Switchable catalysts for end-products flexibility in CO_2 utilisation schemes

Loukia-Pantzechroula Merkouri[a*], Estelle le Saché[a], Laura Pastor-Pérez[a], Melis S. Duyar[a] and Tomas Ramirez-Reina[a]

[a] *Department of Chemical and Process Engineering, University of Surrey, Guildford, GU2 7XH, United Kingdom*

* l.merkouri@surrey.ac.uk

1. INTRODUCTION

CO_2 recycling via various catalytic routes has become an environmental strategy for combating its emissions.

Aim

The aim of this project was one single catalyst as universal advanced materials for CO_2 upgrading.

Reactions

1. Dry reforming of methane DRM:
   $CO_2 + CH_4 \rightarrow 2\ H_2 + 2\ CO$
   $\Delta H_{298K} = +247$ kJ/mol
2. Reverse-water-gas shift RWGS:
   $CO_2 + H_2 \rightleftharpoons CO + H_2O$
   $\Delta H_{298K} = +41$ kJ/mol
3. CO_2 Methanation or Sabatier:
   $CO_2 + 4\ H_2 \rightarrow CH_4 + 2\ H_2O$
   $\Delta H_{298K} = -164$ kJ/mol

2. EXPERIMENTAL

Catalysts' synthesis

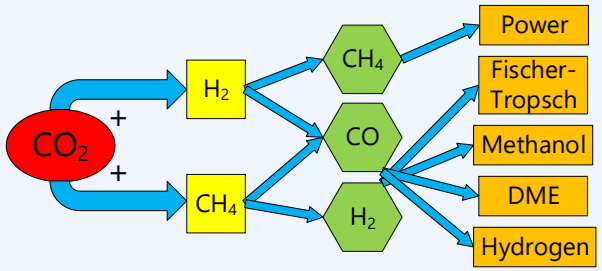
Two catalysts were prepared by co-impregnation:

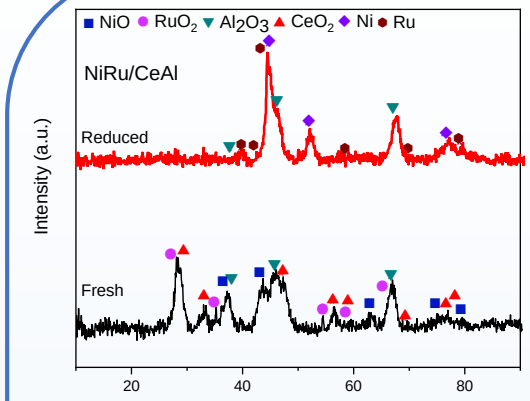
1. 15 wt.% Ni - 1wt.% Ru/ CeO_2 - Al_2O_3 (20% - 80%): NiRu/CeAl
2. 15 wt.% Ni - 1 wt.% Ru/ $Ce_{0.5}Zr_{0.5}O_2$: NiRu/CeZr

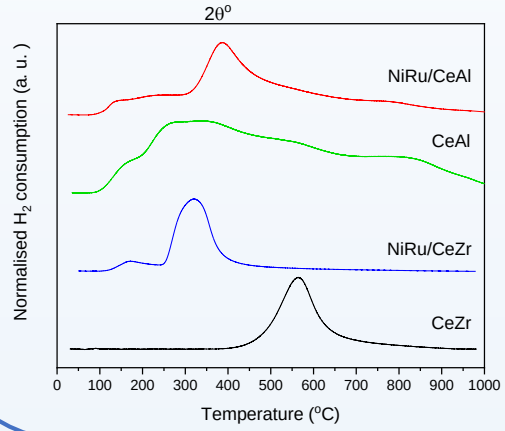
Prior to all experiments, an *in situ* reduction was carried out at 850°C, P=1atm with a 10% H_2/N_2 mixture for 1 h.

Characterisation

1. X-ray diffraction (XRD)
2. Brunauer-Emmett-Teller (BET) method
3. Temperature programmed reduction (H_2-TPR)
4. Temperature programmed oxidation (TPO)
5. Thermogravimetric analysis (TGA)
6. X-ray photoelectron spectroscopy (XPS).



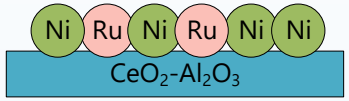


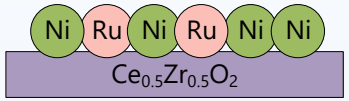


3. RESULTS

After reduction, metallic Ni and Ru, i.e. the active species, were formed.

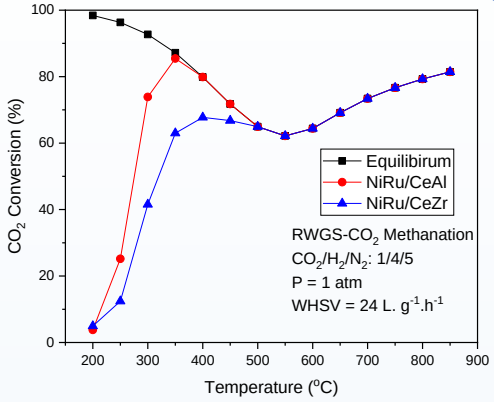
NiRu/CeAl showed a better activity in all gas-phase CO_2 reactions.

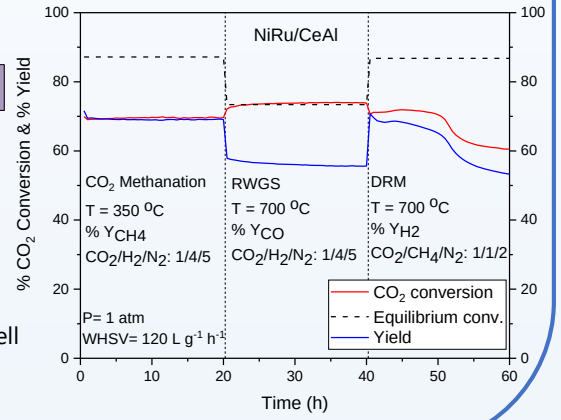




The reduction of the supports was facilitated by the addition of Ni and Ru.

NiRu/CeAl proved to be very stable, especially in the CO_2 hydrogenation reactions, as well as coke-resistant.





"Switchable Ni-Ru catalysts for gas phase CO_2 conversion: bringing closer dry reforming, reverse water gas shift and methanation to enable end-products flexibility": *submitted*

4. CONCLUSIONS

The NiRu/CeAl catalyst is novel for its ability to transform CO_2 emissions into added value chemicals in a number of different scenarios.

5. ACKNOWLEDGMENTS

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