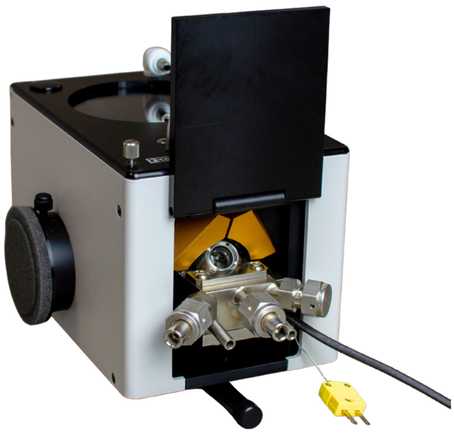
AN-21183
Application Note

High-Temperature DRIFTS and Raman Studies of CO2 and Methane Conversion Catalysts for Electrochemical Cells Using Harrick Scientific Products DRIFTS Chamber

In this note: Understanding the catalytic mechanisms for CO_2 and methane conversion in high-temperature electrochemical cells, such as protonic ceramic electrochemical cells (PCECs) and protonic ceramic fuel cells (PCFCs), is critical for improving energy efficiency and mitigating greenhouse gases. The use of in situ Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFTS) is a powerful tool for probing the surface reactions on catalysts in real-time under operating conditions. This application note discusses the use of Harrick Scientific Products' high-temperature DRIFTS chamber in combination with recent catalytic research on CO_2-to-CO conversion and methane reforming, focusing on key experiments that shed light on catalytic behavior at elevated temperatures.



Praying Mantis™ Diffuse Reflection Accessory

Catalytic Conversion in High-Temperature Electrochemical Cells

In high-temperature electrochemical cells, catalysts facilitate the conversion of CO_2 and methane into valuable chemicals, such as CO and hydrogen, and suppress unwanted side reactions. Recent research has focused on optimizing the electrodes in these cells to selectively convert CO_2 to CO without forming methane, as well as reforming methane (CH_4) into syngas (a mixture of CO and H_2). Protonic ceramic fuel cells (PCFCs) and protonic ceramic electrochemical cells (PCECs) operating between 400 °C and 650 °C have demonstrated high selectivity in these conversions when equipped with specially designed catalysts [1–4].

The Role of Harrick's High-Temperature DRIFTS Chamber

The Harrick Scientific Products high-temperature DRIFTS chamber enables in situ analysis of surface reactions under realistic operating conditions, providing insights into the mechanisms of catalyst activation and product formation. For CO2 and methane conversion catalysts, DRIFTS allows the observation of reaction intermediates, which are critical for improving selectivity and catalytic efficiency in electrochemical cells.

Recent work employed the DRIFTS chamber to study CO2 conversion mechanisms on novel Ni-Fe alloy catalysts. Using DRIFTS, the selective CO2-to-CO conversion process was traced through the identification of intermediate species, such as bicarbonates and carbonates, at different temperatures and gas compositions. For example, in a 2022 study [5], an in situ DRIFTS analysis revealed that a rationally designed Sr2Fe1.4Mo0.5Ni0.175O6-δ-Ni0.175 (SFM-Ni0.175) catalyst prevented the formation of methane by inhibiting formate intermediates, which are precursors to methane formation, thus promoting almost exclusive CO production.

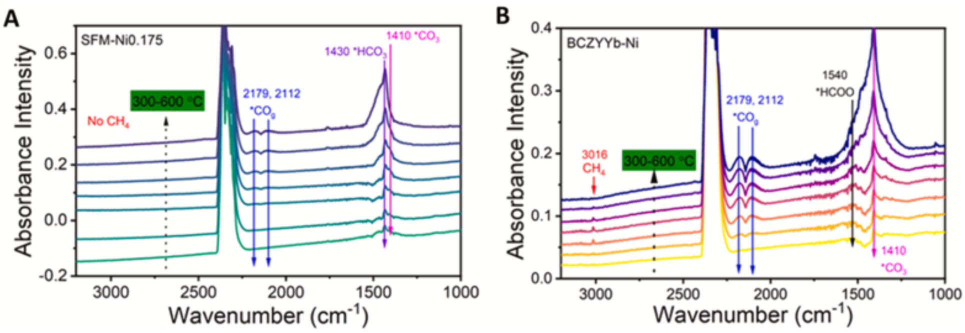


Figure 1: *In situ DRIFTS spectra of CO2 reduction over (A) SFM-Ni0.175 and (B) BCZYYb-Ni cermet negative electrode. Both samples were reduced at 600 °C for 2 h and cooled down to 25 °C under H_2 [3].*

High-Temperature DRIFTS and Raman in Methane Dry Reforming

In a 2023 study [4], the Harrick DRIFTS chamber was applied to investigate the dry reforming of methane (DRM) over a protonic ceramic fuel cell. This process, which simultaneously mitigates two major greenhouse gases—CO_2 and CH_4—converts them into syngas. The DRIFTS analysis identified key intermediate species such as monodentate carbonates and formyl groups, which played a crucial role in the catalytic pathway. The high-temperature DRIFTS measurements at 650°C provided real-time spectral data that enabled the optimization of a Ni-Ru catalyst, improving coking tolerance and DRM activity.

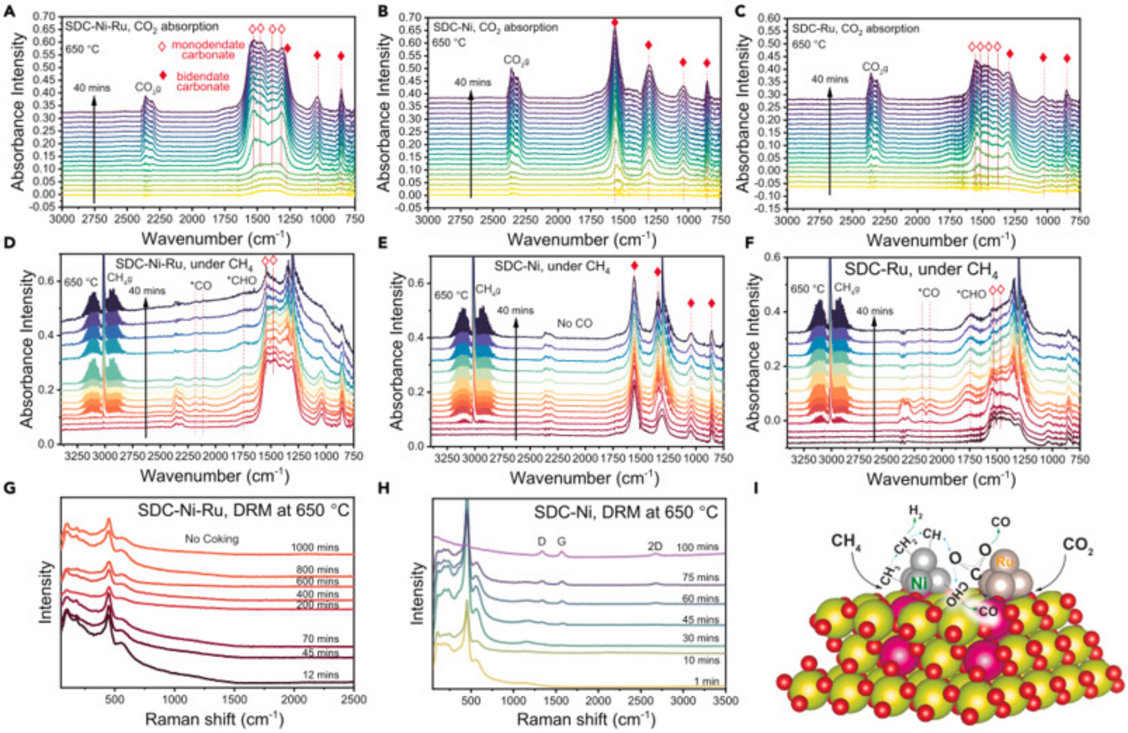


Figure 2: *In situ DRIFTs and Raman spectroscopy to probe the intermediate species and coking tolerance for DRM [4].*

Conclusions

The high-temperature DRIFTS chamber from Harrick Scientific Products has proven to be an invaluable tool in studying catalytic reactions at elevated temperatures relevant to CO_2 and methane conversion in electrochemical cells. Through this research, in situ DRIFT spectroscopy has revealed critical details about reaction mechanisms, enabling the design of more efficient and selective catalysts for high-temperature applications. These insights have significant implications for reducing greenhouse gas emissions and advancing energy storage technologies.

Contact us today

Reach out to us any time for more information on the application described in the text above or visit our website **harricksci.com** to read more and make an enquiry.

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