State of the art developments in the chemistry and properties of dendrimers and hyperbranched polymers

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Nanosciences are at the forefront of scientific and technological developments and are *the* science of the XXI century. Nanochemistry occupies a place of choice in this discipline and can be regarded as the use of synthetic chemistry to make nanoscale building blocks of different size and shape, composition and surface structure, charge and functionality. These building blocks may form, or can be used to form, even more sophisticated architectures having different properties and particular uses.

Dendrimers, monodisperse nanosized polymeric molecules composed of a large number of perfectly branched monomers that emanate radially from a central core, can be considered as one of the most fascinating molecules arising from this area of research. The ability to easily tune the size, topology, molecular weight and consequently the properties of these nano-objects has led to their widespread use in a variety of applications from biology to material sciences, *i.e.* at the interface of many disciplines. Remarkably their unique branched topologies lead to properties that differ frequently from those of linear polymers, thus exciting the interest and curiosity of thousands of researchers worldwide.

The intrinsic qualities of dendrimers—monodispersity, multivalency, weak cytotoxicity, low immunogenicity—make dendrimers ideal molecules for use in the medical and biological fields. Recent applications can be emphasized: controlled diffusion of drugs, DNA chips, medical imaging, gene therapy, antiviral and antimicrobial protection, cellular therapy, tools for diagnosis, reparation of tissues, biomaterials, *etc*. Generally dendrimers have been used as carriers for drugs and nucleic acids but they can be used also as drugs, as it was demonstrated for the removal of prion proteins present in infected cells, or as a vaginal antiviral gel designed to prevent sexually transmitted infections such as HIV or genital herpes.

Amplification of human natural killer cells known to have the potential to improve human stem cell transplants in anti-cancer immunotherapy opens new avenues for further developments of efficient anticancer therapies. Solid tumours resistant to a drug such as doxorubicin can be removed using a combination of the drug with "bis dendrons".

Gels and nanofibres have been prepared using several types of dendrimers. Some of them have proven to have a high degree of bioactivity, with the ability to act as efficient artificial extracellular matrices in regenerative medicine.

Many other uses of dendrimers could be cited, opening fascinating perspectives for biological applications and in nanomedicine for which intelligent therapeutic vectors that combine targeting, imaging, therapy and controlled release of active molecules are needed.

Dendrimers are beginning to play a key role in the field of homogeneous (and to some extent heterogeneous) catalysis. Immobilization of catalyst groups at the core, on the surface or, less frequently, at each branching point, affords a number of possibilities to control and/or to direct reactions.

Positive effects obtained with dendrimers have been explained by drawing on some of the unique parameters of dendrimers, such as active site multivalency,

Fig. 1 Dendritic structure of the dragon tree.

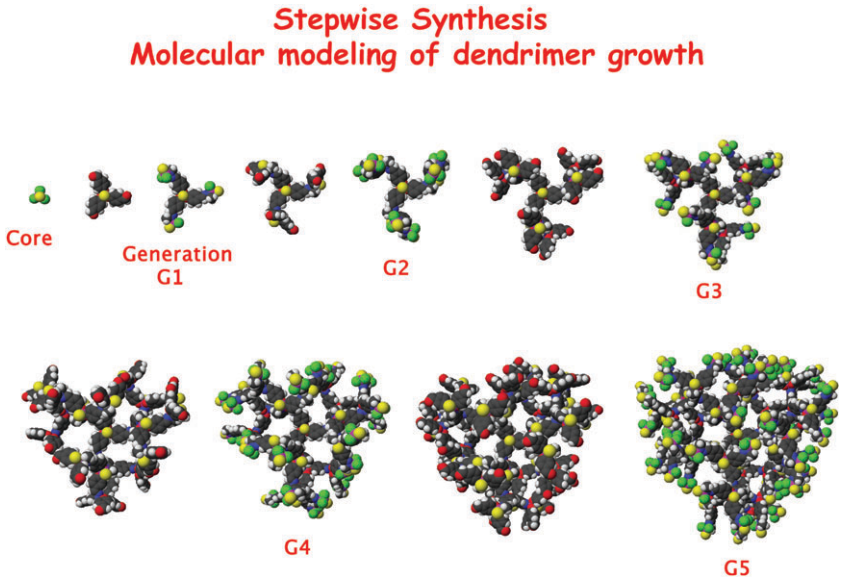

Fig. 2 Molecular modeling of phosphorus dendrimers from generation 0 to generation 5 from X-ray diffraction data of generations 0 and 1.

high loading capacity, unique solubility properties, proximal interactions between catalytic moieties giving rise to cooperative effects, *etc*. Steric crowding at the periphery may confer some specificity to the reactions. As cheaper and readily accessible alternatives to regular dendrimers, hyperbranched polymers are increasingly being used as catalyst platforms. However, the high polydispersity may have negative implications on the characterization of catalyst activity, due mainly to structural non-uniformity.

Similarly, the impact of dendrimers in the field of nanotechnologies is increasing. Dendrimers allow the stabilization and the easier use of nanoparticles. Thanks to their properties, it becomes possible to obtain very resistant fibres, nanolatex, nanotubes, micro- and nanocapsules, biosensors and chemical sensors, systems for nanophotonics, as well as a variety of nanomaterials with exceptional properties.

Dendrimers are also invading the field of the treatment of surfaces and opening new prospects in the application of nanolayers for avionics, the car industry, semiconductors, paints and varnishes, glass, adhesives, anti-adhesives, *etc*.

Therefore, research on dendrimers is integrated in the sustainable development movement with reduction of weight and of energy consumption (surface protection by nanolayers), design of solar cells, synthesis of environmentally benign products, recyclable catalysts and less toxic reagents, *etc*.

The purpose of this special issue is to highlight recent progress in this vast research field. A large number of reviews written by many of the leaders in the field summarise advances in domains where dendrimers and hyperbranched polymers are really effective. Several key feature articles point out exciting new directions.

I do hope that this issue will stimulate future work and will be a valuable reference for the many researchers involved in this field or approaching this fascinating area of research. The *5th International Dendrimer Symposium*, which will be held in Toulouse, France (August 28th through September 1st 2007), will cover many modern aspects of the chemistry, properties and applications of dendrimers and hyperbranched polymers.

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(Guest Editor, Co-Editor in chief)

