

Preface

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Avogadro Colloquia in Rome on “Vision and Opportunities of a Sustainable Hydrogen Society”

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Abstract: The fifth edition of Avogadro Colloquia entitled “From Water to Chemicals: Vision and Opportunities of a Sustainable Hydrogen Society”, jointly organized by the Department of Chemical Sciences and Materials Technologies of the National Research Council (DSCTM CNR) and the Italian Chemical Society (SCI), was held at the CNR headquarters in Rome on December 15th–16th, 2022. This relevant periodic conference of SCI also was one of the first events for the celebrations of the Centenary of the Italian CNR. This edition of the Colloquia was focused on the technologies for hydrogen production and use in the so-called green transition towards a society with reduced CO₂ emissions. Such technologies well fit the objectives recommended by the United Nations and by Mission EU2030 for the mitigation of the climate change. Greeting addresses to this event were given by the CNR president Maria Chiara Carrozza, the president of SCI Gaetano Guerra, the elected president of the European Chemical Society (EuChemS) Angela Agostiano, the IUPAC president Javier García Martínez and the director of DSCTM CNR Lidia Armelao. All the representatives of the national and international chemical societies underlined the key role of chemical sciences and innovative materials in the green transition.

Keywords: Centenary of the National Research Council of Italy; decarbonization; green transition; hydrogen; Avogadro Colloquia 2022.

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The conference was developed through a series of invited lectures presented by researchers and experts from Universities and Industry, active on clean production, storage and transport of hydrogen,

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and relative infrastructures for different end uses. The presentations were divided into four thematic sessions:

- Production and use of green hydrogen
- Transport and storage
- Production of chemicals with high added value
- Decarbonization policies.

As regards hydrogen production, water electrolysis processes and materials used in these processes and in fuel cells technology were mainly discussed. Innovative electrocatalytic systems for electrolysis and mechanisms of the hydrogen evolution reaction (HER) at the surface of the electrodes were examined in detail, also through computational approaches. Ion exchange membranes, essential components of electrolyzers, were also considered. Part of this session was also dedicated to biomasses valorization and to the exploitation of biological processes for the co-generation of chemicals and green hydrogen.

Different possible ways of storing hydrogen were then debated, both through chemical approaches (hydrides, complex hydrides, organic carriers and molecular complexes) and by physical methods (compressed or cryo-compressed gas, liquid hydrogen). Case studies were presented by some of the companies participating in the conference, showing the technological complexity connected to infrastructures for large-scale hydrogen transport.

An entire session was then dedicated to chemical contributions on the use of hydrogen, produced by “green” methods, in the synthesis of chemicals of primary interest, such as methanol or so-called “electro-fuels” (“e-fuels”).

The role of hydrogen in decarbonization policies was the subject of the last session. Political-regulatory issues were examined as well as interactions of the hydrogen energy vector with an energy system that will be increasingly electrified. Particular attention was paid to the most difficult industrial sectors to decarbonize (the so-called “hard to abate”) such as steel, ceramics, glass and cement, which constitute a first and crucial challenge area for the use of green and blue hydrogen.

From the scientific contributions and the subsequent stimulating debates, doubts and different opinions on some topics clearly emerged, such as, for example, the role of hydrogen in the future transport systems. However, a clear convergence was found on at least two major themes: (i) the strategic role of hydrogen produced from renewable sources in the future energy system and, (ii) the urgent need of large hydrogen amounts from renewable sources to start the decarbonization of those sectors that do not present viable electricity-based alternatives, e.g. the heavy industry and the production of fundamental chemicals such as ammonia and methanol.

This special issue consists of the following highly relevant and original 10 contributed papers presented by authors from the National Research Council (CNR), Italian Universities and industrial companies.

- (1) H₂ in the energy transition

Vito Di Noto

University of Padova

- (2) Hydrogen as an energy carrier: constraints and opportunities

Nicola Armaroli, Elisa Bandini, Andrea Barbieri

CNR ISOF – Bologna

- (3) Advanced polymer electrolyte membrane water electrolysis for power to gas applications

Stefania Siracusano, Nicola Briguglio, Fabiola Pantò, Claudio Oldani, Laila Grahl-Madsen, Daniel A. Greenhalgh, Rachel Smith, Ben Green, Gunnar Kielmann, Alexander Flat, Swen Steinigeweg, Anna Molinari, Mette Blom, **Antonino S. Aricò**

CNR ITAE – Messina

- (4) Shaping the future of green hydrogen: De Nora’s electrochemical technologies for fueling the energy transition

Michele Perego, Patrick Scilabra

Industrie De Nora – Milano

- (5) Watching atoms at work during reactions

Tomasz Kosmala, **Stefano Agnoli**, Gaetano Granozzi

University of Padova

(6) *In-situ* and operando Grazing Incidence XAS: a novel set-up and its application to model Pd electrodes for alcohols oxidation

Enrico Berretti, Andrea Giaccherini, Vincenzo Dell'Aquila, Francesco Di Benedetto, Giordano Montegrossi, Giovanni Orazio Lepore, Massimo Innocenti, Francesco D'Acapito, Francesco Vizza, **Alessandro Lavacchi**
CNR ICCOM – Firenze

(7) Hydrogen storage and handling with hydrides

Marcello Baricco, Erika M. Dematteis, Jussara Barale, Mattia Costamagna, Mauro F. Sgroi, Mauro Palumbo, Paola Rizzi

University of Torino

(8) Perovskite: a key structure for a sustainable hydrogen economy

Alessandra Sanson

CNR ISSMC – Faenza

(9) Hydrogen production and conversion to chemicals: a zero-carbon puzzle?

Mario Marchionna

SAIPEM – Milano

(10) Rethinking chemical production with “green” hydrogen

Gabriele Centi, Siglinda Perathoner

University of Messina