

LGPM, EA 4038

LABORATOIRE DE GÉNIE DES PROCÉDÉS & MATÉRIAUX



The LGPM research department works on two fields of investigation in close interaction: chemical and biochemical engineering and materials. Modelling, simulation and experimentation are the common pillars of the different research themes addressed.

Sustainable industrial production as a key challenge for the Twenty-First Century

This complementarity makes possible to start from the understanding of microscopic phenomena to the intensification of transformation and elaboration processes through the simulation and optimisation. Scaling-up and multi-scale approaches are therefore often at the heart of its actions and are the preferred means of moving from academic studies to industrial applications. Our know-how, firmly anchored in process engineering, is applied to the sustainable aspects of material transformation processes (material and energy savings, optimisation and intensification), bioprocesses (use of living organisms to consume and transform biomass into added value products) and the development of bio-materials.

These Departmental competences have been strengthened by the participation of the LGPM in the creation of a Centre of Excellence for Industrial Biotechnology (CEBB) at the end of 2010 in Pomacle (close to Reims/Grand-East Area). Altogether 65 researchers, post-doctorate and PhD students located on both sites (campus Paris-Saclay and campus Reims-Pomacle) are deeply involved in the promising fields of the bio-economy and decarbonisation of the industry.

The Department is organised in three Teams:

MATERIALS & BIOMATERIALS

- Liquid metals, wetting and reactivity at high temperature
- Wood, bio-based materials, building materials
- Coupled heat and mass transfer
- Elaboration and transformation processes
- Characterisation, upscaling, multiscale modelling

CHEMISTRY & SEPARATIVE PROCESSES

- Separation and purification by liquid-liquid extraction, membranes, electro-chemistry, preparative chromatography, crystallization
- Multiphase flows (particles, drops and bubbles), deposition
- Process intensification
- Trace analysis and sample preparation - Exobiology

BIOPROCESSES

- Biological processes (suspended and immobilised cultures)
- Multi-scale modelling and bioreactors control
- Cell/community characterization (biofilm structure, microalgae characterization on *lab-on-chip* systems,...)
- Use of microorganisms to treat wastewater/ produce biofuels (lipids from microalgae, methane generation, ...)
- Production and purification of high value molecules

REMARKABLE EQUIPMENT/SKILLS

2D and 3D imaging:

Confocal Laser Scanning Microscope (CLSM), Environmental SEM + EDS, Interferometric microscope, Nano-tomography, Optical coherence Tomography (OCT), Particle Image Velocimetry, Raman microscope, Image processing tools.

Analysis/characterisation:

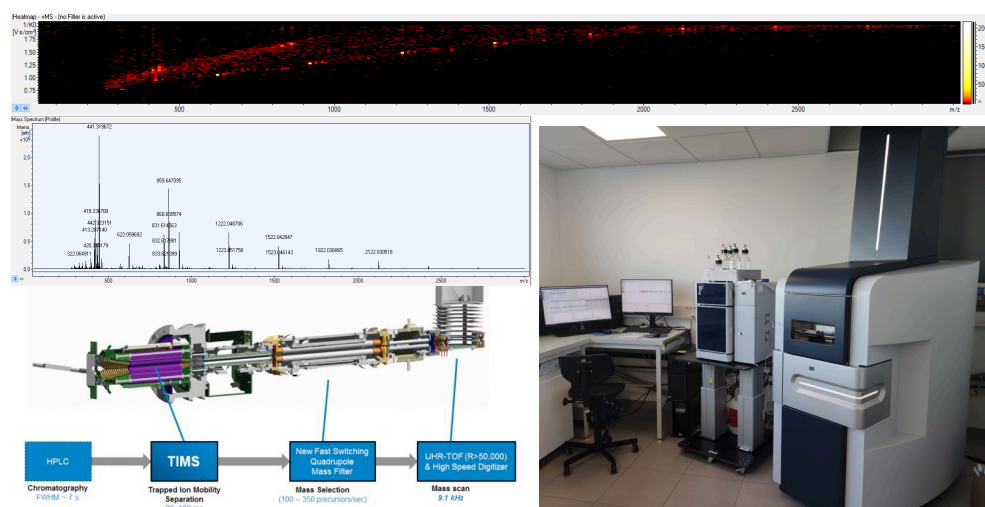
ATG/DSC coupled with GS-MS, BET, CHNSO, DMA, triple quadrupole ICP-MS Spectroscopy (UV, IR, MS, Raman, fluorescence X), UHPLC-Orbitrap (HRMS), UHPLC-IMS-QToF (TIMS-ToF), laser and morphological size analysers, flow cytometry, liquid and gas chromatographs, mass diffusion, permeability, sorption isotherms, tensiometer, wetting measurements at high temperature, Mineralizer.

Processes and pilot devices:

Bioreactors, Drying, Dispensed metal drop device, Electrodialysis, Liquid-liquid extraction, Photobioreactors, Preparative chromatography, Reverse osmosis, Powder flowability tests (rotating drum), Thermal treatment, Ultra- and nano-filtration, Versatile annealing device.

Modelling/simulation:

CFD(OpenFOAM), Discrete modeling of particles (LIGGGHTS), Discrete and continuous modeling of Bioprocess, Machine learning, Chemometrics, Image-based representation, Meshless methods (LB, MPM...), Multiscale modeling of reactive and bio-active transfer in heterogeneous media, Up-scaling. Access to HPC computers (Ruche, Romeo)



UHPLC-IMS-QToF: Liquid chromatography coupled to trapped ion mobility and high-resolution mass spectrometry (TIMS-ToF, Bruker)

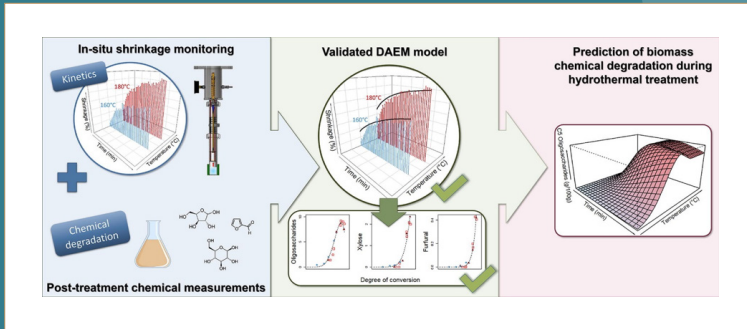
APPLICATION DOMAINS

Iron coating, Liquid metal heat exchanger, Astrobiology, Instrumental development for space application and search for trace of life in the universe, Exobiology, 2G/3G biofuels, Hydrogen production from biomass, Biogas purification, Biotechnologies, Mould/ yeast / bacteria / microalgae production, Tissue scaffold for bone regeneration, Developing innovative bio-sourced materials, Bioprocessing design and evaluation, Digital twins applied to sustainable development.

HIGHLIGHTS 2021

- Renewal of the funding for the **biotechnology chair**, for 7 years – 15.3 M€ (from FEDER/EU/Grand Est, Département de la Marne, Grand Reims)
- LGPM is a partner in the **CALIPSO** project (17 M€ total, 1 M€ for LGPM) which aims to revolutionize the control of bio-production processes in healthcare by using the concept of digital twins. LGPM brings its expertise in bioprocess instrumentation and simulation.
- Discovery of new molecules in a Martian sample named Ogunquit Beach (OG). These molecules include organic nitrogen compounds and high molecular weight molecules. (publication in Nature Astronomy <https://doi.org/10.1038/s41550-021-01507-9>)

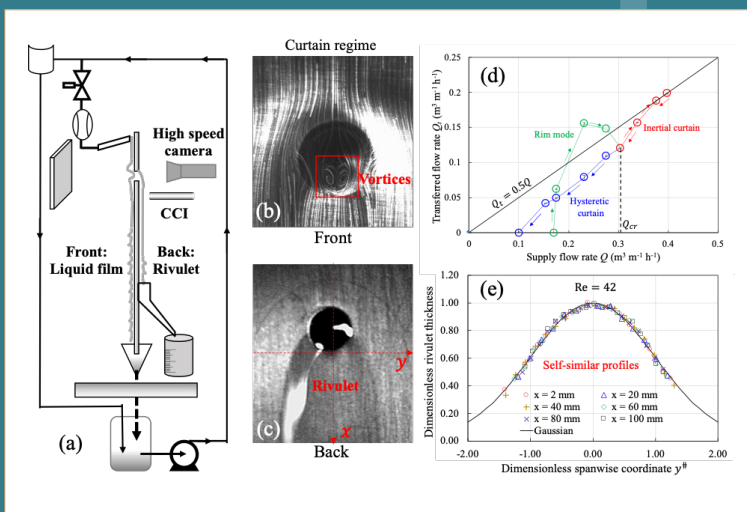




Development of a distributed activation energy model (DAEM) to predict the chemical alterations of lignocellulosic biomass as a function of hydrothermal treatment conditions. The model was tuned by an original device allowing the sample shrinkage to be continuously assessed during hydrothermal treatment. The shrinkage dynamic is supplied in the DAEM model as an indicator of the degree of biomass conversion. A set of chemical analyses was performed to correlate this degree of conversion. A set of functions was then derived from this database to correlate the degree of conversion with the components concentrations. Finally, a validation database was built with different combinations of temperature levels and residence times, demonstrating the model is predictive. (Lancha J.P. et al; **Bioresource Technology** 2021 <https://doi.org/10.1016/j.biortech.2021.125831>).



Machine learning applied to bioprocesses: unravelling the effect of light in microalgae development. The timescales of intermittent light have been investigated through a meta-analysis driven by machine learning. For medium frequencies, with respect to continuous light, lower duty cycle values hinder photosynthetic activity, while higher values produce similar results. In high frequency regime, lowering the cycle time furthers culture performances. Recommendations are drawn to improve future works: flat panel airlift combined with intermittent lighting should be the reference experimental device for this type of investigation. Furthermore, growth rate monitoring should be preferred to its dissolved gases counterpart. (Levasseur, W. et al., **Journal of Applied Phycology** <https://doi.org/10.1016/j.fuproc.2014.07.007>).



Liquid film flows over and around topography: focus on a perforated flat sheet solely supplied with liquid on its front (a). The flow patterns were investigated using a high-speed camera, and the film free-surface profile was assessed using confocal chromatic imaging (CCI). When the film Reynolds number exceeds a threshold value, a liquid curtain closes each perforation (b). At the perforation bottom edge, the curtain flow divides between the sheet's front and back (c). The curtain regime was fully characterized: the volume flow rate of the rivulet leaking from a perforation was quantified (d), and the spreading and the merging of the rivulets on the back of the sheet were carefully analyzed (e). This work provides helpful insight into the elementary mechanisms involved in the liquid redistribution in corrugated distillation packings. (Iyer, M. et al., **AIChE Journal** <https://doi.org/10.1002/aic.17363>, Iyer, M. et al., **AIChE Journal** <https://doi.org/10.1002/aic.17655>).

Industrial Partners

- AIR LIQUIDE
- ARCELORMITTAL
- ARD
- BIOREA
- CEA
- CHENE et Cie
- CNES
- CRISTAL UNION
- DRY4GOOD
- EDF R&D
- ECOTECHNILIN
- GIVAUDAN
- GRT gaz
- HAFFNER Energy
- IFPEN
- INALVE
- INEVO
- INTERNATIONAL ZINC ASSOCIATION
- LESAFFRE
- Metha'groupe
- OLYGOSE
- PROCESSION
- PROSNY NC
- SANOFI
- TIPEE
- THALES ALENIA SPACE
- TMA Process
- VEOLIA
- VITO
- WIGWAM
- YPSO-FACTO

Academic Partners

International: Danish Technological Institute (Denmark), Engineering school of Monastir (Tunisia), Engineering School of Sfax (Tunisia), GSFC-NASA (USA), Gottingen University (Germany), Imperial College London (UK), Institut Von Karman (Germany), JPL-NASA (Pasadena, USA), Max Planck Institute for Solar System Research (Germany), School of Mathematical Sciences QUT (Australia), Technical University of Dresden (Germany), TU Delft (Netherlands), University of São Paulo (Brazil), São Paulo State University (Brazil), Université du Québec in Abitibi-Témiscamingue (Canada), University of Almeria (Spain), University of Hannover (Germany), University of Padova (Italy), Wageningen University (Netherlands), Ohio State University (USA), Higher Institute of Biotechnology of Beja (Tunisia).

France: AgroParisTech, ENS Paris Saclay, ESIEE (Noisy-le-Grand), GEPEA (Nantes), IFREMER, INRAE, IMFT (Toulouse), INRIA, INSERM, IS2M (Mulhouse), Institut de Matériaux Microélectronique, Nanosciences de Provence, SMS (Université de Rouen), Unilasalle Beauvais, Université Picardie Jules Verne, Université Reims-Champagne Ardennes, Université de technologie de Compiègne, Université de Lorraine, Université la Rochelle, Université Savoie Mont Blanc, UPMC.

Key figures

- Professors, Associate Professors & Scientists 29
- Engineers & Administrative staff 17
- PhD Students 16
- PostDocs 4
- Internships 15
- Publications of the year (WoS) 40
- Research Contracts, including chairs 15.2 M€

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