

Xavier Morelle

*CNRS Research Associate
Physico-Chemistry of Solid Polymers*

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10/11/1988
French, English, Spanish



Current position

2021–now **CNRS Research Associate at IMP - UMR 5223, Lyon – France.**

My objective is to build a research path focusing on the mechanics and multi-functionality of polymer materials. From a fundamental standpoint, the molecular structure-properties relationship in glassy networks still remains elusive, especially at large strains where non-linear deformation, chain scission and stress heterogeneity redistribution often occur before failure. Building on the design of well-defined heterogeneous network architectures comprising strong local property contrast, I will study the impact of their nanostructuration and local dynamics on the ultimate properties of macroscopic specimens under different stimuli. Through this approach, I foresee to unveil a better understanding of the complex multiscale deformation mechanisms of glassy polymers, but also to broaden their use by pushing their potential as smart multi-responsive materials.

Education & Academic achievements

2020–2021 **Post-doctoral researcher at IMP - UMR 5223, Lyon – France**, 18 months stay.

Research on the large strain and fracture behavior and network mobility of ionic liquid modified epoxy systems. This study focused on the topological nano-structuration of a phosphonium-ionic liquid modified epoxy system to improve its toughness, ductility as well as ionic conductivity. The work was performed in collaboration with Livi, Pr. Prevost, Pr. Duchet & Pr. Gérard.

2017–2019 **Post-doctoral researcher at ESPCI, Paris – France**, employed by the CNRS through the CHEMECH European Research Council grant.

Fundamental research using mechano-chemistry as a tool to study the mechanics and fracture of soft polymer networks, going from adhesives to hydrogels and elastomers. A focus was set on the understanding of the stress-transfer and fatigue mechanisms occurring in multiple network hydrogels and elastomers through optical analysis of fluorescent molecular markers. The work was performed in the SIMM lab with Pr. C. Creton & Pr. M. Ciccotti.

2015–2017 **Post-doctoral fellow at Harvard University, Cambridge, Massachusetts – USA**, Cabeaux-Jacobs B.A.E.F. Fellow.

Research in the field of soft active materials in the group of Pr. Zhigang Suo. My research involved the preparation of tough hydrogels, their specific mechanical and fracture characterization under a large variety of testing conditions (from sub-zero temperatures to fatigue loading), as well as the development of new engineering devices making use of their multifunctional properties (e.g. noise cancellation, pressure-sensor, etc.).

2011–2015 **PhD in Materials Science at UCLouvain, Louvain-la-Neuve – Belgium**, Doctoral Research Fellowship by the Belgian National Fund for Scientific Research (FNRS).

Research in materials science with both experimental and modeling work in the field of mechanics of polymers and polymer-based composites. Development of an original physics-based theory for modelling the meso-scale heterogeneous micro-mechanisms of glassy polymers. Collaborations with the aeronautical industry (Safran group) as well as with other international groups (KULeuven, Imperial College, IMDEA) were pursued in parallel.

Teaching experience

- 2014–2015 **Lecturer for a topical seminar in a Materials science master course**, *Ecole Polytechnique de Louvain – UCLouvain*, Louvain-la-Neuve – Belgium.
A two-hours seminar on the viscoplasticity of polymers, given for an auditorium of 50 engineering students in their 2nd year of master degree.
- 2011–2015 **Lab assistant in Deformation and Fracture of Materials master course**, *Ecole Polytechnique de Louvain – UCLouvain*, Louvain-la-Neuve – Belgium.
Small theoretical courses and supervision of mechanical testing labs for groups of 20-30 engineering students in their 1st year of master degree.
- 2009–2011 **Teaching assistant in Physics and Chemistry bachelor courses**, *Ecole Polytechnique de Louvain – UCLouvain*, Louvain-la-Neuve – Belgium.
Monitoring of lab and exercise sessions for 1st and 2nd year undergrad engineering students.

Supervision experience

5 at PhD level (not in dissertation committee)

- 2021–2022 **Xavi Lacambra Andreu**, *INSA de Lyon - IMP*, Villeurbanne – France.
Partial thesis mentoring, more specifically on the mechanical characterization by lap-shear tests of bio-sourced 3D printed polymers (PLA-based) for the development of medical devices and prostheses.
- 2020–2022 **Benoit Caprin**, *INSA de Lyon - IMP*, Villeurbanne – France.
Partial thesis mentoring, more specifically on the mechanical characterization of bio-based organo-hydrogels with physical crosslinks. Benoit is currently working as a senior researcher within the R&D team of Gattefossé.
- 2019–2020 **Louis Debertrand**, *ESPCI - SIMM*, Paris – France.
Partial thesis mentoring, more specifically on the mechanical characterization of dual crosslinked hydrogel systems. Louis has now joined the R&D center of Michelin at Clermont-Ferrand.
- 2016–2018 **Jérémy Chevalier**, *UCLouvain*, Louvain-la-Neuve – Belgium.
Mentoring and collaborative work on finding an appropriate fracture criterion for highly-crosslinked epoxy networks and developing a physics-based theory for their meso-scale micromechanical response. Jérémy now works at the Solvay R&D center in Brussels.
- 2016–2017 **Ruobing Bai**, *Harvard University*, Cambridge, MA – USA.
Mentoring and collaborative work on 6 research projects (all published) mainly focusing on the fatigue behavior of hydrogels. Ruobing is now Assistant Professor at NorthEastern University.

7 at Master level

- 2021–2022 **Noémie Maamouri**, **materials science master student**, *INSA*, Lyon – France, *Magna cum laude*.
Silicon elastomers : an academic understanding of the structure-properties relationship in a RTV silicone.
- 2021–2022 **Joanna Baudino**, **materials science master student**, *INSA*, Lyon – France, *Magna cum laude*.
Study of the mechanical toughening of an epoxy resin with a semi-crystalline polymer.
- 2020–2021 **Ana-Carolina Fernandez Rodas**, **materials science master student**, *INSA*, Lyon – France, *Magna cum laude*.
Mechanical and fracture properties of ionic liquid-modified epoxy systems.
- 2019–2019 **Elina Gilbert**, **soft matter and biology master student**, *ESPCI – PSL*, Paris – France, *Magna cum laude*.
A molecular picture of fatigue behavior and crack-growth in methyl-acrylate elastomers.

- 2014–2015 **Loïc Van Nieuwenhuysse, materials science master student**, *Ecole Polytechnique de Louvain – UCLouvain*, L-L-N – Belgium, *Magna cum laude*.
Relation between physical aging and mechanical properties of an aerospace grade epoxy resin.
- 2013–2014 **Minh Le Duy, macromolecular nanotechnology master student**, *Ecole Polytechnique de Louvain – UCLouvain*, Louvain-la-Neuve – Belgium, *Cum laude*.
Study of network heterogeneities in RTM6 epoxy resin by Atomic Force Microscopy.
- 2012–2013 **Jesus Gutierrez Martinez, mechanical engineering master student**, *Ecole Polytechnique de Louvain – UCLouvain*, Louvain-la-Neuve – Belgium, *Cum laude*.
Time dependent response of RTM6 epoxy resin investigated by mechanical testing and modeling.
[3 at Bachelor level](#)
- 2016 – 2018 **Supervision of short-term research interns**, *INSA de Lyon, ESPCI & Harvard University*.
Emmanuel Fabing (INSA Lyon - 2022) on the mechanical response of multi-nanolayers films, Ana Santos (ESPCI - 2018) on the adhesion of a foamed PSA, and Enrui Zhang (Harvard - 2016) on the fatigue resistance of hydrogels were supervised on a daily basis during 3 to 6 months.

Publications in international peer-reviewed journals (impact factor > 1)

pre-prints works

- xx. **X. P. Morelle**, G. Sanoja, J. Comtet, S. Castagnet, C. Costantino, "Cavitation resistance in soft and tough elastomers", *in preparation*.
- yy. P. Sotta, N. Maamouri, **X. P. Morelle**, F. Ganachaud, "Evaluation of actual crosslinking degree in polydimethylsiloxane via different techniques : Swelling, NMR spectroscopy and mechanical analyses", *in preparation*.
- zz. I. Touil, J. Li, E. Fabing, S. Pruvost, A. Maazouz, **X. P. Morelle**, K. Lamnawar, "Fabrication of Well Architected Multilayer Films Based on Low Density Polyethylenes : Structure-Morphology Relationships, Processing Properties and Layer Confinement from Microlayers to Nanolayers", *in preparation*.

2022

- 20. B. Caprin,, G. Vinado-Buil, G. Sudre **X. P. Morelle**, F. Da Cruz-Boisson, A. Charlot, E. Fleury, "k-carrageenan associated with Fructose/Glycerol/Water LTTM : towards natural thermosensitive physical gels", *ACS Sustainable Chemistry & Engineering*, (2022). <https://doi.org/10.1021/acssuschemeng.2c04437>
- 19. X. Lacambra Andreu, **X. P. Morelle**, A. Maazouz, J.-M. Chenal, K. Lamnawar, "Rheological investigation and modeling of healing properties in Innovative fused deposition of medical composites based on poly(lactic- acid)/hydroxyapatite fillers", *accepted in Rheologica Acta*.

2021

- 18. G. Sanoja, **X. P. Morelle**, J. Comtet, C. Costantino, "Why is Mechanical Fatigue Different from Toughness in Elastomers? The Role of Damage by Polymer Chain Scission", *Science Advances*, (2021). <https://doi.org/10.1126/sciadv.abg9410>
- 17. **X. P. Morelle**, G. Sanoja, S. Castagnet, C. Costantino, "3D Fluorescent Mapping of Invisible Molecular Damage after Cavitation in Hydrogen Exposed Elastomers", *Soft Matter*, (2021). <https://doi.org/10.1039/D1SM00325A>

16. H. Chabane, S. Livi, **X. P. Morelle**, R. Sonnier, L. Dumazert, J. Duchet-Rumeau, J.-F. Gérard, "Synthesis of New Ionic Liquid-Grafted Metal-Oxo Nanoclusters – Design of Nanostructured Hybrid Organic-Inorganic Polymer Networks", *Polymers* for "GFP 50th Anniversary" special issue, (2021). <https://doi.org/10.1016/j.polymer.2021.123721>.
15. X. Yao, B. Chen, **X. P. Morelle**, Z. Suo, "Anti-icing propylene glycol materials", *Extreme Mechanics Letters*, vol 44, 101225 (2021). <https://doi.org/10.1016/j.eml.2021.101225>.
14. T. Pardoën, N. Klavzer, S. Gayot, F. Van Loock, J. Chevalier, **X. P. Morelle**, V. Destoop, F. Lani, P. Camanho, L. Brassart, B. Nysten, C. Bailly, "Nanomechanics serving polymer-based composite research", *Comptes Rendus Physique* for the "Plasticity and Solid State Physics" special issue, (2021). <https://doi.org/10.1016/j.polymer.2021.123721>.

2019

13. R. Bai, J. Wang, **X. P. Morelle**, Z. Suo, "Flaw-insensitive hydrogels under static and cyclic loads", *Macromolecular Rapid Communications*, 1800883, (2019). <https://doi.org/10.1002/marc.201800883>
12. J. Chevalier, **X. P. Morelle**, P. P. Camanho, F. Lani, T. Pardoën, "On a unique fracture mechanism for highly cross-linked epoxy resins", *Journal of Mechanics and Physics of Solids*, vol 122, (2019), pp.502-519. <https://doi.org/10.1016/j.jmps.2018.09.028>

2018

11. J. Chevalier, L. Brassart, F. Lani, C. Bailly, T. Pardoën, **X. P. Morelle**, "Unveiling the nanoscale heterogeneity controlled deformation of thermosets", *Journal of the Mechanics and Physics of Solids*, vol 121, (2018), pp. 432-446. <https://doi.org/10.1016/j.jmps.2018.08.014>
10. **X. P. Morelle**, W. R. Illeperuma, K. Tian, R. Bai, Z. Suo, J. J. Vlassak, "Highly stretchable and tough hydrogels below water freezing temperatures", *Advanced Materials*, vol 30, (2018), 1801541. <https://doi.org/10.1002/adma.201801541>
9. P. Rothmund, **X. P. Morelle**, K. Jia, G. M. Whitesides, Z. Suo, "A transparent membrane for active noise cancelation", *Advanced Functional Materials*, vol 28, (2018), 1800653. <https://doi.org/10.1002/adfm.201800653>
8. E. Zhang, R. Bai, **X. P. Morelle**, Z. Suo, "Fatigue fracture of nearly elastic hydrogels", *Soft Matter*, vol 14, (2018), pp. 3563-3571. <https://doi.org/10.1039/C8SL00460A>
7. R. Bai, J. Yang, **X. P. Morelle**, C. Yang, Z. Suo, "Fatigue fracture of self-recovery hydrogels", *ACS Macro Letters*, vol 7, (2018), pp. 312-317. <https://doi.org/10.1021/acsmacrolett.8b00045>.

2017

6. **X. P. Morelle**, R. Bai, Z. Suo, "Localized deformation in Plastic Liquids on Elastomers", *Journal of Applied Mechanics*, vol. 84 : issue 10, (2017), pp. 101002 <https://doi.org/10.1115/1.4037410>.
5. R. Bai, Q. Yang, J. Tang, **X. P. Morelle**, J. Vlassak, Z. Suo, "Fatigue fracture of tough hydrogels", *Extreme Mechanics Letters*, vol 15, (2017), pp. 91-96. <https://doi.org/10.1016/j.eml.2017.07.002>.

4. **X. P. Morelle**, J. Chevalier, C. Bailly, T. Pardoen, F. Lani, "Mechanical characterization and modeling of the deformation and failure of the highly crosslinked RTM6 epoxy resin", *Mechanics of Time-Dependent Materials*, vol. 21 : issue 3, (2017), pp. 419-454. <https://doi.org/10.1007/s11043-016-9336-6>.

2016

3. J. Chevalier, **X. P. Morelle**, C. Bailly, P.P. Camanho, T. Pardoen, F. Lani, "Micro-mechanics based pressure dependent failure model for highly cross-linked epoxy resin", *Engineering Fracture Mechanics*, vol. 158, (2016), pp.192-216. <https://doi.org/10.1016/j.engfracmech.201602.039>.
2. V.-D. Nguyen, F. Lani, T. Pardoen, **X. P. Morelle**, L. Noels, "A large strain hyperelastic viscoelastic-viscoplastic-damage constitutive model based on a multi-mechanism non-local damage continuum for amorphous glassy polymers", *International Journal of Solids and Structures*, vol. 96, (2016), pp. 192-216. <https://doi.org/10.1016/j.ijsolstr.2016.06.008>.

2015

1. A. Bahrami, **X. P. Morelle**, L. D. Hông Minh, T. Pardoen, C. Bailly, B. Nysten, "Curing dependent spatial heterogeneity of mechanical response in epoxy resins revealed by atomic force microscopy", *Polymer*, vol. 68, (2015), pp. 1-10. <https://doi.org/10.1016/j.polymer.2015.04.084>.

Invited talks

2022

10. **Basic Research Challenge (BRC) Program Review Kickoff**, Virtual Meeting – USA, January 20th : "*Mechanisms of cavitation by explosive decompression in hydrogen-exposed elastomers : Insights from 3D in-situ tomography and mechanochemistry*".

2021

9. **EURADH 2021 – keynote session**, Virtual Meeting – France, October 12th : "*Role of damage by sacrificial bonds : Intrinsic differences between fatigue and toughness mechanisms in multiple network elastomers*".
8. **DEPOS 2021 – co-keynote session with Pr. Sylvie Castagnet**, Mandelieu-la-Napoule – France, September 29th : "*Mécanismes de cavitation dans des élastomères sous décompression d hydrogène : apports de la tomographie in-situ et de la mécanochimie*".
7. **UMass, Polymer Science and Engineering, Crosby research group**, Virtual webinar, Amherst (MA) – USA, March 24th : "*Mechanochemistry as a tool to study cavitation in multiple network elastomers*".

2020

6. **UCLouvain – Institute of Mechanics, Materials and Civil engineering (iMMC)**, Louvain-la-Neuve – Belgium, February 26th : "*Tough hydrogels under extreme environment*".

2019

5. **University of Amsterdam (UvA) – Institute of Physics**, Amsterdam – Netherlands, November 29th : "*3D visualization of cavitation process in MN elastomers*".
4. **American Physical Society (APS) March meeting conference**, Boston (MA) – USA, March 6th : "*Towards a unified model of soft adhesives*" (on behalf of Matteo Ciccotti).
3. **University of Michigan**, Ann-Arbor (MI) – USA, February 27th : "*From meso-scale modeling of epoxy resins to the fatigue of hydrogels : a micro-mechanical approach of polymer networks*".
2. **Universidade do Porto**, Porto – Portugal, January 28th : "*Macroscopic viscoplastic behavior of thermosets – RTM6 as a case study*".

2018

1. **INSA Lyon/IMP lab**, Lyon – France, October 2nd : "*From mechanical characterization towards physics-based modeling of soft polymer networks : from epoxy resins to hydrogels*".

Grants, Fellowships & Awards

- 2022 **Project SilGen β** , ANR funding (main carrier F. Ganachaud), IMP – France.
4 years funding for 2 PhD thesis and 1 year post-doctoral stay aiming at producing the "next generation" of (filler-free) silicone elastomers combining super-softness at small deformation and large-strain stiffening at large strains as generally observed in natural tissues.
- 2022 **Project MIMIMED**, Carnot funding (main carrier G. Rival), IMP – France.
Pluridisciplinary project involving 7 different laboratories for a 5 years project funding in order to develop a new platform for pre-clinical tests of medical devices in Lyon.
- 2021 **Project DEVMAN**, BQR (Bonus Qualité Recherche) funding at INSA-Lyon (main carrier N. Blal), IMP – France.
2 years project funding for 4 student internships (co-supervised between IMP and LaMCoS labs) and for purchasing mechanical testing equipment.
- 2021 **CNRS competition for the grade of *Chargé de recherche***, selection by CoNRS section 11, Meudon – France.
Admission to the CNRS with a permanent Research Associate position.
- 2018 **Qualification Maître de Conférences**, aptitude certification to be an engineering professor in France, Paris – France.
- 2017-2019 **WBI World Excellence Fellowship**, provided by Wallonie Bruxelles International, Bruxelles – Belgium.
Two years grant for pursuing a post-doc research stay in the group of Pr. C. Creton and M. Ciccotti in the SIMM Lab at ESPCI, Paris, France.
- 2015-2016 **Cabeaux–Jacobs Fellow**, provided by B.A.E.F., Brussels – Belgium/USA.
One year grant for pursuing a post-doc research stay in the group of Pr. Z. Suo in the School of Engineering and Applied Science at Harvard University, Cambridge, Massachusetts, USA.
- 2012–2015 **FNRS Research Fellowship**, provided by F.R.S. (FNRS), Bruxelles – Belgium.
Three years PhD Fellowship in the group of Pr. Thomas Pardoen in the Institute of Mechanics, Materials and Civil engineering (iMMC) at UCLouvain for pursuing a PhD thesis.
- 2012 **Best Presentation at the 10th Annual SAMPE Benelux student meeting**, organized by SAMPE Benelux, Ermelo – Netherlands.
Best presentation of Benelux young PhD researchers in the field of aeronautical composites.

- 2011–2012 **FRIA Research Fellowship**, provided by *F.R.S. (FNRS)*, Bruxelles – Belgium.
One year PhD Fellowship for starting a PhD thesis in the group of Pr. Thomas Pardoen.
- 2011 **Best Master Thesis Presentation prize**, organized by *AILouvain – Ecole Polytechnique de Louvain – UCLouvain*, Louvain-la-Neuve – Belgium.
Best master thesis presentation (written and oral) of the 2011 EPL engineer promotion.
- 2010 **AGC Scholarship**, organized by *Ecole Polytechnique de Louvain – UCLouvain*, Louvain-la-Neuve – Belgium.
Sponsored scholarship for 5 months international student exchange at TU/e (Netherlands) with a 2 months internship in AGC research center (Belgium).

Services

- 2020–now **Group seminar/webinar organizer**, *Polymer Materials Engineering Lab (IMP - UMR 5223) – INSA de Lyon*, Villeurbanne – France.
Organization of internal group seminars of PhD students, post-docs and permanent researchers' work to promote collaborations and exchanges between lab members.
- 2020–now **Mechanical Testing Room manager and trainer**, *IMP – INSA de Lyon*, Villeurbanne – France.
Lab contact for equipment calibration, revision and renewal. Person-in-charge for new training on mechanical testing machines (tensile, compression, flexural, fracture toughness and Charpy impact tests).
- 2017–2019 **Lab visit and science promotion for teenagers**, *Soft Matter Science and Engineering Lab (SIMM) – ESPCI*, Paris – France.
Organization of small lab visit and experimental demonstration for high school students during occasional week-long science camps.
- 2016–2017 **Lab Safety officer and Equipment trainer**, *Suo Lab – Harvard University*, Cambridge, MA – USA.
Emergency lab contact, development of equipment safety procedures, chemical inventory and waste disposal coordination. Person-in-charge for new training on Instron testing machine, environmental chamber and High-Voltage amplifier.
- 2016 **New Equipment Purchase and Installation**, *Suo Lab – Harvard University*, Cambridge, MA – USA.
Purchase of lab equipment for mechanical characterization and coordination of the new lab duct work and machine installation.
- 2011–2014 **iMMC PhD promotion day co-organizer**, *Institute of Materials, Mechanics and Civil engineering – UCLouvain*, Louvain-la-Neuve – Belgium.
Lab promotion presentation and visit organized for 2nd year engineering master students.
- 2008–2011 **Student Representative**, *EPL - UCLouvain*, Louvain-la-Neuve – Belgium.
Involvement within the Applied Physics and Chemistry degree program commission and work with academic authorities. Coordinate and organize examination schedule as well as other extra-academic group activities.

Miscellaneous

- 2017 – now **Member of the board of directors**, *Gravelines U.S. Aviron*, Gravelines – France.
As a trustee, I get involved into the general management, planning and new projects development of Gravelines rowing club (e.g. international regatta organization and participation, training camp planification).
- 2016–2017 **Board member in charge of communication**, *Harvard-MIT Belgian Society*, Boston, MA – USA.
Organizing social networking events and open debates among the belgian community (and more) in the Boston area, in order to promote Belgian scientific, political or economical personalities and achievements.
- 2012 – now **Rowing athlete**, *RCNSM aviron (Belgium)* – *Gravelines U.S. aviron (France)* – *Riverside Boat Club (USA)*.
Training on a daily basis and competing at national (9 podium finishes with 3 french titles in 2016, 2020 & 2022) and international level (Head of the Charles Regatta (1st club 8+ in 2016), Henley Royal Regatta (2017), World Coastal Rowing Championships (3rd M4x+ in 2018)).
- 2007–2012 **Rowing Instructor**, *Belgium Royal Rowing Federation*, Seneffe – Belgium.
ADEPS level 1 degree (2007) and level 2 degree (2010). Summer camp instructor and young rowers (12 to 16 years old) and senior rowers (20 to 30 years old) coach.

Languages

French **Native language**.

English **Fluent**.

Spanish **Fluent**.

Professional Social Media

Personal website [https : //xmorelle.github.io/webpage/](https://xmorelle.github.io/webpage/)

LinkedIn profile [https : //www.linkedin.com/in/xavier-morelle/](https://www.linkedin.com/in/xavier-morelle/)

Twitter account [https : //twitter.com/xavier_morelle](https://twitter.com/xavier_morelle)

ResearchGate profile [https : //www.researchgate.net/profile/Xavier_Morelle](https://www.researchgate.net/profile/Xavier_Morelle)