Ammonia formation by the successive hydrogenation of N atom trapped solid N_2 at low temperature

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A high abundance of ammonia molecules (NH_3) has been observed in the gas phase but also solid phase in molecular clouds. In the gas phase reaction, the combination process of the successive H atom abstraction reactions

$$N^+ + H_2 \rightarrow NH^+ + H$$
$$NH^+ + H_2 \rightarrow NH_2^+ + H$$
$$NH_2^+ + H_2 \rightarrow NH_3^+ + H$$
$$NH_3^+ + H_2 \rightarrow NH_4^+ + H$$

and the dissociative recombination reaction

$$NH_4^+ + e^- \rightarrow NH_3 + H$$

has been proposed as the formation process of NH_3. However, it was indicated that this process is inefficient especially in cold molecular clouds [1], because the first abstraction reaction were reported to the endothermic reaction [2,3]. In the gas-grain reactions, the successive hydrogenation of N atom

$$N \xrightarrow{+H} NH \xrightarrow{+H} NH_2 \xrightarrow{+H} NH_3$$

has been proposed. Since the grain (solid) surface performs as the third body and adsorbs excess energy of the chemical reactions, these simple addition reactions can proceed. In addition, these reactions are predicted the fast reactions due to the radical-radical reaction. Thus, it has been expected that the high abundance of NH_3 requires the synthesis on the grain surfaces. However, the formation of NH_3 by the surface reactions has been little conducted quantitatively.

We performed the experiments of the NH_3 formation by the H atoms exposure of N atoms in solid N_2 at 10 K. The formed NH_3 was observed by the Fourier transform infrared absorption spectrometry. We will discuss the formation mechanism of NH_3 on/in solid N_2 at low temperature.

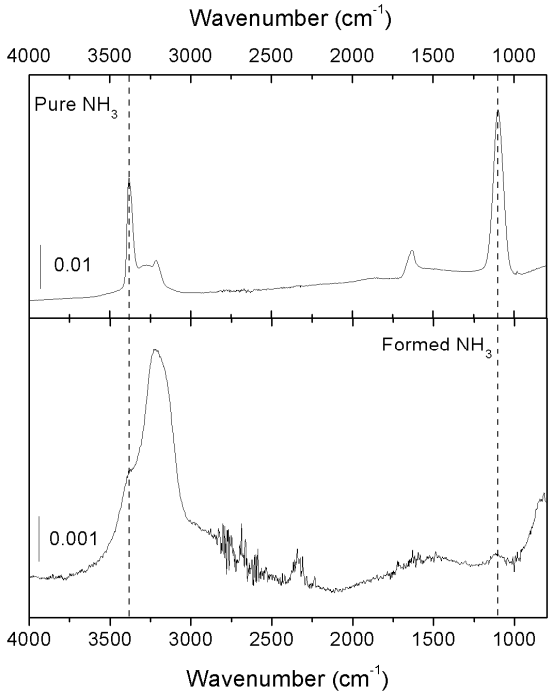

Figure 1: (*top*) Infrared absorption spectra for reference of solid NH_3 at 10 K. (*bottom*) Absorption spectra of the formed NH_3 by the H atoms exposure of N atoms in solid N_2 at 10 K. Dashed lines indicate the identified absorption bands of NH_3.

References

[1] E. T. Galloway & E. Herbst, 1989, Astron. Astrophys. 211, 413.

[2] J. B. Marquette, B. R. Rowe, G. Dupeyrat, & E. Roueff, 1985, Astron. Astrophys. 147, 115.

[3] Su-hong Ge, Xin-lu Cheng, Xiang-dong Yang, Zi-jiang Liu, & Wei Wang, 2006, Icarus 183, 153.