Investigations on IR spectra of astronomically important species using the *para*-hydrogen matrix-isolation technique

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Two types of methods using *para*-hydrogen (*p*-H_2) matrix isolation were employed to prepare species that might be important in astronomy. These species were characterized with infrared (IR) absorption.

(1) The bombardment of *p*-H_2 with electrons produces H_3^+ and H via $H_2 + e^- \rightarrow H_2^+ + 2e^-$ and $H_2^+ + H_2 \rightarrow H_3^+ + H$ reactions. Proton transfer from H_3^+ to species of interest produces mainly protonated and mono-hydrogenated species trapped in a *p*-H_2 matrix. This method has been applied to produce protonated polycyclic aromatic hydrocarbons (designated H^+PAH) and some small molecules. The protonated PAH are potential carriers of the unidentified infrared emission (UIR) bands in interstellar media. Our previous work on protonated pyrene and coronene [1−3] indicates that, as the size of aromatic ring increases, the spectral shifts of IR bands point the direction toward the positions of the UIR bands. When we extended the work to protonated ovalene (7-$C_{32}H_{15}^+$), we found a close resemblance between the laboratory IR spectrum and the UIR emission bands, indicating that H^+PAH can contribute to the UIR emission and protonated ovalene might be an important member of the interstellar PAH inventory [4]. The IR spectra of mono-hydrogenated ovalene 7-$C_{32}H_{15}$ were also identified for the first time.

(2) The N/O chemical network is important in understanding the formation mechanism of amino acids in dark interstellar clouds. We present the results of IR studies on the H + HONO reactions in solid *p*-H_2 at 3.3 K. Isolated HONO molecules were irradiated with light at 355 nm from a Nd:YAG laser. The photoproduct OH radicals react readily with nearby *p*-H_2 to produce H_2O and mobile H atoms. A few hours after irradiations, we observed absorption lines of products of hydrogenation of HONO: hydroxyl nitroxide HON(O)H, dihydroxyloamino radical HONOH, and dihydroxyl amine HONHOH. The spectral assignments were based on comparison with calculated vibrational wavenumbers and IR intensities, and were further confirmed with the observed isotopic ratios for D/H and N^{15}/N^{14} species that were in agreements with predicted values. The formation mechanism including tunneling reactions of H + HONO and other secondary reactions will be discussed. The presented results show some new reaction paths which might lead to formation of prebiotic molecules in the dust grains in interstellar medium.

References

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