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EDITORIAL

Environmental photocatalysis and photochemistry for a sustainable world: a big challenge

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During the two last decades, advanced oxidation processes and especially photocatalysis have caused enormous considerations and have been demonstrated to be the "green" and effective methods for water and air purification, water disinfection, hazardous waste remediation, antibacterial, and self-cleaning and more recently a technology for energy storage (e.g. hydrogen production from photocatalytic water splitting). However, owing to low photocatalytic efficiency, the environmental applications of various photocatalytic materials and technologies are still very limited. Thus, more improvement and investigations are highly required from the viewpoint of practical use.

The present issue includes 20 articles mainly dealing with materials and devices for water and air purification. Among these latter, Nathalie Costamarrone, Sylvie Lacombe and co-workers reported valuable results on the efficiency of air-purifying photocatalytic devices both in a laboratory airtight chamber and in pilot rooms, whereas Italian investigators from Università Politecnica delle Marche developed a TiO_2-photocatalytic oxidation system combined with an electrostatic filter for nitrogen oxide reduction and degradation of VOCs. A new test method was developed at the University of Toulouse to assess the photocatalytic activity of TiO_2-coated plasterboards, with a study under UV illumination focused on the degradation of NO and NO_2 under realistic conditions.

The degradation of emerging pollutants of water mostly implies the photocatalytic or photo-Fenton abatement of textiles or dye-containing wastewaters or of pharmaceutical compounds. Some of the studies reported in the present issue use solar irradiation and verify the extent of toxicity removal in parallel to the degradation of organics. This is the case of the textile wastewaters treatments carried out by the Brazilian groups of Camila Amorim and Ana Maria Lima and co-workers, these latter employing TiO_2, ZnO and Ni_2O_5 photocatalysts. Other Brazilian investigators reported on the use of perovskite-type titanate zirconate as photocatalysts for textile wastewater treatment under UV-C irradiation.

Spanish groups from the Universitat Politècnica de València employed the photo-Fenton process for the treatment of real textile wastewaters containing an elevated amount of complex organic matter. Alessandra Bianco Prevot, in collaboration with a group of la Plata, Argentina, investigated the degradation of caffeine, taken as standard emerging pollutant, under both Fenton and photo-Fenton conditions, as well as in the presence of magnetite nanoparticles. In situ production of hydrogen peroxide in acidic medium was attained in an electrochemical reactor by Peralta-Hernandez, to degrade commercial dyes in an electro-Fenton process. Isabella Natali Sora achieved fast photocatalytic degradation of pharmaceutical micropollutants employing perovskite photocatalysts eventually in combination with hydrogen peroxide, though observing that treatment longer than 5 h is required to attain complete detoxification. Benedetta Sacchi and co-workers reported successful removal of pharmaceutical compounds employing commercial micro-TiO_2 catalysts in deionized and tap water.

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Other studies focus on the development and testing of novel photocatalytic materials or devices. Printed flexible integrated cells for photoelectrochemical oxidation of aqueous pollutants were made by Petr Dzik (Brno University of Technology) and Michael Neumann-Spallart (Université de Versailles) and used in degradation experiments of aqueous solutions of benzoic acid under UVA irradiation. At the University of Strasbourg, the photocatalytic degradation of paraquat was investigated employing sol-gel-synthesized TiO_2 nanoparticles in the presence of different amounts of Pluronic P123. A variation of the particle's aspect ratio, from spherical to rod-shaped, was observed, which influences the photocatalytic activity. Novel magnetically recoverable TiO_2/WO_3 photocatalysts were successfully prepared and tested in bisphenol A oxidation, as model wastewater pollutant under simulated solar light, in a collaboration between the Universities of Cantabria and Cincinnati. The role of surface Cu and Zr sites in the photocatalytic activity of TiO_2 nanoparticles, prepared by the incipient impregnation method, was thoroughly investigated by Štangar and co-workers, University of Nova Gorica. Structural information on metal cation incorporation and its chemical state was obtained by XAS analysis.

Photocatalytic activity tests, performed employing dichloroacetic acid and TiO_2 modified with noble metals and/or graphene oxide, showed that platinum-containing materials are best performing and that the presence of graphene oxide in the composite not always increases the photoactivity of the materials. The role of Se-doped and Se-N-codoped visible light active TiO_2 was investigated in the solar photocatalytic disinfection of *Escherichia coli*, aiming at assessing inactivation of pathogen in drinking water. In a collaboration between Iranian and Slovenian laboratories, effective photocatalysts were prepared, characterized by several complementary spectroscopic techniques and tested in phenol degradation under UV-C illumination. Cr(III)-doped TiO_2 materials prepared by microwave-assisted sol-gel synthesis by Mexican investigators exhibited higher photocatalytic activity than undoped TiO_2 and benchmark P25 TiO_2 under visible light radiation, with an optimal Cr(III) doping amount.

Finally, a very interesting paper of the present issue deals with the development of advanced mortar coatings for cultural heritage protection. Two kinds of polymeric-inorganic coatings were successfully employed by a group of young Italian scientists to improve the water repellence and consequently the damage resistance of the coatings.

This special issue is a collection of key articles presented at the 9th European Meeting on Solar Chemistry and Photocatalysis: Environmental Applications—SPEA9, held at the Convention Center in Strasbourg, France, between 13th and 17th of June, 2016. This meeting was organized by the *Institut de chimie et procédés pour l'énergie, l'environnement et la santé* (ICPEES)—Institute of Chemistry and Processes for Energy, Environment and Health—under the auspices of the French National Center for Scientific Research (CNRS) and the University of Strasbourg.

Launched in 2000 and 2002 in Saint-Avold, France, the European meeting series SPEA progressively gained over the last 15 years its renown among the most relevant meetings in solar chemistry and photocatalysis by travelling around Europe. Three hundred fifty researchers and PhD students from 47 nationalities coming from 5 continents participated at this ninth edition. The program included 6 plenary lectures, 4 extended keynote speakers and 58 regular oral talks. The scientific program was organized into thematic plenary sessions focused on (i) water treatment and advanced oxidation processes, (ii) visible light photocatalysis, (iii) improving photocatalytic processes, (iv) photocatalytic surfaces and membranes, (v) photocatalysis for hydrogen production, (vi) photocatalysis for synthesis reactions, (vii) photocatalytic CO_2 conversion and solar fuels, (viii) water splitting and hydrogen production, (ix) fundamentals and characterization of photocatalysts and (x) photocatalysis and life science.

Didier Robert is an assistant professor in the ICPEES (Institute of Chemistry and Process for Energy, Environment and Health-CNRS) at Saint-Avold in France (antenna of the Universities of Strasbourg and Lorraine). He has initiated in 1997 the research area "heterogeneous photocatalysis" at the University of Metz. Internationally recognized in this field, in 2009, he joined the ICPEES and the group "photocatalysis". The axes of the current heterogeneous photocatalysis on which he work are mainly concerned with environmental applications: (i) treatment of wastewater, (ii) air treatment and (iii) self-cleaning surfaces. He is the creator of the international conference series: European Meeting on Solar Chemistry and Photocatalysis: Environmental Application SPEA, since 2000. He is the editor-in-chief and co-founder of the journal: *Environmental Chemistry Letters*, published by Springer-Verlag in Berlin since January 2003, and most recently the co-editor of the book series *Environmental Chemistry for a Sustainable World* from Springer.

Nicolas Keller is the CNRS Research Director at the Institut de Chimie et Procédés pour l'Energie, l'Environnement et la Santé (ICPEES), a joined research unit from CNRS and Strasbourg University. He received his PhD in catalysis and material chemistry in 1999 from the Strasbourg University. After a post-doctoral position at the Fritz-Haber-Institut of the MPG in Berlin, he was appointed in 2001 by the CNRS. He authored 114 scientific papers and 13 patents. He acted as guest editor for special issues of periodicals, co-organized a European Material Research Society symposium and chaired in 2016 in Strasbourg the 9th European Meeting on Solar Chemistry and Photocatalysis: Environmental Applications (SPEA9). His research activity is mainly concerned with the design of nano- to macro-structured functional materials for photocatalysis and solar photoconversion for environmental, renewable energy-related and biology application.

Elena Selli is a full professor of physical chemistry at the Department of Chemistry of the University of Milan, Italy. She graduated in chemistry cum laude at the University of Pisa and at the Scuola Normale Superiore of Pisa. After 1 year at the Ruhr Universität Bochum, she moved to the University of Milan. She is the president of the Physical Chemistry Division of the Italian Chemical Society and has been president of the Italian Photochemistry Group, Italian section of the European Photochemistry Association. Her present research interests are mainly focused on the mechanistic aspects of photocatalysis on semiconductors for environmental and energy applications and on the development of sensitive and efficient photocatalytic materials and devices for solar energy conversion processes, such as hydrogen production from water.