

LABORATOIRE DE GENIE DES PROCEDES ET MATERIAUX - LGPM, EA 4038

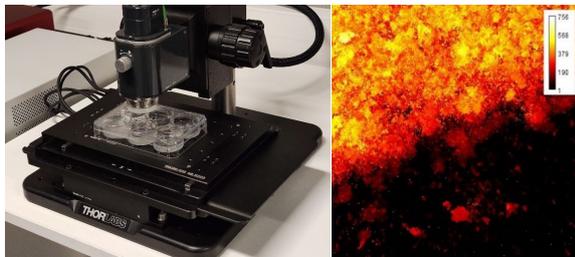
SUSTAINABLE INDUSTRIAL PRODUCTION AS A KEY CHALLENGE FOR THE TWENTY-FIRST CENTURY

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. 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) allowing full-time employment of 25 people (post doctorates and PhD students). Altogether 60 researchers, post-doctorate and PhD students located on both sites (Saclay and Pomacle) are deeply involved in the promising field of the bio-economy.

The Department is organised in three teams:

Materials and 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 and separative processes	Separation and purification by liquid-liquid extraction, membranes, electrochemistry, preparative chromatography, crystallization Multiphase flows (particles, drops and bubbles), deposition Process intensification (vibrations) Trace analysis and sample preparation
Bioprocesses	Biological processes (suspended and biofilm) Multi-scale modelling and bioreactors control Cell/community characterization (biofilm structure, microalgae characterization on <i>lab-on-chip systems</i> , ...) Use of microorganisms to treat wastewater/produce biofuels (lipids from microalgae, methane generation, ...) Production and purification of high value molecules

REMARKABLE EQUIPMENT/SKILLS



SD-OCT (spectral domain Optical Coherence Tomography)
(Thorlabs Ganymede series 621)

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, Spectrophotometers (ICP-AES, UV, IR, atomic absorption, fluorescence X), GCxGC-Orbitrap (HRMS), laser and morphological size analysers, flow cytometry, liquid and gas chromatographs, mass diffusion, permeability, sorption isotherms, tensiometer, wetting measurements at high temperature.

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

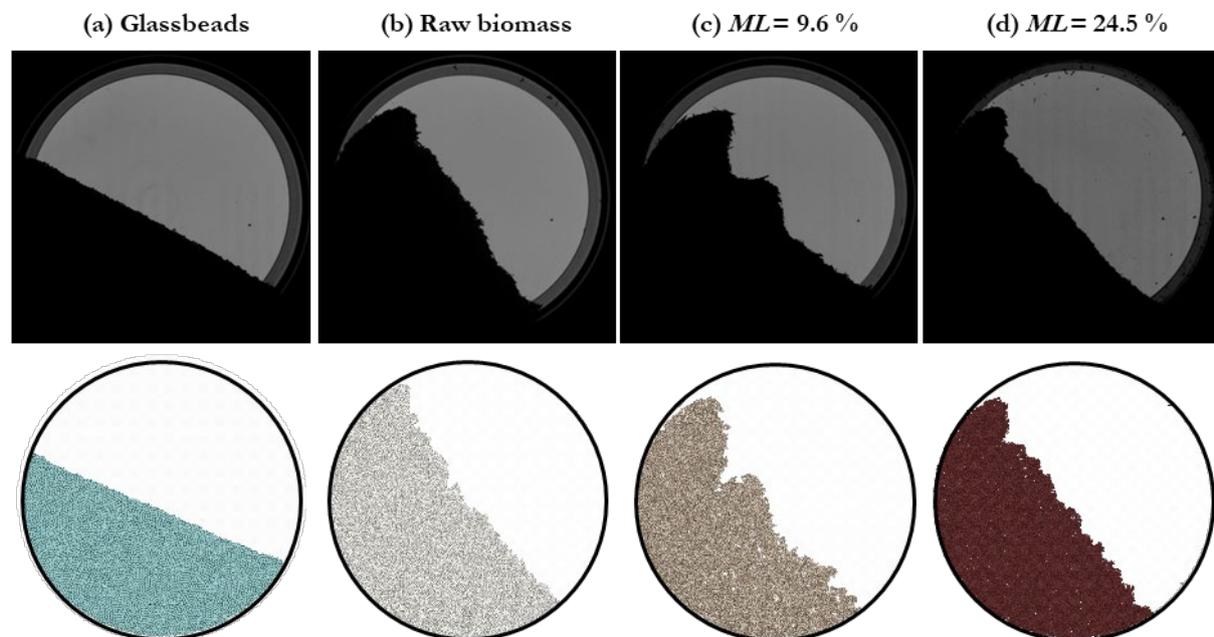
Modelling/simulation: CFD(OpenFOAM), Discrete modeling of particles (LIGGGHTS), Discrete and continuous modeling of Bioprocess, Image-based representation, Meshless methods (LB, MPM...), Multiscale modeling of reactive and bio-active transfer in heterogeneous media, Up-scaling.

APPLICATION DOMAINS

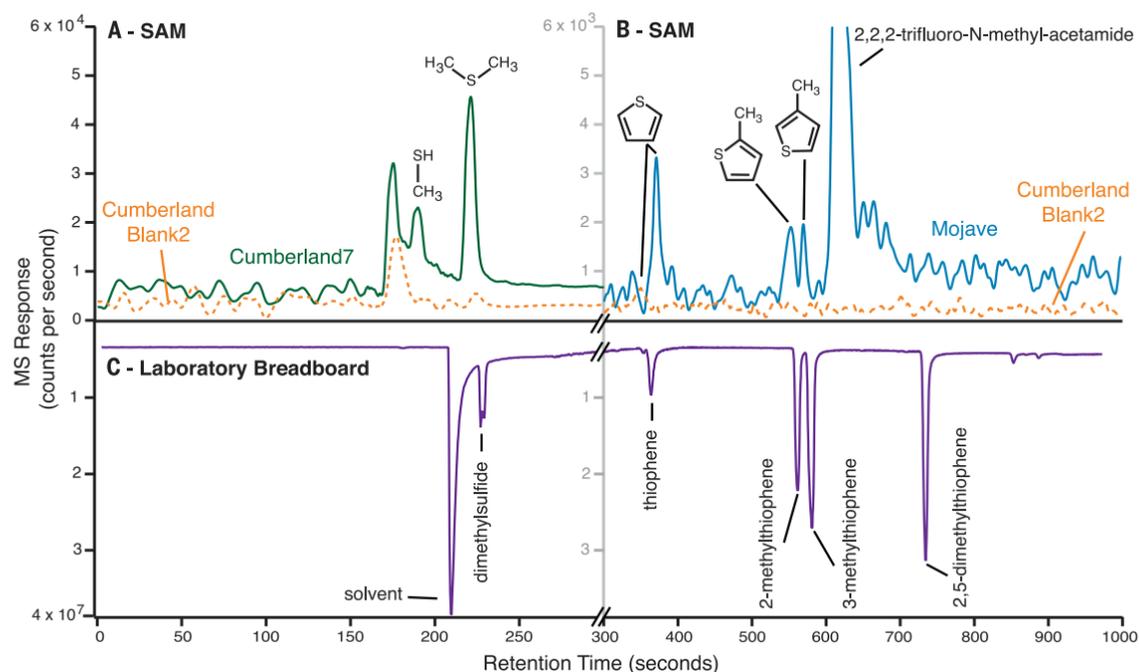
Iron coating, Liquid metal heat exchanger, Astrobiology, Instrumental development for space application and search for trace of life in the universe, Exobiology, 2G/3G biofuels, Hydrogen production from biomass, Biogas purification, Biotechnologies, Yeast / microalgae production, Tissue scaffold for bone regeneration

HIGHLIGHTS 2020

- ✓ Renewal of the funding for the biotechnology chair, for 7 years
- ✓ LGPM is partner in a major project targeting an industrial pilot to produce mobility-ready H₂ from biomass
- ✓ First detection of hydrocarbon compounds by SAM instrument aboard curiosity rover on Mars (publication in Science)
- ✓ LGPM is part of the future Dragonfly Mission (Titan exploration 2030). Development of the DraMS instrument



*DEM simulation of particle motion in a rotating drum (unconfined flow) : qualitative comparison between representative experimental and simulation captions after avalanches of glass bed and elongated submillimetric biomass powder exhibiting different cohesive extent. The differences in flow behavior between the different samples studied here are well captured by the DEM simulations. (Pachon Morales et al. **Advanced Powder Technology** 2020)*



Example of SAM GC-MS identification of S-bearing compounds detected at Pahrump Hills a martian' lacustrine mudstones at the Gale Crater. **(A)** SAM GC-MS chromatograms summing m/z 47 and 62 from 0 to 300 s for Cumberland7 of the Sheepbed mudstone and a blank showing methanethiol and dimethylsulfide. **(B)** SAM GC-MS chromatograms summing m/z 84, 97, and 98 from 300 to 1000 s for Mojave and a blank showing the presence of thiophene, 2-methylthiophene, and 3-methylthiophene. 2,5-Dimethylthiophene was not identifiable. **(C)** Chromatograms from GC run in the laboratory. Chromatograms were smoothed, and the off-nominal GC run from Mojave resulted in the 20-s offset for the thiophene retention time as observed in (B) (11). The 2,2,2-trifluoro-N-methyl-acetamide peak in (B) is a derivatization reaction product that is part of the instrument background (11). GC-MS identifications are based on both SAM and laboratory retention times (table S3) compared to standards and mass spectra in a reference database (33). Axis breaks denote a change in the x-axis scale. (Eigendbrode et al. *Science*, 360, 1096-1101, 2018).



The laboratory has developed gas purification processes which have resulted in two patent applications. The first application was to purify biogas from anaerobic digestion in order to obtain biomethane edible to be injected in gas grid. This application will be demonstrated at large scale on an agricultural methanizer with-Metha'Group within EMMA project supported by Grand Est Region. The second application concerned syngas purification to obtain highly pure hydrogen for mobility. This application is tested within Vitryhydrogen project with Haffner Energy, supported by ADEME PIA.

KEY FIGURES 2020

- PROFESSORS, ASSOCIATE PROFESSORS & SCIENTISTS: 30
- ENGINEERS AND ADMINISTRATIVE STAFF: 17
- PhD STUDENTS: 16
- POSTDOCS : 4
- INTERNSHIPS: 15
- PUBLICATIONS OF THE YEAR (WOS): 36
- RESEARCH CONTRACTS : 13,21 M€

ACADEMIC PARTNERS

International : Danish Technological Institute (Danemark), École Nationale d'Ingénieur de Monastir (Tunisia), GSFC-NASA (USA), Göttingen 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), Universidade de Sao Paulo (Brésil), Université du Québec in Abitibi-Témiscamingue (Canada), University of Almeria (Spain), University of Hannover (Germany), University of Padova (Italy), Wageningen University (Netherlands).

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.

INDUSTRIAL PARTNERS

AIR LIQUIDE, ARCELORMITTAL, ARD, BIOCODEx, CEA, CHENE et Cie, CNES, CRISTAL UNION, EDF R&D, GIVAUDAN, GRT gaz, HAFFNER Energy, IFPEN, INALVE, INEVO, INTERNATIONAL ZINC ASSOCIATION, LESAFFRE, Metha'groupe, OLYGOSE, PROCESSIUM, TIPEE, THALES ALENIA SPACE, TMA Process, VEOLIA, WIGWAM, YPSO-FACTO.

WEBSITES

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