

Confidential

Title: CO₂ Utilization for Renewable Aromatics: Insights, Innovations, and Future Directions

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Abstract: Direct synthesis of aromatics from CO₂ offers a promising route for process intensification, enabling efficient integration and reducing overall investment costs. Our work highlights recent advancements in the direct conversion of CO₂ and green H₂ into renewable aromatic chemicals, supporting the transition toward a circular carbon economy. The chemical industry is undergoing a critical transformation to reduce reliance on fossil resources, with aromatic compounds such as benzene, toluene, and xylenes (BTX) which are essential building blocks for polymers, solvents, and specialty chemicals. However, their current production is almost entirely fossil-based.

Our work demonstrates the development and optimization of bifunctional catalyst systems and integrated reactor technologies for the efficient production of BTX aromatics from CO₂. The core innovation lies in the use of metal oxide + zeolite bifunctional catalysts, enabling the hydrogenation of CO₂ to intermediates (i.e. methanol or CO) and their subsequent conversion to aromatics within a single reactor. Based on the catalyst developed and parametric studies performed Fe-based systems (notably Fe₃O₄ + HZSM-5) were identified as promising candidates, achieving improved selectivity and stability. Various experimental campaigns revealed that advances in catalyst formulation, mixing methods, and process conditions have incrementally enhanced performance while BTX yields remain modest. The gas phase results showed CO was the predominant byproduct, with low selectivity toward BTX aromatics across all tested bifunctional catalyst systems. However, with modified Fe₃O₄ combined with HZSM-5 having high acidity (notably Na-Fe₃O₄ + HZSM-5 (Si/Al=15)) led to increased formation of BTX and other aromatic compounds in the liquid phase. The mixed granular catalyst preparation mode achieved the highest BTX conversion rates and selectivity, emphasizing the strong potential of this approach for advancing CO₂-to-aromatics technology.

At the conference the experimental results of the various parameters tested for bifunctional catalyst combinations and their influence on the performance will be presented. Moreover, the challenges and technical hurdles to overcome the direct CO₂ conversion to aromatics will be highlighted.