Quantitative analysis for the branching ratio of CH_3O and CH_2OH radicals formed from CH_3OH + OH reaction on ice surface

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Complex organic molecules (COMs) with CH_3O incorporated into their structure, such as methyl formate ($HCOOCH_3$) and dimethyl ether (CH_3OCH_3), have been found in various astronomical objects including cold molecular clouds. For these COMs formation, radical reactions on the surface of interstellar dust would play an important role. Recent experiment suggested that the surface reaction of methanol and OH formed promotes the formation of CH_3O-bearing COMs on ice [1]. That is, of the following two reactions, the branch to CH_3O radical formation would be the major.

$$CH_3OH + OH \rightarrow CH_3O \text{ and/or } CH_2OH + H_2O$$

However, while this reaction in the gas phase has been extensively studied [2, 3], little information is available for that on ice surfaces. Since information of branching ratios is needed for constructing better chemical evolution models, we measured the branching ratio of CH_3O and CH_2OH produced by CH_3OH + OH reaction on water ice surface at 10 K.

For trace radical detection, we used a newly developed high-sensitive "Ion Pickup" apparatus. In this method, low-energy Cs^+ ions (~20 eV) nondestructively pickup adsorbates on the ice surface. The adsorbate was then detected as a Cs^+-molecule complex in a quadrupole mass spectrometer, and its mass number was obtained by subtracting the Mass 133 of Cs [1, 4]. Thanks to our various improvements, this apparatus has a sensitivity of ~0.0001-0.001 ML, which is much higher than conventional methods like FT-IR.

The experimental procedure of present study is shown in Figure 1. We first prepared OH radicals on ice surface by UV irradiation at 30 K, where most H atom did not remain on the surface. Then, after UV was turned off, the reaction was triggered by depositing methanol on the ice at 10 K. The radicals formed by this procedure were monitored using Ion Pickup. We also performed experiments with isotopologues (CH_3OD and CD_3OH) to distinguish the products of CH_3O and CH_2OH. Quantitative analysis shown the branching ratio (CH_3O/CH_2OH) of 4.3 ± 0.6 (i.e., CH_3O ~ 80 %) [5].

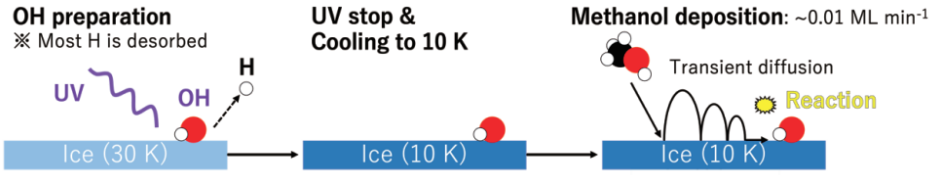

Figure 1: Experimental procedure for the reaction of methanol and OH on ice surface

References

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