Catalytic materials for solid oxide fuel cells fuelled by biogas

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Outline

- Introduction
- Motivation
- Experimental
- Results
- Conclusions

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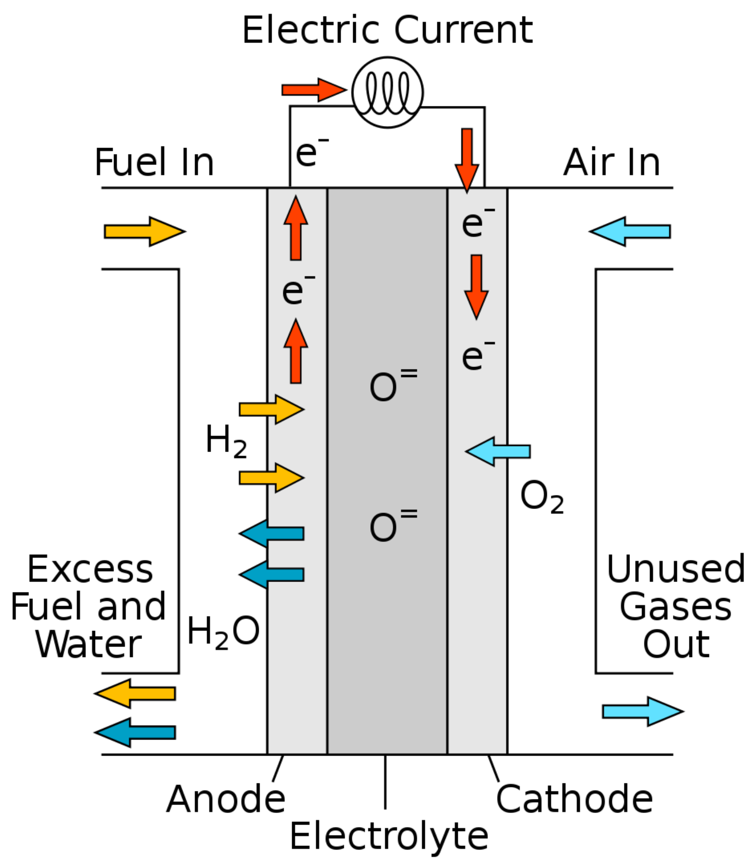
Solid Oxide Fuel Cells

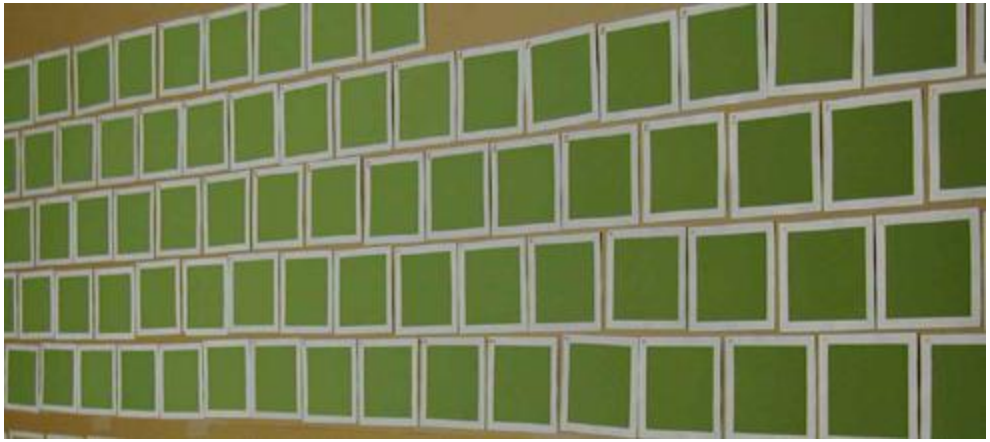
Advantages of SOFC:

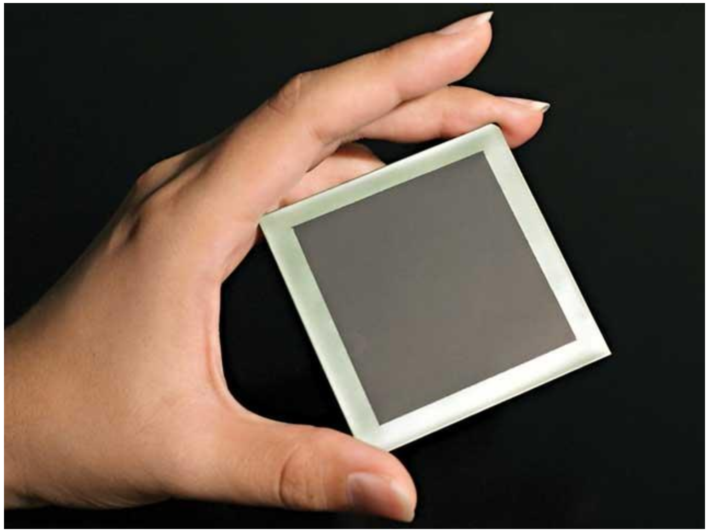
- High **efficiency**
- **Low pollutant** emission
- Fuel **flexibility**



Solid Oxide Fuel Cells

Most commonly used anode material is a nickel cermet (Ni/YSZ – nickel/yttria-stabilized zirconia). This material is **stable in hydrogen**, but **in methane degrades quickly**.





Biogas in SOFC

$$CH_4 + CO_2 \rightarrow 2CO + 2H_2$$ dry reforming of methane

$$CH_4 + H_2O \rightarrow CO + 3H_2$$ steam reforming of methane

$$CO_2 + H_2 \leftrightarrow CO + H_2O$$ reverse water gas shift

$$CH_4 + \frac{1}{2}O_2 \rightarrow CO + 2H_2$$ partial oxidation of methane

$$CH_4 \rightarrow C + 2H_2$$ methane decomposition

$$C + H_2O \rightarrow CO + H_2$$ carbon gasification

↓ **after**

eceramics

Motivation

New or improved materials **must be developed for use in biogas**. To do this, examine their **properties, catalytic activity and stability** are necessary.

BIOGAS

↓

CATALYST

↓

STABLE OPERATION

Studied materials

- $Cu_{1.3}Mn_{1.7}O_4$ (CMO)
- $CeCu_2O_4$ (CCO)
- $Y_{0.08}Sr_{0.92}Ti_{0.8}Fe_{0.2}O_{3-\delta}$ (YSTFO)
- $SrZr_{0.95}Y_{0.05}O_{3-\alpha}$ (SZY)

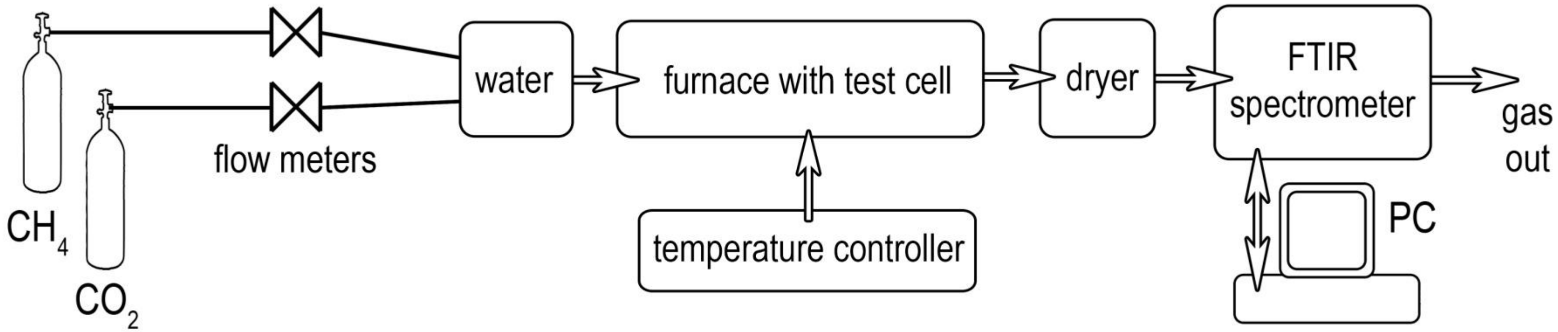
Precursors infiltrated into the Ni/YSZ anode support.

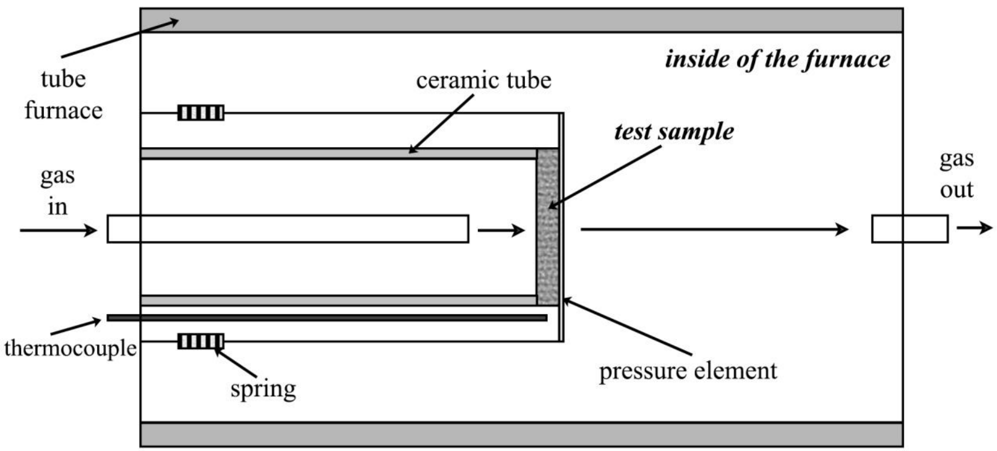
Ni/YSZ - mixture Ni:YSZ-60%:40% sintered at 1400cC and reduced in H_2

Measurements in synthetic biogas - CH_4 : CO_2 : H_2O - 60% : 40% : 3%

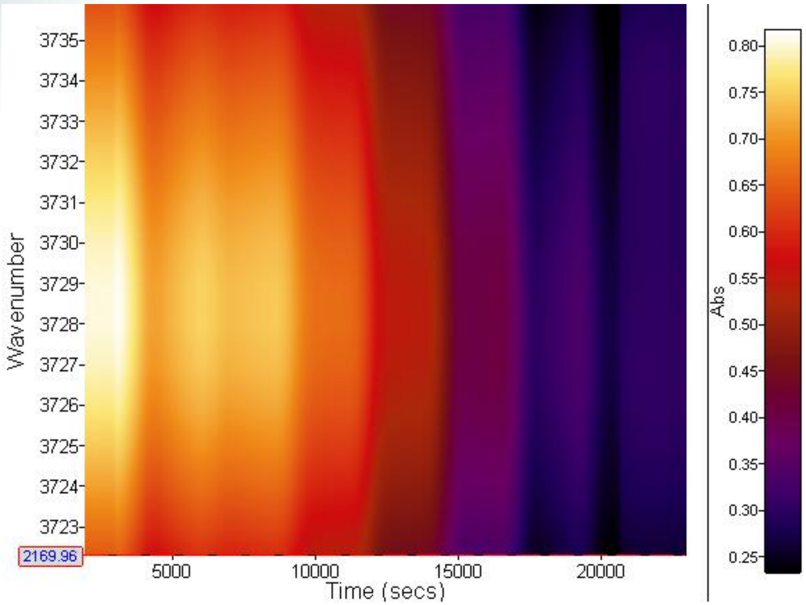
Temperature range 500°C-800°C, every 50°C with 30 minutes dwell

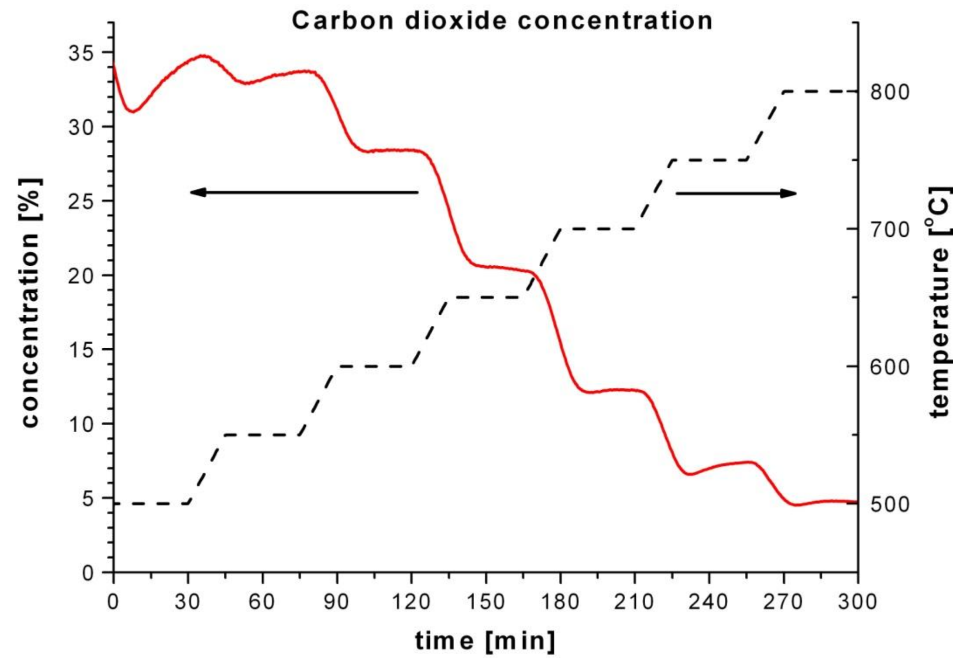
Experimental setup





FTIR spectra



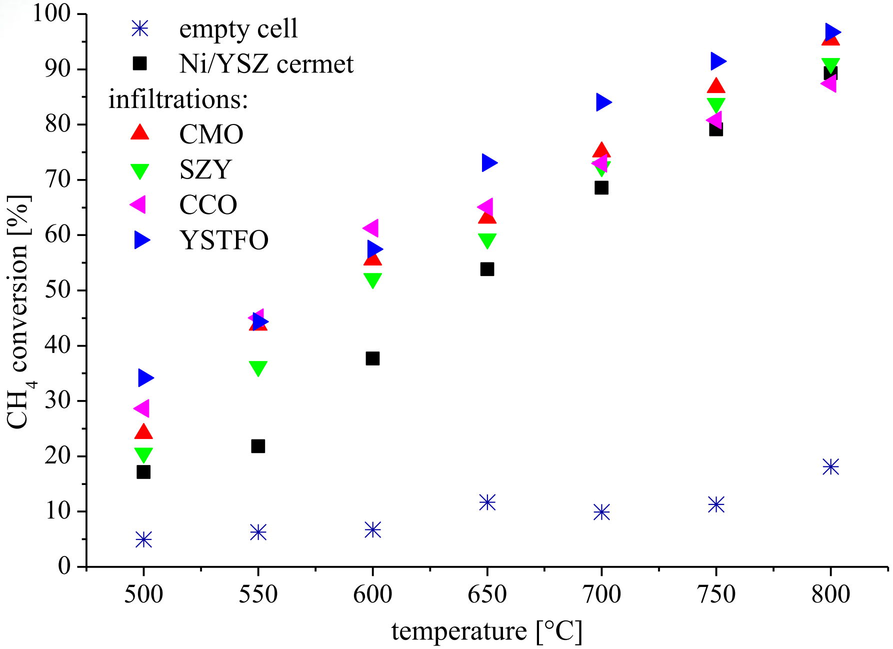


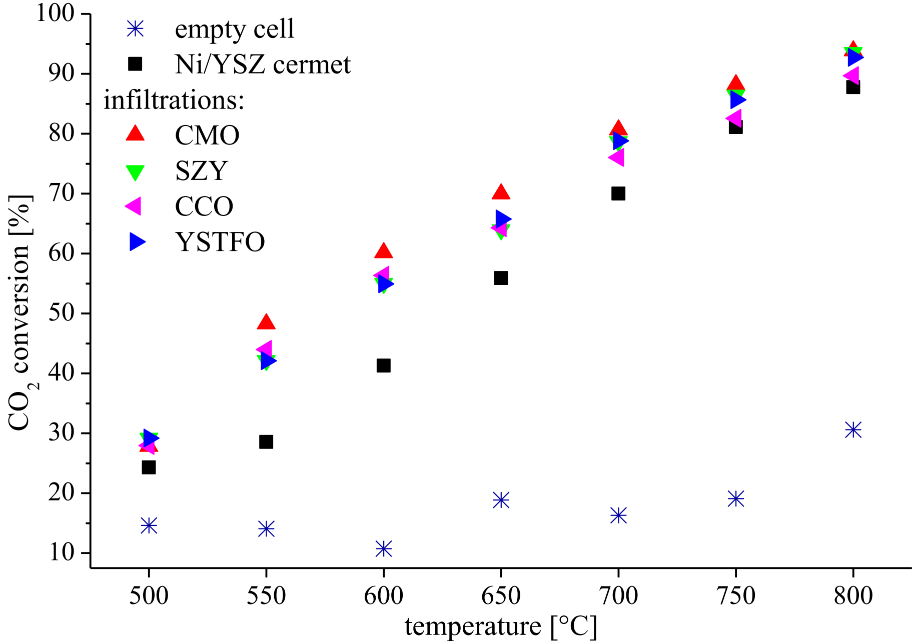
From concetration to conversion and yield:

$$CH_{4\,conversion} = \frac{x_{in}CH_4 - x_{out}CH_4}{x_{in}CH_4} \cdot 100\%$$

$$H_{2\,yield} = \frac{x_{out}H_2}{y_{in}H_2O + z_{in} \cdot 2 \cdot CH_4} \cdot 100\%$$

Conversion - infiltrations





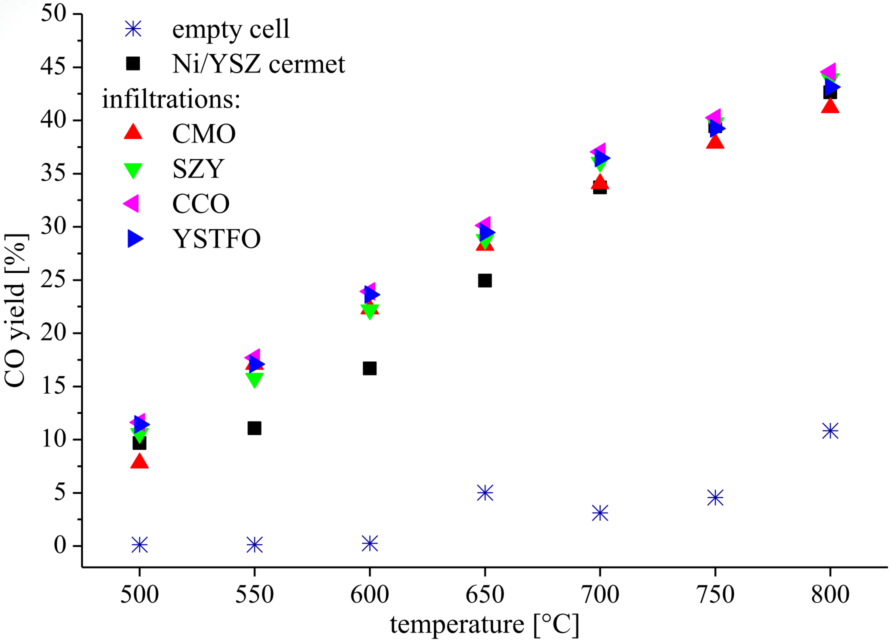
$Cu_{1.3}Mn_{1.7}O_4$ (CMO)

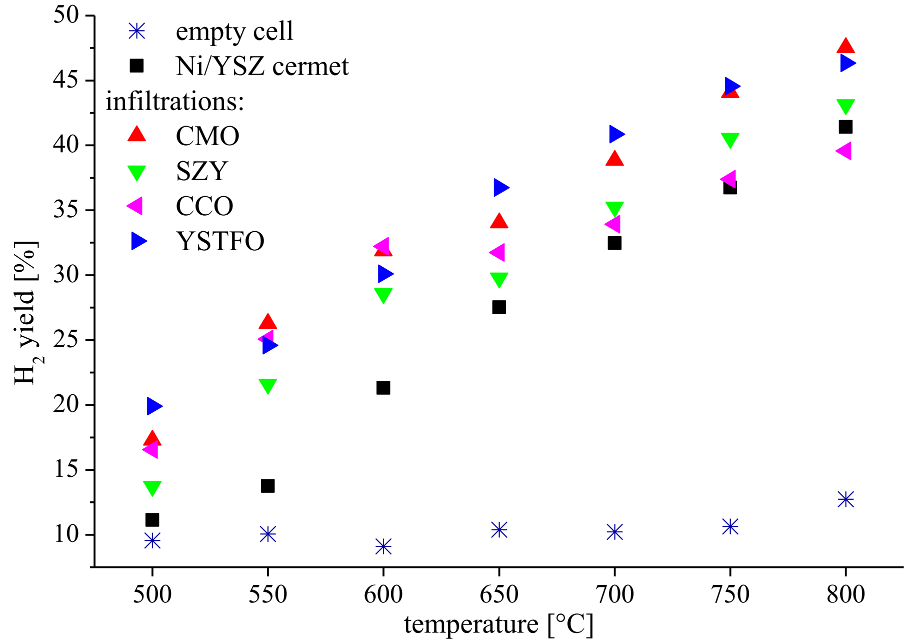
$Y_{0.08}Sr_{0.92}Ti_{0.8}Fe_{0.2}O_{3-\delta}$ (YSTFO)

$CeCu_2O_4$ (CCO)

$SrZr_{0.95}Y_{0.05}O_{3-\alpha}$ (SZY)

Yield - infiltrations





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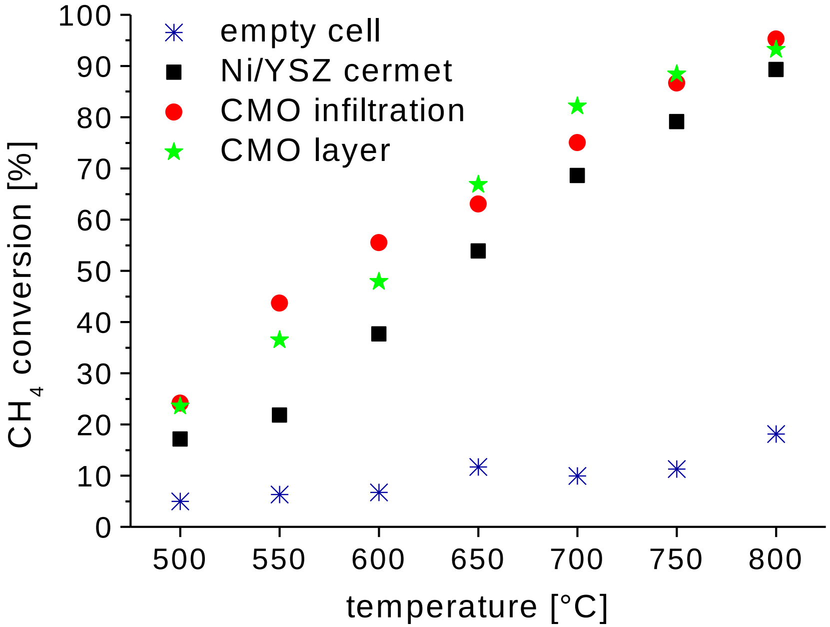
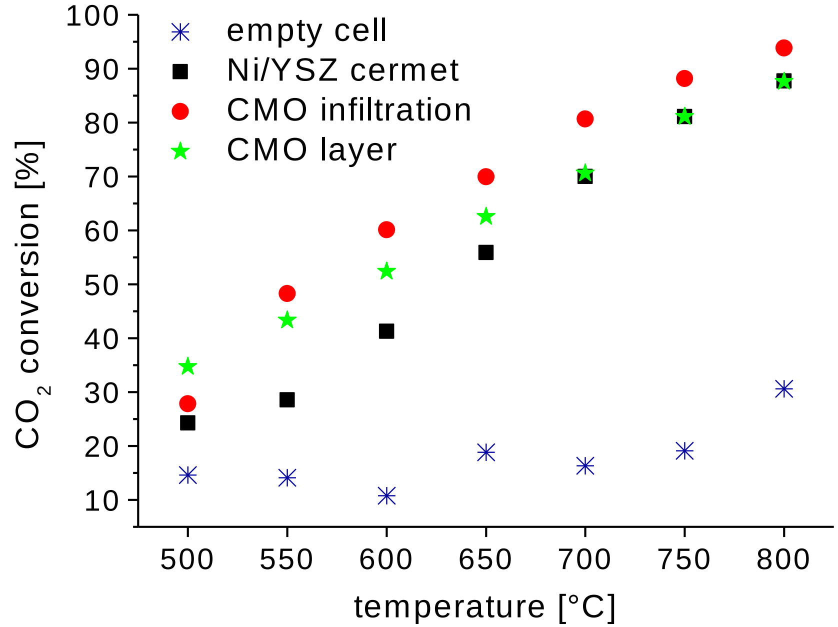
Conversion - layers vs. infiltrations





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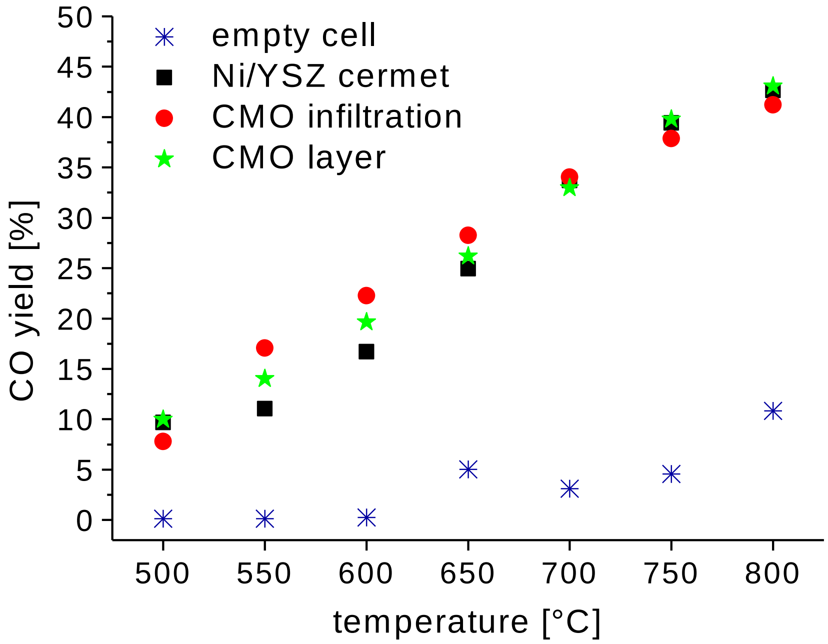

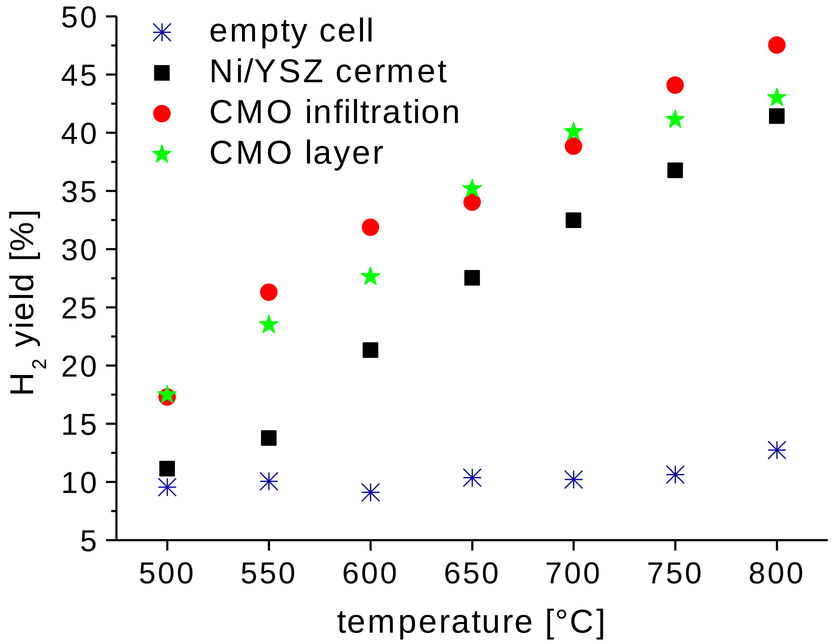

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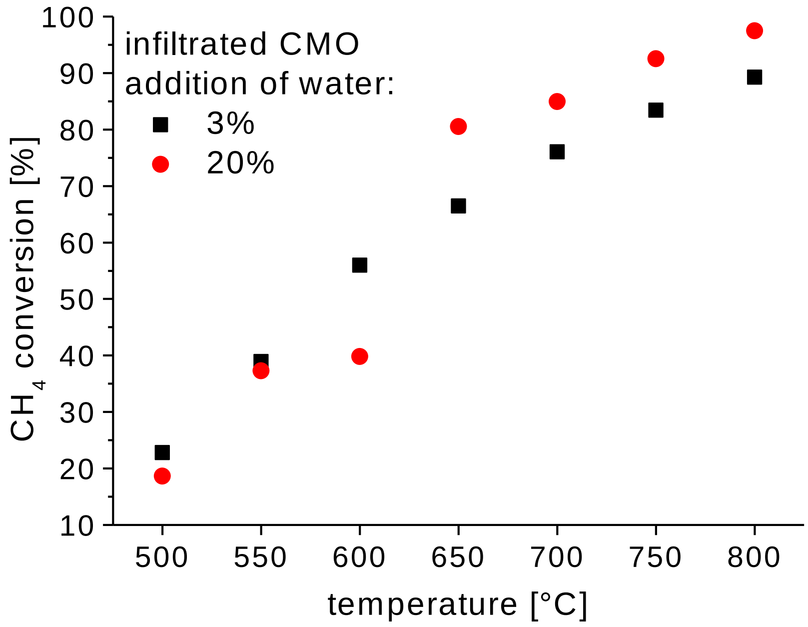
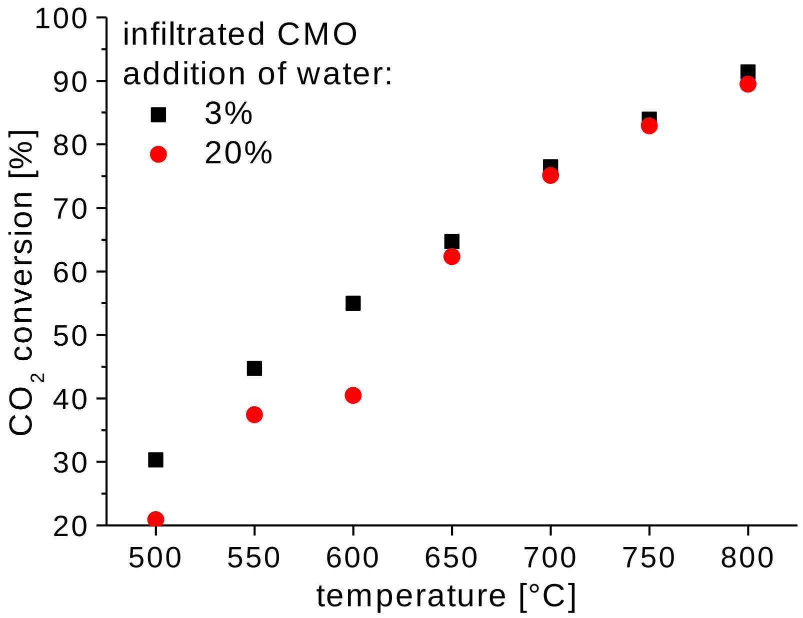
Conversion - water content





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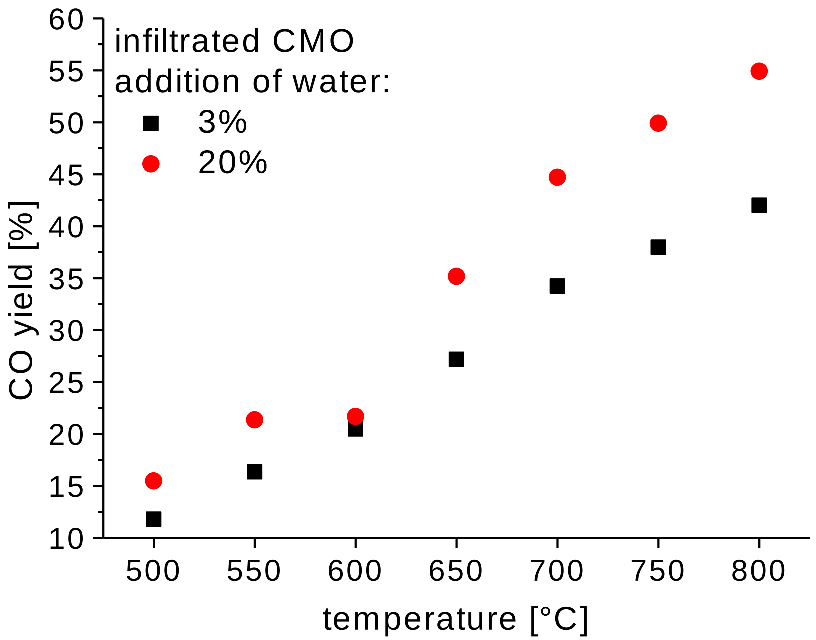

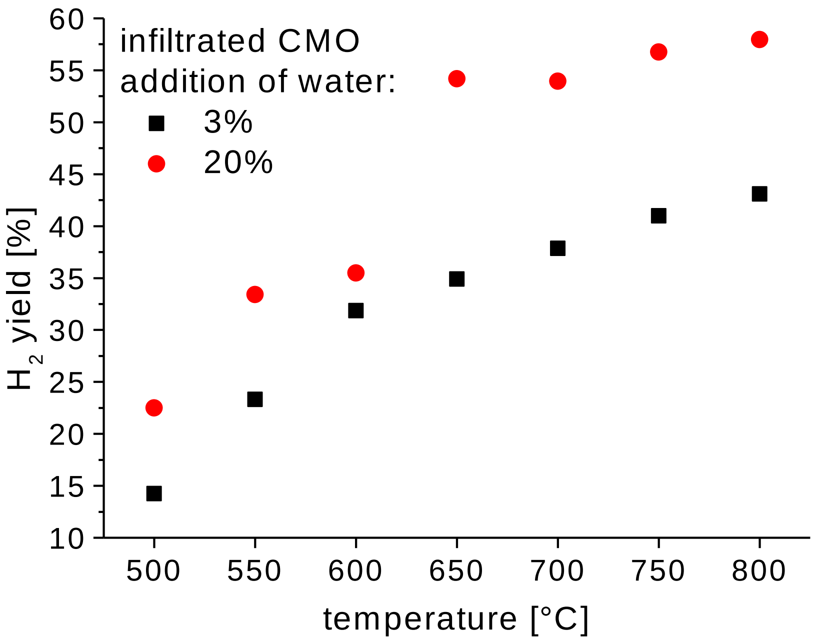

$Cu_{1.3}Mn_{1.7}O_4$ (CMO)

Conclusions

- All tested materials improved catalytic properties of Ni/YSZ cermet.
- The best properties - $Cu_{1.3}Mn_{1.7}O_4$ and $Y_{0.08}Sr_{0.92}Ti_{0.8}Fe_{0.2}O_{3-\delta}$.
- The use of catalytic materials for fuel cells powered by biogas can be an effective solution to the problem of carbon deposition.