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Application Note

Dynamic Gas-Solid Surface Interactions for Dry Reforming of Methane via In-Situ DRIFTS Analysis

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In this note: monitoring surface species on a nanorod catalyst for dry reforming of methane.

Dry reforming of methane (DRM) is a key process for converting CH_4 and CO_2 into valuable syngas (CO and H_2) [1–3]. Understanding gas-solid surface interactions during DRM is essential for the rational design of catalysts.

Here, in-situ Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFTS) using the Harrick Praying Mantis™ accessory and a High-Temperature Reaction Chamber (HVC-DRM-5) is employed to track surface species on a 1.5 wt% Ni–0.5 wt% Ru/ CeO_2 nanorod (NR) catalyst over a temperature range of 50 °C to 450 °C.

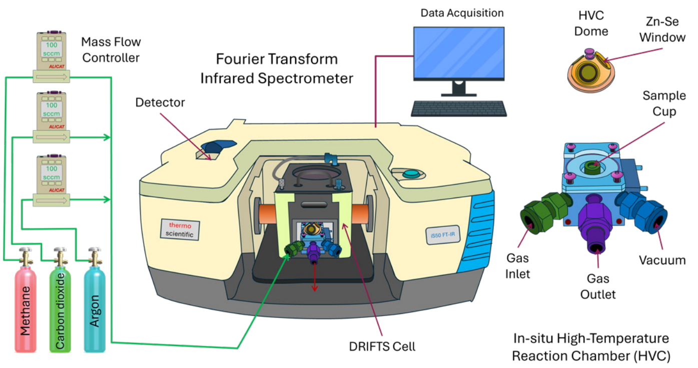

Figure 1: Experimental setup for In-Situ DRIFTS using a Harrick Praying Mantis Cell and High-Temperature Reaction Chamber.

Experimental

Catalyst Preparation: The 1.5 wt% Ni–0.5 wt% Ru/CeO_2 NR catalyst was synthesized via a one-pot hydrothermal method, ensuring uniform dispersion of Ni–Ru on the CeO_2 NR supports.

Instrumentation: In-situ DRIFTS was performed with the Harrick Praying Mantis diffuse reflection accessory along with a High-Temperature Reaction Chamber, integrated into a Thermo Fisher Nicolet iS50 FTIR system (Fig. 1), providing precise temperature and gas flow control for real-time monitoring of surface gas-solid reactions.

Reaction Conditions: A CH_4/CO_2 gas mixture (29:71 ≈ 0.4 ratio) was fed at a total flow rate of 100 sccm. The temperature was ramped from 50 °C to 450 °C at 10 °C/min, with spectra collected every 50 °C after stabilizing the gas flow and temperature for 15 min.

Results and Discussion

The DRIFTS spectra of the 1.5 wt% Ni–0.5 wt% Ru/CeO_2 NR catalyst during DRM reveal several changes in surface reaction intermediates (Fig. 2). The key observations are summarized below.

- At 50 °C, CO_2 adsorbs on the catalyst surface as various carbonate species (Fig. 2(a)) [4,5].
- Beginning at 300 °C, the bidentate carbonate species (~1020 cm^{-1}) begin to convert into monodentate carbonate species (~1078 cm^{-1}), indicating the progression of the reaction [5].
- In the CO region (Fig. 2(b)), several peaks emerge [6], with pronounced changes observed from 300 °C onward. As the temperature increases, the intensity of the adsorbed CO peaks grows, and gaseous CO peaks (~2120 and 2170 cm^{-1}) appear at 450 °C, signifying weakened CO adsorption and the release of CO gas.

These observations provide valuable insight into molecular bond transformations involved in the reaction mechanism. Further analysis of in-situ DRIFTS data will offer a deeper understanding of gas-solid interactions and gas-gas conversions at elevated temperatures.

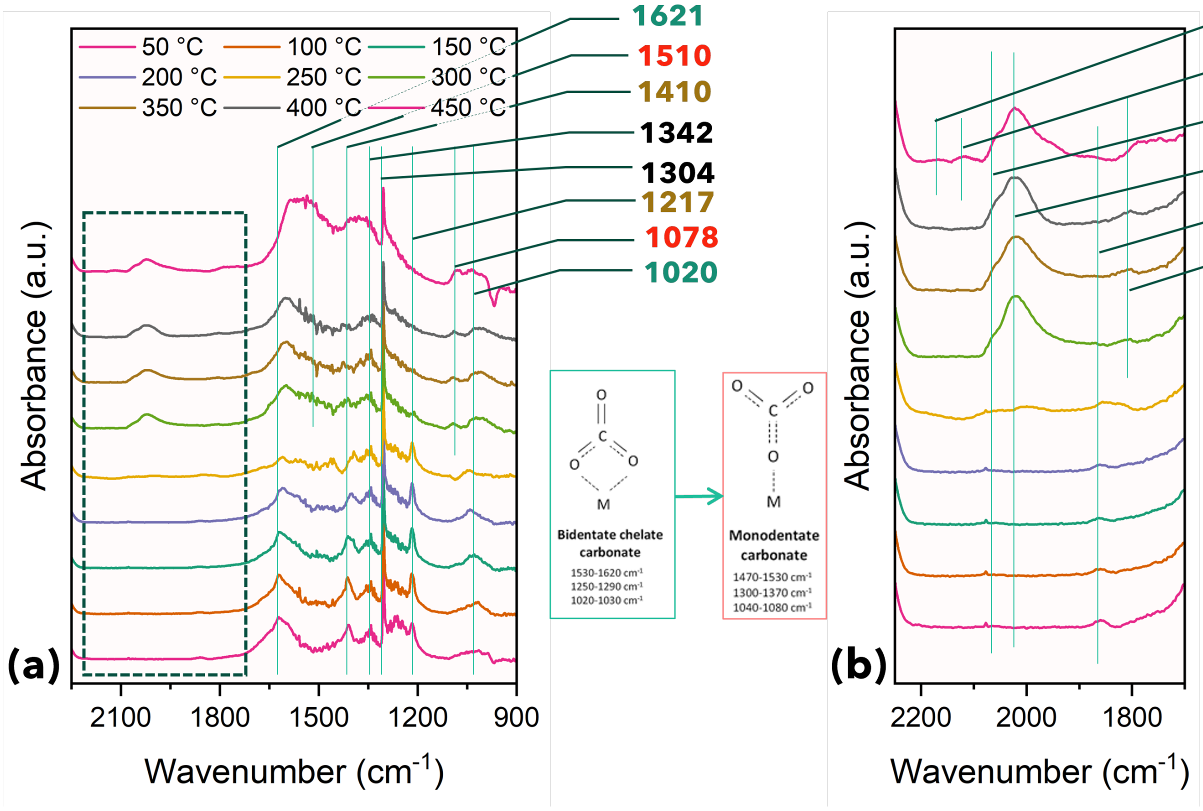

Figure 2: In-Situ DRIFTS spectra for DRM at varying temperatures (CH_4/CO_2 = 29/71 sccm ≈ 0.4 ratio; total flow rate: 100 sccm).

Conclusion

The in-situ DRIFTS investigation with the Harrick Praying Mantis setup revealed the evolution and transformation of surface species during DRM on Ni–Ru/CeO_2 NRs. The findings demonstrate the power of in-situ DRIFTS's ability to elucidate catalytic mechanisms and highlight the promising performance of this catalyst for DRM.

Acknowledgement

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