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Titan and Europa are considered as **ocean worlds** with a **global subsurface ocean**, and therefore are of high interest for astrobiology. Titan, a satellite of Saturne, has a **thick atmosphere** composed by N_2 and CH_4 where a **complex chemistry** occurs. This atmospheric chemistry leads to the formation of **organic aerosols**, that can precipitate on the surface. The **ice water** of the surface can melt under certain conditions, leading to an **interaction between liquid water and aerosols**. This reaction could result in the formation of **potential biomolecules**.



Dragonfly drone

The *Dragonfly* mission was developed to study **surface composition of Titan** thanks to the *Dragonfly Mass Spectrometer system (DraMS)* which is composed by a **Gas chromatograph Mass spectrometer**

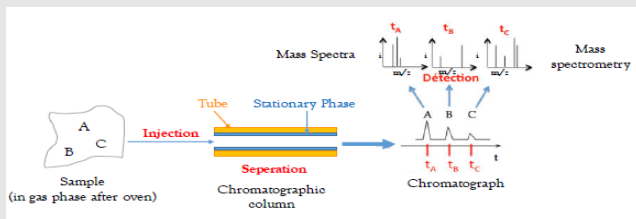
Europa, a satellite of Jupiter, has a **global subsurface ocean**, beneath an **icy shell**. **Plumes** were identified from *Hubble Space telescope* observations, leading to **deposits of subsurface materials** on the surface. In addition, with the **identification of salts** on the Europa surface, an **interaction between ocean and the rock interior** is supposed. Therefore, like in Earth oceans, this interaction could allow **hydrothermalism, where life could thrive**.

The *Europa lander mission concept* was developed to **land on a plume deposit area** to identify organics potentially **related to life**. To do so, **Gas chromatography Mass spectrometry** was recommended to perform the chemical analysis



Europa Lander concept

Gas chromatography Mass spectrometry Principle



Instrumental setup

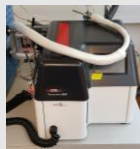
Gas chromatography (GC)
→ **retention times**
Mass spectrometry (MS)
→ **fragmentation pattern**

GC + MS → strict identification of molecules in a sample

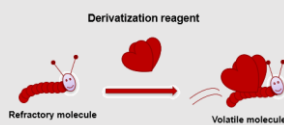
➤ Sample pretreatment methods for improving detection

Pyrolysis

Thermal extraction
(up to 1000°C)



Derivatization reaction

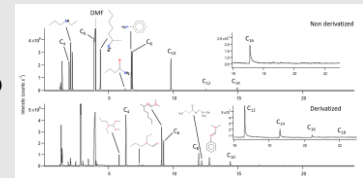


Preparation of Dragonfly in-situ analysis with DraMS



- **Derivatization of amines**
- **Amines** compounds expected on Titan surface. Could be involved in **prebiotic chemistry**. How GC-MS is able to detect amines with derivatization ?

- ❖ **Detection of derivatized amines up to eighteen carbon atoms**
→ **better with derivatization**



Comparison of non derivatized vs. derivatized amines

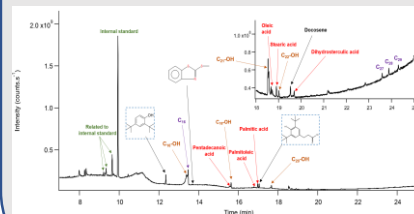
- **Selection of the general chromatographic column for DraMS-GC**



Study of analog samples preparation for future in-situ analysis of Europa



- Tirez lakes are **hyper-saline environments** with a **complex ecosystem**
- GC-MS and associated methods capable of detecting **organic molecules related to life despite the presence of salts ?**



Derivatized Tirez sample

- ❖ **Detection of organic molecules related to microorganisms** in the sample despite the salts:

- **Fatty acids**
- **Bacterial metabolites**

- ❖ **No amino acids or small peptides ?**

Perspectives



Study of **derivatization on biomolecules** (small peptides, nucleobases)



Desalination protocol, comparison to **micro-organisms culture** (archaea)

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