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2019 IYPT International Year of the Periodic Table of Chemical Elements

Consiglio Nazionale delle Ricerche

150° INTERNATIONAL YEAR OF THE PERIODIC TABLE OF CHEMICAL ELEMENTS

AVOGADRO COLLOQUIA 2019

Elements of the Periodic Table for Energy

ROME

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Nanostructured oxides as key components for solar energy conversion

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Nanostructured oxide electrodes had its breakthrough in the discovery of mesoporous dye-sensitized TiO_2 electrodes for efficient solar cells in the early 1990's by Grätzel and co-workers. This was truly a paradigm shift for research in photovoltaics, with the entering of chemistry for the development of molecules, nanomaterials and interfaces. The research has led to other energy applications using nanostructured oxides, such as solar fuel, batteries and displays. The concept of dye-sensitized solar cells is also the origin of presently the hottest topic in solar cells research, perovskite solar cells.
Coming from Uppsala, Sweden, where oxygen was first separated and characterized by Scheele in 1772-1773, it is natural to take number 8 in the periodic system as the key element for my presentation.

Anders Hagfeldt is a Full Professor in Physical Chemistry at EPFL, Switzerland, and Director of Laboratory for Photomolecular Science. His research focuses on the fields of dye-sensitized solar cells (DSSC), perovskite solar cells (PSC) and solar fuels. His research includes physical chemical approaches for fundamental understanding of electronic properties and dynamics of materials, interfaces and devices, materials science and device development, and development of up-scalable manufacturing methods. He has acted as Dean of Chemistry at Uppsala University. He is co-founder and board member of the company Dyenamo AB. From web of science September 2019, he has published 519 scientific papers that have received over 61,000 citations (with an h-index of 118). He was ranked number 46 on a list of the top 100 material scientists of the past decade by Times Higher Education. In 2014-2019 he was on the list of Thomson Reuter's Highly Cited Researchers. He is a member of the European Academy of Sciences, Royal Swedish Academy of Sciences, Stockholm, Royal Society of Sciences in Uppsala, and the Royal Swedish Academy of Engineering Sciences in Stockholm. He is Doctor Honoris Causa at Université Paris Diderot, France.

Silicon, the key element for photovoltaic energy: past, present and future perspectives

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The most important material for solar cells has been, and still is, silicon. In the year 2018, around 100 GW of new photovoltaic modules installed worldwide employed crystalline silicon (Si) as the absorber material. If we consider its peculiar properties and unique advantages with respect to the other materials for solar cell - availability, efficiency, low cost, no toxicity, long lifetime and sustainability - it should be the leading material also in the future.
In this paper, the past, present and future of crystalline silicon solar cells will be discussed also through a personal lens: that of my research activity on silicon for PV carried out for several European Projects since 1991.

Simona Olga Binetti is Associate Professor of Physical Chemistry at University of Milano-Bicocca, Vice director of Milano Bicocca Solar Energy Research Center, representing UNIMIB in Joint Program on Photovoltaics of European Energy Research Alliance. Qualified Full Professor in Physical Chemistry. She graduated in Physics, got a Master in Material Science and then a PhD in Chemistry.
Her research activity has been mainly devoted to the experimental study of the effect of defects on electrical and optical properties of elementary semiconductor (silicon) and composed semiconductor (silicon germanium alloy and chalcogenide alloys CIGS, CZTS) for photovoltaic (PV) application. In this context she developed original research activities on the role of defects on the opto-electrical properties of silicon and now she is recognized an expert of defects on silicon based solar cells. Since 1990, she has been involved in 10 European photovoltaic energy projects, national projects, some of them as leader, collaborating in research for private owned companies. Currently leading 3 projects. Co-author of 130 peer reviewed publications, 4 chapter books, 6 patents. She did more than 30 invited talks mainly on PV conferences. Her research group currently includes, 3 post-doctoral fellows, 1 PhD student and some master students; the main current scientific interest of the group are materials and devices for inorganic photovoltaics.

Functional organic dyes in light harvesting applications

Claudia Barolo
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The term "functional dyes" has been used for the first time in the early '80s to indicate dye or pigment molecules developed for purposes other than the classical coloration of substrates. Starting from the two seminal International Symposium of Functional Dyes on the early nineties the development of this research frontier has been very fast.
In this contribution recent advances on the development of functional dyes for photovoltaics and other energy-related applications will be discussed. More specifically will be highlighted the role of the organic dyes as photosensitizers and solar harvester. In fact, their extended and versatile conjugated carbon structure can be finely tuned in order to absorb not only the visible part of the solar light, but also, selectively if needed, the UV and NIR part of the solar spectrum, making possible the realization of both colorful or colorless transparent solar cells.

Claudia Barolo received her PhD in Chemistry from Università di Torino in 2001. In 2006, she became assistant professor and, in 2014, associate professor in Industrial Chemistry at the Department of Chemistry of the same university. She is vice-coordinator of the Innovative PhD Programme in Innovation for the Circular Economy.
Her research activity is mainly focused on the synthesis and characterization of functional dye molecules and hybrid materials for technological applications (photovoltaics, nanotechnology, biotechnology). As an expert in the field of sensitizers for solar cells, she is the recipient of several national and international research grants and industrial collaborations. She is part of the Management Board of NIS Interdepartmental Centre and of the Scientific Board of the ICxT Interdepartmental Centre. Her research work resulted in more than 100 ISI articles.

Oxygen- and sulfur-functionalized ionic liquids as electrolyte components in lithium batteries

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Lithium-ion batteries have revolutionized the energy storage technology and enabled the mobile revolution, as recognized by the recently assigned Noble Prize in Chemistry 2019. Thanks to its redox potential, high energy density and capacity, lithium, the lightest metal of our periodic table, is the best candidate as negative electrode to replace intercalation materials, like graphite, which is used today in commercial batteries. However, due to the great reactivity of lithium and possible dendrite formation during cycling operations, most suitable electrolytes, stabilizing the interface with lithium and having optimized safety features, must be developed. To combat flammability of the organic electrolyte commonly adopted in lithium-ion batteries, highly stable ionic liquids (ILs), having negligible vapour pressure, have been widely investigated as electrolytes.
The goal of this work was to develop highly conductive, stable IL compounds, with reduced viscosity and suppressed crystallization. Tailored, in-house synthesized new ILs, based on cyclic quaternary ammonium cations, with oxygen or sulfur functionalization [1,2], and bis(trifluoromethanesulfonyl)imide (TFSI) or bis(fluorosulfonyl)imide (FSI) anion [3], will be here described and their electrochemical performances in lithium-metal and lithium-ion configurations will be discussed.

References: [1] *Electrochem. Comm.* 2016, 63, 26; [2] *ChemSusChem* 2017, 10, 2496; [3] *Electrochim. Acta* 2019, 293, 160.

Maria Assunta Navarra has a master degree in Chemistry and a PhD in Materials Science (2006). She is researcher and adjunct professor at Sapienza University of Rome, where she is teaching electrochemical methods. Her research is focused on functional materials for energy storage and conversion, mainly, electrolytes for lithium batteries, fuel cells and electrolyzers. At the Department of Chemistry of Sapienza University of Rome, she is leading the group of Electrochemistry and Nanotechnologies for Advanced Materials (ENAM). She is chart-member of Eco Recycling, a spin-off of Sapienza University of Rome, dealing with the recovery of special wastes and raw materials from electrical and electronic devices. Awarded in 2007 by the international ENI ITALGAS prize "Debut in Research", she is author of 75 peer-reviewed international papers, three extended conference proceedings, three papers in international journals, one chapter in book and one patent.

Carbon-based, layered composites for energy storage and environmental applications

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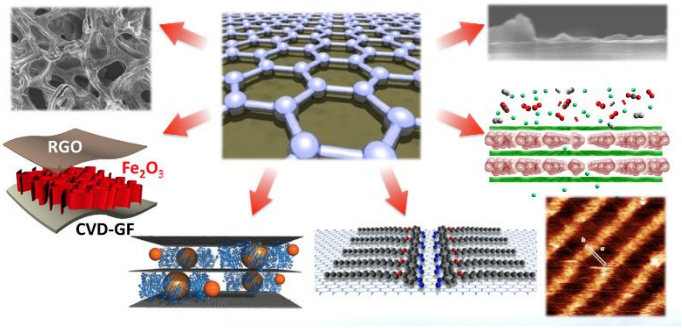

In this talk I will describe how to use graphene and related materials to produce 2D composites with polymers, metal oxides or organic molecules, and how such composites can allow novel technological applications for energy storage, gas and water purification.
The element carbon is the main building block of all forms of life and also of many useful materials, thanks to its versatile chemistry coupled with the ability to form strong chemical bonds. In particular, benzene rings made by six C atoms are stable building blocks in organic chemistry and materials science. Merging together an infinite number of benzene rings we obtain a flat, flexible sheet of carbon atoms, mechanically robust, chemically stable in air and electrically conductive: graphene.
The 2-dimensional (2D) shape of graphene can be used to create nanostructures impossible to do with conventional 3D materials or 1D polymers, like ultralight foams or layered composites, made of different stacked nanosheets. Molecules and ions can penetrate and diffuse in between these 2D nanosheets, allowing applications that span form lithium storage for batteries to water purification, to gas separation.
Using this approach, there is practically no limit to the number of possible 2D structures inspired to graphene which shall be created.

References: *Nanoscale* 2019, 11, 5265; *Mater. Today* 2018, 21, 223; *Chem. Eng. J.* 2017, 326, 130; *ACS Nano* 2016, 10, 7125; *Nat. Commun.* 2016, 7, 11090M; *Nanoscale* 2016, 8, 6739; *Carbon* 2015, 84, 254.

Vincenzo Palermo is a research director of CNR in Bologna, Italy and professor of Chalmers University of Technology in Göteborg, Sweden. He works as the vice-director of the Gra phene Flagship, one of the largest science projects ever launched in Europe, coordinating ca. 150 partners located in 23 countries. He has published >150 scientific articles on international journals in chemistry, nanotechnology and materials science and collaborates with many key industrial partners in Europe. He has won the Lecturer Award for Excellence of the Federation of European Materials Societies (FEMS), the Research Award of the Italian Society of Chemistry (SCI) and the Science dissemination awards of the Italian Book Association. He writes as a columnist for the science magazine SAPERE and has published two books on the life and science of Albert Einstein (Hoepli, Milano, 2015) and of Isaac Newton (Hoepli, Milano, 2016).

In situ NMR and diffraction studies of battery materials: H, Li, Na and Mg

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The development of light, long-lasting rechargeable batteries (and the invention of the lithium-ion battery, now 25 years ago) has been an integral part of the portable electronics revolution. This revolution has transformed the way in which we communicate and transfer and access data globally. Rechargeable batteries are now playing an increasingly important role in transport and grid applications, but the introduction of these devices comes with different sets of challenges. New technologies are being investigated, such as those using sodium and magnesium ions instead of lithium, and the flow of materials in an out of the electrochemical cell (in aqueous-based redox flow batteries for example). Importantly, fundamental science is key to producing non-incremental advances and to develop new strategies for energy storage and conversion.
The first part of this talk will focus on our work on the development of methods that allow devices to be probed while they are operating (i.e., *in-situ*). This allows, for example, the transformations of the various cell components to be followed under realistic conditions without having to disassemble and take apart the cell. To this end, the application of new *in* and *ex-situ* nuclear magnetic resonance (NMR), magnetic resonance imaging (MRI) and X-ray diffraction approaches to correlate structure and dynamics with function in lithium- and sodium-ion and redox flow batteries will be described. The *in-situ* approach allows processes to be captured, which are very difficult to detect directly by ex-situ methods. To illustrate, we have used NMR, theory and pair distribution function (PDF) analysis methods, to determine the local and longer-range structures of a series of amorphous and disordered Li and Na anode structures, including C, Sn, Ge, Si and P. Both thermodynamic and metastable phases are identified via theoretical (DFT) approaches and compared with NMR, PDF and (in situ) diffraction measurements, the materials often transforming via metastable structures. New on-line *vs.* operando methods to study redox flow batteries will be discussed. Finally, many of the battery electrode materials are paramagnetic and their study has involved the development of new experimental (NMR) and theoretical approaches to acquire and interpret spectra. Recent studies to correlate lithium, sodium and magnesium hyperfine shifts with local structure and to probe dynamics will be described.

Clare P. Grey, FRS is a Royal Society Research Professor, the Geoffrey Moorhouse-Gibson Professor of Chemistry at Cambridge University and a Fellow of Pembroke College Cambridge. She received a BA and D. Phil. (1991) in Chemistry from the University of Oxford. After post-doctoral fellowships in the Netherlands and at DuPont CR&D in Wilmington, DE, she joined the faculty at Stony Brook University (SBU) as an Assistant (1994), Associate (1997) and then Full Professor (2001-2015). She moved to Cambridge in 2009, maintaining an adjunct position at SBU. She was Director of the Northeastern Chemical Energy Storage Center, a Department of Energy, Energy Frontier Research Center (2009-2010) and Associate director (2011-2014). She is currently the director of the EPSRC Centre for Advanced Materials for Integrated Energy Systems (CAM-IES) and a member of the Expert Panel of the Faraday Institution. Recent honours and awards include Honorary PhD Degrees from the Universities of Orleans (2012) and Lancaster (2013), the Research Award from the International Battery Association (2013), the Royal Society Davy Award (2014), the Arfvedson-Schlenk-Preis from the German Chemical Society (2015), the Société Chimique de France, French-British Prize (2017), the Solid State Ionics Galvani-Nernst-Wagner Mid-Career Award (2017), the Eastern Analytical Symposium Award for Outstanding Achievements in Magnetic Resonance (2018), the Sacconi Medal from the Italian Chemical Society (2018), the Charles Hatchett Award, Institute of Materials, Minerals and Mining (2019), and the RSC John Goodenough Award (2019). She is a foreign member of the American Academy of Arts and Sciences, and a Fellow of the Electrochemical Society and the International Society of Magnetic Resonance. Her current research interests include the use of solid state NMR and diffraction-based methods to determine structure-function relationships in materials for energy storage (batteries and supercapacitors), conversion (fuel cells) and carbon capture.

Copper for artificial photosynthesis

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Natural photosynthesis operating in plants and photosynthetic microrganisms is responsible for the production of all the biomass on earth from carbon dioxide and water using sunlight as the requested energy. This biological process is a unique source of inspiration for developing artificial photosynthetic systems. Indeed, conversion of carbon dioxide into hydrocarbons and alcohols using renewable electricity as an energy source is an amazingly attractive strategy not only for storing renewable energies into the form of chemical energy (a fuel), but also for using CO_2 as a raw material for the synthesis of chemical products, for example carbon monoxide, hydrocarbons and alcohols. However, CO_2 activation is a complex process requiring multiple electron and proton transfers, which can be controlled only with specific catalysts. Finding new stable, efficient and selective catalysts for CO_2 reduction is critical in order to make this strategy a practical industrial option. However, intriguingly, production of multicarbon organic compounds is only possible with copper (Cu)-based materials so far. Here we describe the artificial photosynthetic strategy and provide some recent examples from our laboratory of original Cu-based heterogeneous catalysts for CO_2 electroreduction. In particular, we describe a dendritic porous Cu oxide material which catalyzes both oxidation of water to oxygen at the anode and CO_2 reduction into ethylene at the cathode [1,2,3]. Coupling such an electrolyzer to a PV cell allow the production of "solar" ethylene [2]. Also a novel class of metal-doped nitrogen-doped carbon materials showing promising properties for CO_2 electroreduction to ethanol is described [4].

References: [1] *Angew. Chem.* 2017, 56, 4792; [2] *Proc. Natl. Acad. Sci.* 2019, 116, 9735; [3] *Nat. Mater.* 2019, 18, 1222-1227; [4] *Angew. Chem.* 2019, 58, 15098.

Marc Fontecave is Professor at the Collège de France, Paris, since 2009, Director of the Laboratory of Chemistry of Biological Processes, President of the Foundation of the Collège de France, Member of the French Academy of Sciences, Member of the Royal Swedish Academy of Sciences, Member of Academia Europea, President of the Scientific Council of VEOLIA Water Technologies, and Member of the Scientific Council of EDF. His research activity is aimed at developing catalysts and biocatalysts, via the study of the structure and the reactivity of metalloenzymes and of synthetic systems mimicking metal-based active sites. A multidisciplinary approach is used, based on the concepts and methods of protein chemistry, enzymology, structural biology, in one hand, and synthetic organic and inorganic chemistry, solid chemistry and catalysis in the other hand. As examples of running projects: (i) characterization of iron-sulfur enzymes involved in protein and tRNA modification; (ii) characterization of the protein machineries involved in the biosynthesis of complex metallobiofactors; (iii) preparation, evaluation and development of novel bioinspired molecular and solid (photo)catalysts based on non-noble metals for hydrogen production and oxidation, water oxidation as well as for carbon dioxide reduction and their development in fuel cells and (photo)electrolyzers. He counts 400 publications, h-index 76, 19500 citations (excluding self-citations), 8 patents and 435 invited conferences and seminars.

The challenge for a more sustainable society: catalysis for chemicals and fuels from renewables

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The so-called *biorefinery* is the emblem of a chemical industry striving to become more sustainable, by replacing conventional fossil-based sources with renewable ones. In the context of the *bioeconomy*, the use of biomass and *bio-platform molecules* to produce chemicals and fuel additives represents one of the most efficient ways to contrast the greenhouse effect by "recirculating" CO_2 emissions, an objective which perfectly fits the *Circular Economy* strategy.
In order to achieve these goals, catalysis plays a fundamental role. In this lecture, I will report about the state of advancements of a few technologies aimed at the valorisation of bio-based building blocks into chemicals and fuels, processes which are currently those offering the best chances to become commercial. Nanomaterials and multifunctional catalysts are the key tools for realising complex transformations, which often include defunctionalisation of highly oxygenated compounds and the introduction of new moieties. From another perspective, it is also crucial that scientists avoid the use of critical metals (e.g., conflict minerals, high-concern metals, critical minerals) for the development of new catalysts; indeed, the replacement of some catalysts currently used in the chemical industry is becoming one of the driving forces for research and innovation in this field.

Fabrizio Cavani received his Ph.D. in Industrial Chemistry in 1987. Then he worked at the Catalysis Centre of EniChem Synthesis. In 1990 he was appointed Assistant Professor at Bologna University, where since 2014 is Full Professor of Industrial Chemistry. Currently he is the Coordinator of the Interdivisional Group of Catalysis of the Italian Chemical Society, and Director of the Department of Industrial Chemistry "Toso Montanari" at Bologna University.His research is mainly in the field of heterogeneous and homogeneous catalysis, mainly oriented to application in the chemical industry.

2D-materials-based energy storage devices

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Graphene and related two-dimensional materials (GRMs) are entering several application areas [1-5], improving the performance of existing devices or enable new ones. A key requirement for the implementation of GRMs in the energy field is the development of industrial-scale, reliable, inexpensive production processes [2], while providing a balance between ease of fabrication and final product quality.
In this context, the production of GRMs by solution processing [2,6] represents a simple and cost-effective pathway towards the development of GRMs-based energy devices, presenting huge integration flexibility compared to other production methods. Here, I will first present our strategy to produce GRMs based on different elements at a large scale by wet-jet milling [7] of their bulk counterpart and then an overview of their applications for energy storage devices [3,8-16].

References: [1] *Nanoscale* 2015, 7, 4598; [2] *Mat. Today* 2012, 15, 564; [3] *Nat. Photonics* 2010, 4, 611; [4] *Opt. Mater. Express* 2014, 4, 63; [5] *Nat. Nanotech.* 2018, 13, 183; [6] *Adv. Mater.* 2016, 28, 6136; [7] *Mater. Horiz.* 2018, 5, 890; [8] *Science* 2015, 347, 1246501; [9] *Nano Lett.* 2014, 14, 4901; [10] *2D Mater.* 2018, 5, 01502; [11] *Nano Energy* 2018, 51, 656; [12] *Nano Lett.* 2018, 18, 7155; [13] *ChemPlusChem* 2019, 84, 882; [14] *ACS Applied Energy Mater.* 2019, 2, 1793; [15] *Nanoscale Horiz.* 2019, 4, 1077; [16] *Adv. Funct. Mater.* 2019, 29, 1807659.

The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation program under grant agreements No. 785219 - GrapheneCore2.

Francesco Bonaccorso gained the PhD from the University of Messina after working at the Italian National Research Council, the University of Cambridge and the University of Vanderbilt. In June 2009 he was awarded a Royal Society Newton International Fellowship at Cambridge University, and elected to a Research Fellowship at Hughes Hall, Cambridge, where he also obtained a MA. He is currently leading the processing and prototyping group at the Istituto Italiano di Tecnologia (IIT), Graphene Labs. He was responsible in defining the ten years scientific and technological roadmap for the European Graphene Flagship. He is now Deputy of the workpackage Innovation of the Flagship. He was featured as 2016 Emerging Investigator by J. Mater. Chem. A and in 2019 by ChemPlusChem. His research interests encompass both the fundamental understanding and solution processing of novel nanomaterials and their technological applications. He is Co-founder of BeDimensional Spa.

Il Sistema Periodico e due anniversari

Pietro Greco
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Il Sistema Periodico e due anniversari. Il primo è quello della proposta di una Tavola periodica degli elementi da parte di Dmitrij Ivanovič Mendeleev, che compie 150 anni. Il secondo anniversario è quello della nascita, cento anni fa, di Primo Levi, chimico e quindi, come amava dire, scrittore. Primo Levi è stato eletto dalla Royal Institution inglese a più grande scrittore di scienza di tutti i tempi. E un suo libro, proprio quello intitolato Il Sistema Periodico è stato eletto, sempre dalla Royal Institution, a miglior libro di scienza mai scritto. Il mio intervento sarà dedicato proprio a Primo Levi e alla sua interpretazione da scrittore del Sistema Periodico.

The Periodic System of the Elements has two anniversaries. The first one is the Periodic Table of Elements that Dmitrij Ivanovič Mendeleev proposed 150 years ago. The second one is the Primo Levi birth, one hundred years ago. The Royal Institution of United Kingdom designated the Italian writer as the best one in science literature history. The Royal Institution designed the Primo Levi's book, Il Sistema Periodico (The Periodic System), as the best one in science literature, also. In my talk I'll speak about Primo Levi and his interpretation of the Periodic System.

Pietro Greco is a scientific journalist and a science writer. He has a degree in chemistry. Actually, he is - charter member of Fondazione IDIS-Città della Scienza in Naples, chief editor of *Il Bo Live*, the web journal of Padua University, editor of *Scienza&Società*, published by Centro Pristem of Bocconi University in Milan, co-editor of web journal *Scienzainrete*, published by *Gruppo 2003*, an association of more highly-cited Italian scientists, editorialist of some magazines, mainly *Rocca*, *Left, Pagina 99, L'Espresso. Prisma*, editorialist of *Radio3Scienza*, a radio program of RAI, member of "Working Group for the advancement of scientific and technological culture" of the Italian Office of Education, University and Research, teacher of courses of Scientific Journalism, Science Communication Theory, History of Science in Milan (MACSIS, Bicocca University), Rome (MGS, University La Sapienza) and Trieste (MSC of ISAS), "socio corrispondente" of Accademia delle Arti del Disegno in Florence. He is author and scientific editor of some television program, namely: *Pulsar. Storia della scienza e della tecnica nel XX secolo*; *X Day. I grandi della scienza del Novecento*. He was one of the founders and for some years director of *Master in comunicazione della scienza* (MCS) of ISAS in Trieste. He was director of FEST 2008 (Fiera dell'editoria scientifica) e science festival in Trieste. He was Adviser of Fabio Mussi, Italian Minister of University and Research (2006-2008). As science writer he published 35 monographies. Awards: Premio Serono for scientific essays with *Figli del genoma* (2004), Premio Frontino-Montefeltro, "Culture and Science" section with *L'astro narrante. La Luna nella scienza e nella letteratura italiane* (2011), Premio Fermi di Cecina with *I nipoti di Galileo* (2012), Premio "Vittorio Castellani" by SAIt (Società Astronomica Italiana) and INAF (Istituto Nazionale di Astrofisica) (2014), Premio Internazionale Calabria per il giornalismo scientifico (2015), "Biogem Maria Antonia Gervasio" award to the career (2017), finalist of "Premio Galileo" in Padua (2019).

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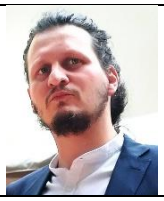
Francesco Barzagli CNR – ICCOM Researcher francesco.barzagli@iccom.cnr.it	*From CO_2 capture to the synthesis of useful chemicals: low energy consumption methods for carbon recycling*	
Linda Bergamini CNR – ISTEC PhD student linda.bergamini@istec.cnr.it	*All-inorganic perovskites for solar conversion*	
Chiara Liliana Boldrini Università degli Studi di Milano-Bicocca Post-doc researcher chiara.boldrini@unimib.it	*Deep eutectic solvents in ecofriendly electrolytes in dye sensitized solar cells: producing electricity with your cupboard foodstuff*	
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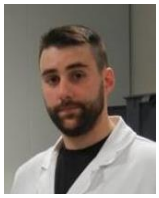
Enrico Lamanna Università degli Studi di Roma "Tor Vergata" PhD student enrico.lamanna@uniroma2.it	*2-terminal mechanically stacked perovskite/silicon tandem solar cells*	
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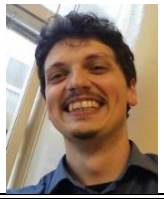
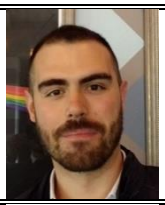
Dario Mosconi Università degli Studi di Padova Post-doc researcher dario.mosconi@unipd.it	*Highly efficient $MoS_2/Ag_2S/Ag$ photoelectrocatalyst obtained from a recycled DVD surface*	

Maria Vincenza Pagliaro CNR – ICCOM PhD student mpagliaro@iccom.cnr.it	*Palladium-ceria catalysts with enhanced alkaline hydrogen oxidation activity for anion exchange membrane fuel cells*	
Mario Prejanò Università della Calabria Post-doc researcher mario.prejano@unical.it	*Iron catalyzed reversible hydrogenation/dehydrogenation between CO_2 and formic acid. Insights from computations*	
Francesco Rigodanza Università degli Studi di Padova Post-doc researcher francesco.rigodanza@gmail.com	*Supramolecular quantasome for artificial synthesis*	
Federico Rossi Università degli Studi di Siena PhD student fe.rossi@unifi.it	*Environmental profile of manufacturing and use phases of different types of batteries*	
Eduardo Schiavo Università degli Studi di Napoli "Federico II" PhD student eduardo.schiavo@unina.it	*CO_2 adsorption and activation on $CuFeO_2$ delafossite photoelectrode, new insights from first-principles calculations*	
Matteo Signorile Università degli Studi di Torino Post-doc researcher matteo.signorile@unito.it	*Copper-based materials for methane oxidation*	
Leonardo Triggiani CNR –IPCF Post-doc researcher l.triggiani@ba.ipcf.cnr.it	*Hot-exciton ultrafast dynamics in all-inorganic perovskite nanocrystals*	
Qian Wang Università degli Studi di Trieste PhD student buctwangq@163.com	*Interfacial structure-determined reaction pathway and selectivity for 5-hydroxymethyl furfural hydrogenation over Cu-based catalysts*