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Modular system based on Molten Carbonate Fuel Cells with tailored composite membranes designed for specific flue gas compositions oriented into CCS integration with an industrial power plant

MOLCAR

„Modular system based on Molten Carbonate Fuel Cells with tailored composite members designed for specific flue gas compositions oriented into CCS integration with an industrial power plant", project contract number NOR/POLNORCCS/MOLCAR/00-17/2020-00

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Work Package 1 Wen (11.2020 .. 07.2022)

Goal: Composite membrane fabrication and tested in lab conditions

- Task 1.1: Material screening of solid oxide ion conducting support materials

MATERIALS	STABILITY TOWARDS CARBONATES	OXIDE ION CONDUCTION	WETABILITY	SINTERING TEMPERATURE
YSZ	High	Low	High	>1400 °C
GCO	Intermediate	Intermediate	High	>1300 °C
BTM	Low	High	Intermediate	950 °C
BPR	Low	High	Low	950 °C
BYS	High	High	Low	950 °C
BYO	High	High	Low	950 °C
LSGM	Unknow	Intermediate	Unknow	>1100 °C
BA DOPED $NA_{0.5}BI_{0.5}TIO_3$ (BA-BNT)	High	High	High	1100 °C
LAMOX	Unknow	Intermediate	Unknow	1300 °C
$LA_{0.5}NA_{0.5}TIO_3$ (LNT)	High	High	High	1500 °C

High Intermediate Low Unknown

The oxide ion conducting materials have been considered in this project for using as the solid oxide support for Molten Carbonate Fuel Cell (MCFC).

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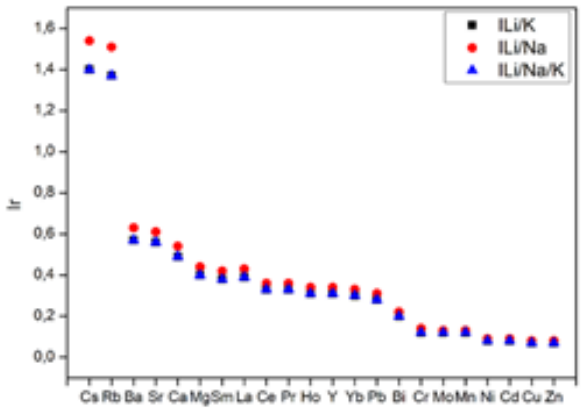
Mixture	Additive	Beneficial concentration	Ionic conductivity	Oxygen solubility	NiO solubility	Cell voltage	Lifetime
Li/Na	MgO	3 mol%					
	LaO	0.5 mol%		10x			
	GdO	0.5mol%		10x			
	$La_2(CO_3)_3$						
	$CaCO_3$	9 mol%			20%		15–20%
	$BaCO_3$	9 mol%			20%		15–20%
	Cs_2CO_3	5 mol%					
	$SrCO_3$	4 mol%					
	$SrCO_3$+$BaCO_3$	3 mol %			50%		
Li/K	SrO	1 wt%			15x		
	MgO						
	La_2O_3	1 mol%			10%		
	La_2O_3	0.5 mol%		3x			
	GdO	0.5 mol%		3x			
	Cs_2CO_3	5 mol%					
	Rb_2CO_3						
Li/Na/K	La_2O_3	2 mol%			30%		
	Y_2O_3						
	CeO_2						
	Ho_2O_3						
	Yb_2O_3						
	$Gd_2O_2CO_3$						
	$Nd_2O_2CO_3$						
	$SrCO_3$	5 mol%					

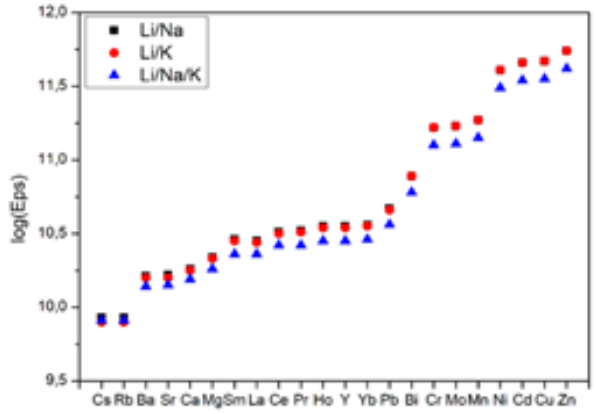
Legend: positive | neutral | negative

- Task 1.2: Novel oxides or carbonates

I_r



έ



According to the literature, two parameters were calculated:

- I_r, to describe and quantify characteristics of rare-earth elements' solubility in the molten carbonates,
- έ, to evaluate how the additives affect the NiO solubility.

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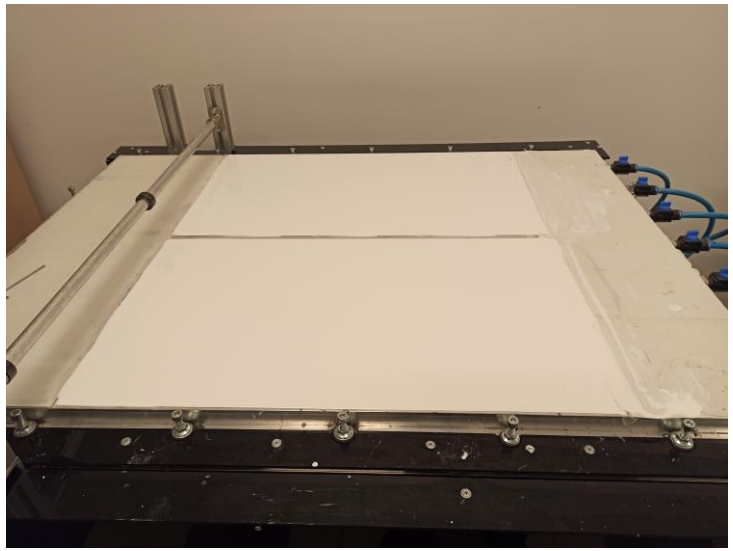
Work Package 1 Wen (11.2020 .. 07.2022)

- Task 1.3: Manufacturing of composite membranes

Known materials (YSZ – tape casting of rectangular tapes)



Known materials (YSZ – **forming of near net shape matrices**)

New materials (BNT, LNT; tape casting)

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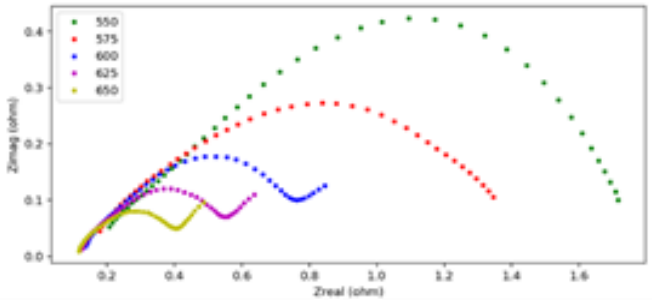
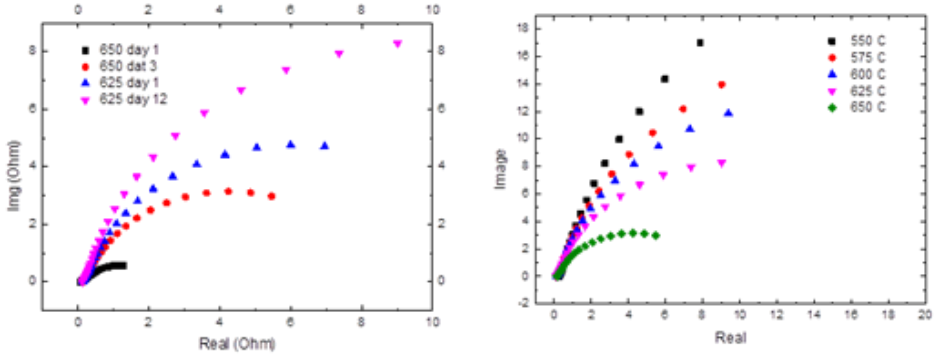
Work Package 1 Wen (11.2020 .. 07.2022)

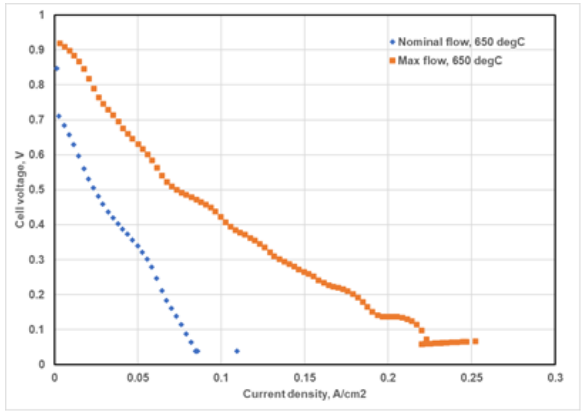
- Task 1.4: Electrical and electrochemical characterization

Electrochemical Impedance Spectroscopy (EIS)
- resistance, degradation

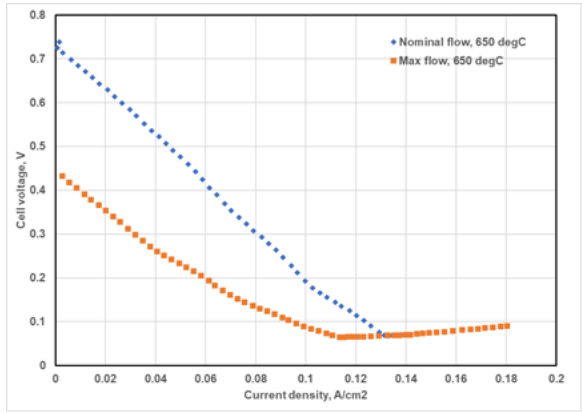




I-V curves – performance, degradation



BNT matrix (manufactured by WUT)



LNT matrix (manufactured by WUT)

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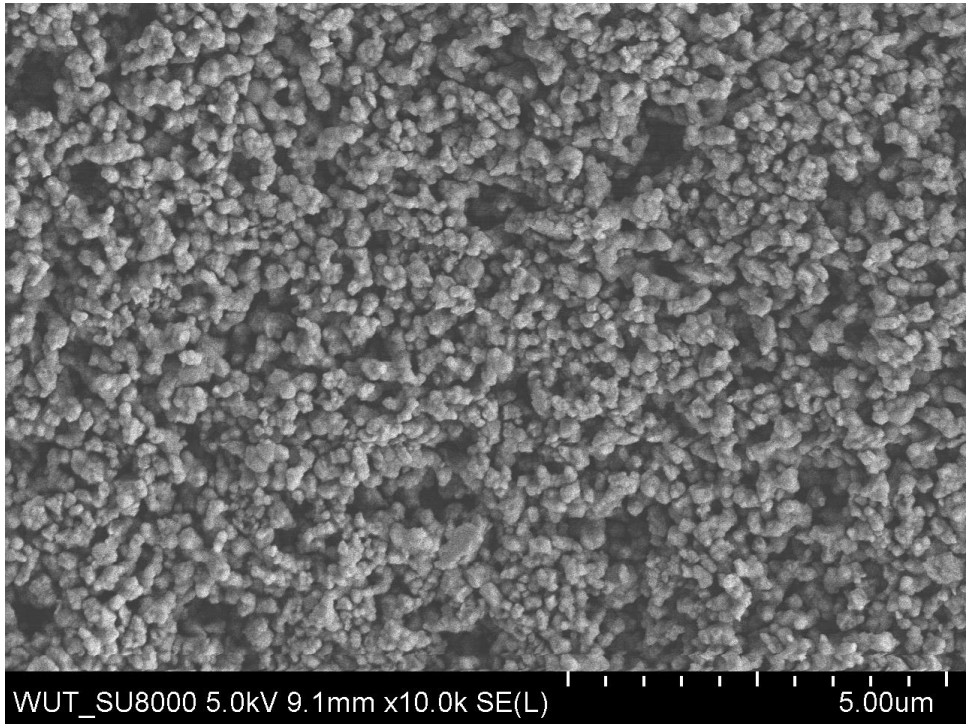
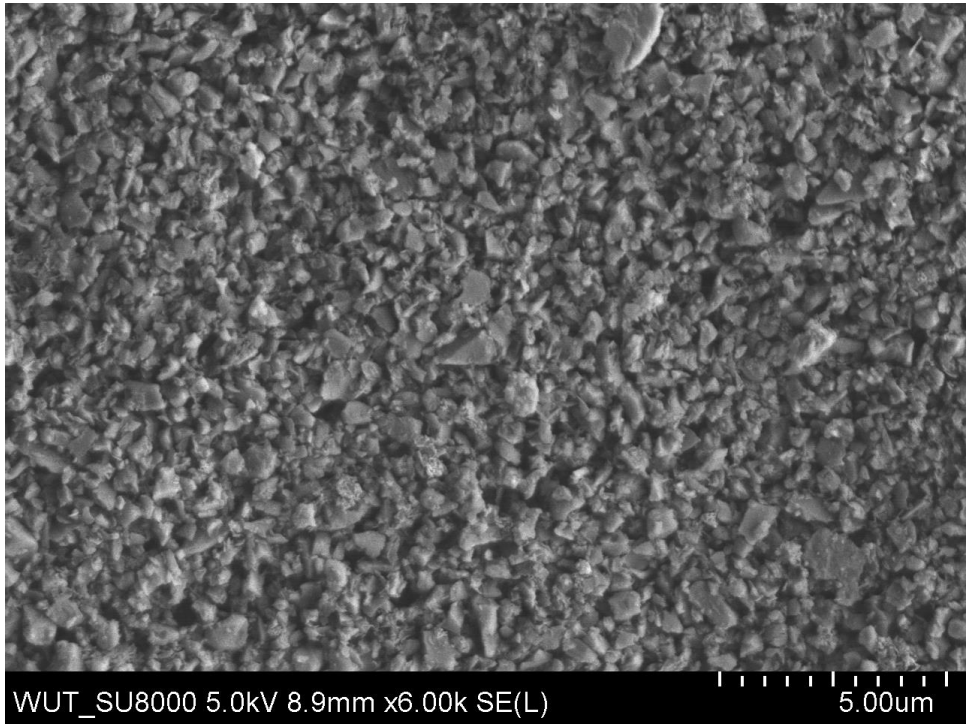
YSZ-based matrix (left) compared with LiAlO3-based matrix (right)





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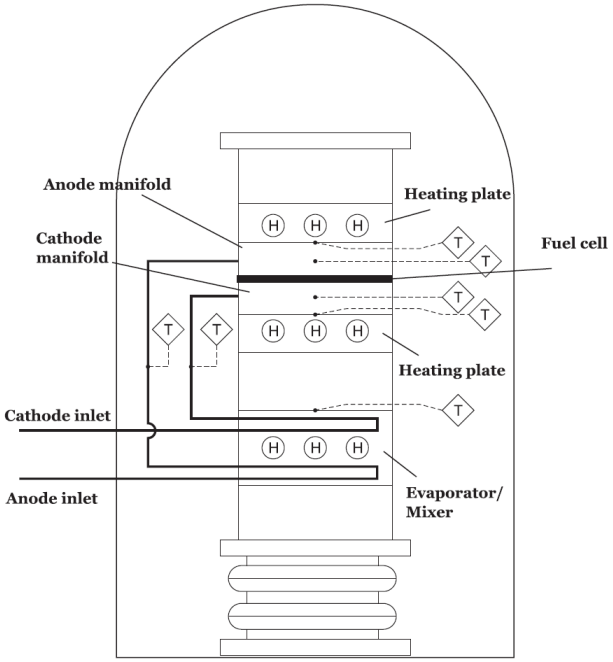
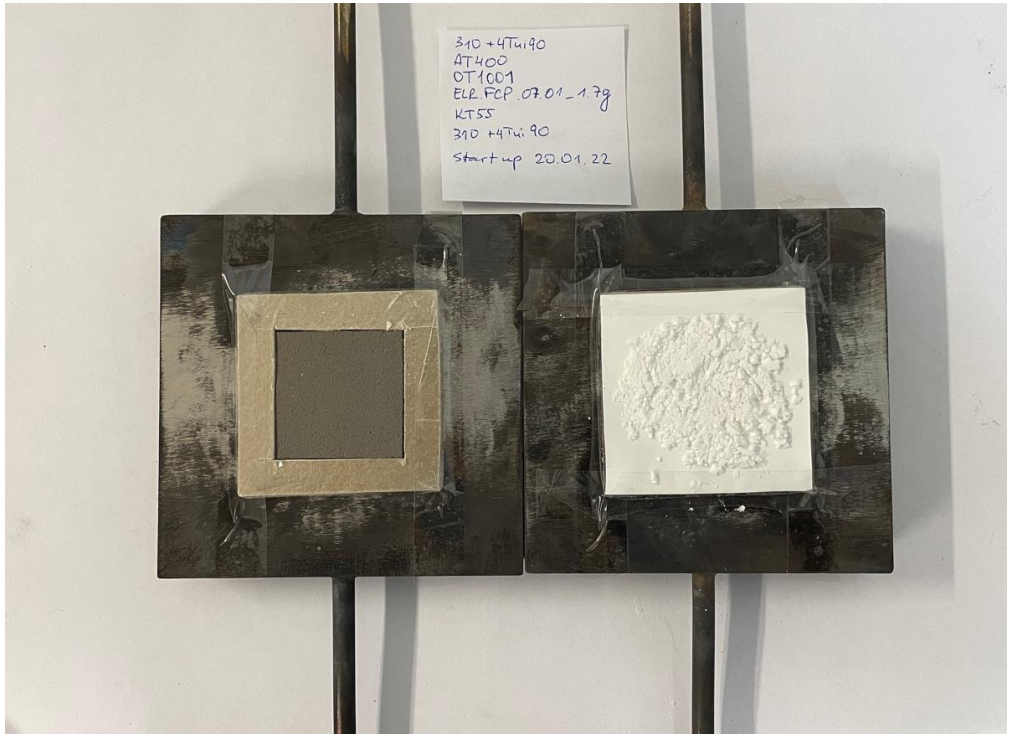
Configuration of the laboratory-scale MCFC





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