

ISTITUTO di ISTRUZIONE SECONDARIA SUPERIORE EINAUDI-CASAREGIS-GALILEI



**ERASMUS PLUS PROGRAMME KA 2
STRATEGIC PARTNERSHIP 2017-2020
EUROPEAN SCHOOLS GO GREEN!
A PROJECT ON SUSTAINABILITY:
THINK GLOBAL, ACT LOCAL!**



INTERVIEW TO MRS BARBARA BOSIO

Associate Professor of Principles of Chemical Engineering

University of Genoa



**QUESTIONS ASKED BY THE STUDENTS OF
GALILEO GALILEI TECHNICAL HIGH SCHOOL
AFTER A WORKSHOP ON THE FUEL CELL**

Can you explain the chemical process of a fuel cell?

Yes, gladly. The process that is at the basis of the operation of a fuel cell converts the chemical energy of a fuel directly in electrical energy. What does it mean? You know that in a traditional thermochemical process, like for example a common internal combustion engine, the fuel is exploited through a combustion, which provides heat, that is thermal energy. Nevertheless, this thermal energy has to be converted into mechanical energy and finally has to be converted into electrical energy. Well, in a fuel cell the conversion is direct, from fuel to electricity, through an electrochemical reaction. And if you take into consideration that each conversion means an efficiency loss, you can understand that this aspect is very important because it entails that the fuel cells have high efficiency and high efficiency means it is possible to reduce the use of fuel and so the impact on the environment. The process at the basis of this advantageous conversion happens thanks to two electrodes, an anode and a cathode, where a gaseous fuel (usually hydrogen) and an oxidant (usually air) are fed respectively. These gases react by means of an electrochemical reaction thanks to ions' migration through an electrolyte, producing steam, heat and, as said, electricity. Actually, the process is very similar to the one occurring in the common batteries, but in the batteries the reactants are stored inside and, after a certain time, are consumed, so that the batteries are exhausted. Instead, in a fuel cell the reactants are fed from the outside, so for example in a stationary plant you can continuously feed the reactants and they never exhaust. This is the case of power generation plants based on fuel cells which provide the energy necessary to an industrial plant, a school, a hospital, a village, a hotel, and so on. So the problem in this case is not the duration of the fuel, like for batteries, but the lifetime of the fuel cell itself, which for the moment does not always meet the desired targets.

Why is the life of fuel cells short?

It depends on many factors, mainly the operating temperature and the quality of the fuel. If the operating temperature is high this can damage the fuel cell materials with ageing. If the fuel is not pure, the contaminants can damage the electrodes and inhibit the reactions. Nowadays, researches are focusing their work on fuel cell degradation problems, the target is to guarantee 40 000 hours of behaviour for stationary applications. The scenario is different for mobile applications, where a shorter lifetime can be sufficient, for example for a PC, a cellular, a car, a bus or other. Anyway in these cases it is not possible to continuously feed the fuel, as previously said for stationary applications, because in these cases the fuel needs to be stored inside the device which has to be independent on any feeding lines and has to be transportable. This, for example, is a power bank which I use for my cellular phone: it works using a fuel cell fed with the oxygen present in the atmosphere and hydrogen, which in this case needs to be stored. This is a little cylinder containing pressurized H₂, when it is exhausted I need to re-charge it from an electrolyser which produces H₂ again, for example from water using solar energy.

How long does hydrogen last in fuel cell cars?

In a car the principle is similar to the previous one: we need to store hydrogen on board to feed the fuel cells and we need to refuel when the hydrogen is exhausted. At the current state of the art, the hydrogen can last as much as a normal full of gasoline, that is more or less how much it is necessary to travel 500 km. Cars of this type are already available on the market, even if they are still few and the network of the hydrogen refuelling needs to be developed on the territory.

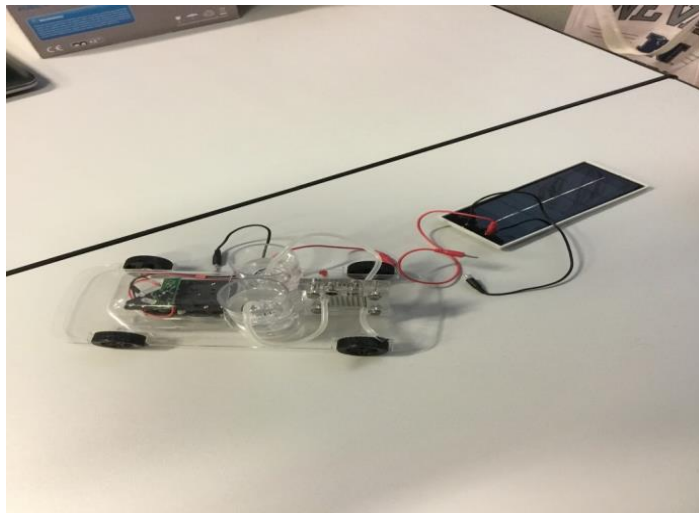
To what extent do fossil fuels pollute?

Their main negative effect on the environment is related to the fact that their use involves the production of CO₂, that is a greenhouse gas, responsible of the dangerous climate changes that we can already observe around us. The use of fuel cells can overcome this problem because they do not produce CO₂, but only steam. Obviously the hydrogen used as fuel does not have to be produced by fossil fuels, but by renewable sources, for example

from the gasification of biomass or from the photovoltaic electrolysis of water, thanks to the energy of the sun.

Do you think that fuel cells will be fully exploited in the future?

Yes, I think so, this technology is very promising. Nowadays many countries worldwide are investing on them. I'm confident that your generation, the generation of my sons, will use this technology in a new energy system which will be able to replace fossil fuels. Obviously, every social and economic revolution needs time, but the technology is ready to enter the market and we must answer as urgently as possible to the needs of our planet to preserve its, and so our health.



BARBARA BOSIO - BIOGRAPHY

Education and training

2000

PhD in Chemical Engineering

Development of Fuel Cell Technologies

Politecnico di Torino - consortium with UNIGE and POLIMI - Torino - IT

1996

Master degree in Chemical Engineering

Modelling and Numerical Evaluation of the Equilibrium and Precipitation Conditions of Mercury in Aqueous Solutions in the Presence of Complex Reactions and Adsorption Phenomena - 110/110 e lode

Università di Genova - Genova - IT

1990

High school diploma (classical studies)

60/60

Liceo Classico C. Colombo - Genova - IT

Academic experience

2011 - ONGOING

Associate Professor of Principles of Chemical Engineering

Univeristà di Genova - Genova - IT

2008 - 2012

Contracted Professor

Università di Trento - Trento - IT

1996 - 2011

Contracted Researcher

Università di Genova - Genova

Teaching activity

Main teachings from 2011:

- Principles of Chemical Engineering 1, Mod. 1: Transport Phenomena at the Macroscopic Level

- Principles of Chemical Engineering 2, Mod. 2: Transport Phenomena at the Local Level

New teachings from 2018:

- Environmental Chemistry and Processes, Mod. 1: Fundamentals of Environmental Processes
- Industrial Processes and Products, Mod. 1: Renewable Energy Production
- Previous teachings:
 - Multiscale analysis and computer simulation of chemical processes (Genova, 2017-2018)
 - Applications of Process Engineering (Genova, 2012-2013)
 - Innovative Chemical Processes (Genova, 2011-2012)
 - Principles of Chemical and Food Engineering (Trento, 2011-2012)
 - Simulation of Fuel Cell Systems (Genova, 2009-2010)
 - Principles of Environmental Engineering (Trento, 2008-2009)
 - Heterogeneous Chemical Kinetics (Genova, 2006-2007).

Responsible of the first Double Degree in Chemical and Process Engineering at the University of Genoa, partner the University of Liège.

Tutor of around 10 master or bachelor theses per academic year. Responsible of Erasmus Programs for studies with University of Edinburgh and Université de Liège.

Responsible of Erasmus Programs for traineeship with Technische Universität München, University College Cork, Arup Deutschland GmbH.

Postgraduate research and teaching activity

Supervision of PhD students, residents and post-doctoral fellows

Supervisor of the following Ph.D. students at UNIGE:

- *Emilio Audasso, Simulation of high temperature fuel cells, XXXIII ciclo;*
- *Bruno Conti, Solid Oxide Fuel Cells: numerical and experimental approaches, XXXI;*
- *Cristina Moliner, Valorisation of agricultural residues, XXVIII ciclo, double degree with Polytechnic University of Valencia (supervisor with Elisabetta Arato e Amparo Ribes);*
- *Nicola Di Giulio, Theoretical and experimental analysis of Molten Carbonate Fuel Cell performance in innovative applications, XXVI ciclo;*
- *Danilo Marra, Fluid-dynamic characterisation of molten carbonate fuel cells in plant optimisation, XX ciclo (supervisor with Elisabetta Arato);* *Co-supervisor* of the following Ph.D. students at Facoltà di Scienze e Tecnologie della Libera Università di Bolzano (*co-supervisor* with Marco Baratieri, *supervisor* Elisabetta Arato):
- *Filippo Marchelli, Processes for Biomass Valorisation, XXXII ciclo;*
- *Dario Bove, Investigation on the biomass gasification in a spouted bed reactor pilot plant, XXIX ciclo.*

Responsible of the following contracted researchers at UNIGE:

- *Dario Bove, Detailed simulation of molten carbonate fuel cells, 2018;*
- *Massimo Curti, Valorisation of food and textile waste for the bio-char production, 2018;*
- *Max Romero Rivas, Sustainable and innovative processes for energy production from biomasses, 2012.*

PhD committees membership

- Civil, Chemical and Environmental Engineering, University of Genoa, 2013- today.
- Fluid-dynamics and Processes of Environmental Engineering, University of Genoa, 2013-2016.

Research interests

My main research activity is focused on the development of fuel cell technology for the clean production of energy.

At the same time, I am involved in associated research topics concerning carbon capture and

transport, water and gas treatment, thermochemical processes like gasification and pyrolysis, re-use of agricultural, municipal and industrial waste for the productions of renewable goods and energy.

Key qualifications:

The detailed simulation of chemical and electrochemical monolithic reactors

The solution of problems related to equipment scale-up

The theoretical and experimental analysis of transport phenomena in porous catalysts

The steady-state and dynamic simulation of process plants

The definition and execution of procedures for testing in laboratories or pilot-plants

Experimental data analyses and estimation of kinetic and thermodynamic non-linear parameters

Computer programming

Grants

2018 - ONGOING

BioChar

FILIDEA srl AGRINDUSTRIA TECCO srl ETG Risorse e Tecnologie srl - IT - IT

Principal investigator

Simulation of an innovative reactor for the production of biochar and syngas from agricultural and textile waste

2017 - ONGOING

Investigation of the phenomena occurring in Molten

Carbonate Fuel Cells (MCFCs)

Exxon Mobil Research and Engineering - US - US

Principal investigator

The projects deals with the study of the phenomena which characterize the behaviour of molten carbonate fuel cells; the planning of experimental campaigns devoted to a better understanding of the reaction mechanisms; the detailed simulation of performance and the proposal of optimized solutions

2017 - ONGOING

Peter on Board

Ministero delle Infrastrutture e dei Trasporti - IT - IT

Participant

Waste treatment on board of cruise ships to reduce environmental impact

2017 - ONGOING

LIBERNITRATE

European Commission

Participant

Responsible reduction of nitrates in the comprehensive water cycle