confined bubbles/droplets dynamics submitted to a temperature gradient

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Two-phase flows studies strongly benefit from the emergence of microfluidics, offering building block experiments or model systems. Our understanding of the dynamics of travelling bubbles or droplets in confined geometries has been steadily refined since the pioneering work of Taylor & Saffman [Taylor and Saffman, *Mech. Appl. Math.* 12, 265 (1959)]. The general consensus is that whatever the geometry of the system, the viscosity ratio of the two phases or the boundary condition at the interface, the lubrication film thickness separating the non-wetting meniscus from the wall is hydrodynamically determined [Bretherton, *J. Fluid Mech.* 10, 166 (1961) ; Hodges et al., *J. Fluid Mech.* 501, 279 (2004); Cantat, *Phys. Fluids* 25, 031303 (2013)]. All these models are 2D. Predicting droplet velocity call for a full knowledge of the dissipation mechanisms at play, this requires determining the full 3D profile of a traveling droplet, mostly close to the walls. We reported recently an experimental characterization of with an accuracy of 2 nm [Huerre et al., *Phys. Rev. Lett.* 115, 064501 (2015)]. In a current project the full topography of a travelling low viscous droplet is experimentally measured and compared to models, in the objective to formally link the film topography to the droplet velocity [Reichert et al., in preparation 2017].

The question we address in this poster is the effect of adding a Marangoni stress at the interface. To start with a simple configuration, i.e. disregarding the inner phase viscosity, we first focus on the dynamics of bubbles. A thermocapillary stress (generated using shape optimized heating resistors) is applied to a traveling bubble pushed by the surrounding media. Comparing the results with the ones obtained without a thermocapillary stress, will allow us modeling the contribution of a constant Marangoni stress boundary condition at the interface.



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