ASIAN JOURNAL OF PHARMACEUTICAL AND CLINICAL RESEARCH

INNOVARE ACADEMIC SCIENCES
Knowledge to Innovation

Vol 16, Issue 10, 2023

Online - 2455-3891
Print - 0974-2441

Review Article

ANALYTICAL METHODS FOR QUALITY CONTROL OF NANOFORMULATIONS-A REVIEW

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Received: 12 April 2023, Revised and Accepted: 25 May 2023

ABSTRACT

There has been a surge in enthusiasm for the creation of innovative medication modes of delivery that utilize nanoparticles in recent years. Nanoparticles provide substantial benefits compared to conventional drug delivery methods with strong stability, specificity, and drug consumption levels. The rate of release, the capacity to use alternative routes of delivery, and the capacity to give off drug compounds that are both hydrophilic and hydrophobic are all advantages. This study concentrates on nanoscale categorization, processing methods, characterization, utilization, and benefits.

Keywords: Nanoparticles, Preparation, Characterization, Applications.

 DOI: http://dx.doi.org/10.22159/ajpcr.2023v16i10.48073. Journal homepage: https://innovareacademics.in/journals/index.php/ajpcr

INTRODUCTION

The prefix "nano" had found growing applicability in various scientific fields throughout the previous decade. Nanomaterials, technology, nanotubes, and nanochemistry are just a couple of the emerging nano-related terminology that appear often in research articles, popular literature, and publications which have grown recognizable to a broad public, including quasi [1-3]. The prefix derives from the ancient Greek o through the Latin nanus, which means basically tiny and, by extrapolation, very little. It is used in the International System of Units convention to signify a reduction factor of 109 times. Therefore, the nanosized universe is often measured in nanometers (1 nm equivalent to 10^{-9} m) and includes systems that are larger than molecular dimensions but smaller than gigantic dimensions (normally >1 nm and 100 nm) [5].

Nanotechnology is the study of the incredibly tiny. It is the utilization and modification of matter on an extremely small scale. At this level, the molecules and atoms behave strangely and have a wide range of unanticipated and intriguing applications [8-10]. Biotechnology and nanoscience, which is research, have exploded in recent years across a wide range of commercial sectors. It allows to produce materials, notably those for medical uses, when standard processes may be limited. Nanostructures should not be seen as a single approach that only has a limited impact. While it is commonly referred to as "tiny research," nanoparticles do not just relate to extremely small buildings and products [12-15]. Nanoscale characteristics are frequently introduced into bulk materials and huge surfaces.

CLASSIFICATION

Nanoparticles with a single dimension

For generations, one-dimensional structures including such as thin coating or fabricated surfaces have been employed in communications, biochemistry, and technology [16-19]. Nanosheets (sizes 1–100 nm) or monolayers are currently widely used in the fields of photovoltaic cells and catalysis. Nanocomposites are used in a wide range of technical purposes, involving systems to store data, biological as well as chemical sensors, fiber-optic systems, ferromagnetic systems, and optical [20-22].

Nanoparticles with two dimensions

Multi-walled carbon nanotubes (carbon nanotubes)

Nanotubes made of carbon are indeed a carbon network that is hexagonal. The coating of graphite wrapped into a cylinder has particles 100 nm in length and 1 nm in diameter. Single-walled carbon nanotubes as well as carbon nanotubes that have several walls (MWCNTs) are indeed the two varieties of CNTs [22-25]. CNTs are one-of-a-kind basic facilities to their short dimensions as well as exceptional physical, mechanical, or electrical capabilities (Kohler *et al*., 2004). Based on the way the carbon leaf is twisted on its own, it has metal as well as semi-conductive qualities [26-33]. The present state that nanotubes can transport is exceptionally high, reaching one million amps per sq.meter, making it a superconductor. Molecular absorption, as well as a three-dimensional structure [34-36].

Nanoparticles in three dimensions

Fullerenes (C60)

Fullerenes are spherical cages of 28 equal to or greater carbon atoms. C60 has over 100 carbon atoms. The above is a hollowed soccer ball made up of linked carbon pentagons or hexagons. Fullerenes are indeed a group of substances with different physical properties [37-40]. These can withstand extreme pressure and afterward go back to their usual form whenever the release of pressure occurs. Because these compounds need not react to each other, they have a significant potential for use as lubricant. These offer fascinating electronic characteristics which have been proposed for usage inside the electronic area, varying from data storage to solar array manufacture. Cell lines - Fullerenes have prospective applications inside the vast field of nanoelectronics. Carbon-based materials are useful because they have hollow molecules with proportions identical to various compounds with biological activity [41-52].

NANOPARTICLE PREPARATION

The extension takes for manufacturing nanoparticles is determined by the thermodynamic properties of the polymer and the medication to be loaded. The following are the basic ways for producing nanoparticles from premade polymer [54].

Technique of emulsified evaporation

This is among the most often used techniques to create nanoparticles. There are two steps to microemulsions evaporation. The first procedure is to emulsify the reaction mixture into an aqueous environment. The polymer solvent is evaporated in the second stage, causing polymer condensation as microspheres [55-58]. The nanomaterials are ultracentrifuged and cleaned using distilled water to eliminate any stabilizer residual or free medication before being lyophilized before keeping (Song *et al*., 1997). This process has been modified by a high-pressure emulsifying agent and vapor deposition.

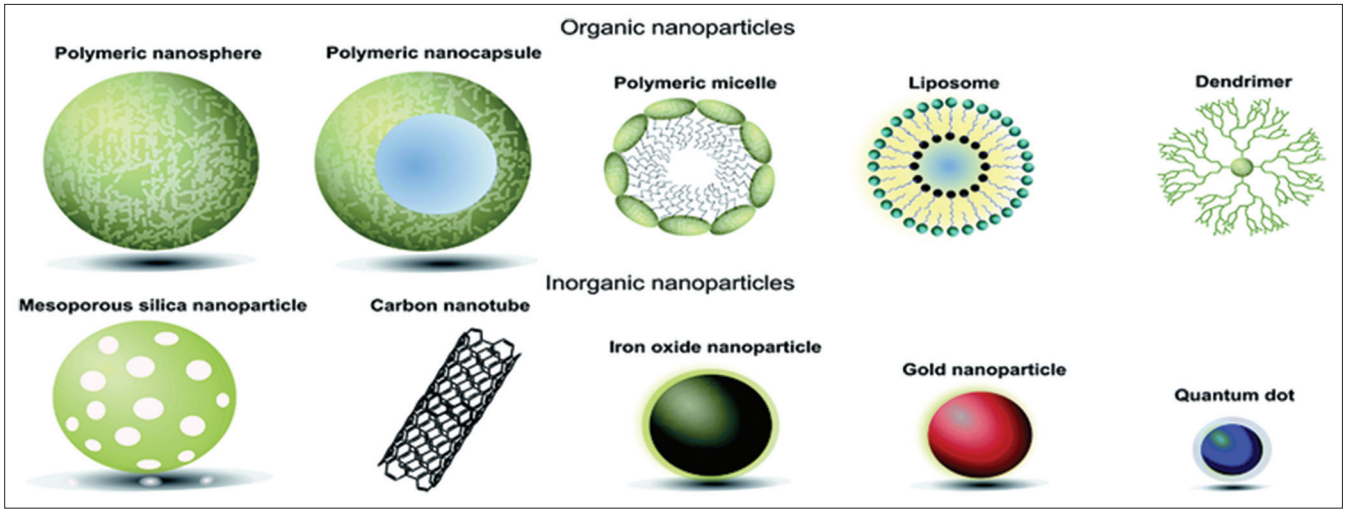

Fig. 1: Types of nanoformulation

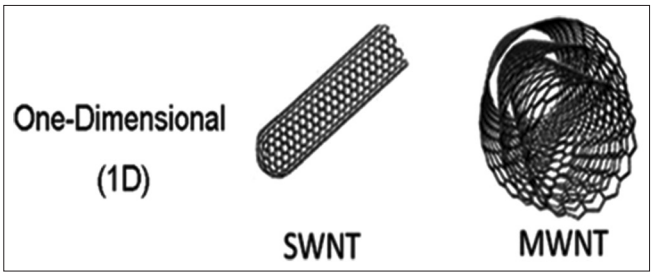

Fig. 2: Nanoparticles with one dimension

The double emulsion and evaporation methods

The dispersion and evaporation processes are both affected by the poor trapping of hydrophilic medicines is a limitation. To incorporate hydrophilic drugs, it is a double dispersion approach is used, which includes vigorously swirling aqueous solution-containing solutions into organic polymer solutions to generate w/o emulsification. This organic solvent is continuously stirred into the subsequent aqueous environment to generate the w/o/w mixture [60-62]. The mixture is subsequently magnetic nanoparticles that can be exposed to solvent removal through evaporation separated through high-speed centrifugation [63-67]. Before lyophilization, the produced nanostructures must be properly cleaned. The number of hydrophilic substances to be integrated, the quantity of preservatives employed, the type and concentration, and the amount of aqueous medium are all determined by this approach [68,69].

Emulsions-diffusion approach

This is yet another popular approach for producing nanoparticles. The enveloping polymer melts in a partially absorbed solvent. Liquid-miscible solvent and soaked using water to achieve both liquid' preliminary symmetry in temperature [70]. Following that, the polymer-water saturating moisture phase becomes combined in a stabilizer-containing solution of water, resulting in solvent dispersion to the exterior phase and the creation of tiny spheres or nanocapsules depending on the oil-to-polymer ratio. Finally, depending on the point at which it reaches boiling, the chemical solvent is removed through absorption or screening [71].

Solvent replacement/precipitated method

The solvent-based displacement procedure comprises the formation of precipitates of a prepared polymeric into a solution of organic material as well as the dissolution of the organic solvent that has been prepared in the water-based medium in the non-appearance or the presence of a surfactant [72,73]. Polymers, drugs, and lipophilic surfactants are dispersed in acetone or a solution of a solvent that is semipolar and water miscible. The mixture then gets poured or infused into a magnetically stirred water solution containing a stabilizer [74]. Rapid solvent diffusion produces tiny molecules in an instant. The solvent is subsequently extracted from the solvent droplets under decreased pressure. The organic layer rates absorption toward the watery phase influence particle size. It was discovered that as the rate of mixing of the two phases rises, both the dimension of particles and drug absorption decrease. The nano-precipitating approach is especially appropriate toward most barely soluble medicines [75,76].

NANOPARTICLE CHARACTERIZATION

Employing sophisticated microscopic imaging methods scanning electron microscopy, or electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM) are examples. Particle size: The most essential parameters of nanoscale characterization are particle size distribution and shape [77-80].

Particle size

The maximum essential limits of nanoscale description are particle size distribution and shape. Electron microscopy is used for determining appearance and thickness. The primary use of nanomaterials is trendy drug absorption and therapeutic targeting [81]. The situation has been discovered that particle size influences medication release. Atoms with a smaller size have a greater area of coverage. Consequently, most of the medicine applied to them is exposed to the granular surface. Resulting in rapid drug release. Pharmaceuticals, conversely, gradually permeate within bigger particles. Particles of smaller size are inclined to clump during storage and transit of nanoparticle variation, this is an advantage. As a result of this, there is a trade-off between nanoparticle dimension and the greatest degree of stability [83].

Light scattering in motion

Photon-correlation spectrometer (PCS) is now an efficient and commonly employed technique for determining the size of particles as well as light scattering in motion (DLS) [84,85]. The dimension of Brownian nanomaterial in colloidal solutions is frequently determined using DLS at nanoscale and micron-sized scales. A single-color light (laser) is stand out upon a solution of cylindrical particles when light meets an intriguing particle; it generates a Doppler shift, which changes the length of the wavelength of the incoming light. This variation is caused by the particle's size [86]. Using the function for autocorrelation and keeping track of the particle's coefficient of diffusion, which is it is feasible to determine the amount of space distribution and describe the particle's motion in the surrounding environment [87,88]. PCS is an extremely often used approach for estimating particle dimensions and size distributions based on DLS [89].

SEM

SEM provides anatomical evaluation using direct viewing.

Even though microscopy using electron techniques has significant benefits in architectural and dimension studies, they provide little knowledge regarding the size dispersion and genuine demographic average. The granular solution needs to be transformed into a powder form before being mounted on a container for the samples and covered with a conductor metal, such as precious metals, using a single coaster [90]. This is necessary for analysis. The object being studied is then canned use a tightly focused microscope laser beam. The additional electrons released from the sample's outermost layer are employed to ascertain the surface qualities. The small particles must be vacuum resistant, and the beam of electrons can harm the polymer [91].

The TEM stands for transmission electron microscope

TEM works on entirely different evidence than SEM, yet it frequently produces the same type of data. The material's processing for TEM is difficult and slow. It takes time since it needs to be super thin for particle transmission [21]. The dispersion of nanoparticles is placed onto supporting squares or sheets. Nanotechnology is fixed by employing either an adverse coloring substance, such as phosphor tungstic acid, or its analogs or instruments such as derivatives uranyl acetate, etc. or by soft implantation by helping particles tolerate the device's atmosphere and allow manipulation. Following the encapsulation of the specimen in hexagonal ice, an alternative option is of exposing it to cold nitrogen conditions. The physical characteristics of the surface of the sample are determined by passing an electron microscope through an ultrathin sample and reacting with it as it passes [93].

AFM

AFM is a physical technique that provides unprecedented detail in particle size measuring. Survey of resources available at the sub-micron level with an atomic-sized probing tip according to the loads connecting the top and the base and the material's surface, the device generates a map of the topography of the material being studied. According to their qualities, materials are typically inspected in contact. In the communication mode of operation, the structural map is formed by touching the probe against the electrically conducting surface throughout the sample, whereas in passive mode, the probe hangs over the leading surface [91]. The biggest benefit of AFM is its capacity to picture non-conducting specimens requiring any additional procedures, allowing photography of non-conducting materials. AFM stands for atomic force microscopy. Sensitive biomedical and nano and tiny structures made of polymers. The most exact depiction of size and size spread is provided by AFM. It does not necessitate any theoretical treatment. Furthermore, the particle size produced by AFM technology offers an accurate representation that aids in understanding the implications of diverse biological situations [94-97].

Charge proceeding the surface

The form and power of nanoparticle superficial responsibilities are critical because they impact how they communicate with the biological surroundings and additionally their electrostatic attraction with bioactive substances [100]. The zeta potential of the nanoscale is used to evaluate colloidal nanoparticle stabilization. This potential is a rough estimate of the surface charge. It denotes the potential discrepancy that exists between the outermost Helmholtz line and the shear stress surface. The zeta potential measurement provides for forecasts regard dispersion of colloidal particles. Zeta values that are high ding the storage durability of which may be optimistic as well as negative, essential to be obtained to guarantee particle integrity and avoid particulate aggregation. The extent of the surface hydrophobic nature can then be anticipated using zeta potential readings. The possible zeta may additionally indicate the substance contained within the nano chambers or deposited on the outside of them [102].

CONCLUSION

Nanotechnology-enabled drug delivery is opening a prospective future in pharmaceutics. The emergence of nanotechnology is likely to have a significant impact on the drug delivery sector, affecting just about every route of administration from oral to injectable. The present pharmaceutics is often characterized by poor bio-availability which far too often results in higher patient costs and inefficient treatment but also, more importantly, increased risks of toxicity or even death. Nanotechnology focuses on the very small and it is uniquely suited to creating systems that can better deliver drugs to tiny areas within the body. Nano-enabled drug delivery also makes it possible for drugs to permeate through cell walls, which is of critical importance to the expected growth of genetic medicine over the next few years. The payoff for doctors and patients from nanotechnology-enabled drug delivery should be lower drug.

ACKNOWLEDGMENT

I would like to acknowledge our beloved principal Prof. M. Sumakanth and Faculty of Department of Pharmaceutical Analysis for giving me this opportunity to perform the review work.

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