Editorial

Chemistry and Nanotechnology: a great partnership. Current developments in Science and Technology (S&T) are integrating many different areas of knowledge, leading to an increasing miniaturization of functional devices and systems. The modern focus of S&T is on the nanoscale, where a remarkable progress has been achieved thanks to the evolution on the molecular designing of materials and on the ability to deal with the structures at the atomic-molecular level. In fact, at the present time, the advances in materials are being determined by the capability of controlling the space distribution of the structural elements. By merging into the nanosciences, dramatic changes of paradigm are already taking place in Physics, Chemistry, Biology, Medicine, Electronics and Materials Science, extrapolating the limits of the classical world to enter the quantum domain of the atoms and molecules, so familiar to the Chemists.

Chemistry is indeed everywhere, even in our heart and mind. Mother Nature has played Chemistry for billions of years, and learned how to choose the right species to form more organized systems, capable of self-assembling and evolving into self-replicating systems, and also performing useful work. In photosynthesis and mitochondrial respiratory chain one can find typical examples of organized processes in which the energy/electron flow matches the gradient of potentials of the biomolecules strategically distributed along the internal membranes, ensuring efficient energy conversion which sustain all the living organisms. Nature has also learned how to perform normally drastic processes under mild conditions, as exemplified by the bacterial nitrogen fixation, and to control the activity of enzymes using allosteric mechanisms, forcing them to work or to rest, as real nanomachines. Finally, Nature succeeded in using molecules to create a learning machine, which has evolved into a fantastic network of interactions, capable of performing 10^{17} processes per second; a thousand times faster than the IBM Blue Gene computer, the best machine ever made by man. Such wet computing machine is, of course, the Brain!

So, Nature is giving the Chemist all the clues to climb another evolutionary step. But, it will be necessary some changes of paradigm; start thinking beyond the molecules and learning their languages for communication. Molecules are playing this game all the times; for instance, phenolphthalein turns into red color in basic media, signalizing in this way the lack of protons. This trivial color change is not so different from the binary electrical response of a classical p-n junction, used as logic gate (namely YES or NOT) in your computer. In fact, all the molecules signalize in some way when they undergo chemical or physical changes, providing close analogues to the classical logic gates (NOT, AND, OR, NOR etc) employed in binary processing. So, definitely, molecules can be used for computation. But can we use a single molecule as a logic gate device? The answer is yes, but the challenge is indeed enormous!

Single molecule properties does not always coincide with those well known to the Chemist, for the bulk species. As a matter of fact, electron transfer through a single molecule can be such challenging problem that new theories are often appearing, incorporating for instance their internal energy levels, coulomb blockade effects and more effective models capable of dealing with the molecular-electrode interface. On the other hand, it is far from easy to put a single molecule between two electrodes separated by a nanometric distance. Such process can be rather tedious and irreproducible. So, how long would it take to scale up the production, to make one million of such devices?

Certainly, another approach will be necessary to assemble molecular devices. In fact, Nature has learned that the molecules can be guided using their natural chemical affinity to form self-organized systems, and to find their complementary partners in molecular recognition processes, giving rise to self-assembled and self-replicating structures. In principle, Chemistry can do even more than this, since it is not limited by the use of naturally occurring molecules.

There is also a new concept to be exploited. Different molecules can be assembled into organized entities in which the several components are able to act synergistically, performing beyond their own individual limits. This is the genuine concept of Supramolecular Chemistry, as proposed by Jean-Marie Lehn. Nowadays, it is considered the best route for Molecular Nanotechnology. Indeed, new strategies are evolving based on Supramolecular Chemistry, leading to intelligent drugs and materials, as well as to the development of advanced sensors, energy conversion and electronic devices.

In the same way, Chemistry, through the molecular design of materials, is converting the classical metal-oxides, polymers and metals into new, exciting nanostructured materials, nanowires and colorful nanoparticles, exhibiting very interesting properties. Hybrid organic-inorganic nanocomposites are already invading the automobile and plastic industry, improving the mechanical and barrier performance of the components and materials. Carbon and semiconductor nanotubes are being exploited as nanotransistors, nanowires and nanoLEDs. Similarly, new catalysts bearing nanostructured channels and highly active sites are being developed, aiming a better selectivity and efficiency. New drugs, anchored on nanoparticles, intercalated into nanolayered materials or encapsulated into nanospheres, dendrimers or nanosomes are being used in medicine and cosmetics. New therapies and imaging processes are being associated with magnetic nanoparticles and quantum dots.

Nowadays, Nanotechnology is part of the strategic plans of all leading countries, because of its increasing impact as the last wave of technological innovation, capable of injecting trillion of dollars in the World economy, in the next decade. In fact, the World public investments are already approaching 4 billion dollars, at comparable rates in USA, Japan, EU and the remaining countries (mainly China and South Korea). Nanotechnology centers are flourishing in those countries, stimulating and attracting venture capitals, while creating new jobs and opportunities. In Brazil, the public investment in nanotechnology can exhibit impressive numbers, if one take into account the existence of the National Laboratory of Syncroton Radiation and four National Networks in molecular nanotechnology and interfaces (RENAMI), semiconductors and nanomaterials, and in nanobiology. In addition, there are three Millennium Institutes devoted to nanosciences and technology; and the parallel support from some state research foundation agencies, such as *FAPESP*, to research proposals dealing with the nanoscale. As it is happening all over the World, a National Program on Nanotechnology is also under discussion by the Brazilian Government, and the attention of the scientific societies are start moving in this direction.

Finally, Chemistry is having a unique opportunity to launch into Molecular Nanotechnology on a very competitive basis. This is already evident by the inclusion of nanotechnological themes in the international chemistry journals, even in the classical ones. On the other hand, special attention should be given to the formation of qualified Chemists for the Nanotechnology market. Nanosciences and Nanotechnology are essentially interdisciplinary, and strong links should be established between Chemistry and Materials Science, Electronics and Biology, in the undergraduate curriculum, while improving the connections with Physics and Mathematics. So, let's start thinking about it: the students will be the main actors in the incoming Nanotechnology age!

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