Application of two-step laser mass spectrometry to the characterization of fossil organic matter and prospects for Exobiology

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Abstract

The Two-step Laser Mass Spectrometry (L2MS) technique has been extensively used in the PhLAM laboratory to characterize the chemical composition of various environmental interest samples (mainly combustion products) over the last decade[1, 2]. L2MS involves a desorption laser (Nd:YAG, 532 nm, 10 ns, 10 Hz) to transfer a micro-volume of the analyzed sample into gas phase, and then a second laser (Nd:YAG, 266 nm, 10 ns, 10 Hz) to ionize it. The generated ions are extracted and analyzed by a time-of-flight mass spectrometer (ToF-MS). The similarity of our L2MS technique with the LDI method envisaged for MOMA has motivated us in extending its field of application to geological and paleontological interest samples.

As a first step, we analyzed various reference materials such as cholestane and tryptophan, and geological samples like Orbagnoux rock from French Jura Mountains (Kimmerdgian, Jurassic). Preliminary results on cholestane and tryptophan showed that L2MS can detect the parent molecule along with the presence of specific fragmentation patterns. Other reference molecules relevant to the search of traces of fossils/extant life will be characterized similarly in order to build a database. In addition, the analysis of the Orbagnoux sample and its dichloromethane/methanol extract showed that polyaromatic hydrocarbons (PAHs) and aromatic fragments were detected from the extract, and carbon clusters were detected from the rock. This important difference in detected compositions between rock sample and soluble extract will be discussed with respect to analytical parameters and molecular structures inferred from previous GC-MS studies.

More studies will take place for other relevant reference materials and additional geological and paleontological samples. In addition, we are currently developing a new micro-L2MS system, which couples optical microscopy with L2MS to improve the lateral resolution of

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the technique at better than 10 μm, thus providing the ability of molecular mapping of the sample surface. This microscale analysis will be crucial to address micro-heterogeneities (primary and late contaminants) and target single microfossils in rocks.

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2. Faccinetto, A., et al., *Progress toward the Quantitative Analysis of PAHs Adsorbed on Soot by Laser Desorption/Laser Ionization/Time-of-Flight Mass Spectrometry.* Environmental Science & Technology, 2015. **49**(17): p. 10510-10520.