

Microwave-Assisted Reforming of Tar Model Compound Using the Ni/La-CeO₂ Catalyst

Anitha Shankara Linge Gowda^{1,2}; Pranjali Muley^{1,2}

¹National Energy Technology Laboratory, 3610 Collins Ferry Road, Morgantown, WV 26505, USA; ²NETL Support Contractor, 3610 Collins Ferry Road, Morgantown, WV 26505, USA



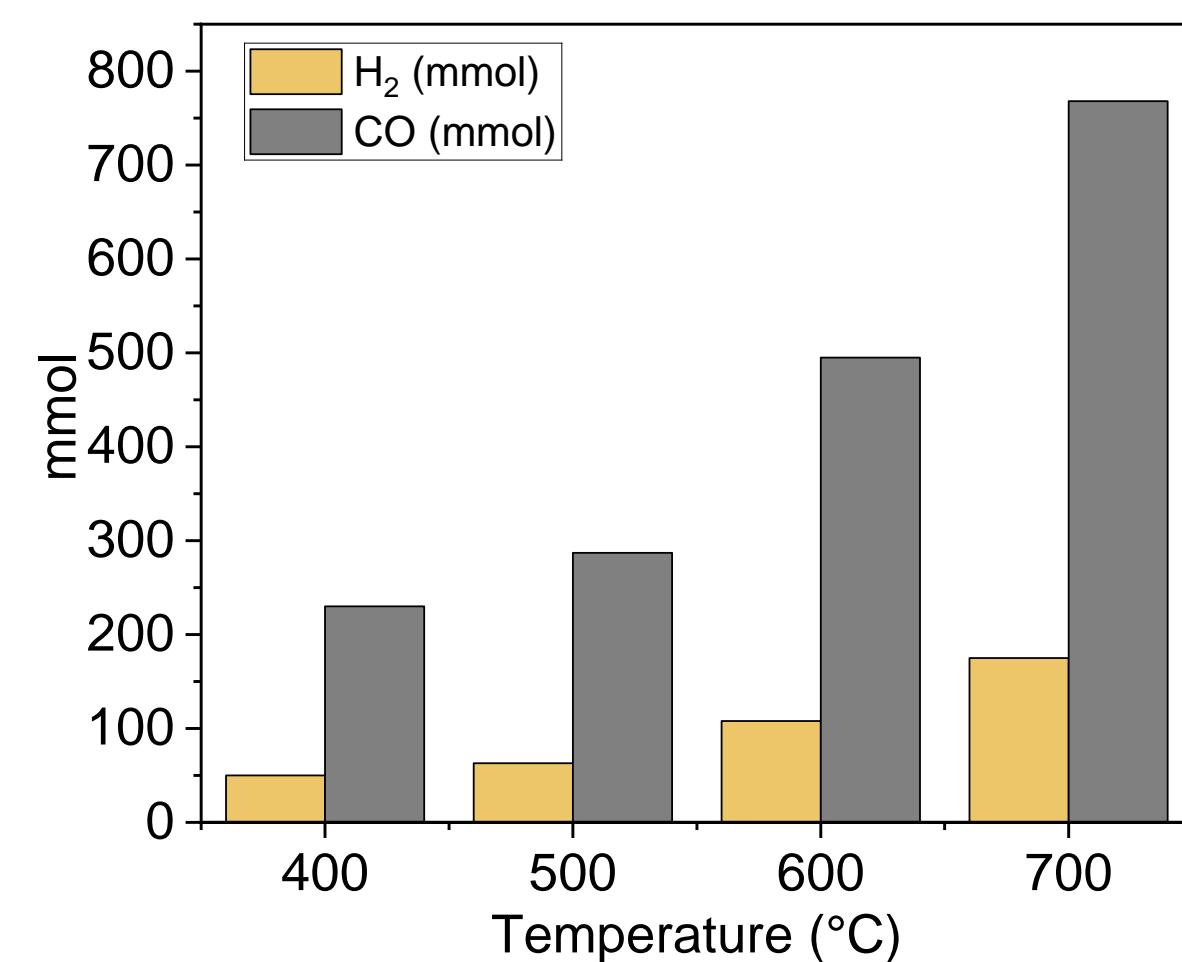
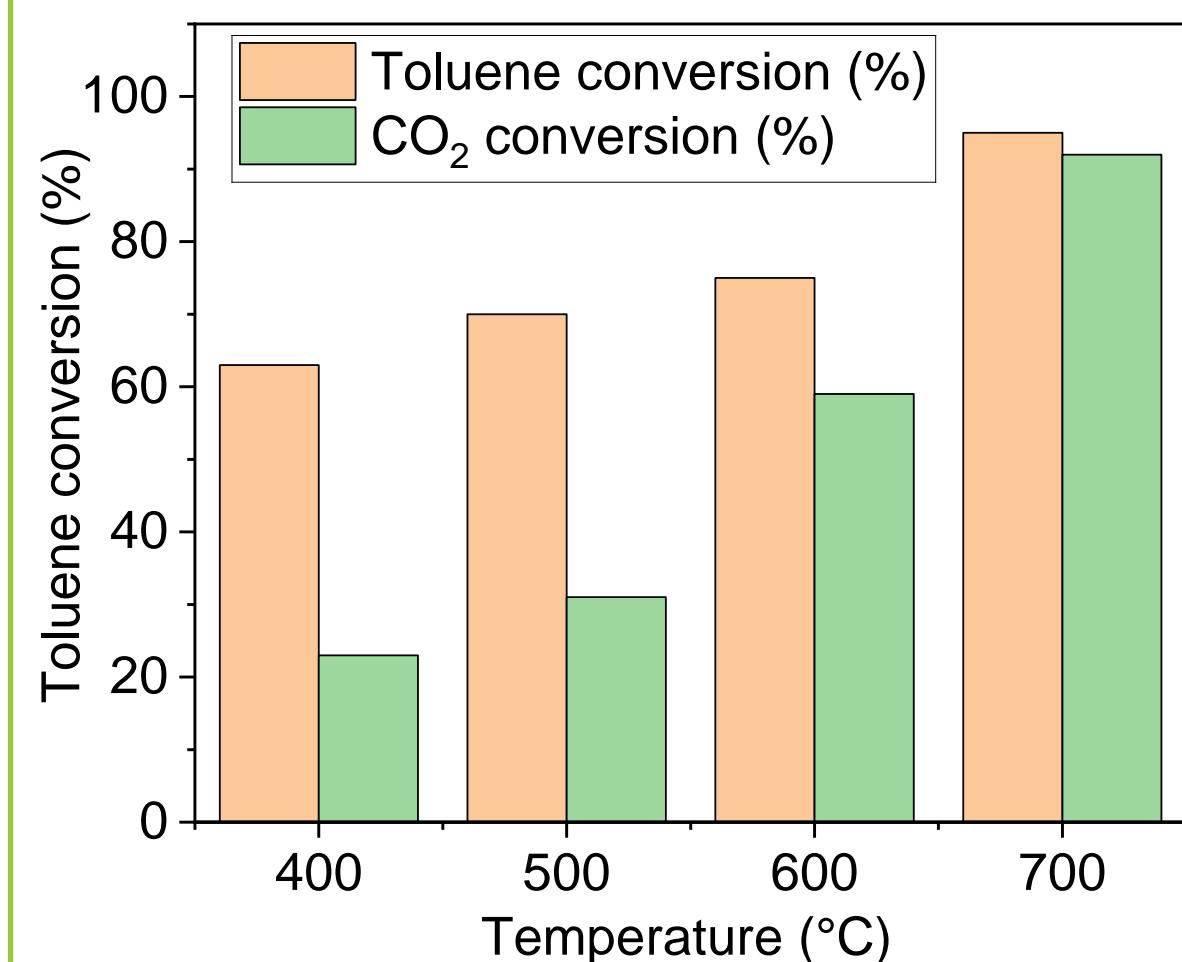
Introduction

Tar is an unwanted byproduct formed during gasification, lowering syngas yields and reducing gasification efficiency. This work explores microwave-assisted catalytic tar conversion to syngas. Microwaves offer direct and volumetric heating, faster response rates and enhanced catalytic performance. In this study, toluene is used as a model tar compound as it is a major tar constituent and is stable and easy to handle. Ni-La/CeO₂ catalyst was synthesized by wet impregnation method. Fresh and spent catalysts were characterized using various techniques to understand the reaction mechanism. Role of microwave was determined by performing reactions using microwave (MW) and conventional (CV) reactors.



Effect of Toluene Flow Rate

- Toluene flow study was done at 500 °C, conversion rate >70% was observed for 0.02-0.09 mL flow rates
- Syngas production increased with increase in flow rate
- The reaction was highly selective to syngas

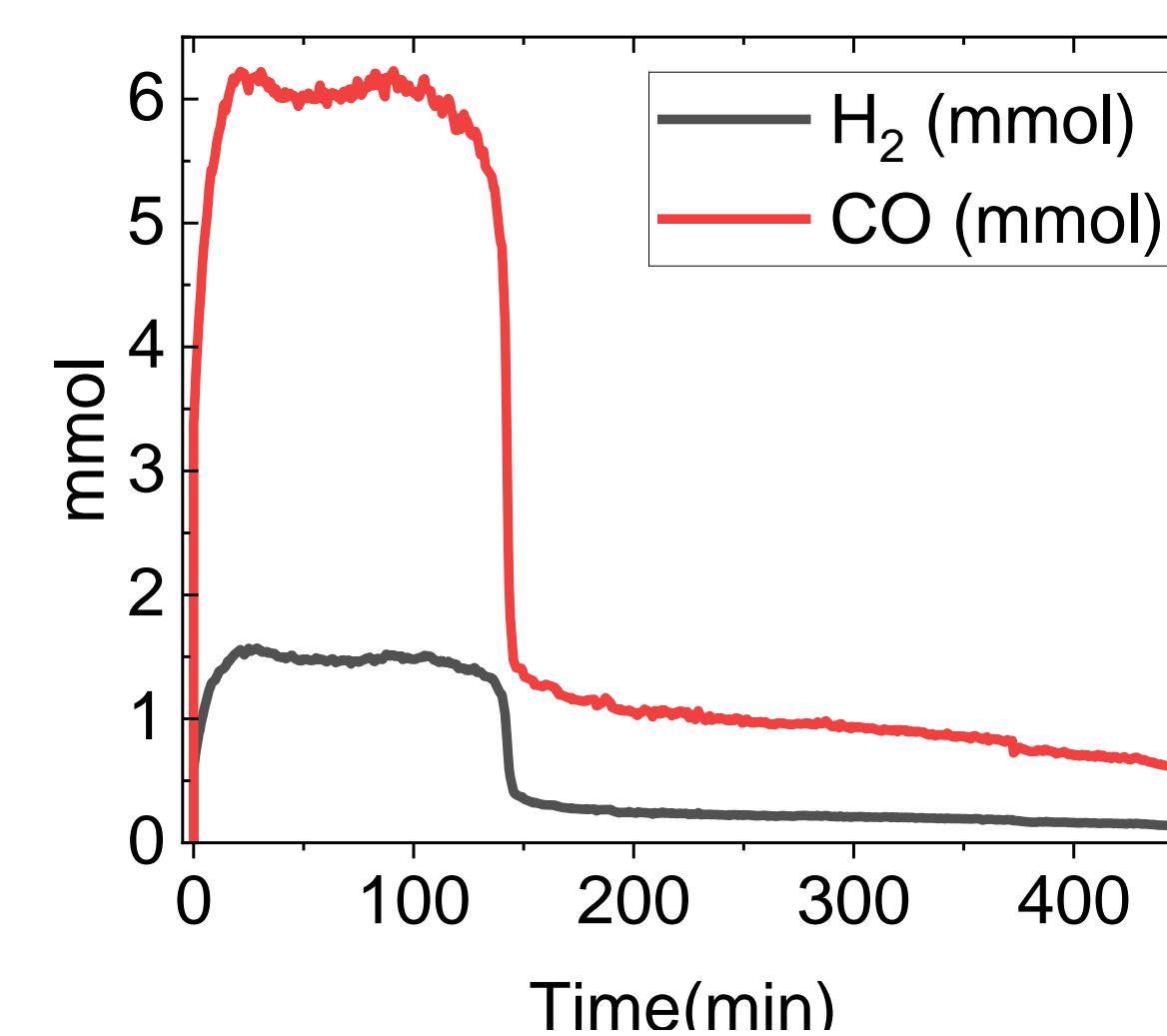


Effect of Temperature

- Toluene and CO₂ conversion increased with increase in temperature
- Toluene and CO₂ conversion reached 95% and 92% at 700 °C
- The reaction was highly selective to syngas

Catalyst Time-on-Stream

- The toluene and CO₂ conversion rate increased up to 2 hrs.
- The conversion rate decreased drastically after 2 hrs and then stayed linear for the next 6 hrs.
- H₂ and CO production also decreased as toluene and CO₂ conversion decreased
- The decrease in conversion rate could be due to coke formation and catalyst sintering

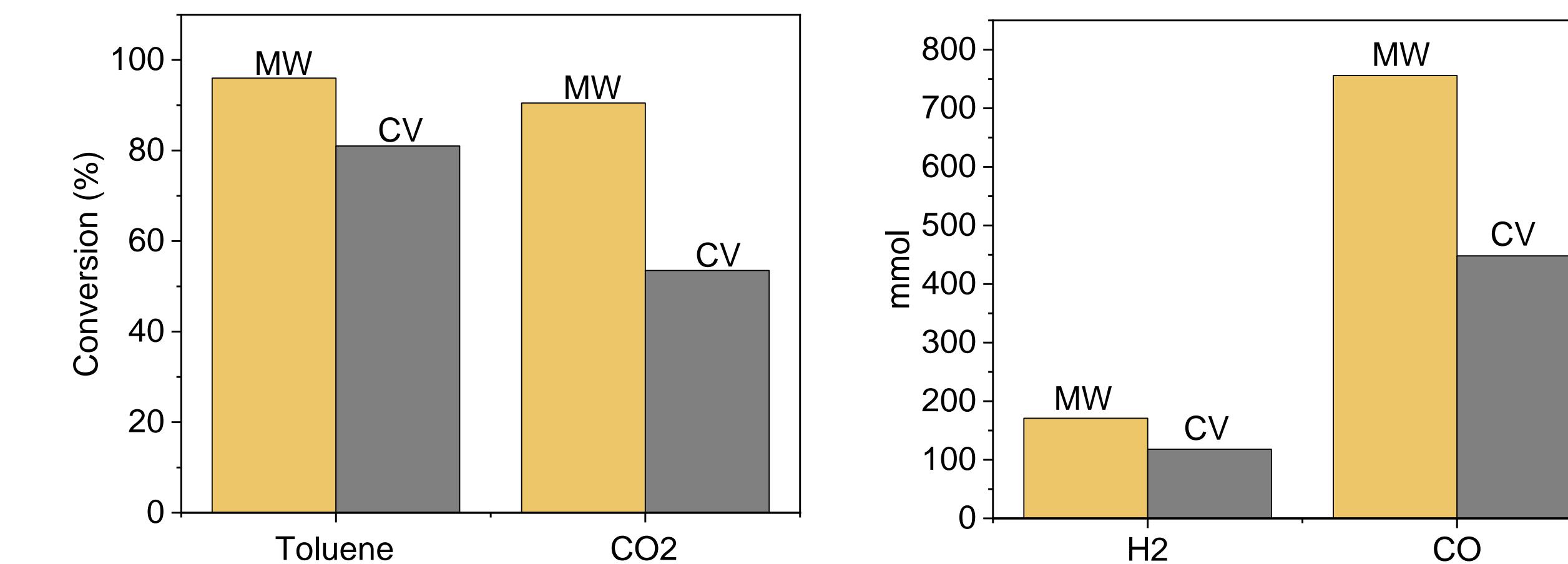


References

- Deng, T. et al. *Int J Hydrogen Energy*, **2024**, 87, 138-47.
- Amin, R. et al. *Int. J. Hydrogen Energy*, **2016**, 41, 12869-12879.
- Abdelsadek, Z. et al. *JOM*, **2023**, 75, 727-738.
- Bai, X.; et al. *Fuel*, **2024**, 370, 131843.
- Rached, J. A. et al. *Journal of Environmental Chemical Engineering*, **2018**, 6, 4743-4754.

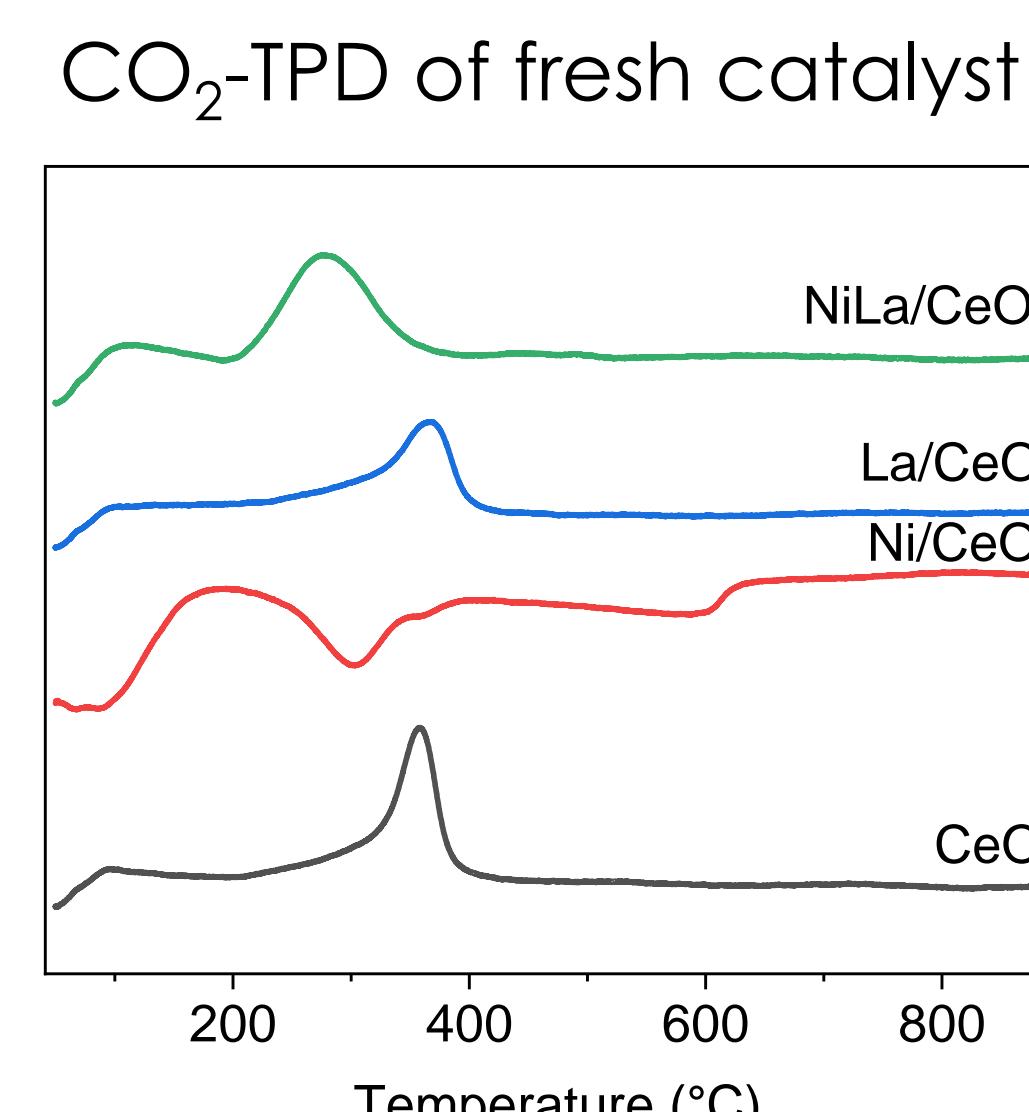
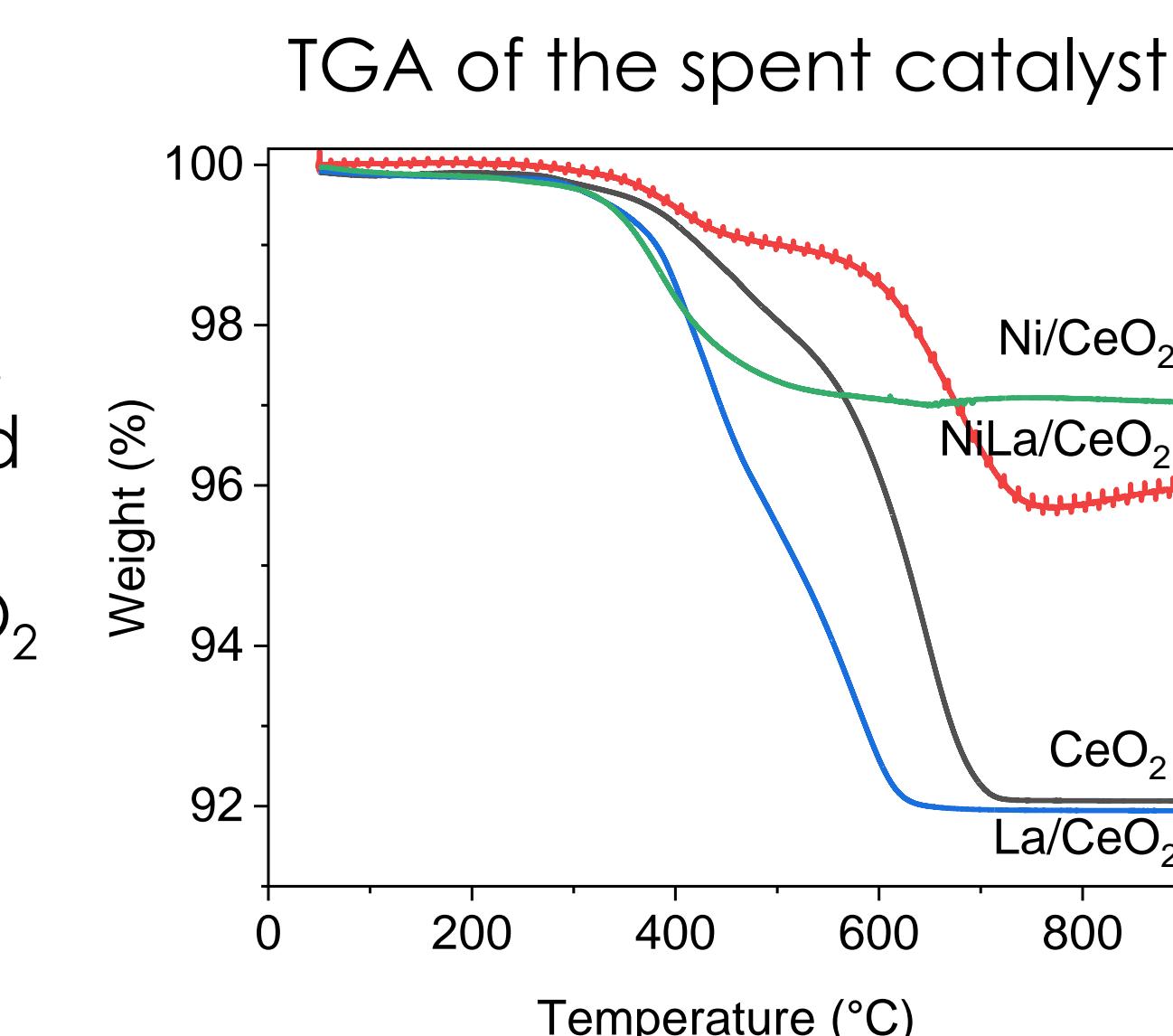
Conventional vs. Microwave Runs

- Reaction was performed at 700 °C and 900 °C under thermal conditions.
- Toluene selectivity and the conversion rate were very low at 700 °C for thermal runs
- Significant coke formation was observed under thermal conditions
- Microwave runs are more efficient than thermal with high selectivity for syngas

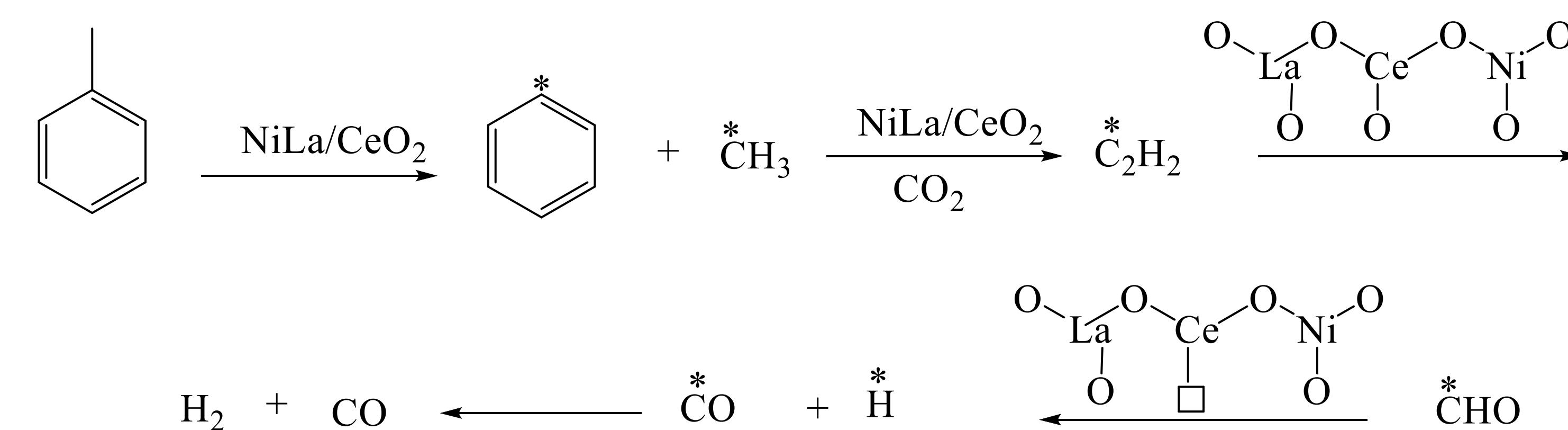


Catalyst Characterization

- Conventional runs showed higher coke deposition than microwave reactions.
- CeO₂ and LaCeO₂ showed higher coke deposition compared to the NiLaCeO₂ catalyst.
- Addition of La increased the basicity of the NiCeO₂



Reaction Mechanism



Conclusions

- NiLaCeO₂ was highly selective toward syngas formation with 96% toluene and CO₂ conversion
- Presence of a bimetallic system increases the synergistic effect between the metal and support increasing the reactivity and decreasing the coke formation
- Catalyst deactivates after 2 hr and should be further investigated
- Microwave reactions offer higher conversion and syngas selectivity over thermal tests

Disclaimer

This project was funded by the United States Department of Energy, National Energy Technology Laboratory, in part, through a site support contract. Neither the United States Government nor any agency thereof, nor any of their employees, nor the support contractor, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.