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Reply to the ‘Comment on the “Reaction intermediates recognized by *in situ* FTIR spectroscopy in CO₂ hydrogenation over the Cu/ZnO/SPP-zeolite catalyst”’ by Comment author F. C. Meunier, *RSC Appl. Interfaces*, 2025, 2, <https://doi.org/10.1039/D5LF00014A>

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We agree with Professor Meunier’s comment that the two IR peaks at 2075 and 2060 cm⁻¹ belong to CO₂ in the cell in the gas phase, and not to Cu–C=O. We sincerely appreciate his insightful correction. The correction and conclusion related to the original paper are discussed.

We have re-examined the spectra in question, and agree with Professor Meunier’s comment that the two IR peaks at 2075 and 2060 cm⁻¹ belong to CO₂ in the cell in the gas phase, and not to Cu–C=O.

Consequently, the text on the interpretation of these peaks should be corrected. And the discussion on the carbonyl adsorbates should focus only on the absorption bands around 1900–2000 cm⁻¹, which represent the bridged and linear C=O on Cu or ZnO surfaces.^{1,2}

In the most efficient catalyst CuZn-SPP-E (Fig. 4), these peaks built up to a barely perceptible level within 5 minutes upon contact with the CO₂ stream. And in the reactive stream of CO₂ + 3H₂, the ad-species were rapidly and completely consumed. In contrast, in the less active catalyst CuZn-SPP, which has larger Cu particles (Fig. 5), these bands were strong and persisted throughout the reactions. This fact that significantly larger amounts of carbonyl species form on the larger Cu particles and are slowly converted was one of the phenomena associated with the low activity.

The corrected interpretation of the IR bands therefore does not contradict the main conclusion of the work, that CuZn-SPP-E can maintain a constant carbonate coverage and low water adsorption during the catalytic reaction. Intermediates related with the hydrogenation processes, such as adsorbed carbonyl and formate species, are turned over very rapidly.

We sincerely appreciate Professor Meunier’s insightful correction.

Data availability

The data supporting this article have been in the original paper and related ESI, including the preparation and characterization of the starting SPP zeolite, and additional *in situ* FTIR and quasi-*in situ* XPS spectra recorded in various reactive flows. Further details are available from the authors upon request.

Conflicts of interest

There is no conflict of interest.

References

- 1 F. C. Meunier, Hydrogenation of CO and CO₂: Contributions of IR operando studies, *Catal. Today*, 2023, **423**, 113863.
- 2 E. Shaaban and G. Li, Probing active sites for carbon oxides hydrogenation on Cu/TiO₂ using infrared spectroscopy, *Commun. Chem.*, 2022, **5**, 32.

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