International Journal of Pharmaceutical Research and Applications
Volume 6, Issue 5 Sep-Oct 2021, pp: 741-749 www.ijprajournal.com ISSN: 2249-7781

A Review on Evaluation of Dendrimers

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Date of Submission: 25-09-2021 Date of Acceptance: 08-10-2021

ABSTRACT

The dendrimer is the combination of the two Greek word dendron and meros. Dendron means tree and meros means part. The dendrimers are highly branched three-dimensional structure. Two strategies have been proposed for the preparation of dendrimers first one is divergent method and the second one is a convergent method. The size of the dendrimer is in nanometers. The size of the dendrimer depends on how many steps are there in the building process. This criticism is an examine the techniques, which is used for evaluation of dendrimers, investigate the shape of the dendrimer, reaction rate, morphology, structural defects, conjugation, synthesis, chemical composition, physical state, polydispersity, molecular weight, homogeneity and purity of dendrimer. It includes (IR) infra-red, Raman spectroscopy, NMR, mass spectroscopy, fluorescence technique, x-ray photoelectron technique, atomic force microscopy, ultra-violet–visible (UV–vis), (LLS) laser light scattering, (SANS) small angle neutron scattering, , (SEM) scanning electron microscopy, electrophoresis, electrochemistry, (SEC) size exclusion chromatography, (EPR) electron paramagnetic resonance, dielectric spectroscopy, intrinsic viscosity, (DSC) differential scanning calorimetry.

Keywords: NMR, IR spectroscopy, Scattering technique, SEC.

INTRODUCTION

A dendrimer is the taxonomic group of the supramolecular chemistry. The dendrimer is the combination of the two Greek word dendron and meros. Dendron means tree and meros means part. The dendrimers are highly branched three-dimensional structure. A dendrimer has a tree-like fashion type structure which grows from the central core molecules. The size of dendrimer is in nanometers[1]. The size of the dendrimer depends on how many steps are there in the building process. Structurally the dendrimer begins with multifunctional core molecules. Various molecules like ammonia, benzene, fluorine, etc. can be used as a dendrimer core. This criticism will examine the techniques used for evaluation or characterization of dendrimers. Characterization/evaluation is used to investigate the shape, reaction rate, morphology, structural defects, conjugation, synthesis, chemical composition, physical state, polydispersity, molecular weight, homogeneity and purity of dendrimer[2].

In this review: we will be used different generation dendrimers structures such as PMMH for phenoxymethyl (methylhydrazono), PBzE poly (benzyl ether) dendrimer, PAMAM dendrimer, PPI dendrimer,ARB arborol dendrimer, Chiral dendrimer, Peptide dendrimer, PHEN for polyphenylene.[3-4].

The characterization/evaluation of the dendrimer can be done by various techniques like; spectroscopy and spectrometry, scattering techniques,
microscopy, Size exclusion chromatography (SEC), electrical methods, rheology, physical properties[4].

1. SPECTROSCOPY AND SPECTROMETRY:

Spectroscopy and spectrometry of dendrimer is a qualitative or quantitative technique. It is used to determine both inorganic and organic compound. It can be done by IR, Raman spectroscopy, NMR, mass spectroscopy, fluorescence technique, x-ray photoelectron technique, atomic force microscopy, ultra-violet–visible (UV–vis)[5].

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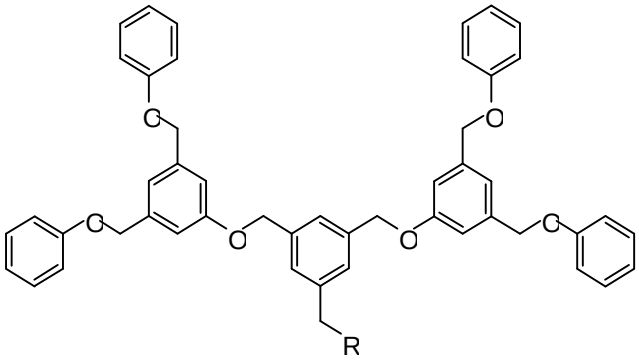
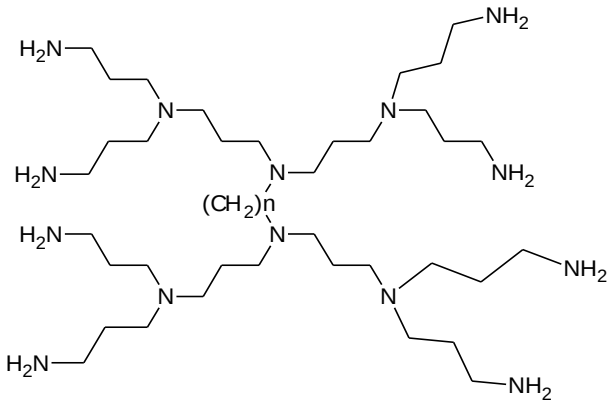
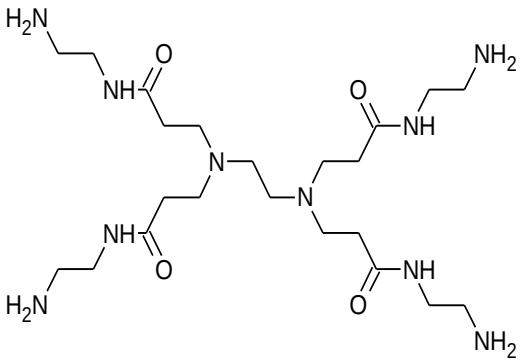


PBzE dendrimer G-2



PPI dendrimer G-2 (n=2, 3, 4….)



PAMAM dendrimer G-1

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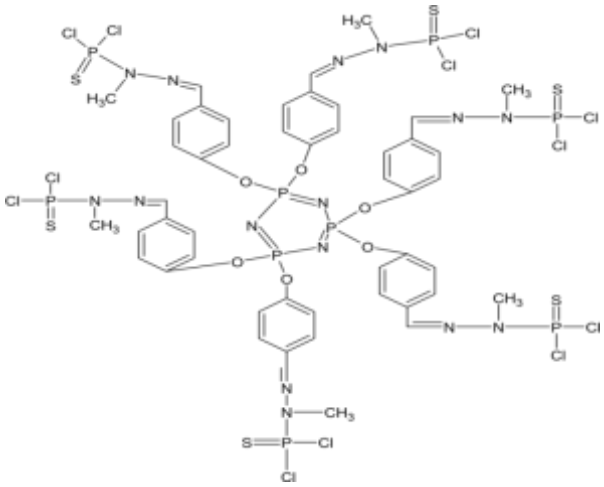
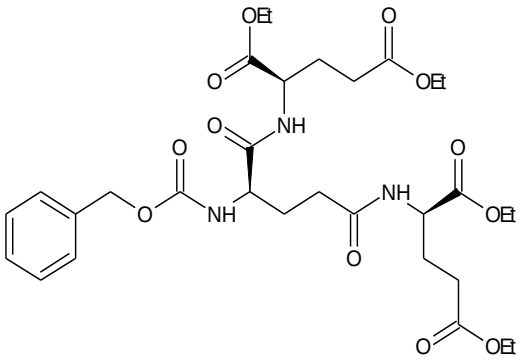


PMMH dendrimer G-2

ARB dendrimer G-2



Chiral dendrimer G-1

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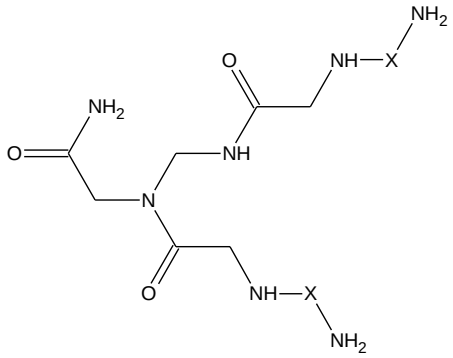
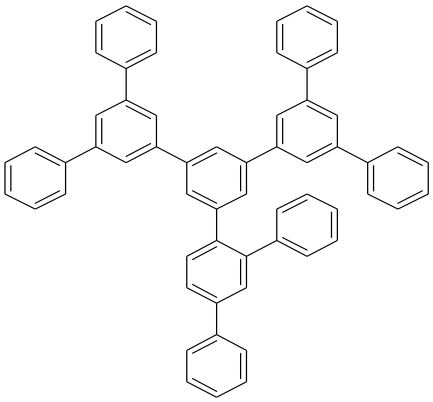


Peptide dendrimer G-1



PHEN Dendrimer (G-1)

Ultra-Violet–Visible (UV–Vis) Spectroscopy: UV–Vis technique gives us the proof of synthesis due to specific highest absorption or shift in the value of lambda max. The range of the UV-Vis spectroscopy lies between 200 to 800nm. The functional moiety which is attached to the dendrimer molecules can be detected by UV spectroscopy. In UV spectroscopy characteristic curve tell us definite highest absorption peak at definite wavelengths[6].

Infrared (IR): At the surface of dendrimers this technique gives us the information about routine analysis of chemical transformation. It is also used for the determination of synthesis.IR gives us the proof of synthesis progress by appearance-disappearance-reappearance of characteristics peaks.IR range lies between 0.8 to 1000 micrometer. Kolhe et al. confirmed that the disappearance of aldehydes all through the synthesis of phenoxy methyl (methyl hydrazono) (PMMH) dendrimers ruminates synthesis[7].

Raman Spectroscopy: This technique can be used for the study of vibrational, rotational and another frequency mode. It may be used in the determination of interaction of poly (amidoamine) dendrimer with a lipid layer[8].

Nuclear Magnetic Resonance (NMR): When we go for grade by grade synthesis of dendrimers (NMR) nuclear magnetic resonance analyses are mainly used. Because nuclear magnetic resonance (NMR) provides us the tips about analytical transmutation undergone by the last group. By the help of (REDOR) rotational echo double resonance, NMR solid-state spectroscopy complexed PAMAM^{s} dendrimers,and PAMAM^{s} dendrimers are evaluated. H^{1} and C^{13} NMR are mostly used for an organic compound such as poly (ester ketone), Poly (propylene imine), polyphenylester.One-dimensional and two-dimensional NMR research used to probe the conformation of melamine dendrimer which bears specific NMR alerts from the middle to the periphery[9-13].

Mass Spectroscopy: It is used to measure the mass to charge ratio of charged particles. The rapid and exact resolution of molar masses, impurities,etc. is realized with mass spectroscopy. On the idea of function fragmentation pattern, the completed

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investigation of structural faults in dendrimer is suitable for (MALDI-TOF) matrix-assisted laser desorption/ionization time of flight. For the determination of fragmentation pattern of different dendrimers, mass spectroscopy is used[14].

Fluorescence Spectroscopy: By the use of fluorescence spectroscopy we are able to decide without difficulty the scale and shape of molecules. By this approach, we can be gotinformation about the drug and dendrimer interaction. It is in the form of electromagnetic spectroscopy. Electromagnetic spectroscopy analyzes fluorescence from a sample. Whenever we get the defects during the synthesis of dendrimer, we can easily quantify that faults by the use of fluorescence because it has high sensitivity[15].

X-ray Photoelectron Spectroscopy: It is also known as (ESCA) Electron Spectroscopy for Chemical analysis. Aromatic rings, C-O, C=O,etc. can be evaluated by (ESCA). With the help of x-ray photoelectron spectroscopy, we can be introduced Immobilization of poly (amidoamine) dendrimers, NiSn dendrimer, synthesis,etc. This technique can be used as a quantitative.It can be used to measure the thickness of one or more skinny layered dendrimers (1–8 nm), empirical formula, chemical state etc[16].

Atomic Force Spectroscopy: This technique gives us the three-dimensional surface image and good resolution. With the help of atomic force spectroscopy (AFS), we can easily characterize/evaluate the behavior of dendrimer agent and structures.With the help of atomic force microscopy, PAMAM dendrimer (dMNTs) modified multi-walled carbon nanotube was evaluated and invented[17].

SCATTERING TECHNIQUES: Scattering techniques can be done by (SAXS) small angle x-ray scattering, (SANS) small angle neutron scattering, (LLS) laser light scattering.

(LLS) Laser Light Scattering: It can be used to determine the hydrodynamic radius of the dendrimer. We can also use this technique as a coupled detector to size exclusion chromatography instrument. For the detection of aggregates, dynamic laser light scattering is used.Laser light scattering (LLS) can be utilized in the direct analysis of the pattern of dendrimer in solution. With the help of low angle laser light scattering (LLS), we can evaluate the molecular weight of PPI dendrimers[18-19].

(SAXS) Small Angle X-ray Scattering: This technique can be used for the evaluation of polymers. By applying this technique on the dendrimer, we can easily get information about their average (R_g) radius of gyration in solution. To afford the radius of gyration (R_g) values of Poly (amidoamine) (PAMAM) dendrimer and fluorinated carbosilane dendrimers SAXS was used[20].

(SANS) Small Angle Neutron Scattering: SANS is used to determine the area of completing organizations of the PPI dendrimers and PAMAM dendrimers. They are having labeled, and unlabeled end groups but in the prior case near the periphery end groups are concentrated. It gives us the correct data about the inner shape of the whole dendrimer than SAXS. SANS denoted us the molecular weight of Poly (amidoamine) (PAMAM) dendrimers, Poly (benzyl ether) (PBzE) dendrimers etc[21].

MICROSCOPY: Microscopy is a scientific instrument. It uses as a beam of an active electron to observe objects on a utterly first-rate scale. Microscopy technique can be done by TEM transmission electron microscopy, SEM scanning electron microscopy.

(SEM) Scanning Electron Microscopy: To study of the surface topography of dendrimers, SEM is usually applied.To attaining the deeper understanding and investigation of phenyl-OH terminated dendrimer and its surface properties, scanning electron microscopy was applied.At a few angstroms of sensitive cantilever arm with the sample, (SEM) scanning electron microscopy provide us an image by touch contact.To have a look at metallo-dendrimers which is having rhodamine B at the focal point(NSOM) near-field, scanning optical microscopy has been used.Dadapeeret al. Implemented(SEM)Scanning Electron Microscopy in studying a phenyl-OH terminated dendrimer that lets in you to get a deeper expertise of its surface properties[21-23].

(TEM) Transmission Electron Microscopy: It is a microscopic technique used to observing only aggregates of small arborols (ARB). In this approach, the beam of electrons is transmitted thru an extremely fine specimen. After transmitting the

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beam of electrons thru the extremely fine specimen then they may be interacting with the specimen and as it is passed via it. Transmission electron microscopy was used to study the PAMAM dendrimer molecules if you want to get a deeper expertise of form, common length and length distribution for G10 to G5[24-25].

ELECTRICAL TECHNIQUES: Electrical techniques are used for producing low detection limit. With the help of electrical technique, we can describe a lot of evaluation information electrochemically such as equilibrium constants for chemical reactions, the extent of adsorption and the rates, a rate of mass transfer, Stoichiometry and rate of interfacial charge transfer. It can be done by electrophoresis, electrochemistry, electron paramagnetic resonance (EPR)[26].

Electrophoresis: This technique offers useful data about the purity and homogeneity of numerous water-soluble dendrimers. The purity of poly (amidoamine) (PAMAM) dendrimer was investigated by the use of mass spectroscopy, gel electrophoresis and C^{13} NMR spectroscopy (Ottaviani et, al). To the separation of biopolymers such as nucleic acid and proteins, gel electrophoresis is used.It is also used in biology for routine analysis[27].

Electrochemistry: To concerning the structure of the dendrimer electrochemistry may afford generally three types of information.To measure the number of electroactive groups, exhaustive coulometry has been used. But in many studies, ferrocenes united to the surface of phenoxy methyl (methyl hydrazono) (PMMH) dendrimers, poly (propyl imine) (PPI) dendrimers etc. which is joined to the PAMAM dendrimers. With the help of cyclic voltammetry, we can be detected the burying degree of the electroactive groups inside the dendrimers[28].

(EPR) Electron Paramagnetic Resonance: To have look at the chemical species with one or more unpaired electron which includes inorganic complexes owning transition metallic or inorganic and natural free radicals, electron paramagnetic resonance (EPR) method is used. Ottaviani et al. Pronounced the usage of (EPR) electron paramagnetic resonance within the studies of the adsorption of dendrimers on activated alumina, homo-porous silica[26-28].

SIZE EXCLUSION CHROMATOGRAPH (SEC): To the separation of molecules in step with size, size exclusion chromatography (SEC) is used. The detector inclusive of a differential refractive index is hooked up to the(SEC) size exclusion chromatography equipment for the determination of the polydispersity. There are many types of dendrimers evaluated by size exclusion chromatography (SEC), even self-assembled dendrimers are also evaluated by SEC. For polyether dendrimers, well-evaluated PAMAM dendrimer was used as a standard. Because of increasing the generation number of poly benzyl ether (PBzE) and Phenoxy methyl (methyl hydrazono) (PMMH) dendrimers. To change the monitor size of arborols (ARB) dendrimer with PH variance size exclusion chromatography (SEC) was used[29].

RHEOLOGY, PHYSICAL PROPERTIES: Rheology, physical properties can be done by dielectric spectroscopy, intrinsic viscosity, (DSC) differential scanning calorimetry.

(DSC) Differential Scanning Calorimetry: To detect the glass transition temperature (Tg), (DSC) differential scanning calorimetry is used. Tg is predicated upon at the chain-end composition of polymers, entanglement and molecular weight. Tg is influenced by the molecular mass of poly benzyl ether (PBzE) dendrimers, correlates with n_e /M (n_e is the number of chain ends) and end group substitutions. To detect physical aging of phenoxy methyl (methyl hydrazono) (PMMH) dendrimers temperature modulated calorimetry (TMC) and DSC is used[25-30].

Dielectric Spectroscopy: Dielectric spectroscopy can be used for attaining the deeper understanding of the molecular dynamic processes in polymers (alpha, beta, gamma and delta relaxation). Dielectric spectroscopy was executed on several dendrimers. Dielectric spectroscopy was generally found that alpha relaxation values. Several dendrimers were analyzed by dielectric spectroscopy such as carbosilazane dendrimers, phenoxy methyl (methyl hydrazono) (PMMH) dendrimers, poly(ether amide), carbosilane, arborol (ARB)[31].

Intrinsic Viscosity: It may be used as an analytical probe of the morphological form of dendrimers. The dendrimers must display off a most inside the dependence of the intrinsic viscosity [g] on

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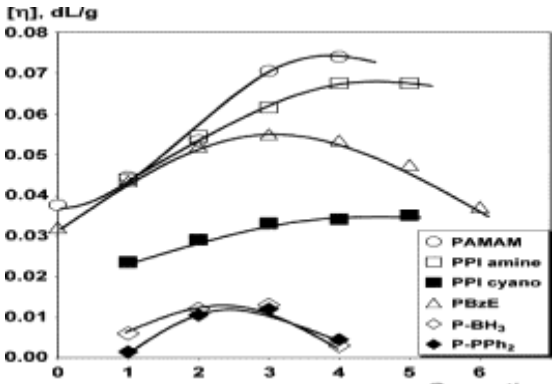
generation, because of the fact the volume grows quicker with era than the molecular weight for the primarygenerations. The intrinsic viscosity maxima befall at dissimilargenerations such as G5 for (PPI) poly (propylene imine) dendrimers, G4 for (PAMAM) poly (amido amine) dendrimers, G3 for phosphorus dendrimers, G2 or G3 for poly benzyl ether (PBzE) dendrimers.There is only one exclusion which is come from polylysine (Ply) dendrimers. Polylysine (Ply) dendrimers showed constant intrinsic viscosity across the nine generation. This is probably because of the geometrical asymmetry of the branches permitting very close segmental packing.



This graph shows the variation of intrinsic viscosity with era for numerous varieties of the dendrimers like (P-BH3, PAMAM, PPI dendrimers and so on)[32-37].

CONCLUSION: Many techniques can be used for the characterization of dendrimer. IR often used to determine the functional groups in molecules. To assess the purity of sample and molecular structure of the sample NMR often used. To attaining the more profound understanding and investigation of the phenyl-OH terminated dendrimer, SEM was applied. To establish the construction of the new compound or to prove the identity of two compound, Mass spectroscopy is often used.

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