Chapter 1

Introductory Chapter: Dendrimers as Nanoengineered Materials and Their Applications

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Additional information is available at the end of the chapter

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1. Introduction

Over the last years, a great attention has been paid to develop and discover new materials with potential applications in our daily lives. From these new materials, dendrimers, as a new class of synthetic polymers discovered in the late 1970s by German scientist Fritz Vögtle, at the University of Bonn, and American chemist Donald Tomalia who was working at Dow Chemical Corporation have been readily engineered to be used in many industrial applications.

Dendrimers are defined as nano-scaled macromolecules having a particular architecture with three definite domains: (1) one central core represented by either a single atom or an atomic group with at least two similar chemical functions, (2) many branches bonded to the core composed by repeat units resulting a series of radially concentric layers named generations and (3) numerous terminal functional groups located at the edge of the molecule which determine the properties of dendrimers [1]. These structural characteristics imposed properties essential for their applicability such as: (i) controlled shape, (ii) accurate dimensions and an extraordinary diversity of peripheral functions (theoretically inexhaustible), (iii) ability to simultaneously create isotropic and anisotropic assemblies, (iv) almost perfect compatibility with other nanomolecules such as: DNA, metal nanocrystals or carbon nanotubes, (v) a remarkable self-assembly potential, (vi) the ability to combine both mineral and organic compounds simultaneously, (vii) the tendency to encapsulate or to be associated in unimolecular functional mechanisms. All these are in accordance with the high number of the researches reported in scientific literature and with the numerous applications of dendrimers. By using as keyword “dendrimers” one searching on ScienceDirect revealed a number of 18,549 results of which 550 are in the first 2 months of this year.

Regarding the applications of dendrimers, the most important are in: medicine [2], catalysis [3], nanoparticle synthesis [4], environmental protection and remediation [5], electrochemistry [6], photochemistry [7], electronics [8], sensors [9], batteries [10], optics [11], biology [12], cosmetics, and personal care product [13].

Substantial progress and many studies have been performed towards the employing of dendrimers for therapeutic and diagnostic purposes for cancer treatment. In this field, the dendrimers were involved as anti-neoplastics and contrast agents, in photodynamic therapy, photothermal therapy and neutron capture therapy [14]. Impressive results have been registered regarding uses of dendrimers for lung, breast, ovarian, pancreatic, cervical and brain cancer treatments.

An emerging field to apply dendrimers is genetics. Selective replacing of defective or deficient genes inside cells is expecting to take place by embedding genetic material into dendritic structures. This is called "gene therapy" and it was previously attempted using a genetically modified virus. In this therapy, the genetically modified virus has been attached to the cells and injects its DNA. The body recognized these "good" viruses as a disease and it attacks them. In case of dendrimers, this immune-system reaction does not occur and they can be applied successfully.

Dendrimers are also considered as excellent candidates for tissue engineering applications [15].

Recently, dendrimers have shown exciting applications in environmental remediation [15]. They are used as adsorbents for organic and inorganic compounds from water as well as materials for different treatment technologies. Many studies reported the application of dendrimers for removal and recovery of heavy metals, precious metals, dyes, and phenol from wastewater. The removal mechanisms and the factors affecting adsorption/removal parameters have been discussed and presented in these studies [5]. These applications are due to their tunable architectures and their selectivity [5, 15].

The cavity of dendrimers has been exploited as "nanoreactors" for accommodating of different guests from metallic nanoparticles to biomolecules [16]. By this encapsulation, it will be registered an improving properties of guests such as solubility and biocompatibility. One control of the size and the shape of nanoparticles can be also shown when the synthesis of nanoparticles has been performed in dendrimers.

Considering the key role of dendrimers in many processes and reactions, it is expected an increase of developments and researches/articles and books in this field.

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References

[1] Caminade A-M, Laurent R, Majoral J-P. Characterization of dendrimers. Advanced Drug Delivery Reviews. 2005;**57**:2130-2146

[2] Tomalia D, Reyna L, Svenson S. Dendrimers as multi-purpose nanodevices for oncology drug delivery and diagnostic imaging. Biochemical Society Transactions. 2007;**35**(Pt 1):61-67

[3] Karakhanov EA et al. Palladium nanoparticles on dendrimer-containing supports as catalysts for hydrogenation of unsaturated hydrocarbons. Molecular Catalysis. 2017;**440**: 107-119

[4] Sun W et al. Dendrimer-based magnetic iron oxide nanoparticles: Their synthesis and biomedical applications. Drug Discovery Today. 2016;**21**(12):1873-1885

[5] Sajid M et al. Removal of heavy metals and organic pollutants from water using dendritic polymers based adsorbents: A critical review. Separation and Purification Technology. 2018;**191**:400-423

[6] Jin X, Zhou L, Zhu B, Jiang X, Zhu N. Silver-dendrimer nanocomposites as oligonucleotide labels for electrochemical stripping detection of DNA hybridization. Biosensors and Bioelectronics. 2018. DOI: 10.1016/j.bios.2018.02.033

[7] Militello MP et al. Novel PAMAM dendrimers with porphyrin core as potential photosensitizers for PDT applications. Journal of Photochemistry and Photobiology A: Chemistry. 2018;**353**:71-76

[8] Sun K et al. Near-infrared thermally activated delayed fluorescent dendrimers for the efficient non-doped solution-processed organic light-emitting diodes. Organic Electronics. 2017;**48**:389-396

[9] Wang H, Xu Q, Wang J, Du W, Liu F, Hu X. Dendrimer-like amino-functionalized hierarchical porous silica nanoparticle: A host material for 2,4-dichlorophenoxyacetic acid imprinting and sensing. Biosensors and Bioelectronics. 2018;**100**:105-114

[10] Bhattacharya P et al. Polyamidoamine dendrimer-based binders for high-loading lithium–sulfur battery cathodes. Nano Energy. 2016;**19**:176-186

[11] Shoaee S et al. Assessing the sensing limits of fluorescent dendrimer thin films for the detection of explosive vapors. Sensors and Actuators B. 2017;**239**:727-733

[12] Caminade A-M, Ouali A, Laurent R, Turrin C-O, Majoral J-P. Coordination chemistry with phosphorus dendrimers. Applications as catalysts, for materials, and in biology. Coordination Chemistry Reviews. 2016;**308**:478-497

[13] Caminade AM, Wei Y, Majoral JP. Dendrimers and macrocycles: Reciprocal influence on the properties. Comptes Rendus Chimie. 2009;**12**:105-120

[14] Wolinsky JB, Grinstaff MW. Therapeutic and diagnostic applications of dendrimers for cancer treatment. Advanced Drug Delivery Reviews. 2008;**60**:1037-1055

[15] Sajid M. Dendrimers based sorbents: Promising materials for analytical extractions. Trends in Analytical Chemistry. 2018;**98**:114-127

[16] Sadjadi S. Chapter 6: Dendrimers as Nanoreactors. In book: Organic Nanoreactors: From Molecular to Supramolecular Organic Compounds. In: Samahe S, editor. Kidlington, UK: Academic Press Elsevier; 2016:159-201. ISBN: 978-0-12-801713-5. DOI: 10.1016/B978-0-12-801713-5.00006-9