Solid-State Single-Molecule Sensing with the Electronic Life-Detection Instrument for Enceladus/Europa (ELIE)

Background

If we want to find life elsewhere in the universe, we must develop tools capable of detecting biosignatures that can be flown on spacecraft and operated remotely. The upcoming missions to Enceladus and Europa provide the opportunity to test some of these developing technologies, including the newly proposed Electronic Life-Detection Instrument for Enceladus/Europa (ELIE). This solid-state single-molecule detector is specifically designed to detect extremely low levels of amino acids and informational polymers, employing a highly sensitive approach to analyze these molecular components indicative of potential extraterrestrial life.

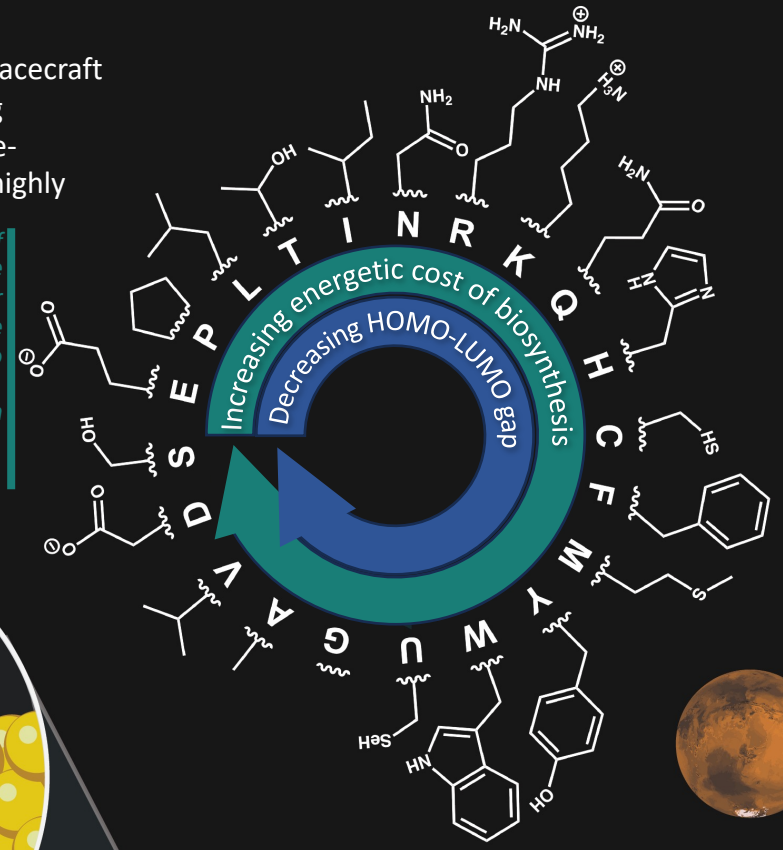
Experiments

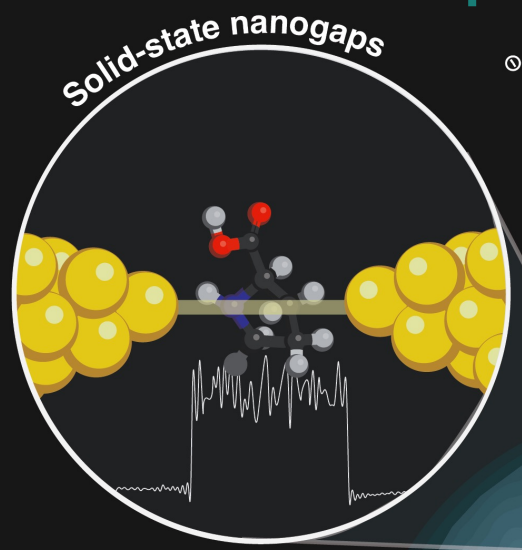
The ELIE would use ***quantum electronic tunneling nanogap sensors to detect and discriminate among single amino acids, RNA, and DNA***. The ELIE prototype was tested using an amino acid, L-proline, at a concentration of 10 µM to determine the final sensitivity of the instrument. Many different proteinogenic amino acids were also tested in the detector, and these conductance patterns were analyzed for relationships with known amino acid properties. Finally, abiotic and biotic samples were studied to assess the potential of ELIE to discriminate between biotically and abiotically derived amino acids.

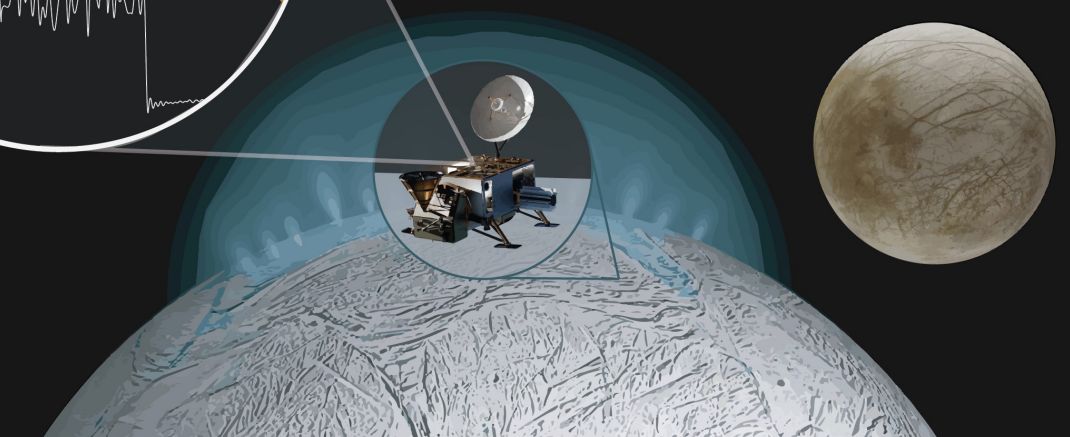
Results

- ELIE prototype successfully detected L-proline at a concentration of 10 µM, with potential sensitivity extrapolated to 1 nM, ***meeting the proposed threshold for Enceladus Orbilander missions***
- The HOMO–LUMO gap was an accurate predictor of amino acid conductance, and therefore complexity. The 0.7 nm nanogap electrodes yielded statistically significant differences in conduction, demonstrating ELIE can discriminate 8 amino acids.
- Homo-Lumo gap may reflect the importance of electron transfer for life as we know it, and ***low HOMO-LUMO gap amino acids are proposed as a potential biosignature***
- ELIE prototype demonstrated the ability to discriminate between biotically and abiotically derived amino acids, using abundance of low HOMO-LUMO gap molecules
- The study provides preliminary evidence for integrating ELIE into future in situ life-detection missions

→ Predicted order of appearance of proteinogenic amino acids within the genetic code, along with their functional groups. Arrows indicate increasing patterns of some amino acids' thermodynamic properties. Arrows indicate trends with quantitative support.







NFoLD NETWORK FOR LIFE DETECTION

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