

## From Interlocking Rings to Molecular Machines

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The area referred-to as “Chemical Topology” is mostly concerned with molecules whose molecular graph is non-planar, i.e. which cannot be represented in a plane without crossing points. The most important family of such compounds is that of **catenanes**. The simplest catenane, a [2]catenane, consists of two interlocking rings. **Rotaxanes** consist of rings threaded by acyclic fragments (axes). These compounds have always been associated to catenanes although, strictly speaking, their molecular graphs are planar. Knotted rings are more challenging to prepare. One of the most spectacular topologies in this respect is the trefoil knot. Our group has been much interested in knots and, in particular, in their properties in relation to coordination chemistry or chirality.

Since the mid-90s, the field of **artificial molecular machines** has experienced a spectacular development, in relation to molecular devices at the nanometric level or as mimics of biological motors. In biology, motor proteins are of utmost importance in a large variety of processes essential to

life (ATP synthase, a rotary motor, or the myosin-actin complex of striated muscles behaving as a linear motor responsible for contraction or elongation). Many examples published by a large number of highly creative research groups are based on complex rotaxanes or catenanes acting as switchable systems or molecular machines. Particularly significant examples include a “pirouetting catenane”, “molecular shuttles” (Stoddart and others) as well as multi-rotaxanes reminiscent of muscles. More recent examples are those of multi-rotaxanes able to behave as compressors and switchable receptors. The molecules are set in motion using electrochemical, photonic or chemical signals. Particularly impressive light-driven rotary motors have been created by the team of Feringa.

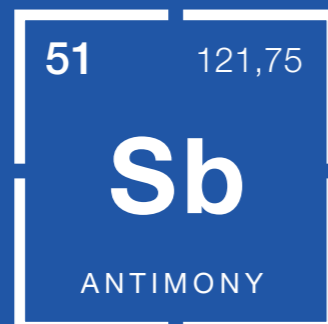
Finally, potential applications will be mentioned as well as possible future developments of this active area of research.

J.-P. SAUVAGE, “From Chemical Topology to Molecular Machines”, *Angew. Chem. Int. Ed.*, **2017**, 56, 11080.

## Periodic ID card of the day

### 51 . Antimony

Discovery: 300 BC  
by Babyloniens  
Family: Pnictogen  
Period: 5<sup>th</sup>

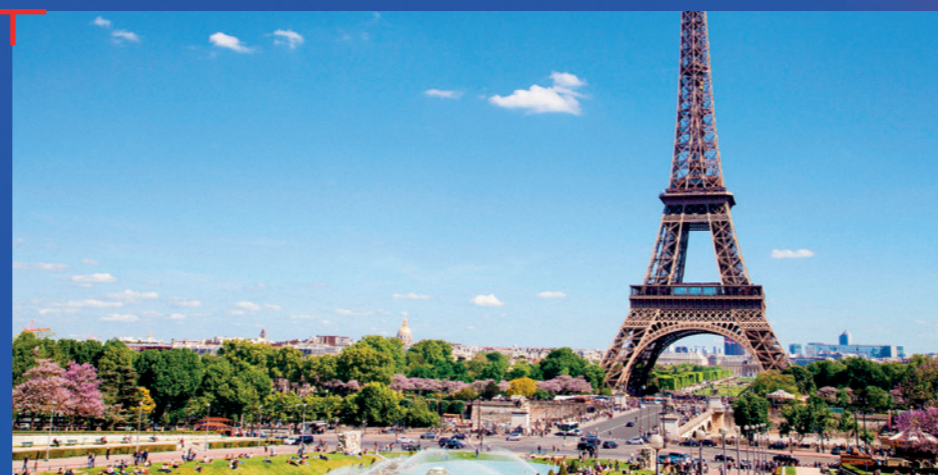


### A few of its properties

Its name means “not alone” in Latin, and indeed antimony is often combined with another element. Its most abundant ore is stibine ( $Sb_2S_3$ ), that gave the symbol Sb. Addition of antimony to lead hardens the latter; Gutenberg used such an alloy to create clear and reusable typefaces for printing. In ancient times, antimony compounds were powdered and used as cosmetics. Today, it is mainly used in its oxide form, in lead batteries (30%), from which it is well recycled, flame retardants (50%), but also in fireworks! Its production is 170kt/year.

# making science together!

## 2018-2019 in France: School year of Chemistry, from primary school to university



IYPT2019, IUPAC Congress, 51<sup>st</sup> IChO in Paris: the French 2018-2019 school year has been declared “The Year of Chemistry, from Primary School to University”, in order to encourage pupils and students to discover or explore chemistry but also to introduce chemistry to the general public, with audiences in primary and secondary schools, universities, and through museums, centers of scientific culture and also chemical companies.

Researchers, engineers, teachers and students organized many events or lessons in schools, universities, chemical companies and with museums, in order to highlight the role of chemistry in academic science, in industry and its contributions to technological, economical and sustainable development.

Many events of this “year of chemistry” are of course relevant to IYPT2019! For instance, we can mention the “Mendeleiev contest” which is organized by the French physics and chemistry teachers’ society, and gathers 437 candidates from all types of schools and colleges. On Avogadro’s day (6<sup>th</sup> February, at 10.23), the French Ministry of Education and Youth turned into a short-lived chemistry lab, welcoming students who allowed pupils from primary and low secondary schools to do chemical experiments on dyes, pigments and aromas.

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POUR L'ÉCOLE  
DE LA CONFIANCE

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catalyzer



© Philippe Devernay / MEN

Jean-Michel Blanquer  
Minister of Education

It is a great honour for France to host the 51<sup>st</sup> International Chemistry Olympiads, and I am very happy to see the Ministry of Education directing the organisation of this important event. The development of science as a whole, and of chemistry in particular, is an essential step in the technological and social progress of humanity and in the protection and the future of our planet. That is why I place my faith in the younger generation of scientists who, I know, will rise to the challenges of the 21<sup>st</sup> century, and lead the ecological transition and digital revolution that will ensure a more balanced world.

The three hundred and more IChO candidates, from eighty countries on five continents will “make science together”. As well as chemistry connects a variety of scientific fields, such an event also helps to sustain the international scientific community and to build new partnerships that go beyond borders. The 51<sup>st</sup> edition of The International Chemistry Olympiads will also allow young scientists to discover our capital city and its surroundings, and to meet key players from the French and international chemistry communities. They have worked with the Ministry of Education to ensure the success of this event, and I want to thank

them very warmly for their cooperation. Our steering committee will undoubtedly make IChO in Paris an enriching and truly memorable event.

In 2019, Paris will be at the centre of international chemistry. Shortly before the IChO opens, the 47<sup>th</sup> IUPCA World Congress, will celebrate the centenary of IUPAC in Paris. Furthermore, on the 29<sup>th</sup> of January 2019 “the International Year of the Periodic Table” (IYPT) has been launched at the UNESCO headquarters to celebrate the 150<sup>th</sup> anniversary of Dmitri Mendeleev’s paper on his periodic system. In honour of these events the French 2018-2019 school year has been declared “The Year of Chemistry, from Primary School to University”. The objectives are first and foremost to encourage pupils and students to discover or explore chemistry but also to introduce chemistry to the general public, to audiences in primary and secondary schools, universities and Grandes Écoles, and through museums or centres of scientific culture.

We look forward to participants in the 51<sup>st</sup> International Chemistry Olympiads experiencing ten remarkable days of science and true cultural exchange in the heart of Paris, the capital of our country, with its proud tradition of warmth and hospitality.

I<sup>T</sup> C<sup>H</sup> O  
51<sup>st</sup> — International  
Chemistry Olympiad  
France — Paris — 2019





## Jean-Pierre Sauvage

Nobel Prize in Chemistry 2016,  
Honorary President of the Scientific Committee

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## International Chemistry Olympiads, July 2019

As the Honorary President of the Scientific Committee of these Olympiads, I am happy to greet you all and to welcome the many participants and their delegations. It is indeed wonderful that such an event can bring together hundreds and hundreds of young people who are full of passion for chemistry and who devote much of their time to this beautiful and important science.

Paris is certainly a very special location when it comes to chemical science. Although it is virtually impossible to rank scientists according to the importance of their contribution to science, it must be recognised that Antoine-Laurent de Lavoisier occupies a special place since he is one of the fathers of modern chemistry. Lavoisier was born in Paris (1743). It is also in Paris that he was beheaded in 1794, just a few years after he published his "Traité Élémentaire de Chimie" ("Elementary Treatise of Chemistry").

This opus was literally revolutionary in the sense that it presents chemistry as a real science, with rules and the quantitative treatment of various phenomena.

Today, chemical industry is everywhere in our surroundings and it plays a crucial role in our everyday life. Major French chemical companies have always played and continue to play an important role today. They have strong international influence in several fields of activity.

There is no doubt that the serious environmental problems that mankind has to face today will have to be resolved in the near future, at least in part. It is with chemistry, along with other sciences and technologies, that these difficulties will be resolved through the new mild techniques that industry is in the process of developing with the help of researchers from various origins and cultures. This multinational and multi-science approach should ensure the essential transition towards environmentally friendly behaviour.

France has a long tradition of advanced teaching and research in chemistry. The dual teaching system involving Universities and "Grande Ecoles" (or Engineering Schools) opens up a wealth of possibilities for motivated students. This diversity of opportunities is reflected in the research orientations of these institutions: often basic-science oriented in Universities, it can use a more applied approach in Engineering Schools.

Finally, I would like to stress that the Olympiads represent an important event directed at you, the young people interested in science. It is indeed reassuring to observe that many young women and men have a rational approach to the world and have a strong respect for science and knowledge, recognising that facts must predominate over opinions.

I would like to wish you all a very pleasant moment in Paris on the occasion of this unifying and important event. It is undeniably a competition but I am confident that it will be a fair and friendly one.

## Reference partners

### Representing a French leading industry

France Chimie is the professional body that helps to develop and enhance the competitiveness of the chemical industry and its applications in France. It takes action at regional, national and European levels, bringing stakeholders together and actively driving chemical industry's sustainable development in France.

French chemical industry, the 2<sup>nd</sup> largest in Europe, employs 167,000 persons in 3,300 companies.

France boasts several major chemical industry parks that benefit from some

of the world's top infrastructures, which put them in direct contact with both European and global markets.

For further information, please visit: [www.francechimie.fr](http://www.francechimie.fr)

In addition to the support of the national node of France Chimie, several regional France-Chimie support the IChO as well: France Chimie Île-de-France (see below), France Chimie Nord-Pas-de-Calais and France Chimie Picardie-Champagne-Ardennes!



### "Engaged entrepreneurs!"

France Chimie Île-de-France, affiliated with France Chimie, serves Chemical Industry's interests and represents its companies on a regional level.

Île-de-France chemistry is employing more than 50,000 people, half of whom are women, representing an important part of national chemical industry. These companies are committed to improve health, safety and to protect the environment by providing solutions to the biggest technological issues such as global warming or energy transition.

They are also concerned to pass on to younger generations their passion for chemistry, an Innovative science that contributes to the well-being of each and every one of us in our daily life. Therefore they developed a strong bond with colleges and schools, leading young people to Chemistry and allowing them to enhance their taste for this science.

Île-de-France chemical companies are very tied to the "Olympiades de la Chimie" (French national contest in chemistry) and have been successfully supporting it for the last 35 years. Naturally they put the same energy to promote the IChO.

Besides, France Chimie Île-de-France has joined the "Lavoisier challenge" to choose four items, representing the works of this great chemist, made by art school students. You will find one of those items in your welcome bag!

We are thrilled and proud of the enthusiasm around this event, that shows the strong interest of young people in Chemistry and the tremendous commitment of their teachers, all around the world.

Long live the IChO!

**Gilles le Maire**  
Executive Director



## The Foundation's Goals in Education

Chemistry can be found in all sectors and as such it is important that the Foundation's endeavors and initiatives be well known. The Foundation acts in many ways, some of them target students and teachers more specifically. Among them, we can highlight the Conferences "Chemistry and..." and the "Mediachimie.org" web site.

"Chemistry and...", conference cycles, are organized and funded by the Foundation and aim to:

- Spread the current and estimated contribution of science in the future
- Address the public questionings with honesty and the highest scientific rigor expected
- Open students to professions and innovation
- Promote cross-border exchanges between Industries and Academies in the same field, since the conferences have a transdisciplinary focus.

Each conference is recorded, broadcasted on the Foundation's website and can be found in bookshops: <https://maisondelachimie.com>

"Mediachimie.org", the website founded and financed by the Foundation, is the library dedicated to chemistry in all its aspects such as innovation, trainings, teachings and professions. It is a wealth of resources as the Foundation invests in high-quality tools and scientific resources to ensure that teachers and students are provided with everything they need to complete their education:

<http://www.mediachimie.org>



Fondation de la Maison de la Chimie

## French Chemical Society

Created over 160 years ago, the French Chemical Society is a scientific society. It is the network of French chemists, and it connects them to the worldwide chemists' community (researchers, teachers, scholars and students, engineers...). Our missions are to promote the image of chemistry to a wide audience and to defend its power and benefits. To achieve these objectives, we organize and support international conferences and interdisciplinary

events. The monthly journal, L'Actualité Chimique, and the bimonthly newsletter, SCF info en ligne, are platforms to inform and share with our community. The French Chemical Society builds awareness toward public authorities and promotes initiatives of the Young Chemists Network, in particular in the field of sustainability.

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Société Chimique de France  
Le réseau des chimistes