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CO_2 Hydrogenation to Synthetic Fuels Using a Multifunctional Catalyst

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ABSTRACT

Anthropogenic CO_2 emissions are a principal driver of climate change, and their catalytic conversion via the reverse water-gas shift (RWGS) reaction represents a key enabling step within the carbon capture and utilisation (CCU) framework. RWGS converts CO_2 and H_2 to CO and H_2O, generating a syngas stream suitable for downstream fuel synthesis. Achieving high CO_2 conversion and CO selectivity under industrially relevant conditions requires catalysts with strong basicity for CO_2 activation, sufficient reducibility for active phase formation, and thermal stability. This work presents the design and synthesis of a multifunctional catalyst system for RWGS, comprising a metal oxide-supported active phase selected to provide the requisite basicity, reducibility, and stability, with the potential for integration into a broader single-reactor CO_2-to-fuel system. Catalyst synthesis was performed by wet impregnation and incipient wetness impregnation, with the effect of synthesis route on metal dispersion, crystallite size, and textural properties assessed via N_2 physisorption (BET), X-ray diffraction (XRD), CO_2-TPD, NH_3-TPD, and Raman spectroscopy. H_2 temperature-programmed reduction (H_2-TPR) was used to identify key reduction events and establish pre-reduction conditions for selective catalyst activation. Catalytic performance under RWGS conditions is currently being investigated, with CO_2 conversion, CO selectivity, and stability expected to be characterised as a function of catalyst composition and synthesis route. This work aims to contribute to the development of efficient RWGS catalysts as a foundation for scalable CO_2 conversion using renewable H_2.

KEY WORDS

CO_2 conversion; reverse water-gas shift; syngas; carbon capture and utilisation; multifunctional catalyst

BIOGRAPHY

Akshaya Anil Sheeba is a Higher Degree by Research Scholar at WASM-MECE, Curtin University, specialising in heterogeneous catalysis for CO_2 valorisation. She holds a Bachelor of Technology (Hons) in Chemical Engineering with a Minor degree in Metallurgy . Her current research focusses on the design and synthesis of multifunctional catalysts for CO_2 conversion via the reverse water-gas shift reaction, with a focus on catalyst activity, selectivity, and stability under industrially relevant conditions. She is supervised by Dr Tejas Bhatelia and Dr Laure Braconnier at Curtin University.

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