Methods of Catalysis for Enhanced Methanol Production from Carbon Dioxide (CO2)

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HIGHLIGHTS

- Composite materials for catalysis of CO_2 hydrogenation.
- Composite materials comprised of phenyl polyhedral oligomeric silsesquioxane (POSS) and one or more metals.

OPPORTUNITY

The conventional industrial process for the production of methanol employs syngas (CO + H_2) hydrogenation catalyzed by Cu/ZnO/Al_2O_3. However, when the same catalytic system is employed with CO_2, water forms as a byproduct reduces the activity, stability, and selectivity of the process.

University of Alberta researchers developed a polyhedral oligomeric silsesquioxane (POSS) based catalysis for direct CO_2 hydrogenation to methanol. Mild calcination of copper−zinc-impregnated POSS material affords the formation of catalyst-POSS nanoparticles able to reach a 3.8% yield of methanol with selectivity as high as 87.5% in a batch reactor. The catalytic system metal-POSS is stable and recyclable under H_2 reduction and CO_2/H_2 conditions. The increased number of aromatics in the structure of POSS results in an increased hydrophobic character that plays a decisive role in the methanol formation. For comparison, catalysts supported on reduced graphene oxide (RGO) showed 0% selectivity to methanol under the study conditions. Anticipated further advancements include a substantial increase in methanol yield when transitioning to a continuous flow reactor setup.

The developed composite materials have high thermal stability in both inert and oxidative atmospheres. The supports show promise for applications in catalytic systems that require hydrophobic and thermally stable supports.

COMPETITIVE ADVANTAGE

- Increase selectivity to methanol synthesis from CO_2 hydrogenation.
- Thermal stability of catalyst supported on phenyl polyhedral oligomeric silsesquioxanes.
- Potential application of hydrophobic POSS materials with other metals such as Fe, Co, and Ni for different industrial reactions that are hindered by water.

STATUS & PUBLICATIONS

- Patent pending.
- Rodriguez Herrero, Yanet, and Aman Ullah. "Thermal stability study of catalyst (CuO/ZnO) supported on phenyl polyhedral oligomeric silsesquioxanes." Journal of Thermal Analysis and Calorimetry 148.19 (2023): 9875-9891.
- Rodriguez Herrero, Yanet, and Aman Ullah. "Hydrophobic Polyhedral Oligomeric Silsesquioxane Support Enhanced Methanol Production from CO2 Hydrogenation." ACS Applied Materials & Interfaces 15.11 (2023): 14399-14414.

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