Catalytic Reaction Engineering Approaches in Sustainable Low Temperature CO_2 Conversion

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ABSTRACT: Chemical reaction lie at the heart of processes where molecules are transformed from raw materials (waste) to valuable upgrading products. Catalytic reaction engineering is a scientific discipline to bridge the gap between the fundamentals of catalysis and its application in industrial processes which are from a simple reaction between molecules to the economical design of a chemical reactor, kinetics and catalysts are the main key. CO_2 utilization and sequestration are the recent hot issue around the world. High thermal stability of CO_2 molecules, robust nanocatalysts, extreme reaction condition and equilibrium limit created a limitation to have an efficient and less energy consumption CO_2 conversion. Hence, development of highly active and stability of catalysts can assist to overcome this issue. In this work, CO_2 conversion via hydrogenation and methanation reaction will be discussed. This is two-pronged strategy covered CO_2 utilization and H_2 storage. The CO_2 methanation and hydrogenation over 3D materials-based catalysts such as graphitic carbon nitride (g-C_3N_4) and molybdenum disulfide (MoS_2) showed a good reaction performance at relatively low temperature ranging of 120 to 300 °C. While, the promoted catalysts enhanced physical transport and reaction by increasing the number of mesopores, higher degree of dispersion of transition metal nanoparticles, moderate metal-support interaction, and more surface basic sites. In terms of catalytic performance, promoted catalyst exhibited the best CO_2 methanation (X_{CO2} = 83%; S_{CH4} > 99%) and hydrogenation (X_{CO2}= 15-20%; S_{SCCA} >90%. The enhancement of CO_2 adsorption and activation sites by the promoter and 3D materials support could be the key factor for the high catalytic activity of CO_2 conversion at low temperature. The water production as by-products during reaction was identified as a main substance contribute to thermodynamic equilibrium limitation. Therefore, future researches should evaluate catalyst design and reactor modification.