# Origin and fate of interstellar sulfur-bearing molecules: a solid-state laboratory perspective

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The chemical network governing interstellar sulfur has been the topic of unrelenting discussion for the past decades due to the conspicuous discrepancy between its expected and observed abundances in different interstellar environments. Carbonyl sulfide (OCS) is particularly relevant since it is a major carrier of gaseous sulfur and is one of the only two sulfurated molecules detected in interstellar ices to date. Hydrogen sulfide ($H_2S$) is another riveting case, whose efficient formation on interstellar dust grains contrasts with its observationally constrained upper limit. More recently, the astronomical detections of ethanethiol ($CH_3CH_2SH$) and thioketene ($CH_2CS$) highlighted the importance of interstellar formation routes to more complex sulfur-bearing organic molecules.

In this presentation, we showcase laboratory experiments of solid-state chemistry in interstellar ice analogues that allow us to explore potential formation and destruction mechanisms for sulfurated species in space. We investigate the chemical network initiated by the interaction between $C_2H_2$ molecules and SH radicals at 10 K, both thought to be present in interstellar icy mantles (Figure 1a). We also expand on recent literature[1,2] and directly quantify $H_2S$ ice destruction mechanisms (Figure 1b), as well as explore a particularly promising pathway to OCS in interstellar ices. We confirm that SH radicals can kick-start a prolific sulfur reaction network under interstellar-cloud conditions leading to the sulfurated products $CH_3CH_2SH$, $CH_2CHSH$, $HSCH_2CH_2SH$, $H_2S_2$, OCS, and tentatively $CH_3CHS$ and $CH_2CS$. Complementarily, we utilize computational calculations to pinpoint the reaction routes that play a key role in the chemical network behind our experiments. These results contribute to elucidating the still elusive origin and fate of interstellar sulfur-bearing molecules.

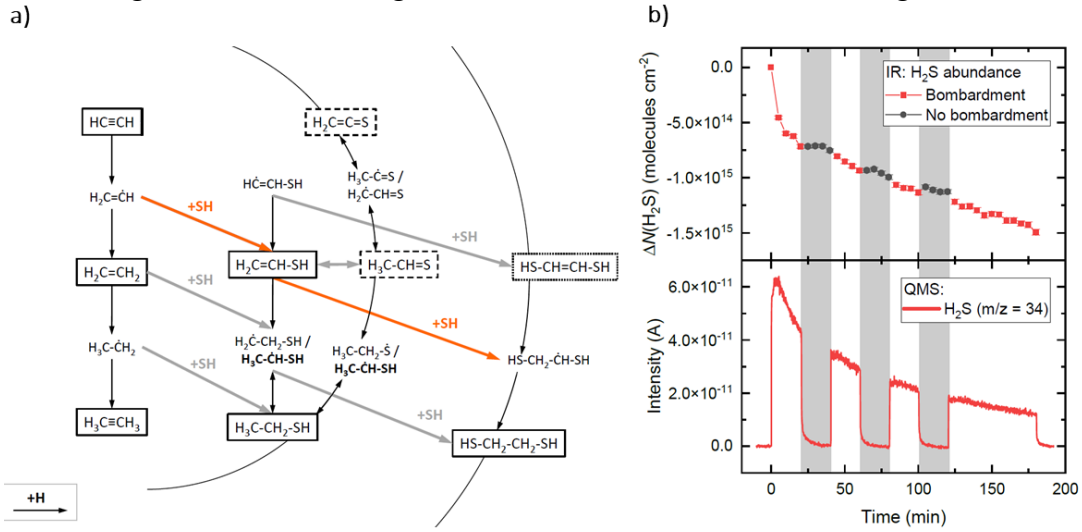


**Figure 1:** a) Ice chemical network probed by the $C_2H_2$ + HS experiments at 10 K. b) $H_2S$ ice destruction due to chemical desorption and chemical conversion upon H atom exposure.

[1] Oba, Y.; Tomaru, T.; Lamberts, T.; Kouchi, A.; Watanabe, N. An infrared measurement of chemical desorption from interstellar ice analogues. *Nat. Astr.* **2018**, *2*, 228.
[2] Nguyen, T.; Oba, Y.; Sameera, W. M. C.; Kouchi, A.; Watanabe, N. Successive H-atom Addition to Solid OCS on Compact Amorphous Solid Water. *Astrophys. J.* **2021**, 922, 146.