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Formation of molecules on cosmic dust grains: a laboratory view

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Molecular ices covering dust grains are known to be a source of molecules, including complex organic molecules (COMs), in the interstellar medium (ISM) and circumstellar shells and disks, the molecules, which cannot be created via gas phase reactions. Studying the formation of COMs is crucially important to understand the processes that lead to stars and planets formation, and to understand a degree of molecular complexity on planetary bodies, which can shed some light on the origin of life on Earth. Many laboratory experiments have been performed on the formation of simple and complex molecules, including amino acids, in interstellar and circumstellar ice analogues by a number of triggering processes, such as UV and X-ray irradiation, bombardment by energetic particles and atom addition. But a major part of the laboratory work deals with molecular ices covering standard substrates not related to the cosmic dust. The dust grain surface can participate in ice chemistry and can alter the efficiency of the molecular formation. There is a handful of laboratory works on the formation of molecules in ice-dust systems. Only CO and CO_2 have been synthesized in laboratory cosmic ice-dust analogues up until very recently, when we performed our experiments on the formation of formaldehyde on hydrogenated fullerene-like carbon grains by the O/H atom addition. Our results demonstrate, for the first time, that the bombardment of carbonaceous grains by O and H atoms at low temperatures causes the formation of CO molecules with their further hydrogenation leading to the formation of solid formaldehyde. The formation of H_2CO is an indication for a possible methanol formation route in such systems and CH_3OH, in turn, is well known as a starting point for the formation of more complex organic molecules in the ISM and circumstellar phases.

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