

**Review Article**

A Review on Dendrimers and Metallo dendrimers, the Important Compounds as Catalyst in Material Chemistry

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Abstract: The research and the usage of the dendrimers and metallo dendrimer compounds which are also known as supramolecules are attracted by the scientists very fast. The use of these two types of compounds are developed and spread out from the chemical to materials throughout the world. One of the important applications of these supramolecules is as catalyst in the different fields of chemistry and material sciences.

Keywords: Dendrimers, Metallo dendrimers, Synthetic, Catalyst, Materials, Supramolecules

1. Introduction

Dendrimer compounds are onion-type polymers which bear branching units or points in each shell [1-2]. Consequently, the number of branches and their molecular masses increase exponentially from the core outwards. Metallo dendrimers [3-13] are now the well-defined and well established term of research due to the efforts of both the

fields of dendrimer and inorganic chemists. They potentially provide ecologically viable and re-generable catalysts whose efficiency can be equal to those of mononuclear homogeneous catalysts and which can be easily recovered and re-used. They are also ideal hosts for supramolecular chemistry [14] and, as such, have been designed as exo-receptors for sensing and titration of biologically relevant anions [15].

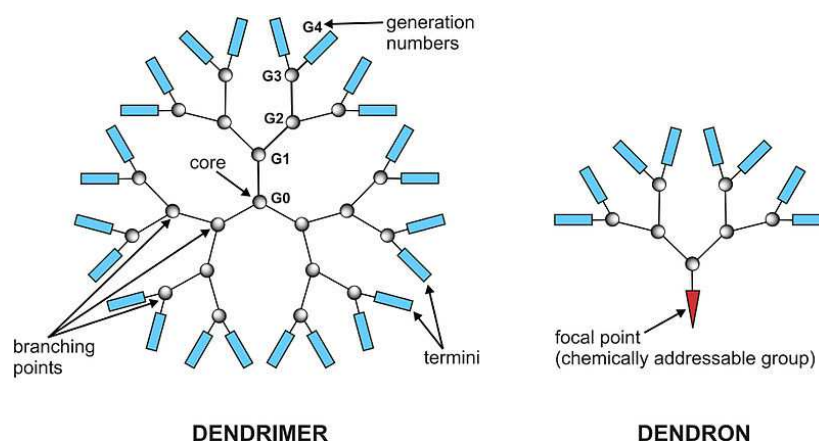


Figure 1. Dendrimer and Dendron.

2. A Brief Discussion

Dendritic and metallo dendritic polymers are unique “ball shaped” polymeric substance, whose molecular architecture consists of an initial core and repeating units with branching and terminal groups (Figure 1). Each repeating units bears a branching point to which two or several new repeating units are attached. Owing to their unique properties such as solubility in water, well defined molecular architecture, and spherical shape, dendrimers and metallo dendrimers have found numerous applications in chemical, physical and biological processes [16-18].

The dendrimer and metallo dendrimer compounds can be synthesized in many ways. Convergent and divergent synthetic methodologies for the synthesis of dendrimers provide a high degree of control in terms of the molecular size, shape, and location of functional groups, leading to almost total control over the molecular architecture [19, 20]. These two polymeric compounds used in the vast range of fields in science as in synthetic organic chemistry, materials chemistry, sensors, energy transfer as well as in the molecular electronics. During the past few decades, considerable effort has been devoted to the design of dendrimers & Metallo dendrimers and to their applications in coordination chemistry. Metallic moieties can be attached at various points in dendrimers, specifically the peripheral surface, the branching unit, or multiple sites within the dendrimers, all of which can lead to a variety of applications, including catalysis [21, 22]. The dendrimers have become suitable materials to overcome the drawbacks of linear-chain polymers, and dendritic structures have been shown to act as light harvesting antennas [23-25] and to be appropriate compounds for optoelectronics applications [26, 27]. Recently, the study of directional energy transfer in dendrimers has attracted significant attention

because their unique structures can mimic the biological photosynthetic process and can be applied to optoelectronic molecular devices such as organic light-emitting diodes (OLEDs) [26, 27].

3. Applications of Dendrimers and Metallo dendrimers in Material Chemistry

In the past two decades, the design and synthesis of diverse dendrimers has received increasing attention [28] not only because of the aesthetically pleasing structures of these molecules but also as a result of their various applications in host-guest chemistry [29], material science [30], and membrane chemistry [31]. Up to now, two complementary methodologies [32, 33], the divergent and the convergent, have been employed in the preparation of dendrimers. When the dendrimer branches are sufficiently long, the redox events at the many termini of the metallo dendrimer are independent, appearing as a single wave in the cyclic voltammogram, because of very weak electrostatic effects. As a result, these metallo dendrimers have applications in the molecular recognition, sensing, and titration of anions (e.g., ATP^{2-}) and cations (e.g., transition metal complexes) (Figure 2). When the recognition properties are coupled with catalysis, the metallo dendrimers function in an enzyme-like manner. For example, Pd^{II} can be recognized and titrated using the dendrimer's terminal redox centers and internal coordinate ligands. Redox control over the number of Pd^{II} species located within a dendrimer allows us to predetermine the number of metal atoms that end up in the form of a dendrimer-encapsulated Pd nanoparticle (PdNP).

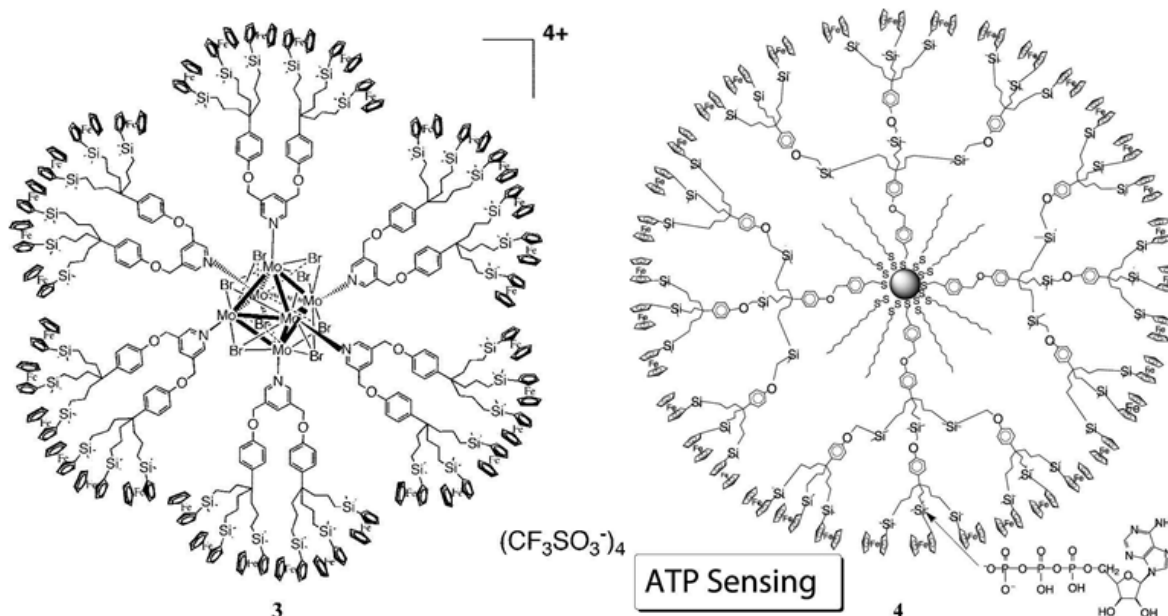
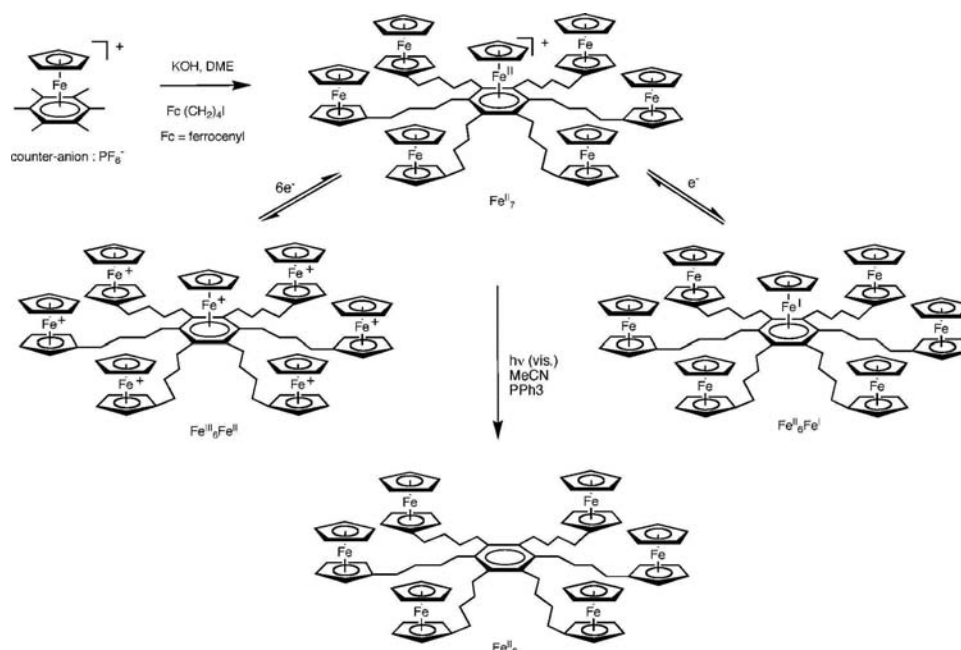


Figure 2. Dendrimer and Metallo dendrimers as the Design for Molecular Electronics.

Star compounds and dendrimers were synthesized with metal-sandwich units located either at the center or at the periphery or even both [34-43]. The redox activity of each redox center showed reversibility and the possibility to isolate

at least two redox forms by multiple electron-transfer reactions. Early examples included the first dendrimers terminated by ferrocenyl (Scheme 1), cobaltocenyl (eq. 1) [41, 42], and $[\text{FeCp}(\eta\text{-arene})]^+$ (eq. 2) [36, 41] units.



Scheme 1. Synthesis and Electron-Transfer reactions of Polyiron Complexes.

Although dendrimers presenting catalysts at their branch termini can be recovered and reused readily, their inner sphere components can lead to steric inhibition of substrate approach. In contrast, star-shaped catalysts do not suffer from such steric problems, as has been demonstrated for water-soluble dendrimers bearing cationic iron-sandwich termini, which are redox catalysts of cathodic nitrate and nitrite reduction in water.

Finally it can be predicted that the applications of dendrimer and metallodendrimer compounds are typically involved conjugating other chemical species to the dendrimer and metallodendrimer surface that can function as detecting agents (such as a dye molecule), affinity ligands, targeting components, radioligands, imaging agents, or pharmaceutically active compounds. Dendrimers and metallodendrimers have very strong potential for these applications because their structure can lead to multivalent systems.

4. Conclusion

In this study, it was shortly discussed that the importance and application of these dendrimer and metallodendrimer types macromolecular compounds are vast. The usages cover the huge fields from the catalyst in the synthetic organic to materials chemistry. From a polymer chemistry point of view, dendrimers are nearly perfect monodisperse macromolecules with a regular and highly branched three dimensional molecular architecture. Dendrimers and metallodendrimers are precisely defined, synthetic non-material's that are

approximately 5-10 nanometers in diameter. Dendritic polymers or dendrimers provide a route to create very well-defined nanostructures suitable for drug solubilization applications, delivery of DNA and oligonucleotide, targeting drug at specific receptor site, and ability to act as carrier for the development of drug delivery system. It is assumed that within the short period, the research of the dendrimers and metallodendrimers will be the hotcake to the scientists in different fields.

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