Theoretical investigation of low-energy glycine formation and spectral masking in star-forming regions

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The search for amino acids in the interstellar medium (ISM) has long motivated studies on the astrochemical origins of life. While glycine, the simplest amino acid, has been identified in meteorites and comets[1–3], its unambiguous detection in star-forming regions remains elusive[4,5]. In this presentation, I will introduce a theoretical approach where we employ quantum chemical simulations to investigate glycine formation on bare silicate grains—uncovered after water-ice sublimation during warm stages (>150 K) of star formation. Our results show that the classical Strecker-type synthesis is hindered by high activation barriers, rendering it inefficient under astrophysical conditions. Instead, we identify a low-energy, surface-induced neutral pathway involving formaldehyde, CO, and NH_3, which yields glycine in a spontaneous, exoergic process on forsterite (Mg_2SiO_4) surfaces. The formed glycine is strongly stabilized (binding energies >70 kcal mol^{-1}), preventing thermal desorption and favoring retention in dust aggregates and parent bodies. Moreover, vibrational analyses reveal that surface-bound glycine exhibits suppressed and shifted IR features compared to its gas-phase counterpart, providing a possible explanation for its persistent non-detection in astronomical surveys. These findings uncover a silicate-mediated route for glycine formation that links interstellar chemistry with the inventory of prebiotic organics delivered to planetary systems.

References

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