CV Pierre Audebert

Personal details

Gender	Male
Age and birth	Born in Périgueux (France) on february 12th, 1959
Name and given name:	Audebert Pierre
Country	France
Family situation	Married with Aifang Audebert-Wang, two children

Current position

Function

Professor, Exceptionnal Class.

Organisme(s) public(s) français / French public organisation(s)

Institute type	Institute	Laboratory	Unit code	Postcode	Town
"Grande Ecole"	ENS Paris-Saclay	PPSM	UMR 8531	91190	Gif s. Yvette

Previous positions

Start date	End date	Town	Institute	Function
May 88	Sept. 93	Paris	CNRS section 13/U. Paris 7	Chargé de recherches
Oct. 93	Sept. 98	Besançon	Université de Franche Comté	Professor
Oct. 98	Ongoing	Cachan/Saclay	ENS Cachan, then Paris-Saclay	Professor

Languages spoken

French (mother language) English (fluent) German (very good) Polish (very good) Chinese (utilitary level)

Formation supérieure / Education[1]

Engineer ESPCI Paris/PhD (these d'Etat) in University J. Fourier Grenoble (1987) + 6 months post-doc in CEA Grenoble.

Scientific production (summarized)

Achievements, including Grants, prizes, awards, fellowships, etc.

Participation to numerous ANR (national French research agency) projects (leader of project Nanoencre 2005-2008) Leader member of the European ITN Excilight Grant. Minor partner of the H 2020 Gotsolar project.

Participation to many projects selection committees in France and Poland.

Special invited professor positions abroad: (Zhejiang prof., ECNU Shanghai 2006-11, World Class Univ. Prof. in SNU Seoul 2011, Tarrant Prof. U. Florida in 2009, Associate Prof. in Yonsei U., Seoul 2013) Numerous invited stays in Germany, Japan, Korea, US, Poland, Canada, China, etc… Member of about 120 PhD and habilitation jurys, including about 15 outside France (Poland, China, Belgium, The Netherlands, Germany, USA, Cyprus)

Teaching special courses (Conducting polymers, Batteries, Electrochemistry) in Korea (Seoul), Poland (Gdansk), China (Shanghai), Cambodia (Phnom Penh) and Vietnam (Hanoï).

Honorary Member of the Polish Chemical Society (should have been special guest in national conf. 2020 for the occurrence, delayed to sept. 21, plenary lecture in honor)

Institut Universitaire de France (IUF) Junior member (1999-2004) and Senior member (2014-19).

Author of 240 + research publications, 12 reviews and/or book chapters, one teaching book on electrochemistry, invited co-editor of a book: "Luminescence in electrochemistry".

Teaching activities

I started my career as a full researcher (CNRS scientist) but in 1993 I got the opportunity to become a professor, which was helpful in terms of building a research team, which I did in Besançon. Then I started to tech organic chemistry, mainly. Progressively, I went on an advanced electrochemistry course (Organic electrochemistry) and polymers.
When I was granted the position in the ENS Cachan, I started again wiith mainly organic chemistry, but, as long as the department went on recruiting more organic chemists, I teached a mixture of heterocyclic chemistry, electrochemistry, materials chemistry and polymers. Since then, I have been adaptable and more or less stayed in the same track except that I had a bit of NLO and fluorescence in the mix.

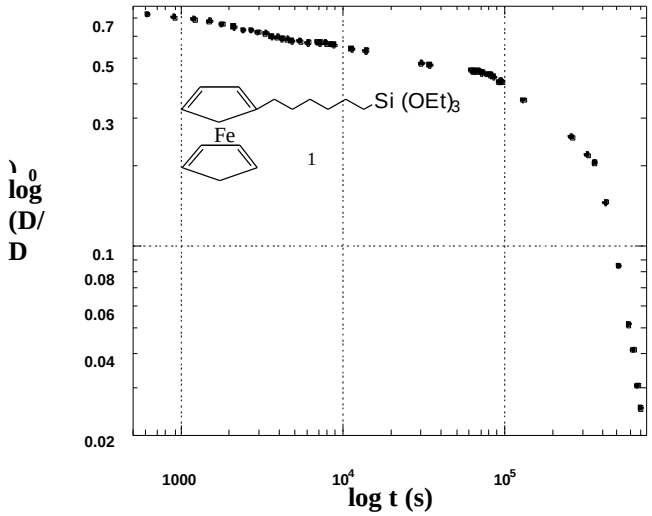
I Former research subjects.

1) Electrochemistry in sol-gel systems

In this second section of my research activity (roughly 1991-2006) our goal was to follow the different steps experienced in the course of the polycondensation of inorganic sols and gels, using electrochemistry as a spectroscopy. The key information was the analysis of the diffusion of redox species that may be free of attached to the sol-gel polymers. The electrochemistry of the redox probes allows measuring their diffusion coefficient, which in turn informs on the size and the *in situ* size variation of the sol-gel polymers.

Our most recent work has consisted into functionalizing a ferrocene with a trimethoxysilane function, so that it binds to the silica polymers in the course of the polymerization. The *in situ* electrochemical response allows the independent determination of the sol-gel transition, and of subsequent previously unknown transitions in the gel (check fig. below).

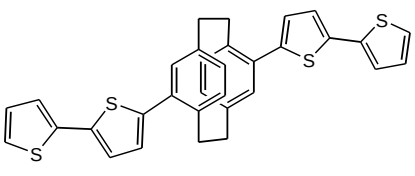
We have also prepared new hybrid modified electrodes from xerogels, and analyzed their electrochemical behavior, which occurs *via* electron hopping. We have demonstrated that the analysis of the cyclic voltametry response could led to the determination of the fractal dimension of the electrode material, and determined it a few cases. We have also deposited functionnalized nanoparticles on microelectrodes, and analyzed the electrochemical response in relation with the fractality of the particles surfaces. This response is indicative if the nanoparticle structure.



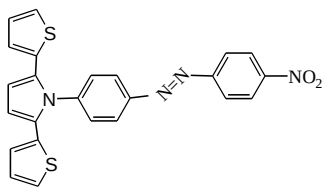
Dependance of the diffusion coefficient of a functionnalized ferrocene in a DMAP silica gel.

2) Synthesis and physico-chemical study of molecular materials.

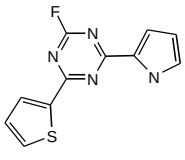
About ten years ago, with my first research group we became interested in the synthesis of original functionnal thiophene based oligomers, and the analysis their electrochemical and optical properties. We have also prepared new pull-push-pull molecules with enhanced third order NLO properties, made of a pyrrole donor and a classical attractor. We have also prepared new cyclophanes where a cyclophane ring blocks both positins of an oligothienyl chain.These new oligothiophenes are highly fluorescent and display interesting hole transport properties (See below).



Functionnalized cyclophane



NLO-SNS type compound



Fluorescent triazine

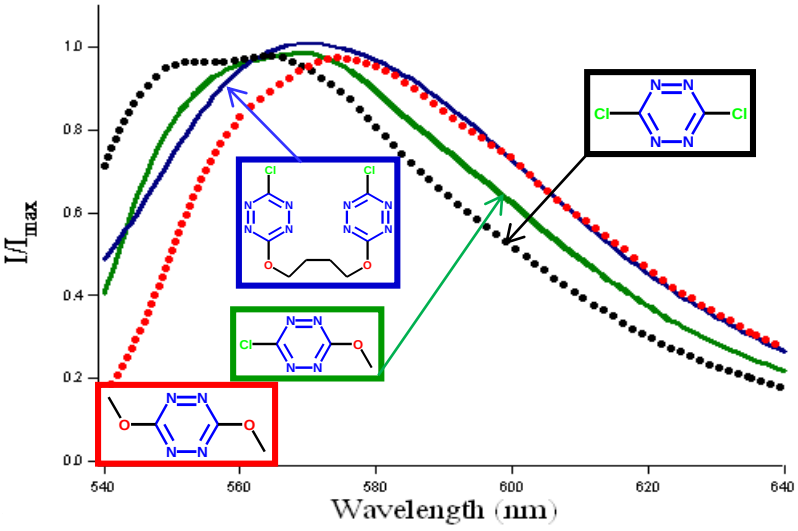
II-Recent and continuing research interests.

1) Tetrazines and electrofluorochromism

We have started recently a new field of research on functionnalized tetrazines. Such molecules have a wide range of properties including 3rd order NLO, fluorescence and reversible electrochemical behavior in reduction.

New NLO active tetrazines with redox properties.

We have developed new fluorescent tetrazines that are the smallest usable fluorophores of all organic chemistry. These organic molecules, possessing more nitrogen atoms than carbon, are very original fluorophores, working on a normally forbidden n-π* transition. Their very high redox potential in the excited state renders them able to oxidize a wide range of compounds, when in the excited state. In addition, because both of the partially forbidden character of the transition, and the quasi-absence of hydrogen atoms on many molecules, they have a very long fluorescence life-time (up to 140 ns in solution.



Spectres de fluorescence de didiverses tétrazines en fonction des substituants

ne can be balanced by linking them to good chloroalkoxytetrazine and one to three imides ith the number of antennas, as can be seen on to date providing yellow fluorescence from ecule shines white light, mixture of blue (from imide) and yellow (from tetrazine) as a result of uncomplete energy transfer.

Image showing the diverse dyads ("antenna" tetrazines) featuring the increasing brilliance at low concentration (5 10^{-6} M) solutions.

Finally, based on tetrazines, and supported by a research contract with the CST society, we have jointly developed the commercial product Lumicyano®, a mixture of performing cyanoacrylate glue, and a tetrazine, which allows to let appear fingerprints directly fluorescent using exactly the same procedure than previously with uncolored cyanoacrylate.

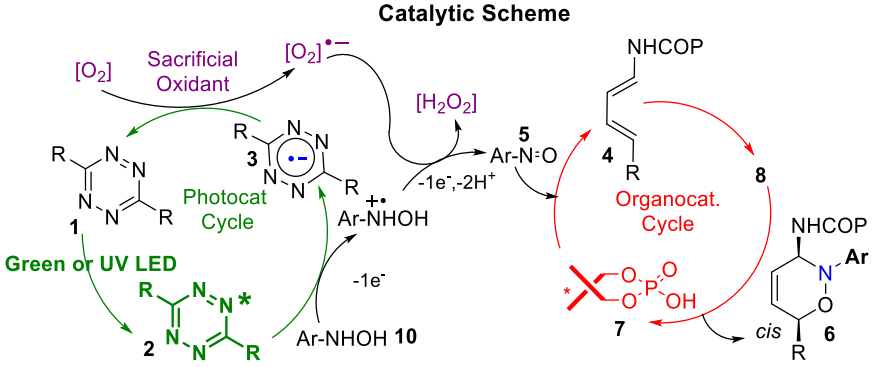
On the right, a vial of Lumicyano ®, (more than 8000 samples sold).

2) Most recent: Photocatalysis and heptazines photophysics and chemistry**.**

While the first two themes have reached maturity, a novel thema is emerging in my activity today, which is photocatalysis, both homogeneous, and supported, with two aims, photooxidation reactions (like water splitting) and photopolymerization of conducting polymers.

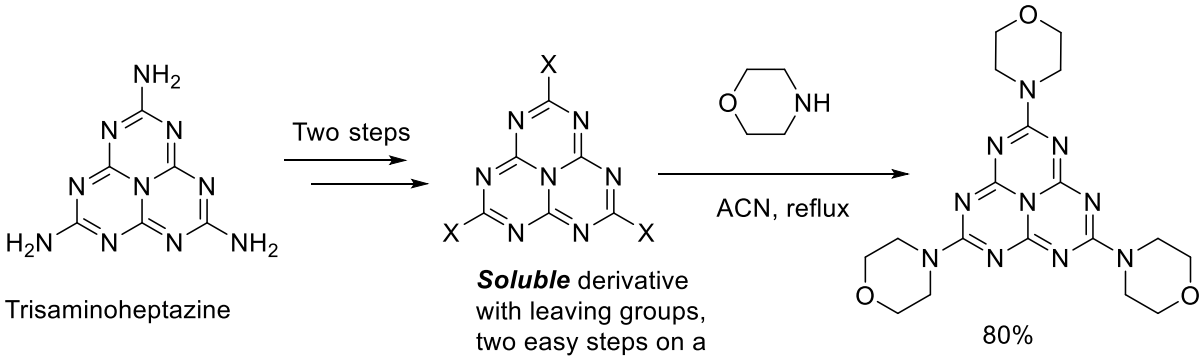
a) Activated tetrazines in homogeneous reactions in organic chemistry.

Tetrazines have a high oxidation potential, and can be used in organic chemistry. The following Scheme has been shown to work out, in collaboration with G. Masson in ICSN (Orsay)



b) New photoactive systems based on heptazines

Recently a new photoactive heptazine has been produced in the group in large quantity, based on an original synthetic process (CNRS patent request N° 18 52111) This molecule has already been used to produce original heptazine derivaitves, with properties of delayed fluorescence. These molecules are highly efficient photocatalysts.as we have demonstrated in an article in Chem. Commun. In 2021.

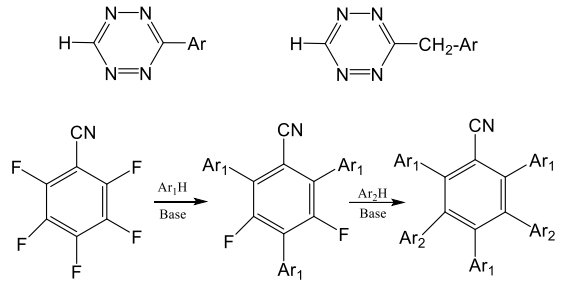


Trisaminoheptazine

Soluble derivative with leaving groups, two easy steps on a several grams scale

c) Delayed fluorescence and H-tetrazines

In the context of the Excilight European project, we have been able to prepared and study original compounds, based on cyanobenzene, and H-tetrazines. The H-tetrazine are specially interesting, since they are commercialized in the 500-1000 €/g in the US, and have been the topic of another patent request in 2018 (N° 18 51715).



	5 recent most relevant publications	What is the major contribution of this publication?
1	G. CLAVIER and P. AUDEBERT "s-Tetrazines as building blocks for new functional molecules and molecular materials", *Chem. Rev*., **2010**, 110, 3299.	This review is the very first on physico-chemical properties of tetrazines, and especially their fluorescence. It also provides along a report of the activity of our team on the fluorescence and electrofluorochromism of tetrazines
2	Three Invited Chapters in the series "*Progress in Heterocyclic Chemistry* (PHC) published by the International Society of Heterocyclic Chemistry (ISHC)" (J. Joule, G. Gribble Ed.) "Triazines, Tetrazines and Fused Rings Polyaza Systems" P. AUDEBERT, C. ALLAIN and G. CLAVIER. Editions **2016**, **2017** and **2018**	This series (directed by Pr J. Joule) is the most important annual record in heterocyclic chemistry. We were invited to write 3 years in a row this chapter, on high nitrogen content aromatic heterocycles, which is also a recognition of our contribution to the field.
3	Metal-Free Synthetic Approach to 3-Monosubstituted Unsymmetrical 1,2,4,5-Tetrazines Useful for Bioorthogonal ReactionsY. QU, F. X. SAUVAGE, G. CLAVIER, F. MIOMANDRE and P. AUDEBERT, *Angew. Chem. Int. Ed*., 57, **2018**,12057.	This article (with a patent linked) reports a very easy synthesis of clickable H-tetrazines, involving DCM as the provider of the C-H fragment. This unprecedented synthetic path is considerably cheaper than the concurrent one, which used nickel or scandium triflate.
4	Extending accessible heptazine chemistry; 2,5,8-tris(3,5-diethyl-pyrazolyl)-heptazine, a new highly soluble heptazine derivative with exchangeable groups, and examples of new derived heptazines with their physical chemistry. T. LE, C. ALLAIN, L. GALMICHE, R. GUILLOT and P. AUDEBERT, *Chemical Science*, 10, **2019**, 5513	This article (patent linked) describes the second to-date heptazine with leaving groups easily exchangeable through SNAr substitution. The synthesis of this compound, much easier to prepare that its sole concurrent, trichloroheptazine, is indeed a noticeable advance in synthetic heptazines chemistry.
5	P. AUDEBERT, E. KROKE, C. POSERN and S.-H. LEE, State of the Art in the Preparation and Properties of Molecular Monomeric s - Heptazines: Syntheses, Characteristics, and Functional Applications. *Chem. Rev.* **2021**, 121, 2515.	This review is the very first on heptazine molecules, at the exclusion of graphitic carbon nitrides and related polymers. It provides a report of the activity in synthetic chemistry, physical chemistry and derived materials on this emerging family, emphasizing Pr Kroke's, as well as ours, contributions.

Valorisation (patents, finalized products…)

(confidential title) C. ALLAIN, L. GALMICHE, C. PRETE and P. AUDEBERT, French Patent deposited on March 30th, 2012; It describes the direct fluorescent revelation of latent fingerprints, using a mixture of a tetrazine and a cyanoacrylate glue. Under exploitation since 2013, the product is used by most police forces in France (and partly abroad).

Two recent patents (N° 18 52111, deposited on 2018, march 12th, Synthèse de nouvelles heptazines, and N° 18 51715, deposited on 2018, feb. 27th, Procédé de Fabrication de Tétrazines), both approved in 2019, European extension following. Confidential content.