Evolution of the Molecules of Life on Distant Planets

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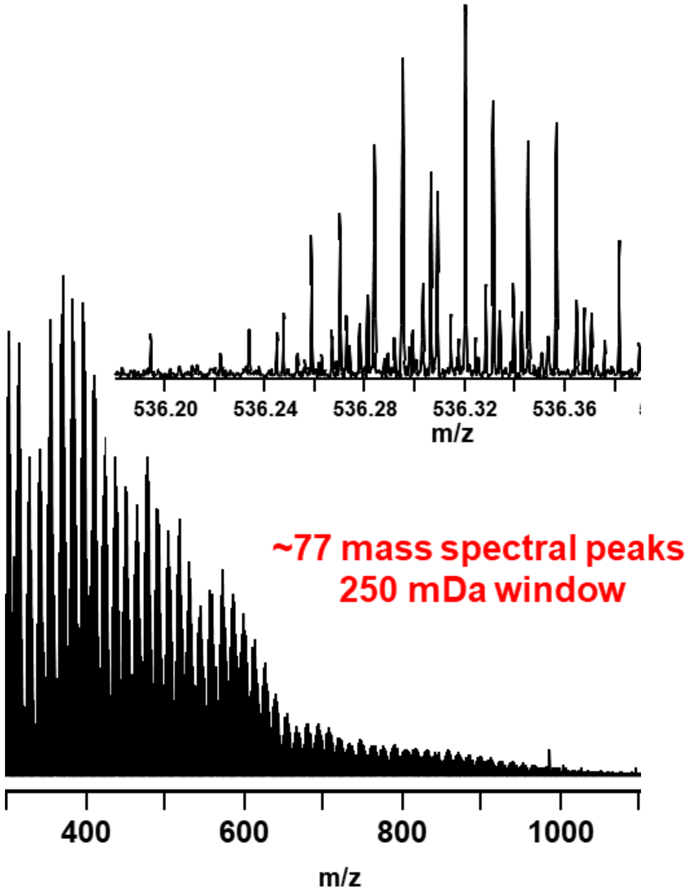
Photochemical hazes are expected to form and significantly contribute to the atmosphere of exoplanets, possibly in the habitable zone of the host star. In the presence of humidity, haze particles may serve as cloud condensation nuclei and trigger the formation of water droplets. *In this work, MagLab users observe chemical reaction products between photochemical haze and water vapor, which reveals the capacity to generate organic molecules needed for life*. The experiments combine a nitrogen-rich atmosphere similar to that of Titan (the largest moon of Saturn) with humid conditions expected for exoplanets in habitable zones. *Researchers observe a logarithmic increase with time for the relative abundance of oxygenated species, species that dominate after only one month*. The rapidity of the process suggests that the humid evolution of nitrogen-rich organic haze provides an efficient source of molecules with high prebiotic potential.

Analysis of the complex mixture of organic molecules requires ultrahigh resolving power only achievable by 21 Tesla FT-ICR mass spectrometry at the MagLab. The **figure** at left shows a mass spectrum of the methanol-soluble fraction of the initial sample before aging. Analytes are distributed across a wide m/z range (from 180 < m/z < 1200) in a log-normal distribution with more than 30,000 analytes detected. Mass-scale zoom insets at m/z 558 highlight the immense compositional complexity, with striking increase of oxygenated species detected with reaction period. *Further experiments demonstrate the presence of carbonyl, amide, and carboxylic acid functional groups, which are all important contributors to the chemistry of life*.



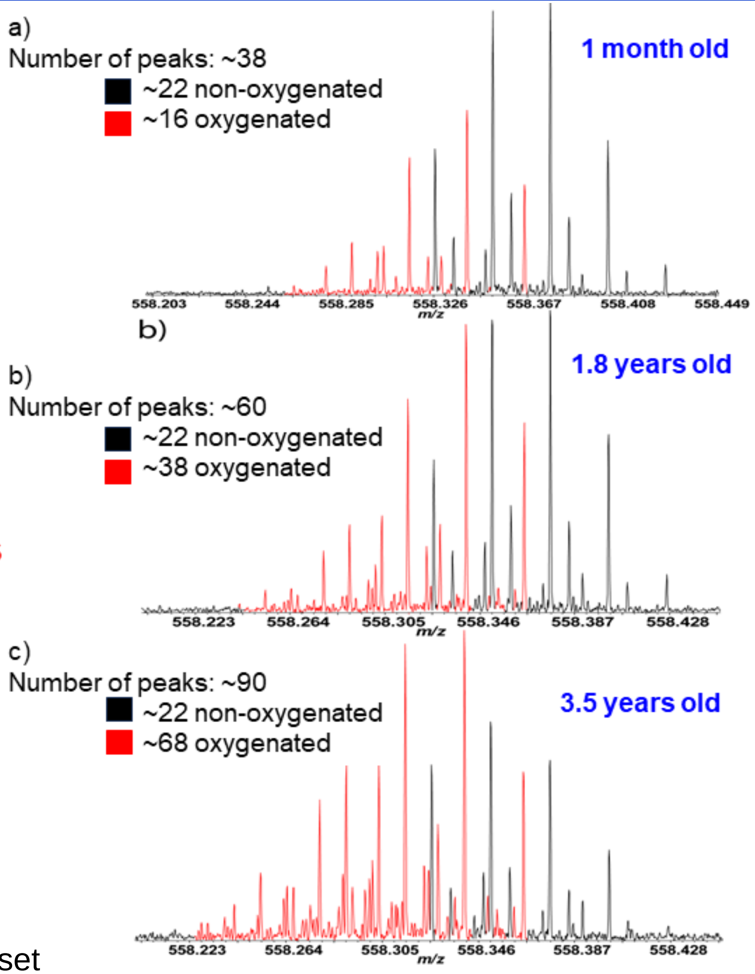


Figure: Mass spectrum of the initial sample extracted in methanol, with mass-scale zoom inset at *m/z* 536 (left) and mass-scale zoom insets at *m/z* 558 after **a)** one month, **b)** 1.8 years, and **c)** 3.5 years. Note growth in number of oxygenated species with reaction period (in red).

Facilities used: Ion Cyclotron Resonance facility, 21T FT ICR-MS Magnet

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