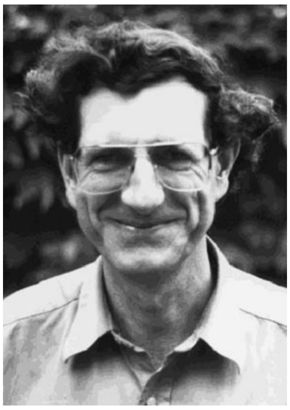

D. Astruc

*The author presented here has recently published his* ***10th article*** *since 2000 in Angewandte Chemie:* "Click Synthesis of 1,2,3-Triazolylbiferrocenyl Dendrimers and the Selective Roles of the Inner and Outer Ferrocenyl Groups in the Redox recognition of ATP$^{2-}$ and Pd$^{2+}$": R. Djeda, A. Rapakousiou, L. Liang, N. Guidolin, J. Ruiz, D. Astruc, *Angew. Chem.* **2010**, *122*, 8328–8332; *Angew. Chem. Int. Ed.* **2010**, *49*, 8152–8156.

# Didier Astruc

**Date of birth:** June 6, 1946

**Position:** Professor of Chemistry at the Université Bordeaux I (France)

**E-mail address:** d.astruc@ism.u-bordeaux1.fr

**Homepage:** http://astruc.didier.free.fr/welcome.htm

**Education:**
1964–1967 Undergraduate studies, Université de Rennes 1 (France)
1970 3ème cycle thesis, Université de Rennes 1
1975 State thesis with Prof. René Dabard, Université de Rennes 1
1977 Postdoc with Prof. Richard R. Schrock, MIT, Cambridge (USA).

**Awards since 2000:** **2005** Fellow of the Royal Society of Chemistry; **2006** Member of the Academia Europaea; **2006** Member of the Leopoldina (Nationale Akademie der Wissenschaften, Germany); **2007** Member of the European Academy of Sciences; **2008** Gauß Professur of the Akademie der Wissenschaften zu Göttingen (Germany); **2009** Joint Prize by the Italian and French Chemical Societies, Golden Medal of the Società Chimica Italiana; **2010** 3M Lecturer at the University of Western Ontario, London (Canada); **2010** Member of the European Academy of Sciences and Arts

**Current research interests:** My research interests are in the design of inorganic and organometallic nanomaterials (in particular metallodendritic nanostructures and transition-metal nanoparticles) for original physical properties that include multi-electron-transfer processes, the catalysis of C–C bond formation and transformations, and nanomedicine. My group is presently carrying out research in the following areas:
1) dendritic molecular batteries based on electron-reservoir complexes
2) nanomaterials as sensors
3) green chemistry with the use of dendritic nanoreactors for catalytic reactions in water, and
4) dendritic and gold-nanoparticle-based nanovectors for drug delivery

**Hobbies:** Music (classic, jazz), walking, spending time with friends, Bordeaux wine

**My favorite subjects at school were …** history and mathematics.

When I was eighteen I wanted to be … Professor in a scientific field.

The most significant scientific advance of the last 100 years has been … made in the biomedical field.

The biggest problem that scientists face is … to find the most important and at the same time most appropriate field of research.

The biggest challenge facing scientists is … at the individual level to be as creative as possible and find the best means of research and at the universal level to understand nature.

My favorite piece of research is … Neil Bartlett's rational approach to and discovery of the first rare gas compound, xenon hexafluoroplatinate $Xe^{+}[PtF_6]^{-}$.

The greatest scientific advance in the next decade will be … finding efficient and green catalytic processes.

I am waiting for the day when someone will discover … efficient catalytic processes for nitrogen fixation and methane activation under ambient conditions.

My greatest achievement has been … the discovery, stabilization, and study of electron-reservoir complexes, and their starburst polybranching reactions into dendrimers.

The three qualities that make a good scientist are … creativity, intelligence, and courage.

My science "heroes" are … Marie Curie, Bianka Tchoubar, Henry Taube, and Neil Bartlett.

Chemistry is fun because … you create new compounds, materials, and processes.

I chose chemistry as a career because … I had good chemistry teachers during my undergraduate studies in Rennes.

My biggest inspiration is … reading the literature, writing up manuscripts, and my daily walk.

My favorite music composer is … Maurice Ravel, but I also very much like many other European composers.

### How is chemistry research different now than it was at the beginning of your career?

Considerable technical progress in the instrumentation has made research in chemistry much faster and more profound. The internet has enormously improved and accelerated the communication in the scientific community and stimulated competition for originality and productivity. Students no longer only come from nearby, as they did previously, but they come from all continents, especially from Southeast Asia. Students from Western countries have been educated with a comfortable life style contrary to several decades ago, which now makes it more difficult for them to struggle in the competition. In sum, science is richer, more intense, diffusing much faster, and is more competitive.

### Has your approach to chemistry research changed since the start of your career?

I question my approach to chemistry every day, thus it necessarily does change. Looking back on the beginning of my career, I see that I had very little scientific knowledge and means of research, which limited the possibilities. Yet, I am impressed by what I was able to accomplish. Chemists are like wine, getting better upon aging, because their acquirement of experience and knowledge is essential in delineating the most important and best research. Thus, as times passes, my approach has involved wider scientific areas and progressively has become more interdisciplinary. These interconnections are very enriching even for each subfield, a trend that is accelerated by the technical progress. The needs of society and thus also the needs for applications have changed. We now have to consider many more parameters and react more quickly because of new environmental constraints and variations of means of research. The easier access to fast communication and literature has a deep influence on the rhythm of research and adaptability. In a way, one also has to be careful to resist this acceleration and retain a reasonable pace of thinking about the essence and essential features of research.

### Has your approach to publishing your results changed since the start of your career?

At the beginning of my career, publications were usually in national journals and in the national language. It rapidly appeared that this way of publishing hindered the optimization of research communication in the scientific community. Fortunately, scientific communication has now improved for everyone, also long-standing top journals such as *Angewandte Chemie*, the *Journal of the American Chemical Society*, and *Chemical Communications* have been improved. An aspect that has not changed, however, is my effort to conduct the best chemistry possible and to publish it in the best journals.

### What do you think the future holds for your field of research?

As I said, my field of research is enlarging every day, and I am convinced that it is interdisciplinarity that will dominate the science of the 21st century. The nanomaterials we create now and their interplay will be essential for further molecular and materials engineering for our society.

### Have you changed the main focus of your research throughout your career and if so why?

Yes, in the beginning my research was based in a narrow organometallic chemistry area, mainly dealing with synthesis and characterization of compounds. As I felt that I wanted to enlarge my research views and fields, I became interested in electron-transfer processes in all areas, which led to me writing my first book "Electron-Transfer and Radical Processes in Transition-Metal Chemistry" during my sabbatical year at Berkeley in 1990–1991. This project evidently opened a lot of possibilities for my research in a number of new directions that involved redox systems and processes. Since then, I would often spend my holidays writing a review, because I found that it was a good way to make progress in my thinking about chemistry and to fabricate a network of scientific interconnections.

### What has been your biggest influence/motivation?

Chemistry is a marvelous field for creation. In this respect it is an art, and chemists who create their new molecules, materials, and processes feel a tremendous driving force to work hard. It is also a wonderful subject of communication, probably richer and more fascinating than many other more common ones. Research is one of the most exciting adventures of our times, and we are very fortunate to deal with it.

### What advice would you give to up-and-coming scientists?

Keep reading the literature continuously, work hard, communicate, teach, travel, and collaborate. Have good contacts with your students in the lab. Develop your own scientific personality accurately without running after fashionable subjects, but read the most-cited papers of the best-known scientists. Be aware of modern techniques.

### What is the secret to publishing so many high-quality papers?

Publishing many papers should not necessarily be an objective, but high quality is a must. A "secret" for chemists: as a starting point, only undertake and carry out science that can be published in high-quality journals such as *Angewandte Chemie* and the *Journal of the American Chemical Society*.

**My 5 top papers:**

1. “Design, Stabilization, and Efficiency of Organometallic “Electron Reservoirs”. 19-Electron Sandwiches $\eta^5$-$C_5R_5$Fe(I)–$\eta^6$-$C_6R_6$, a Key Class Active in Redox Catalysis”: D. Astruc, J.-R. Hamon, G. Althoff, E. Román, P. Batail, P. Michaud, J.-P. Mariot, F. Varret, D. Cozak, *J. Am. Chem. Soc.* **1979**, *101*, 5445 – 5447.
   This is the first paper of our series of articles on the synthesis and redox chemistry of electron-reservoir compounds that are to date the most electron-rich neutral complexes known, based on the very low values of their ionization potentials. I had prepared crystals of the emblematic complex $\eta^5$-$C_5H_5$Fe(I)–$\eta^6$-$C_6Me_6$ that were subjected to a set of techniques including X-ray crystal structure analysis, EPR, Mössbauer spectroscopy, paramagnetic NMR spectroscopy, sublimation, and reaction with $O_2$ (by superoxide ions), and the excellent new undergraduate and graduate students of my group prepared substituted analogues. The $CpFe^+$ induced starburst peralkylation of the $C_6Me_6$ ligand to star-shaped molecules upon iteration of a set of two reactions was also delineated in this paper.
2. “The Dendritic Effect in Molecular Recognition: Ferrocene Dendrimers and their Use as Supramolecular Redox Sensors for the Recognition of Small Inorganic Anions”: C. Valério, J.-L. Fillaut, J. Ruiz, J. Guittard, J.-C. Blais, D. Astruc, *J. Am. Chem. Soc.* **1997**, *119*, 2588 – 2589.
   This paper together with the book chapter that appeared in *Supramolecular Magnetism*, NATO ASI Series (Ed.: O. Kahn), Kluwer, Dordrecht, **1996**, pp. 107–127, were the first publications on ferrocenyl dendrimers constructed with the help of iterations, and it was the first use of dendrimers as (viruslike) exoreceptors. Moreover, a remarkable positive dendritic effect was disclosed, that is, the redox recognition characterized by the shift of ferrocenyl redox potential was all the larger as the dendrimer generation increased (in catalysis, the opposite is true with analogous catalyst-terminated dendrimers).
3. “Nanoscopic Assemblies between Supramolecular Redox Active Metallodendrons and Gold Nanoparticles: Syntheses, Characterization, and Selective Recognition of $H_2PO_4^-$, $HSO_4^-$, and Adenosine-5’-Triphosphate ($ATP^{2-}$) Anions”: M.-C. Daniel, J. Ruiz, S. Nlate, J.-C. Blais, D. Astruc, *J. Am. Chem. Soc.* **2003**, *125*, 2617 – 2628.
   This is the first paper on gold-nanoparticle-cored dendrimers and it indicated that gold nanoparticles could easily play a templating role. Therein it was also shown that silylferrocenyl-terminated dendrimers could interact in a supramolecular fashion with oxo anions because of the delocalization of the positive charge of ferricinium onto the silicon atom. This was the first time that dendritic exoreceptors were shown to efficiently recognize ATP.
4. “Click Assembly of 1,2,3-Triazole-Linked Dendrimers, Including Ferrocenyl Dendrimers, Which Sense Both Oxo Anions and Metal Cations”: C. Ornelas, J. Ruiz, E. Cloutet, S. Alves, D. Astruc, *Angew. Chem.* **2007**, *119*, 890 – 895; *Angew. Chem. Int. Ed.* **2007**, *46*, 872 – 877.
   This publication is the first article on the click assembly of metallodendrimers. Moreover, it was shown therein that the 1,2,3-triazole heterocycles formed could also be used for molecular recognition with positive dendritic effects both for anions and for cations. Very recently (*Angew. Chem.* **2010**, *122*, 8328–8332; *Angew. Chem. Int. Ed.* **2010**, *49*, 8152–8156), we could also “click”-assemble giant triazolylbiferrocenyl-terminated dendrimers and selectively use either of the two ferrocenyl groups of biferrocenyl for cation recognition (inner ferrocenyl) and anion recognition (outer ferrocenyl) involving multiple redox states. The remarkable richness of the redox chemistry of ferrocenyl-type dendrimers also has potential as a model for molecular batteries, which we are now designing with more electron-rich and redox-robust metallocenes.
5. “‘Homeopathic’ Catalytic Activity and Atom-Leaching Mechanism in the Miyaura-Suzuki Reactions under Ambient Conditions Using Precise ‘Click’ Dendrimer-Stabilized Pd Nanoparticles”: A. K. Diallo, C. Ornelas, L. Salmon, J. Ruiz Aranzaes, D. Astruc, *Angew. Chem.* **2007**, *119*, 8798 – 8802; *Angew. Chem. Int. Ed.* **2007**, *46*, 8644 – 8648.
   Whereas organic and bio-organic chemists have generalized the use of the Cu(I)-catalyzed alkyne–azide cycloaddition (CuAAC) click reactions for the assembly of molecular fragments, we have disclosed the inorganic functions of the 1,2,3-triazolyl ligand in assemblies such as dendrimers and polymers. For instance, this paper is the first one to show that a precise number of metal atoms corresponding to the same number of triazole ligands can be assembled in a metal nanoparticle inside the dendrimer by precoordination of the dendritic triazolyl ligands to the metal cation followed by reduction. The dendritic protection can also be extended to small dendrimers, in which case the nanoparticle precatalyst is surrounded by small dendrimers. Using this triazolyldendrimer strategy of precise nanoparticle formation, it was possible to suggest that the extraordinarily efficient Pd nanoparticles in the Miyaura–Suzuki heterocoupling (down to ppm of Pd at 20°C) operate according to an atom-leaching mechanism (the more dilute the catalyst, the better it works, because the catalytically efficient atoms are less quenched by the nanoparticles as they are more dilute).

**DOI: 10.1002/anie.201007009**