Carbon Chain and CO_2 Formation Induced by EUV Irradiation: Thickness and Hydrogenation Effects in Water-Ice Covered Dust

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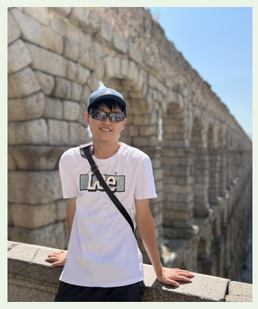


Introduction

Carbonaceous dust is one of the major component of interstellar grains and serves as a reservoir of pristine molecules in star-forming regions. However, The interaction between porous carbon dust and the overlying H_2O ice remains unclear. Variations in surface structure and chemical composition may further influence this ice–dust interface under stellar radiation. This work shows that ice–dust interface reactions play an important role in molecular formation in space.

Experiment Information

- **Dust**: amorphous carbon (a-^{13}C) and hydrogenated amorphous carbon (a-^{13}C:H) produced by gas quenching of laser-ablated **^{13}C** graphite target.
- **Irradiation:** EUV-photon irradiation (30-94 nm) of water ice (~400 ML) deposited over selected carbon dust grains with varying thickness and hydrogen content.
- **Goal:** Quantification of the **$^{13}CO_2$** formation efficiency at the ice-dust interface.

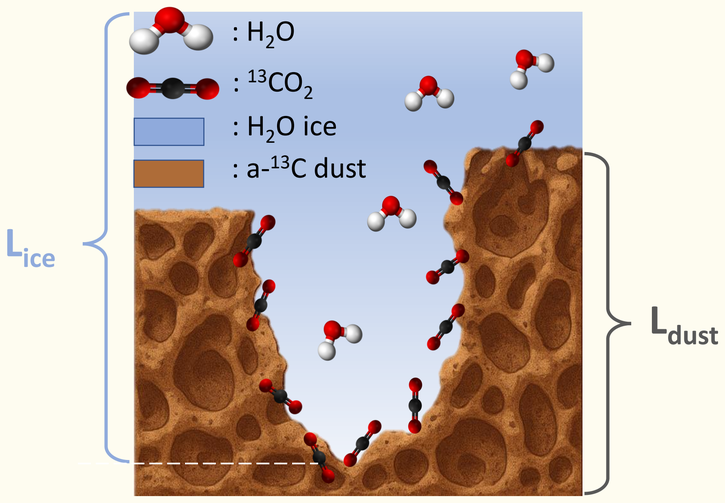


Figure 1. Model of water-covered carbon dust grain.

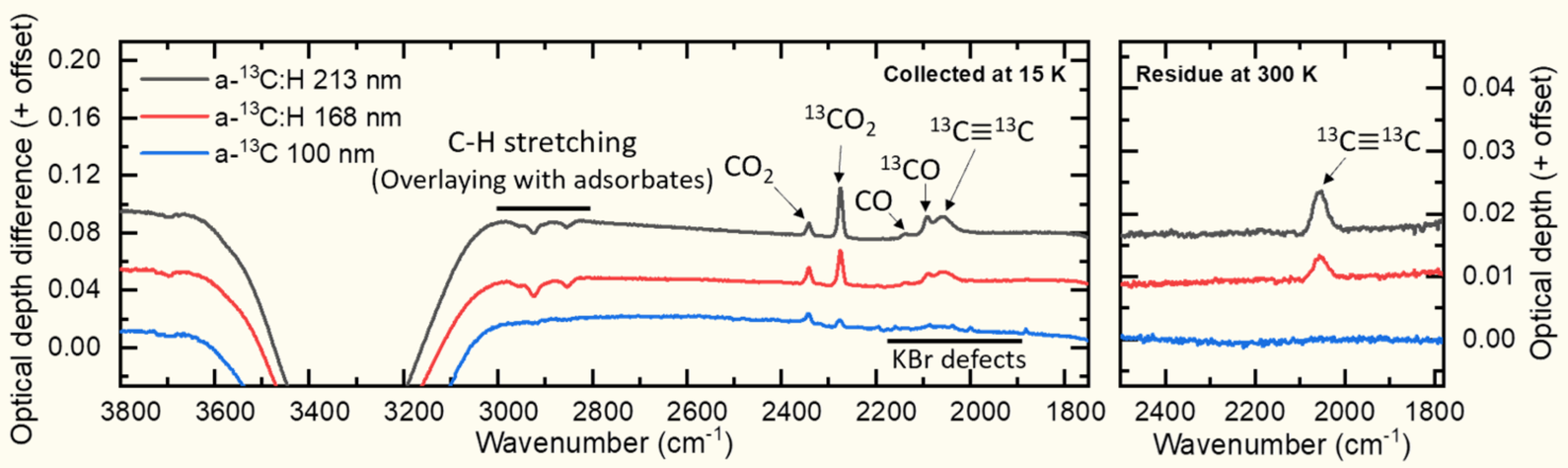


Figure 2. (a) IR difference spectra upon EUV irradiation of H_2O ice on a-^{13}C and a-^{13}C:H dust at 15 K for 60 minutes, (b) IR residual spectra obtained at 300 K after the EUV irradiation experiment.

Photoproduct ^{13}CO vs. $^{13}CO_2$

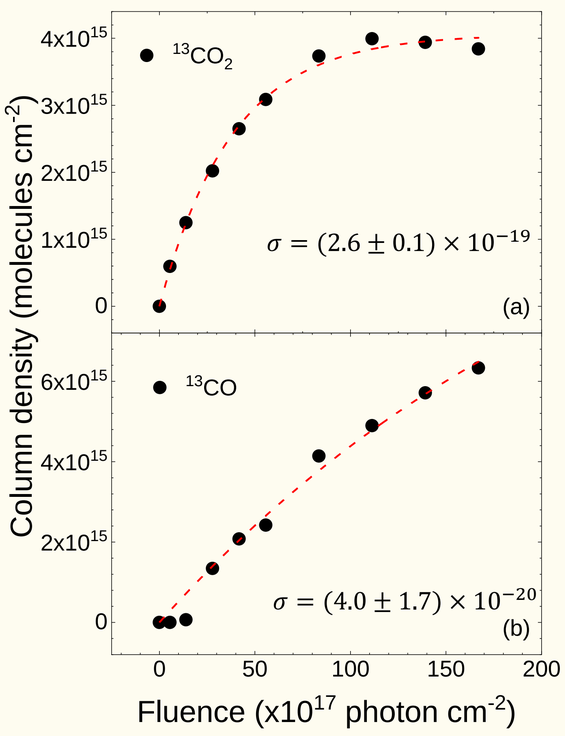
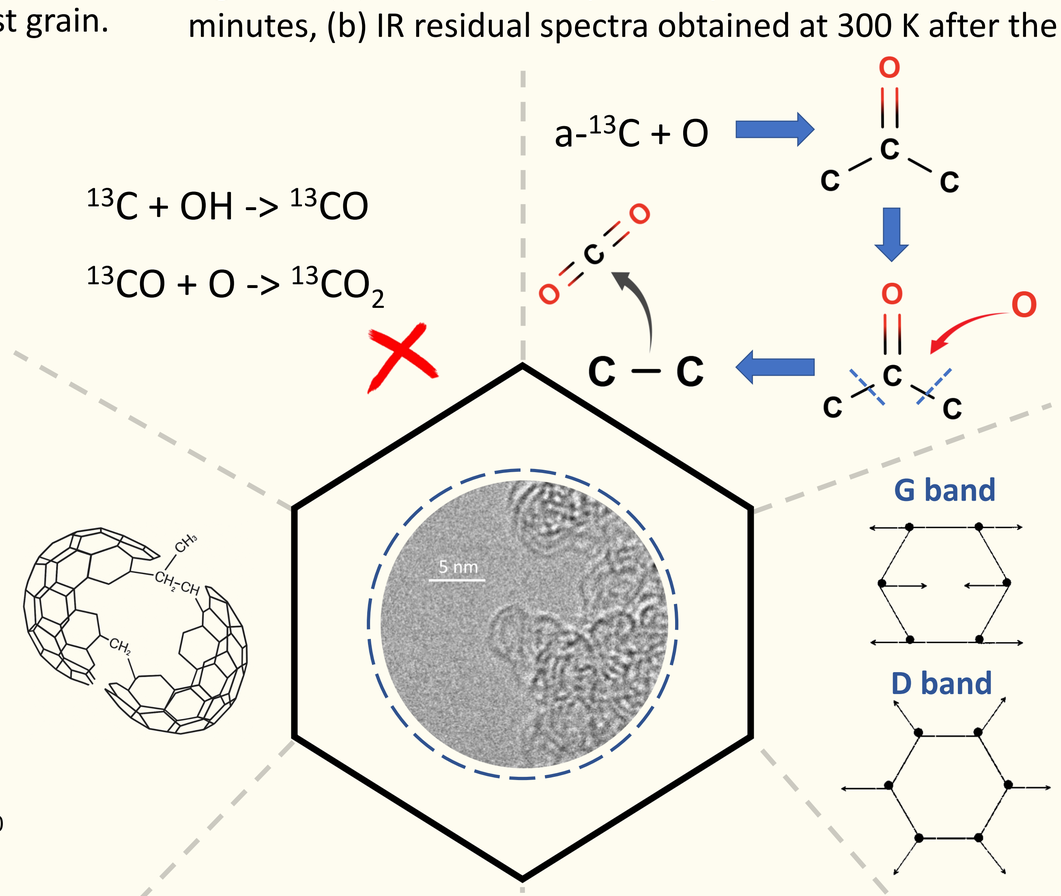


Figure 3. Formation curves of (a) $^{13}CO_2$ and (b) ^{13}CO upon EUV irradiation on a-^{13}C:H dust (168 nm).



Raman spectra

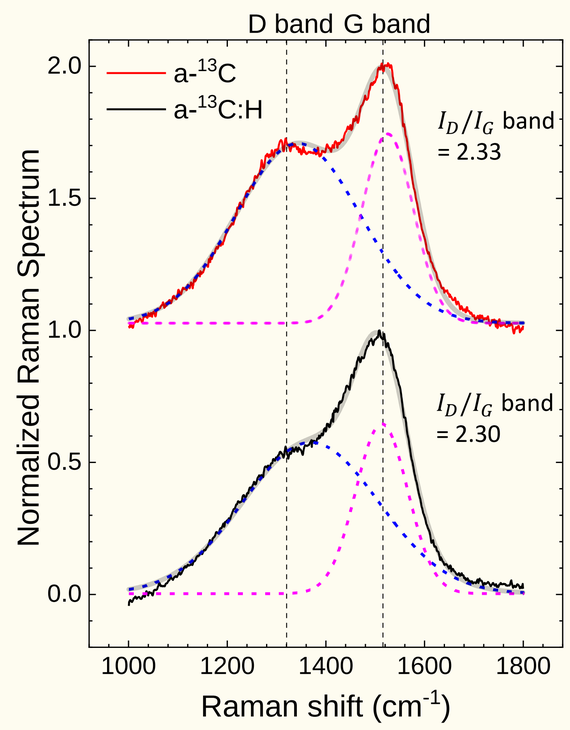
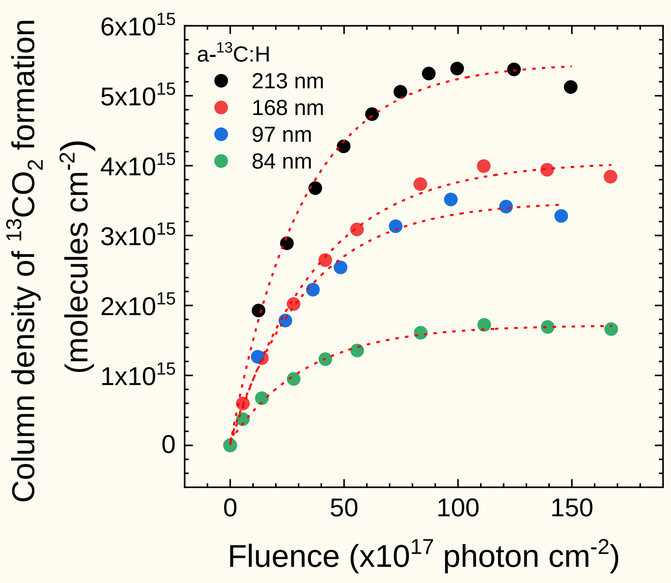
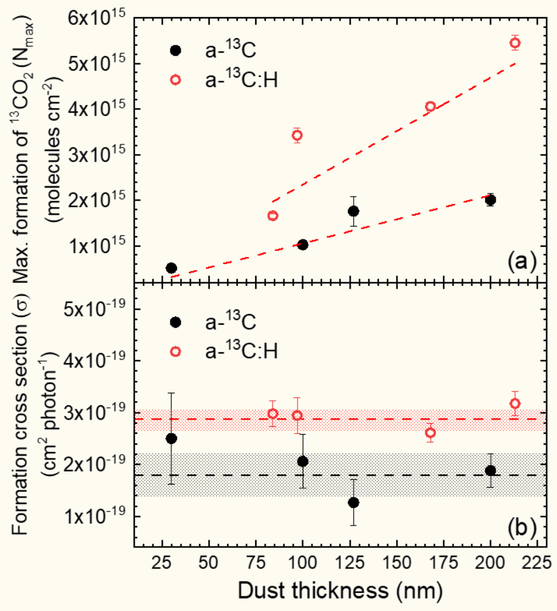


Figure 4. Normalized Raman spectra of fresh a-^{13}C and a-^{13}C:H dust.

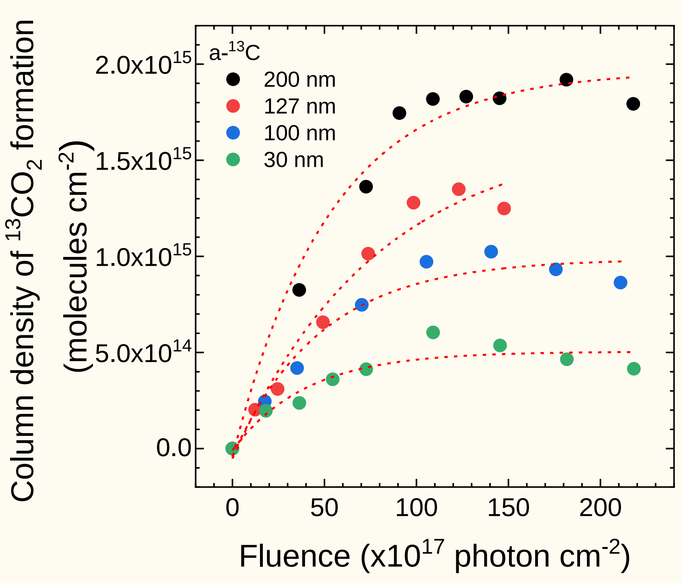
Formation on a-^{13}C:H dust



Fitting-derived parameter



Formation on a-^{13}C dust



Conclusion

- On a **porous carbonaceous dust**, the $^{13}CO_2$ formation is **strongly associated with interfacial sites** between the ice layer and the dust substrate and **a-^{13}C:H dust** offer **more reactive surface sites**, leading to higher $^{13}CO_2$ formation yield.
- **EUV irradiation induces $^{13}C\equiv^{13}C$ bond** signatures on amorphous carbon, suggesting structural reconfiguration of the carbon network and providing an alternative pathway to explain the observed triple-bond-bearing species in the protoplanetary disk. (e.g. C_2H_2, C_3H_4 and C_4H_3).

Reference

[1]: Jäger, C., *Astrophysical Journal,* 696 (2009): 706-712. [2]: Lee, C.-Y., *Astrophysical Journal, (submitted)*

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