# Mass spectrometry of astrobiologically relevant organic material - Implications on future space missions to ocean worlds in the outer Solar System

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## 1. Introduction

Most astrobiologists agree that it is fundamental to characterize the abundance of various amino acids and fatty acids in the search for extraterrestrial life. For future space missions these investigations are possible with impact ionization detectors [1,2] that assess the abundance of these key species in ice grains that might emerge from ocean bearing moons like Enceladus and Europa. Since amino acids exist also in comets and other primitive bodies it is crucial that biotic and abiotic fingerprints of these organic substances can be distinguished.

## 2. Analog experiment

With our worldwide unique setup in Heidelberg we are able to generate analog mass spectra of amino acids, peptides and fatty acids in ice grains. It simulates the impact ionization mechanism in space instruments by an IR Laser intersecting an ultra-thin water beam. The resulting spectra have been demonstrated to be highly comparable to those of icy particles detected by impact ionization space detectors like the Cosmic Dust Analyzer (CDA) on board the Cassini spacecraft [2] or the Surface Dust Analyser (SUDA) on board the future Europa Clipper mission [1]. The experimental setup (FL-MALDI-ToF-MS) consists of a vacuum chamber (5 x $10^{-5}$ mbar) in which a water beam (radius of 7.5 µm) is inserted. Chemical substances like amino acids and fatty acids are dissolved in water. A pulsed infrared laser hits the beam of the aqueous solution. In this way ions, electrons and neutral molecules of the dissolved substances and water are created. The generated cations as well as the anions can be detected in a commercial ToF mass spectrometer.

## 3. Results

Our laboratory results show a high sensitivity on the tested substances. The detection limits are in the ppm or even ppb range. Different amounts of the organic substances lead to different intensities of the related peaks in the mass spectra. We are able to easily differentiate between biotic and abiotic signatures of amino acids and fatty acids in the analog spectra. Peptides can also be reliably characterized. By comparing the laboratory results with spacecraft data we have the ability to recognize and distinguish such signatures in ice grains from icy moons with a subsurface ocean. In the future we aim to create a comprehensive mass spectral reference library for in situ mass spectrometers in space from a wide variety of organic analog materials in icy grains.

## 4. References

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**Short Summary**

With our experimental setup mass spectra of impact ionization space detectors can be accurately reproduced. Biotic and abiotic signatures of organic key compounds important for the origin of life like amino acids can be distinguished in the laboratory and compared to mass spectra of ice grains of ocean bearing moons.