Formamide production during dust grain impacts

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Thus far, amino acids have not been identifi ed in the ISM. However, a few species with the peptide moiety have been detected (e.g., formamide, NH2CHO) , perhaps the most important for proteins. The role played by formamide in the emergence of terrestrial life is one of the hottest subjects of contemporary research on the origins of life (e.g. Saladino et al. 2015 and Becker et al. 2016). While formamide is readily formed in interstellar ice analogs (e.g., Jones et al. 2011, and references therein), its gas-phase synthesis has also been suggested (Kahane et al. 2013; Barone et al. 2015). Possible support for this new chemical scenario may come from the observations of formamide emission in a shocked region around a solar-type protostar (Codella et al. 2017). However, Quénard et al. (2018) have shown that either gas-phase formation or grain surface synthesis may dominate depending on the physical conditions of the source. Consequently, both formation routes may possibly co-exist. This makes dust-related chemistry a very lively area of current research.

Here we report on a study, based on the multi-scale shock-compression technique combined with ab initio molecular dynamics approaches, where the shock-wave-driven chemistry of mutually colliding isocyanic acid (HNCO) containing icy grains has been simulated by first principles. At the shock-wave velocity threshold triggering the chemical transformation of the sample (7 km/s), formamide is the first synthesized species, thus being the springboard for the further complexification of the system. Also, upon increasing the shock impact velocity, formamide is formed in progressively larger amounts. More interestingly, at the highest velocity considered (10 km/s), impacts drive the production of diverse carbon– carbon bonded species. In addition to glycine, the building block of alanine (i.e., ethanimine) and one of the major components of a plethora of amino acids including, e.g., asparagine, cysteine, and leucine (i.e., vinylamine), have been detected after shock compression.

Conversion from chemical simplicity to chemical complexity can thus occur very rapidly within the transient events following catastrophic impacts.

References

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