PhD Proposal 2017

School: CentraleSupelec	
Laboratory: LGPM	**Web site: http://www.lgpm.ecp.fr/**
Team: Chimie et Procédés Séparatifs	**Head of the team: Moncef Stambouli**
Supervisor: Arnaud Buch	**Email: arnaud.buch@centralesupelec.fr** **Pin.lu@centralesupelec.fr**
Collaboration with other partner during this PhD: **In France: LATMOS**	**In China:**

Title: Decoding organic matter of the solar system with combined analytical methods and instrumentation for understanding the origins of life
Scientific field: Planetology, Astrobiology, Analytical chemistry, Space instrumentation
Key words: Meteorites, Comets, Mars, Titan, Astrobiology, TGA/DSC-GC-MS, GC-MS, LC-Orbitrap

Details for the subject:

Background, Context:

The search and characterization of extraterrestrial organic materials is one among the most important objectives to understand how life has emerged on Earth and where it could be found in the solar system and the Universe. With this aim, several space missions have recently been sent to planets (Mars/Mars Science Laboratory), satellite (Titan/Cassini-Huygens), and comets (67P/Churyumov–Gerasimenko/Rosetta) to detect and characterize the organic matter they contain, among various scientific objectives. Our knowledge about these organic materials is thus significantly increasing but the treatment and interpretation of these data requires a hard work at the laboratory.

Other ways to get information about organic materials in the solar system are to study samples returned to Earth by dedicated space missions (Osiris-Rex to Bennu asteroid) or falling at its surface (meteorites) in the laboratory., or samples analogous to extraterrestrial materials (e.g. Titan's tholins) produced in the laboratory with experimental reactors.

As our team is involved in all these activities, the objective of the proposed work is to contribute to the characterization of the organic material contained in a wide range of solar system bodies of astrobiological interest in order to improve the understanding of the prebiotic chemistry and the way life arose Earth

Research subject, work plan:

This project addresses the development of new analytical techniques or methods to analyze the organic composition of several solar system bodies of astrobiological interest. Among these materials we propose to study rare analogs of different planetary objects (Mars, Titan, comets) and some meteorites from several origins.

The main goal of this PhD proposal is the development of new sample preparation techniques and the characterization of their structure through the use of different and complementary analytical techniques dedicated to search for trace of organic compounds.

Technics and methods used to detect and characterize the organic compounds should be adapted to the target. Indeed, targeted organic material could be volatile or non-volatile (refractory, macromolecule, kerogen…). Matrix should be under gaseous, liquid or solid state. If the matrix is solid, then depending of the mineralogy, the preservation of the organic material will not be the same and the difficulty to extract it could be more or less difficult. Thus, depending on the function of the matrix and of the state of the organic compounds, the sample preparation and the analytical characterization should be chosen carefully. With this goal the student will explore new analytical methods to extract the extraterrestrial organic material from several solid matrixes. Among these methods, derivatization and thermochemolysis extraction (already onboard the SAM experiment) should be privileged as these techniques are already used in different space instruments .The influence of the mineralogy of the matrix on the extraction efficiency will also be studied.

Several new analytical technics should be used and tested. Some of them involve high resolution mass spectrometry (Orbitrap) which will be coupled to liquid or gas chromatography.

New analytical devices, based on the themogravimetry (TGA/DSC) coupled to GC-MS (gas chromatography coupled to mass spectrometry), will be used to characterize the mineralogy and organic compounds released during the heating process.

This thesis will therefore result to a close collaboration between LGPM, LATMOS. Indeed, these laboratories have essential skills to analyse the extraterrestrial organic material and to

understand the physicochemical processes involved in their formation. The results obtained will be used to interpret data collected by the Sample Analysis at Mars (SAM) experiment aboard the Curiosity rover on Mars, and the observations of Titan by the Cassini-Huygens probe, to better characterize the satellite and its evolution.

Because this project is a part of projects related to the current space exploration (MSL and ExoMars missions) devoted to the detection of trace of life in the universe, the PhD student will collaborate with three other partners:

NASA (USA)
CNES (Centre National d'Etudes Spatiales, France)
MPS (Max Planck Institute, Germany)

References:

Freissinet, C., D. P. Glavin, P. R. Mahaffy, K. E. Miller, J. L. Eigenbrode, R. E. Summons, A. E. Brunner, A. Buch, C. Szopa, P. D. Archer, H. B. Franz, S. K. Atreya, W. B. Brinckerhoff, M. Cabane, P. Coll, P. G. Conrad, D. J. Des Marais, J. P. Dworkin, A. G. Fairén, P. François, J. P. Grotzinger, S. Kashyap, I. L. ten Kate, L. A. Leshin, C. A. Malespin, M. G. Martin, F. J. Martin-Torres, A. C. McAdam, D. W. Ming, R. Navarro-González, A. A. Pavlov, B. D. Prats, S. W. Squyres, A. Steele, J. C. Stern, D. Y. Sumner, B. Sutter, M. P. Zorzano and M. S. L. S. T. the (2015). "Organic molecules in the Sheepbed Mudstone, Gale Crater, Mars." Journal of Geophysical Research: Planets **120**(3): 495-514.

Leshin, L. A., P. R. Mahaffy, C. R. Webster, M. Cabane, P. Coll, P. G. Conrad, P. D. Archer, S. K. Atreya, A. E. Brunner, A. Buch et al. (2013). "Volatile, Isotope, and Organic Analysis of Martian Fines with the Mars Curiosity Rover." Science **341**(6153).

Ming, D. W., P. D. Archer, D. P. Glavin, J. L. Eigenbrode, H. B. Franz, B. Sutter, A. E. Brunner, J. C. Stern, C. Freissinet, A. C. McAdam, P. R. Mahaffy, M. Cabane, P. Coll, J. L. Campbell, S. K. Atreya, P. B. Niles, J. F. Bell, D. L. Bish, W. B. Brinckerhoff, A. Buch, P. G. Conrad, D. J. Des Marais, B. L. Ehlmann, A. G. Fairen, K. Farley, G. J. Flesch, P. Francois, R. Gellert, J. A. Grant, J. P. Grotzinger, S. Gupta, K. E. Herkenhoff, J. A. Hurowitz, L. A. Leshin, K. W. Lewis, S. M. McLennan, K. E. Miller, J. Moersch, R. V. Morris, R. Navarro-Gonzalez, A. A. Pavlov, G. M. Perrett, I. Pradler, S. W. Squyres, R. E. Summons, A. Steele, E. M. Stolper, D. Y. Sumner, C. Szopa, S. Teinturier, M. G. Trainer, A. H. Treiman, D. T. Vaniman, A. R. Vasavada, C. R. Webster, J. J. Wray, R. A. Yingst and M. S. L. S. Team (2014). "Volatile and Organic Compositions of Sedimentary Rocks in Yellowknife Bay, Gale Crater, Mars." Science **343**(6169): 9.

Morisson, M., C. Szopa, N. Carrasco, A. Buch and T. Gautier (2016). "Titan's organic aerosols: Molecular composition and structure of laboratory analogues inferred from pyrolysis gas chromatography mass spectrometry analysis." Icarus **277**: 442-454.

Freissinet, C., A. Buch, R. Sternberg, C. Szopa, C. Geffroy-Rodier, C. Jelinek and M. Stambouli (2010). "Search for evidence of life in space: Analysis of enantiomeric organic molecules by N,N-dimethylformamide dimethylacetal derivative dependant Gas Chromatography-Mass Spectrometry." Journal of Chromatography A **1217**(5): 731-740.