Università di Genova
DICCA DIPARTIMENTO DI INGEGNERIA CIVILE, CHIMICA E AMBIENTALE

Molten Carbonate Fuel Cells

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Where am I from?

University of Genoa

The University of Genoa (UNIGE) was founded in 1481.

Nowadays, it consists of 5 Schools:

- School of Natural Sciences, Mathematics and Physics
- School of Medical and Pharmaceutical Sciences
- School of Social Sciences
- School of Humanities
- Polytechnic School

Schools are further organised in departments, with a total of 22.

Department of Civil, Chemical and Environmental Engineering

- Chemical and Process Engineering
- Civil and Environmental Engineering
- Construction and Architecture Engineering
- Engineering for Building Retrofitting
- Environmental Engineering

What is my research focused on?

Molten Carbonate Fuel Cells (MCFCs)

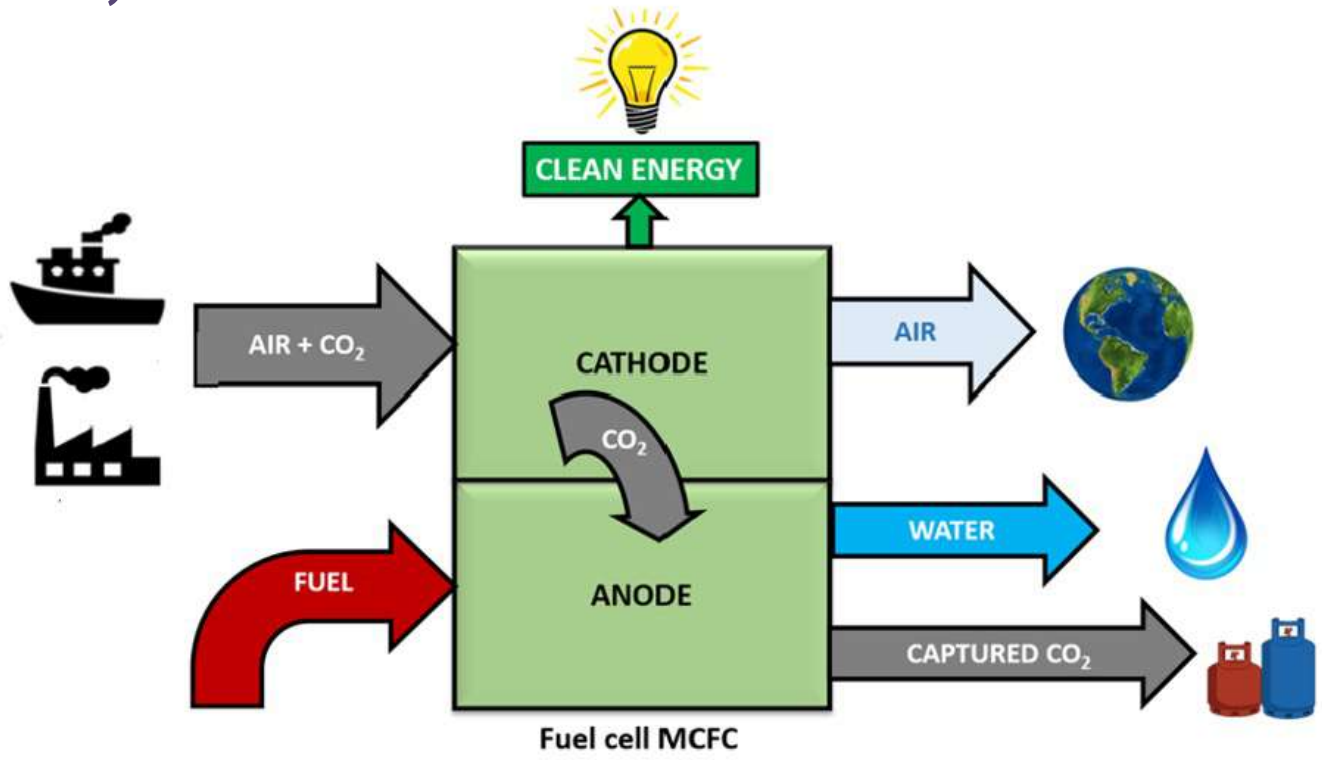
MCFCs are electrochemical devices able to directly convert the fuel chemical energy in electrical energy and at the same time to capture CO_2 from the exhaust of fossil fuel power systems.

FUEL: methane, bio-LNG, methanol, ammonia, ...

ELECTRICAL ENERGY EFFICIENCY: up to 50%

PRODUCTS: clean air, water and captured CO_2

CO_2 CAPTURE RATE: up to 90%



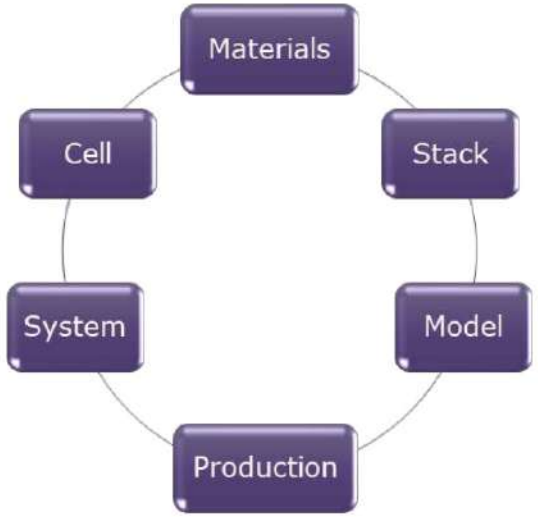
CO_2 CAPTURE + POWER PRODUCTION

In maritime applications CO_2 emission constrains can be respected just with a retrofitting action

My last slide at the Decarbonization Seminar 2022 in Athens

What are we doing?

To develop MCFC technology at each level, we are promoting a strong European task force and we launched the new CapLab laboratory joined between Ecospray and the University of Genoa.



UniGe | DICCA

CapLab
ELECTROCHEMICAL CELLS

Università di Genova + ECOSPRAY
technologies for the planet

ELECTROCHEMICAL CELLS
FOR CARBON CAPTURE &
ENERGY TRANSITION

What have we done?

Network

- ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development
- PSL Research University, Chimie ParisTech
- WUT, Center of Hydrogen and Fuel Cells, Warsaw University of Technology
- KIST, Korea Institute of Science and Technology

CapLab

- Opening on 23/3/23
- CapLab's VIDEO


CapLab
ELECTROCHEMICAL CELLS

Results: scientific publications and feasibility analyses

- R. Risso, L. Cardona, M. Archetti, F. Lossani, B. Bosio, D. Bove
  A review of on-board carbon capture and storage techniques: solutions to the 2030 IMO regulations
  (2023) Green Technologies for Energy Transition - Energies

- L. Cardona, D. Bove, R. Risso, J. F. Basbus, M. Archetti, B. Bosio
  Development of matrices for Molten Carbonate Fuel Cells
  (2023) European Fuel Cell and Hydrogen Conference, Capri, Italy

- M. Archetti, F. Bianchi, B. Bosio, D. Bovea, I. Capestro, L. Cardona, R. Risso
  CapLab: Electrochemical Cells
  (2023) European Fuel Cell and Hydrogen Conference, Capri, Italy

- B. Bosio, M. Archetti, E. Audasso, D. Bove
  Process analysis of a molten carbonate fuel cell on-board application to reduce vessel CO2 emissions
  (2023) Chemical Engineering and Processing - Process Intensification

- M. Archetti, B. Bosio
  Road to Maritime Sector Decarbonization
  (2022) Progress in Marine Science and Technology

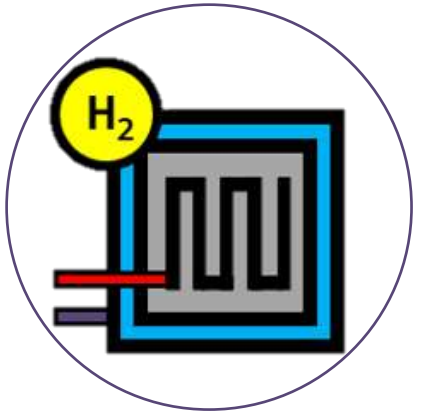
- M. Archetti, E. Audasso, B. Bosio, D. Bove
  High temperature fuel cells to reduce CO2 emission in the maritime sector
  (2022) E3S Web of Conferences, 334, art. no. 04013

Results: experimental development

MCFC production facilities

To develop new optimised MCFC components using innovative production processes appropriate for industrial scale-up

MCFC testing facilities

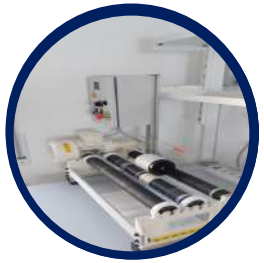


To test MCFC cells and stacks under real operating conditions characteristic of maritime and industrial applications

MCFC production facilities

Raw materials

Raw materials are properly stored and can be metallic and non-metallic fine powders, organic solvents, binders and defoamers, …



Shaping

Different alternative solutions are under study: arc spray, plasma deposition, tape casting, screen printing, …

Characterization

Many analysis instruments are available to check the quality of the produced components, for example to evaluate the porosity, the permeability and the final microstructure.

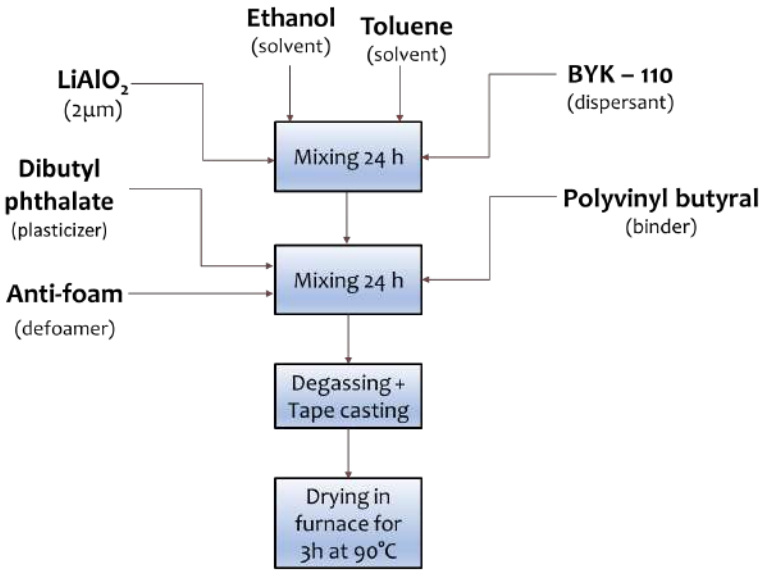
Resulting components

An example of production: $LiAlO_2$ matrixes

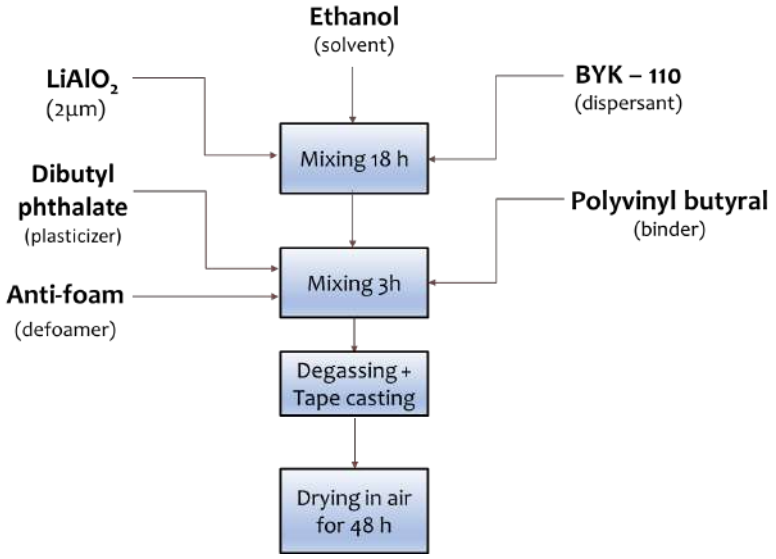
In MCFCs electrolyte fills a ceramic matrix which guarantees high stability, mechanical resistance, gas and electron insulation.

Compared matrix recipes under study

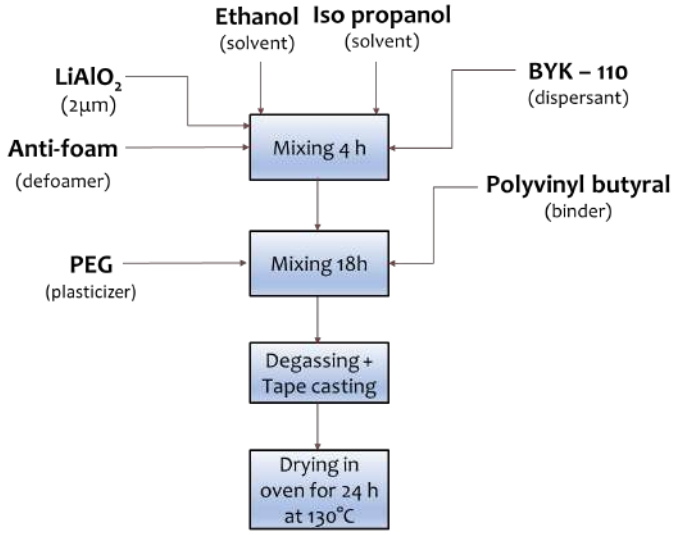
KIST



WUT



ParisTech



1) J. Kim, J. Han, S. Yoon, S. W. Nam, T. H. Lim, H. Kim, "Mechanical properties of the lithium aluminate matrix for MCFC reinforced with metal oxide materials", Current Applied Physics 2010.

2) Baron R, Wejrzanowski T, Milewski J, Szablowski L, Szczesniak A, Fung K Z. Manufacturing of g LiAlO2 matrix for molten carbonate fuel cell by high energy milling . Int J Hydrogen Energy 2018.

3) E. Gurbuz, S. Hubert, L. Jordan, V. Albin, A. Ringuedé, V. Lair, M. Cassir, "Reinforcement of the MCFC matrix by Al-based additives: Effect of lithiation", Ceramics International 2022.

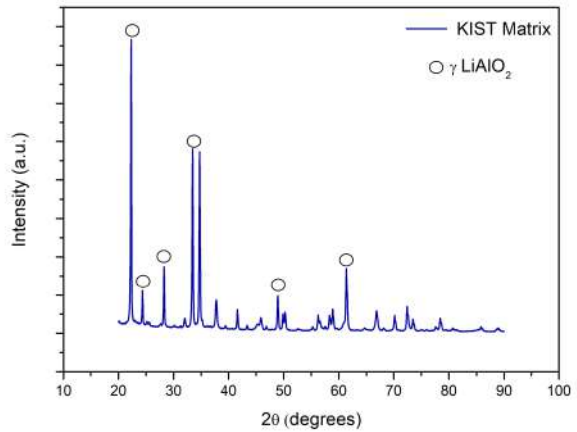
An example of production: $LiAlO_2$ matrixes

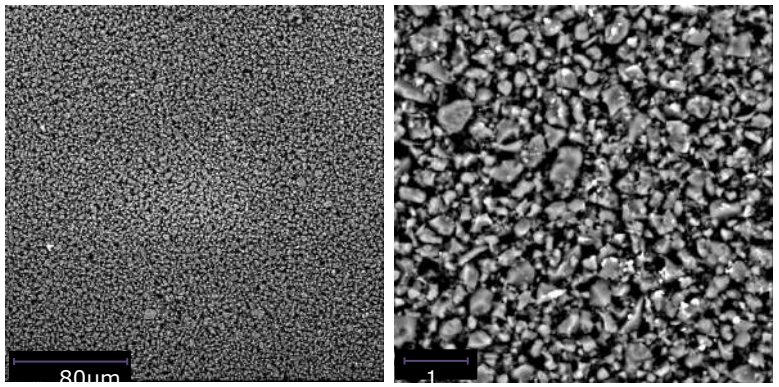
Porosity	*≈50 %*
Pore size	*<1 µm*
Specific surface area	*>10 m^2/g*
Mechanical strength	*>100 gf/mm^2*

Characterization results

X Ray diffraction and SEM analyses

KIST





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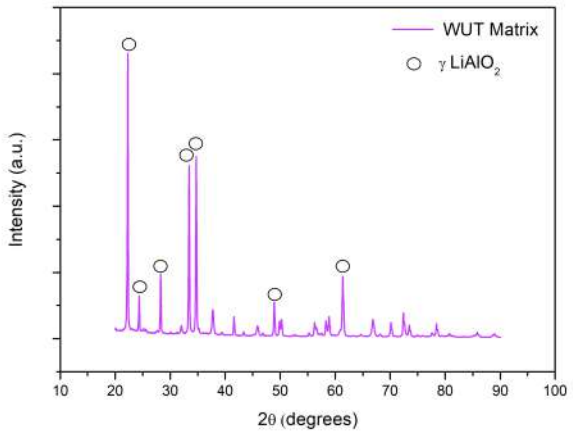
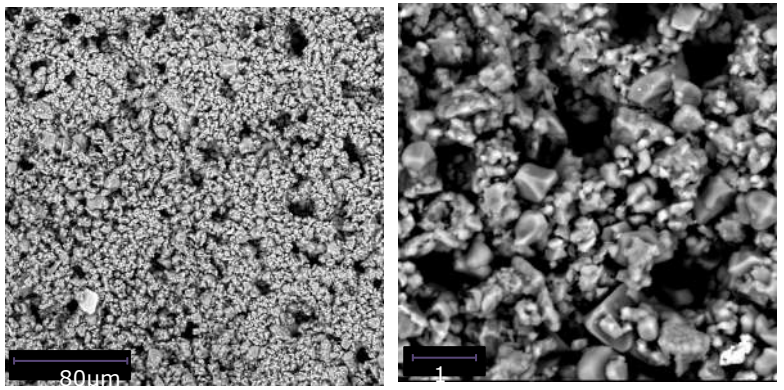
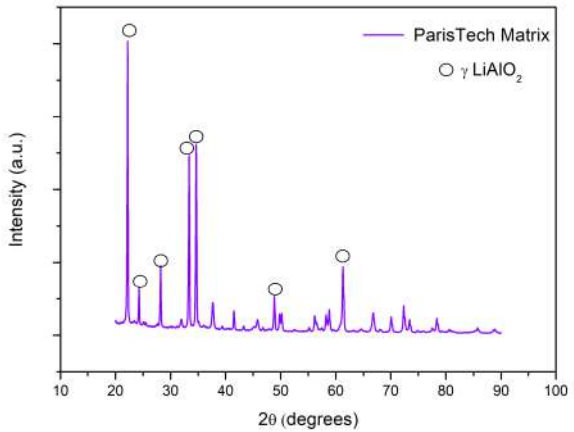
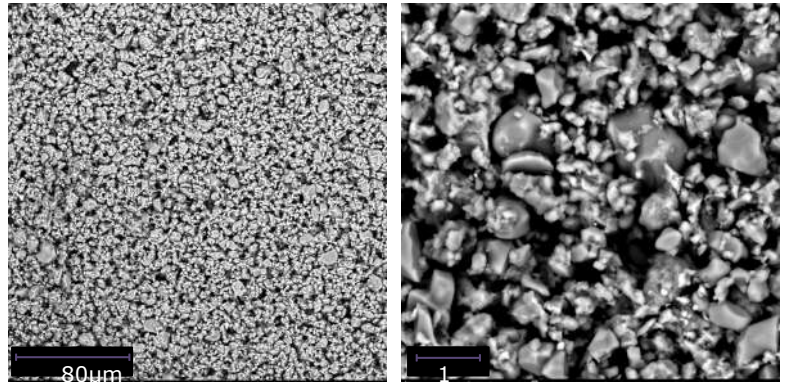




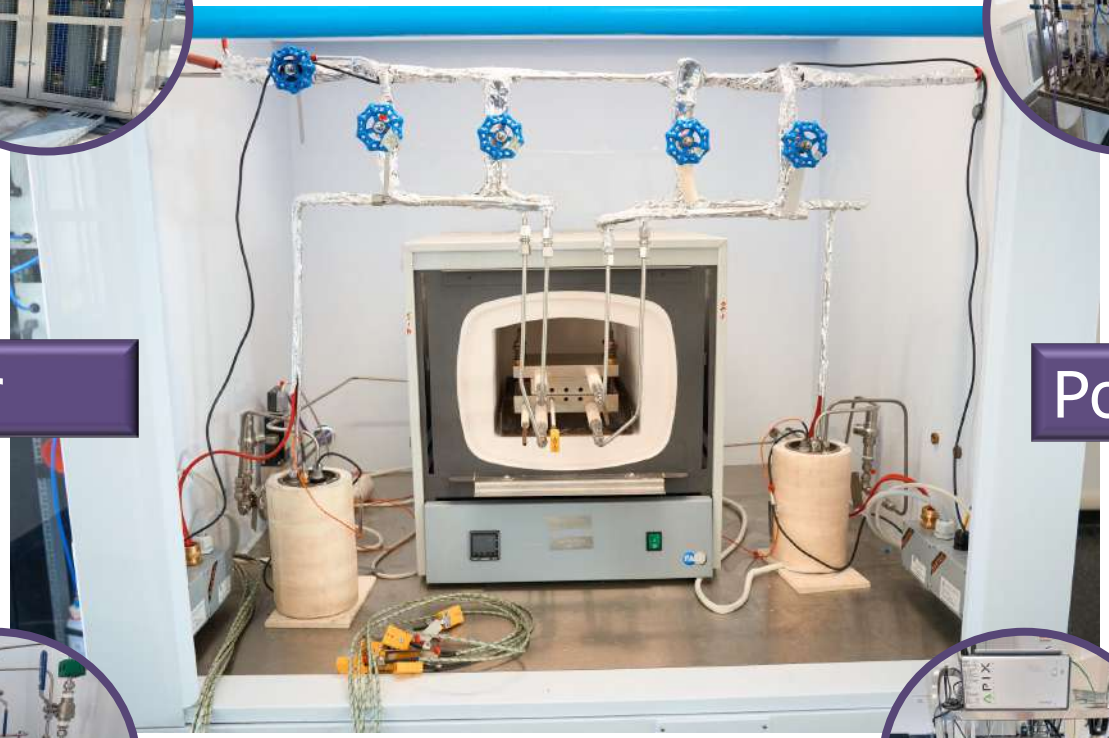
ParisTech





MCFC testing facilities

Gas bottles



Flow meters

Electrolyzer

Potentiostat

Humidifier

Gaschromatograph

THANK YOU FOR ATTENTION

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... see you next time with our optimised MCFC prototype!