

Reactive CO₂ capture using dual-function catalysts based on zeolitic structures and transition metals

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Background and motivation. The increase in carbon dioxide (CO₂) in the atmosphere, a result of fossil fuels combustion, is a global challenge. This surge in CO₂ levels is causing climate changes directly associated with global warming and ocean acidification. Considering this, there is a growing interest in developing technologies to capture and convert CO₂ into value-added compounds, such as CH₄ and CO. The selectivity of transition metals for these reactions, when combined with zeolite materials, enables their application in heterogeneous catalysis. This study, which evaluates the controlled application of rhodium encapsulated in modified ZSM-5 for the formation of C₁ compounds, presents a novel approach in the field of CO₂ conversion technologies.

Materials and methods. The sodium-exchanged zeolitic support (Na-ZSM-5) was obtained by ion exchange of commercial H-ZSM-5. Rh was deposited into micropores by incipient wetness impregnation in two different weight percentages (0.7 and 1.0 %). Catalysts containing extra-framework sodium were also prepared, firstly by impregnating sodium carbonate, followed by Rh addition. All catalysts were calcined in a static atmosphere at 400 °C for 2 hours. The catalytic tests were carried out at a WHSV of 44 L.g⁻¹.h⁻¹ and temperatures between 300 and 450 °C, in a simultaneous gas feed of CO₂, H₂, and N₂ as internal standard (ratio 1:4:0.5), after reduction in a hydrogen atmosphere at 400 °C. The output stream was analyzed by GC with FID and TCD detectors.

Results and discussion. Figure 1 shows the selectivities achieved for the catalysts at the investigated temperatures. The catalyst containing 0.7% Rh exhibits higher selectivity, which is associated with the presence of single atoms and clusters due to the reduced metal content. Additionally, catalysts with extra-framework Na sites have shown higher selectivity across all temperatures, suggesting that these sites influence the metal structures formed and contribute to relevant reaction pathways. In-situ techniques will confirm the specific metallic structures formed on the catalysts and help clarify how CO₂ is adsorbed at these sites, revealing the preferred reaction mechanisms.

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References

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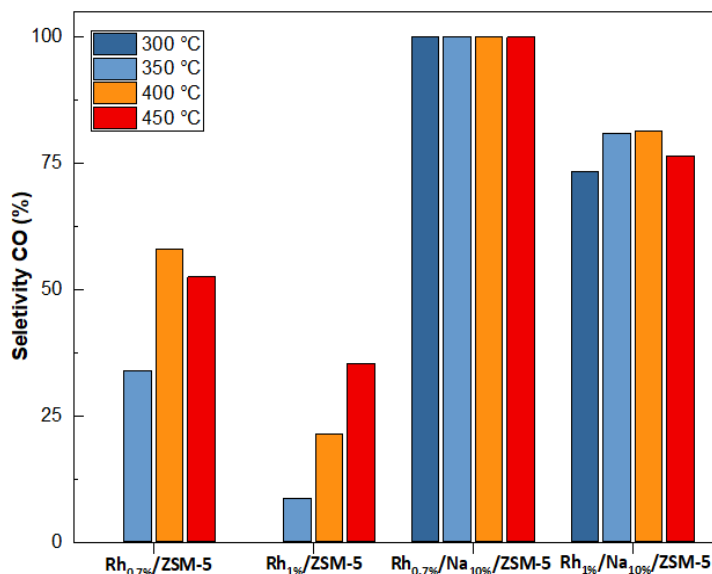


Figure 1. Selectivities of the catalysts studied.