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# The CNRS-Summer School PHOTOCHEM on Preparative and Applied Photochemistry from 16<sup>th</sup> to 21<sup>st</sup> September 2018 in Anglet, France.

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Over the last decade, photochemistry has seen a remarkable comeback with significant contributions to green chemistry, organic synthesis, waste treatment, chemical engineering, continuous-flow technologies and new light sources.<sup>1</sup> At the same time, the neglect of this research area by academia as well as industry has caused an urgent need for training in photochemical principles, reactor engineering and applications. Historically, France has been a key location in photochemical research and manufacturing.<sup>2,3</sup> The first comprehensive Summer School on Photochemistry, chaired by Dr Karine Loubière, was thus organized as an École Thématique of the Centre National de la Recherche Scientifique (CNRS). The event took place between September 16<sup>th</sup> and 21<sup>st</sup> 2018 at the Atlantic seaside location of Anglet in the Southwest of France (Fig. 1).<sup>4</sup>



Figure 1. Logo of the CNRS-Summer School PHOTOCHEM.

The main objective of the CNRS-Summer School was to offer high quality and multidisciplinary training in photochemistry. The scientific program was primarily intended for professionals in chemistry related areas, but in particular to:

- Chemists, especially those involved in green and sustainable chemistry, as the provided training in photochemical technologies and engineering enabled them to select the most suitable reactor, light source and operating conditions for any future applications.
- Chemical engineering specialists, who wanted to complement their professional skills with a fundamental knowledge of photochemical concepts and applications, and the subsequent impact on reactor engineering (considering radiative transfer in the reaction medium).
- All current (or potential future) users of photochemistry, particularly in research areas outside organic synthesis (health, materials, environment etc.).

The event was split into 5 modules with a total of 19 talks over 4  $\frac{1}{2}$  days, delivered by 16 professionals from academia and industry, and a workshop & demonstration session. The topics covered fundamental concepts, organic synthesis, technologies, engineering and related applications of photochemistry (Table 1).

Module 1: Fundamental concepts of photochemistry			
1.1	Light absorption, electronically excited states, absorption spectra		
	Prof Thierry Pigot, Univ. Pau Pays de l'Adour, IPREM, Pau, France		
1.2	Photophysical deactivation of excited states, energy transfer and photochemical		
	reactions		
	Dr Sylvie Lacombe, CNRS, IPREM, Pau, France		
Module 2: Applications of photochemistry in organic synthesis			
2.1	Structural diversity and molecular complexity through organic photochemical		
	reactions		
	Dr Norbert Hoffmann, CNRS, ICMR, Reims, France		
2.2	Photoredox catalysis		
	Prof Louis Fensterbank, Sorbonne Univ., IPCM, Paris, France		
2.3	Sensitized photooxidations		
	Dr Esther Oliveros, CNRS, France		
2.4	Photopolymerization processes: State of the art, trends, perspectives		
	Prof Jacques Lalevée, Univ. Haute-Alsace, IS2M, Mulhouse, France		

2.5	Industrial photochemistry: An appraisal		
	Prof André M. Braun, Karlsruhe Institute of Technology, Germany		
Module 3: Photochemical technologies			
3.1	Laboratory-scale photochemistry: Reactors and light sources		
	A/Prof. Michael Oelgemöller, James Cook Univ., Townsville, Australia		
3.2	Safety issues of industrial photochemistry and adequate responses		
	Alexander C. Peschl, CEO, Peschl Ultraviolet GmbH, Mainz, Germany		
3.3	Solar Photochemistry		
	A/Prof. Michael Oelgemöller, James Cook Univ., Townsville, Australia		
3.4	4 Microstructured technologies and flow photochemistry		
	Dr Karine Loubière, CNRS, LGC, Toulouse, France and A/Prof. Michael		
	<u>Oelgemöller</u> , James Cook Univ., Townsville, Australia		
3.5	LED and OLED Technologies		
	Laurent Massol, CEO, LED Engineering Development, Montauban, France		
3.6	3-6 Practical workshop and demonstrations		
	various exhibitors		
Module 4: Photochemical reactor engineering			
4.1	Design and dimensioning of industrial photochemical equipment		
	Prof André M. Braun, Karlsruhe Institute of Technology, Germany		
4.2	Physics and place of radiative transfer in the modeling of photoreactors for		
	conception and optimization purposes		
	Prof Jean-François Cornet, SIGMA Clermont, Institut Pascal, Clermont-		
	Ferrand, France		
4.3	Integral formulation and Monte Carlo method for the simulation of radiation		
	transfer in photoreactors of any geometry		
	Dr Jeremi Dauchet, SIGMA Clermont, Institut Pascal, Clermont-Ferrand,		
4.4	France		
4.4	application in flow photochemistry		
	Dr. Karine Loubière CNRS LGC Toulouse France		
Module 5: Environmental energy material and medical applications			
5.1	Environmental and energy applications of photocatalysis		
5.1	Dr Nicolas Keller, CNRS, ICPEES, Strasbourg, France		
5.2	Photoswitchable materials and systems		
0.2	Dr Rémi Métivier, CNRS, PPSM, Cachan, France		
5.3	Photodynamic therapy in medicine		
0.0	Prof Gilles Lemercier, Univ. Reims Champagne-Ardennes. ICMR. Reims.		
	France		

Table 1. Program and speakers of the CNRS-Summer School on Photochemistry.

A highlight and well received event of the PHOTOCHEM Summer School was the practical workshop, which enabled all participants to experience photochemical reactors and light sources for themselves and to interact with experts from industry, research and education. The displays included home-made laboratory equipment as well as commercial devices. The participants were split into small groups and subsequently rotated through the 6 stations over a 2 hours period (Table 2).

Station 1: Laboratoire de Génie Chimique (LGC) (Robbie Radjagobalou and Dr Jean-François Blanco) Polymeric tube LED-driven microreactors for laboratory photochemistry	
Station 2: Corning (Dr Marc Winter) Laboratory and mesoscale microstructured photoreactors	
<b>Station 3:</b> Institut des Sciences Analytiques et Physico- Chimique pour l'Environnement et les Matériaux (IPREM) (Dr Mickaël Le Bechec) <i>Reactor for standardized tests of photocatalytic</i> <i>materials for</i> NO <sub>x</sub> <i>removal</i>	
<b>Station 4:</b> Peschl Ultraviolet GmbH (Alexander C. Peschl) Industrial photochemical technologies and their design	

Station 5:	
LED Engineering Development (Laurent	
Massol)	
LEDs and LED panels	
Station 6:	
Laboratoire de Chimie de Coordination	100 m
(LCC/ENSIACET) (Dr Odile Dechy-Cabaret)	
Teaching and training of microscale organic synthesis: A	
common chemistry/ chemical engineering tool	

Table 2. Program and exhibitors of the practical workshop and demonstrations.

The Summer School was fully booked with 55 participants, of which 20% came from industry (Arkema, Minakem, Corning, Firmenich and Peschl UV), 53% were academic researchers, 20% were PhD students or postdoctoral fellows and 7% were engineers and technicians (Fig. 3). Upon registration, all participants were asked to provide a short paragraph on their research background & interests. 76% of the participants came from a Chemistry discipline, but 23% had a Chemical Engineering background. While the majority of the participants came from France, 4 participants came from Germany, Switzerland or Australia, respectively.



### Figure 3. CNRS-Summer School Picture.

Overall, the CNRS-Summer School PHOTOCHEM was a huge success with lively discussions and engaging interactions between participants and speakers. It clearly demonstrated a strong interest in all aspects of photochemistry. The Summer School delivered high-level teaching and training of photochemical principles, technologies, photoreactor engineering and applications to industrial and academic participants. It is hoped that the Summer School will be repeated in the foreseeable future and will be offered to a broader European audience.

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