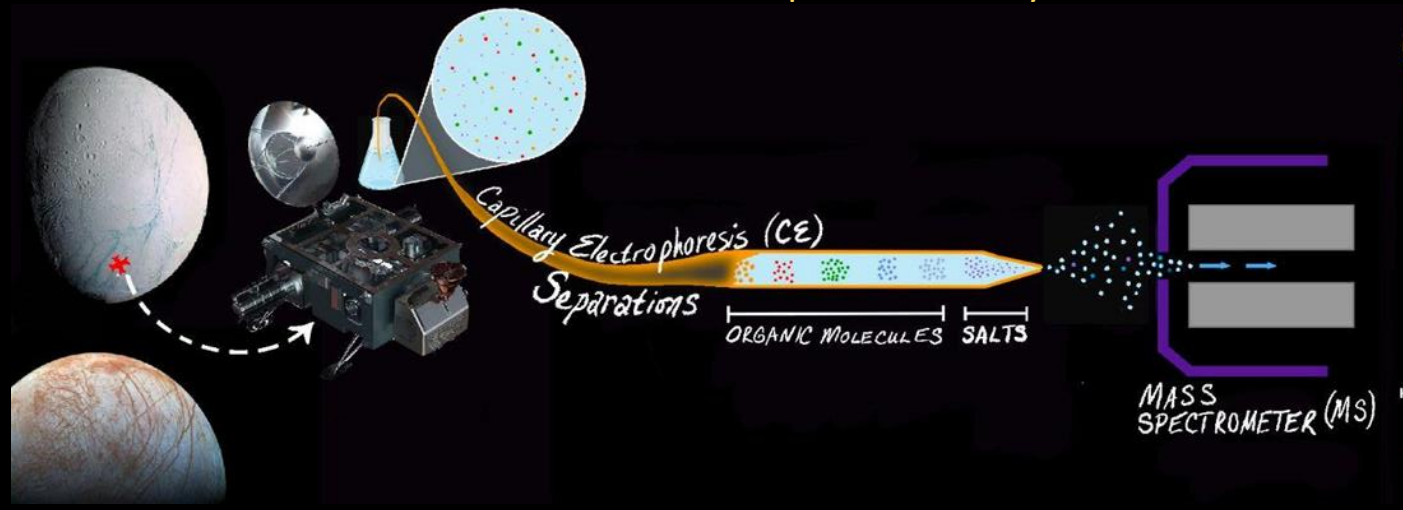
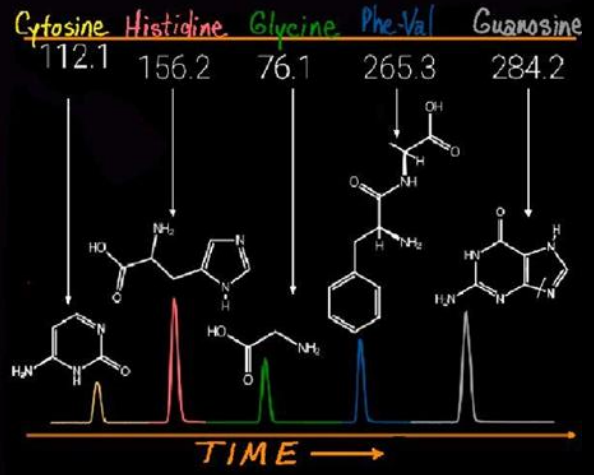
Detection of Biosignatures by Capillary Electrophoresis Mass Spectrometry in the Presence of Salts Relevant to Ocean Worlds Missions

Enceladus and Europa, two icy moons of the outer solar system, are key astrobiological targets. However, detecting life in their cold and salty oceans presents a unique challenge; detectors will need to be small enough to be packaged on a spacecraft, while the presence of high amounts of salt can interfere with typical separation methods needed to produce high resolution data. Capillary electrophoresis (CE) can overcome these challenges by using the charge on organic molecules to separate the molecules of interest from the unwanted salts before detection. Further, by interfacing CE with mass spectrometry (MS; CE-MS) it is possible to analyze the separated organic molecules based on mass, enabling the characterization of known and unknown compounds at very low concentrations despite being originally present in a salty matrix.





CE-MS's ability to deal with high levels of salts while allowing detection of a wide range of organics at parts-per-billion concentrations demonstrates that CE-MS is uniquely suited for detecting signs of life in future missions to ocean worlds.

Experiments & Results: A mixture of four classes of organic compounds relevant to the search for life was used to test the CE-MS limits of detection in salty matrices: amino acids, short peptides, nucleosides, and nucleobases. Mixtures were analyzed in the presence of two salts thought to be prominent on Europa and Enceladus: NaCl and $MgSO_4$. Limits of detection for the selected organics in the absence of salts range from 0.05 to 1µM (8 to 89 ppb), demonstrating its capability of detecting organics at ⅓ the magnitude of organics in Earth's ocean. More importantly, organics in the low µM range (1 to 50 µM) can be detected by CE-MS in the presence of 3 M NaCl without pre-experiment cleanups.

Significance: This work demonstrates, for the first time, direct laboratory analysis of organic biosignatures by CE-MS on synthetic samples designed to mimic expected samples from ocean worlds, either from the surface or the plumes. Limits of detection in the low µM range are obtained even in the presence of 3 M NaCl, six times the salinity of Earth seawater.

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