CODEN [USA]: IAJPBB ISSN: 2349-7750

INDO AMERICAN JOURNAL OF
PHARMACEUTICAL SCIENCES

http://doi.org/10.5281/zenodo.1486099

Available online at: http://www.iajps.com *Review Article*

ROLE OF NANOTECHNOLOGY IN HERBAL MEDICINE

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Abstract:
Herbal medicines have been used for several years throughout the world. The developments of novel herbal formulations were reported to have several advantages over respective crude drug formulations. Nanophytomedicines were prepared from active phytoconstituents or standardized extracts. Delivering therapeutic compound to the desirable site is a major problem in treatment of many diseases. Novel drug delivery system is advantageous in delivering the herbal drug at the site of action which minimize the toxic effects with the increase of bioavailability. Conventional utilization of drugs is characterized by poor bio distribution, limited effectiveness, undesirable side effects, and lack of selectivity. Recent advancement in nanotechnology has proven that nanoparticles acquire a great potential as drug carriers. Size reduction methods and technologies yields different types of nanostructures that exhibit unique physicochemical and biological properties. Incorporation of herbal drugs or extracts with nanocarriers shows increased solubility, bioavailability, decreased toxicity, increased pharmacological activity, decreased dose and increased stability. This review article will provide a brief discussion of Nanoparticles synthesis, characterization by various techniques for production and its impact on herbal medicines.

Keywords: *Nanotechnology, Novel drug delivery systems, Synthesis, Characterization, Herbal nanoparticles.*

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Please cite this article in press Lekshmi N. G et al., ***Role of Nanotechnology in Herbal Medicine.,*** *Indo Am. J. P. Sci, 2018; 05(11).*

INTRODUCTION:

Nanotechnology is defined as the science and engineering carried out in the nanoscale that is 10^{-9} meters. Nanotechnology has emerged as a tremendous field in the medicine. Nano refers to particles size range of 1-1000nm [1]**.** Many of the drug candidates are exhibiting poor aqueous solubility. The use of drug nanosuspension is an universal formulation approach to increase the therapeutic performance of these drugs in any route of administration. Nowadays phyto constituents are obtained in nanoparticle form for improvement of their pharmacokinetic and pharmacodynamic profile. Phytotherapeutics need a scientific approach to delivering the components in a sustained manner to increase patient compliance and avoid repeated administration. This can be achieved by designing novel drug delivery systems (NDDSs) for herbal constituents. NDDS not only reduce the repeated administration to overcome non-compliance but also help to increase the therapeutic value by reducing toxicity and increasing the bioavailability. One such novel approach is nanotechnology. The nanonization of phyto pharmaceuticals leads to a high surface area to volume ratio, enhanced solubility and bioavailability, and enhanced physicochemical stability.

Advantages of nanoparticles over NDDS [2]

- ❖ Increase the drug solubility
- ❖ Improve drug stability in biological environment
- ❖ Increase bioavailability and pharmacological activity
- ❖ Localize the drug in a specific site
- ❖ Improve drug loading and targeting
- ❖ Improve patient compliance.
- ❖ Protection from toxicity
- ❖ Improve tissue macrophages distribution
- ❖ Sustained delivery
- ❖ Protection from physical and chemical degradation.

Disadvantages of nanoparticles over NDDS

- ❖ Due to high surface area and energy, they tend to high aggregation in biological system
- ❖ High immunogenicity
- ❖ Long and expensive to cost
- ❖ Chance of poor targeting.

IDEAL CHARACTERISTICS OF NANOFORMULATION [3]

a) Improved biological performance

In nanosuspension technology, the drug is maintained in the required crystalline state with reduced particle size, leading to an increased dissolution rate and therefore improved bioavailability. An increase in the dissolution rate of micronized particles (particle size < 10 μm) is related to an increase in the surface area and consequently the dissolution velocity. An increase in the dissolution velocity and saturation solubility of a drug leads to an improvement in the in-vivo performance of the drug irrespective of the route used.

b) Increase solution velocity and saturation solubility[4]

Nanosized particles can increase solution velocity and saturation solubility because of the vapor pressure effect. The diffusional distance on the surface of drug nanoparticles is decreased, thus leading to an increased concentration gradient. The increases in surface area and concentration gradient lead to a much more pronounced increase in the dissolution velocity as compared to a micronized product. Furthermore, the saturation solubility is increased as well. The reason behind the increase in the dissolution velocity and saturation solubility of the nanosuspension can be given as follows. According to the Nernst–Brunner and Levich modification of the Noyes Whitney dissolution model equation, the dissolution velocity of the nanosuspension increases due to a dramatic increase in the surface area of the drug particles from microns to particles of nanometer size:

$$\frac{dX}{dt} = \frac{(D-A)}{h} * \frac{(Cs-X)}{V}$$

Where,

dX/dt - the dissolution velocity

D - diffusion coefficient
A - surface area of the particle
h - diffusional distance
Cs - saturation solubility of the drug
X - concentration in the surrounding liquid
V - volume of the dissolution medium

c) Long-term physical stability [5]

Another special feature of nanosuspension is the absence of Ostwald ripening, which is suggestive of their long-term physical stability. Ostwald ripening is caused by the differences in dissolution pressure/saturation solubility between small and large particles. Molecules diffuse from the higher concentrated area around small particles (higher saturation solubility) to areas around larger particles possessing a lower drug concentration. This leads to the formation of a supersaturated solution around the large particles and consequently to drug crystallization and growth of the large particles. The diffusion process of the drug from the small particles to the large particles leaves an area around the small

particles that is not saturated any more, consequently leading to dissolution of the drug from the small particles and finally completes disappearance of the small particles.

d) Versatility

The flexibility offered in the modification of surface properties and particle size, and ease of post-production processing of nanosuspension enables them to be incorporated in various dosage forms, such as tablets, pellets, suppositories and hydrogels, for various routes of administration, thus proving their versatility.

e) Ease of manufacture and scale-up

Nanoparticles are easy to manufacture. The production processes will be described later and can be easily scaled up for commercial production.

HERBAL NANOTECHNOLOGY [6]

Herbal nanotechnology helps in incorporation of the active phyto constituents to obtain desired therapeutic effect. Nanonization of herbal drugs, will make the development of nano herbal medicine which consequently will open the new era of herbal drug discovery. Nowadays the use of herbal medicines has increased because of their ability to treat different diseases with fewer side effects. However, the effective drug delivery of herbal medicines has not still been achieved. Novel formulations including nanoparticles have been developed for the effective delivery of herbal drugs. Nanoparticulate formulations such as polymeric nanoparticles, liposomes, proliposomes, solid lipid nanoparticles and microemulsions present potential to deliver herbal medicines effectively. The requirement of an ideal nanoparticulate system is that it should be capable of circulating in blood stream and should be small enough to reach target cells and tissues. Herbal medicines can be targeted to various organs such as brain, lung, liver, kidney, gastrointestinal tract, etc. Most of the herbal actives are poorly water soluble because of their hydrophobic nature. This property leads to decreased bioavailability and increased systemic clearance thus necessitating repeated administration or increased dose, and thus limits the clinical use of herbal medicines.

Advantages of Herbal Drugs [7]

- Low risk of toxicity
- Wide spread availability
- More effectiveness
- Long history of use and better patient tolerance as well as public acceptance.
- Renewable source.
- Cultivation and processing environmental friendly.
- Local availability, especially in developing countries.

Disadvantages of Herbal Drugs

- Longer duration of treatment
- Not suitable for many drugs
- Lack of dosage instruction
- Low bioavailability

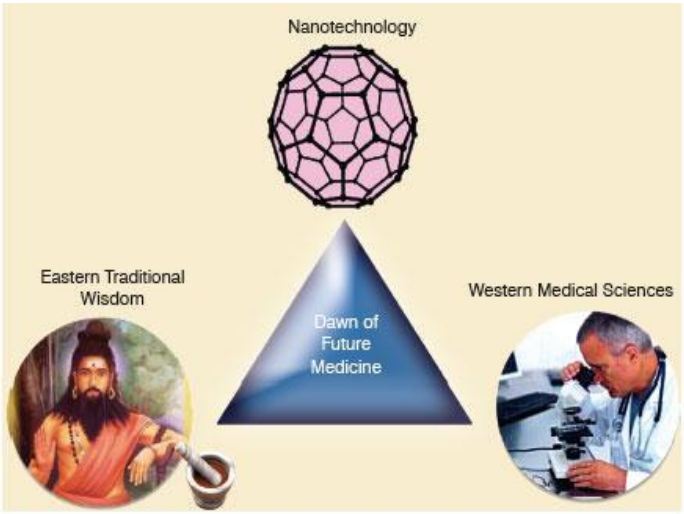

Figure 1: A fusion of Eastern and Western medicinal systems integrated with nanotechnology

STANDARDISATION OF HERBAL DRUGS [7,8]

Standardization of herbal drugs is essential in order to assess the quality of drugs, based on the concentration of their active principles. Therapeutic activity of an herbal formulation depends on its phytochemical constituents. The development of authentic analytical methods which can reliably profile the phytochemical composition, including quantitative analyses of marker/ bioactive compounds and other major constituents, is a major challenge to scientists. Standardization minimizes batch to batch variation; assure safety, efficacy, quality and acceptability of the polyherbal formulations. TLC and HPTLC fingerprint profiles were used for deciding the identity, purity and strength of the polyherbal formulation and also for fixing standards for this Ayurvedic formulation**.**

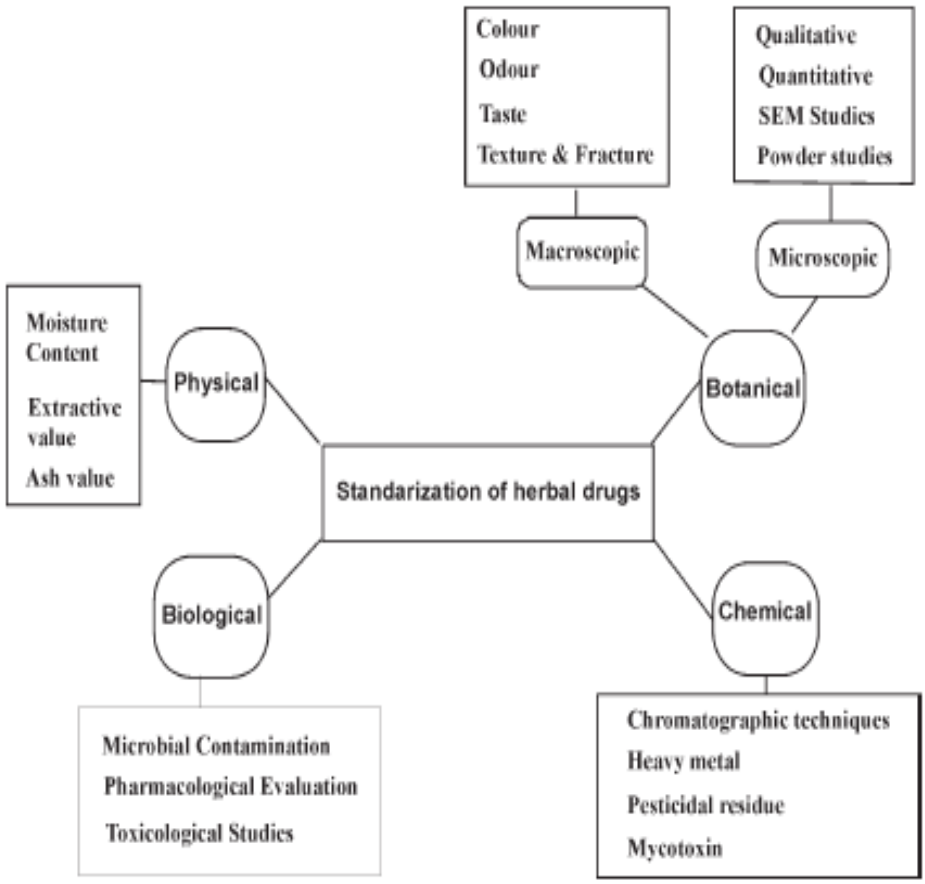

Figure 2: A schematic representation of herbal drug standardization

PREPARATION OF NANOPARTICLES [9,10]

Preparation of nanoparticles were reported to be a more cost effective and technically more simple alternative, particularly for poorly soluble drugs and yield a physically more stable product than liposomes; conventional colloidal drug carriers. There are two converse methods:

- **Bottom-Up technology**

The bottom-up technology is an assembling method from molecules to nanosized particles, including micro precipitation, micro emulsion, melt emulsification method and so on. The conventional methods of precipitation (Hydrosols) are called 'Bottom up technology'. In this technology the drug is dissolved in a solvent, which is then added to non-solvent to precipitate the crystals. The basic advantage of precipitation technique is the use of simple and low cost equipments. The basic challenge of this technique is that during the precipitation procedure the growing of the drug crystals needs to be controlled by addition of surfactant to avoid formation of micro particles. The limitation of this precipitation technique is that the drug needs to be

soluble in at least one solvent and this solvent needs to be miscible with non-solvent.

- **Top- Down technology**

The 'Top Down Technologies' are the disintegration approach from large particles, micro particles to nanoparticles and are preferred over the precipitation methods. It includes Media Milling (Nanocrystals), High Pressure Homogenization in water (Dissocubes), High Pressure Homogenization in nonaqueous media (Nanopure) and Combination of Precipitation and High-Pressure Homogenization (Nanoedege).

1. Media milling (Nanocrystal or Nanosystems).
2. Emulsification-solvent evaporation technique.
3. Hydrosol method
4. Supercritical fluid method
5. Homogenization in water (Dissocubes).
6. Homogenization in non-aqueous media (Nanopure).
7. Combined precipitation and homogenization (Nanoedege).
8. Nanojet technology

1. Media milling (Nanocrystal or Nanosystems) [11,12]

The nanosuspensions are prepared by using high-shear media mills. The milling chamber charged with milling media, water, drug and stabilizer is rotated at a very high shear rate under controlled temperatures for several days (at least 2-7 days). The milling medium is composed of glass, Zirconium oxide or highly cross-linked polystyrene resin. The high energy shear forces are generated as a result of the impaction of the milling media with the drug resulting into breaking of microparticulate drug to nanosized particles.

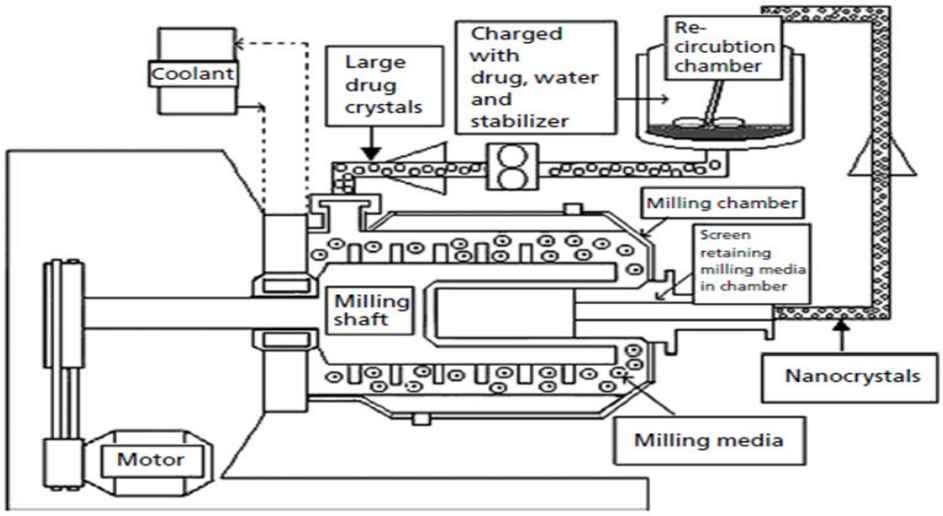

Figure 3: Schematic representation of the media milling process [9]

2. Emulsification-solvent evaporation technique [12,13]

This technique involves preparing a solution of drug followed by its emulsification in another liquid that is a non-solvent for the drug. Evaporation of the solvent leads to precipitation of the drug. Crystal growth and particle aggregation can be controlled by creating high shear forces using a high-speed stirrer.

3. Hydrosol method

This is similar to the emulsification- solvent evaporation method. The only difference between the two methods is that the drug solvent is miscible with the drug anti-solvent. Higher shear force prevents crystal growth and Ostwald ripening and ensures that the precipitates remain smaller in size.

4. **Supercritical fluid method**

Supercritical fluid technology can be used to produce nanoparticles from drug solutions.

- ❖ Rapid expansion of supercritical solution process (RESS)
- ❖ Supercritical anti-solvent process (SAS)
- ❖ Precipitation with compressed anti-solvent process (PCA).

The RESS involves expansion of the drug solution in supercritical fluid through a nozzle, which leads to loss of solvent power of the supercritical fluid

resulting in precipitation of the drug as fine particles.

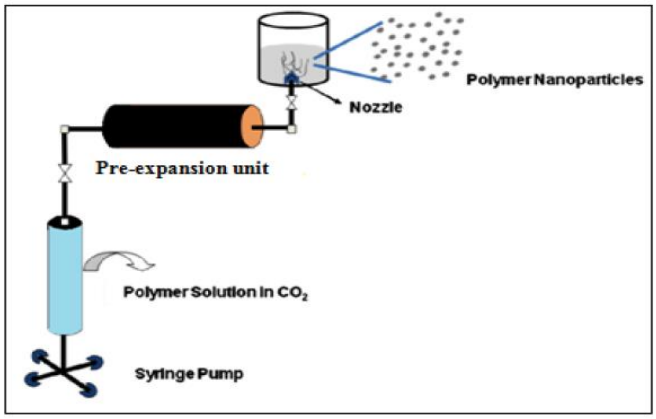

Figure 4: Representation of preparation of nanosuspension by RESS

In the PCA method, the drug solution is atomized into a chamber containing compressed CO_2. As the solvent is removed, the solution gets supersaturated and thus precipitates as fine crystals. The supercritical anti- solvent process uses a supercritical fluid in which a drug is poorly soluble and a solvent for the drug that is also miscible with the supercritical fluid. The drug solution is injected into the supercritical fluid and the solvent gets extracted by the supercritical fluid and the drug solution gets supersaturated. The drug is then precipitated as fine crystals.

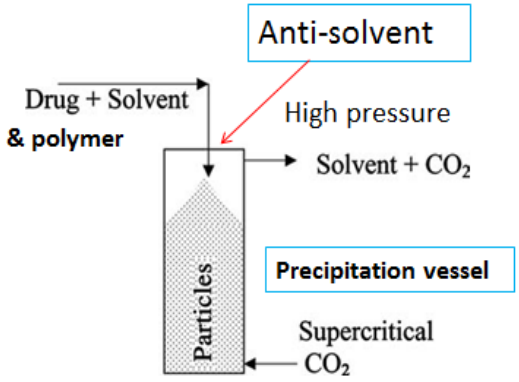

Figure 5: Schematic representation of SAS process

The disadvantages of the above methods are use of hazardous solvents and use of high proportions of surfactants and stabilizers as compared with other techniques, particle nucleation overgrowth due to transient high super saturation, which may also result in the development of an amorphous form or another undesired polymorph.

5. Homogenization in water (Dissocubes) [14]

The instrument can be operated at pressure varying from 100 – 1500 bars (2800 –21300psi) and up to 2000 bars with volume capacity of 40ml.In piston gap homogenizer particle size reduction is based on the cavitation principle. The dispersion contained in 3cm diameter cylinder; suddenly passes through a very narrow gap of 25µm. The reduction in diameter from 3cm to 25µm leads to increase in dynamic pressure and decrease of static pressure below the boiling point of water at room temperature. Due to this water starts boiling at room temperature and forms gas bubbles, which implode when the suspension leaves the gap (called cavitation) and normal air pressure, are reached.

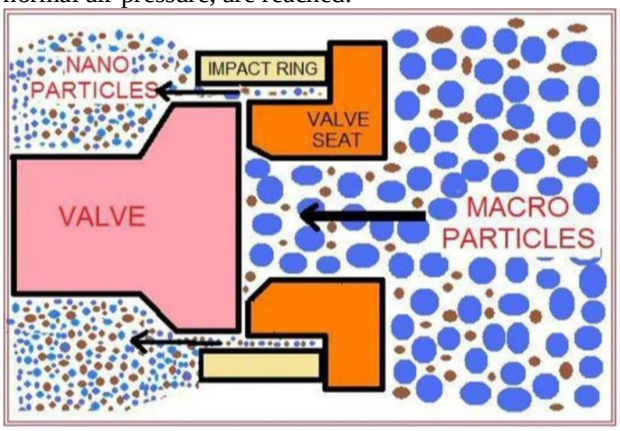

Figure 6: Schematic representation of high pressure homogenization[13]

6. Homogenization in nonaqueous media (Nanopure)

Nanopure is suspensions homogenized in water free media or water mixtures. In nanopure technology, the drug suspensions in the non- aqueous media were homogenized at 0^{o} C or even below the freezing point and hence are called "deep-freeze" homogenization. The results obtained were comparable to Dissocubes and hence can be used effectively for thermolabile

substances at milder conditions.

7. Combined precipitation and homogenization (Nanoedege) [15,16]

The basic principles of nanoedge are the same as that of precipitation and homogenization. A combination of these techniques results in smaller particle size and better stability in a shorter time. The major drawback of the precipitation technique, such as crystal growth and long-term stability, can be resolved using the nanoedge technology. In this technique, the precipitated suspension is further homogenized, leading to reduction in particle size and avoiding crystal growth.

8. Nanojet technology

This technique, called opposite stream or nanojet technology, uses a chamber where a stream of suspension is divided into two or more parts, which colloid with each other at high pressure.

The high shear force produced during the process results in particle size reduction. Equipment using this principle includes the M110L and M110S microfluidizers (Microfluidics). The major disadvantage of this technique is the high number of passes through the microfluidizer and that the product obtained contains a relatively larger fraction of microparticles.

CHARACTERIZATION OF NANOPARTICLES [17]

A. *In-Vitro* Evaluation

- **Mean particle size and particle size distribution**

It is the most important parameter, as it is having the direct effect on the solubility and dissolution rate and the physical stability of the formulation. The mean particle size and the width of particle size can be determined by Photon Correlation Spectroscopy (PCS), laser diffraction and coulter current multisizer. Particle size and polydispersity index (PI) governs the saturation solubility, dissolution velocity and biological performance. PCS (also known as dynamic light scattering) measures the fluctuation of the intensity of the scattered light, which is caused by particle movement. The particle size determination by photon correlation spectroscopy (PCS) detects size range of 3nm to 3µm and by laser diffraction in size range of 100 nm to 180 µm. Dynamic light scattering (DLS) also known as PCS or quasi-elastic light scattering (QELS) records the variation in the intensity of scattered light on the microsecond time scale.

- **Particle charge (Zeta Potential) [18,19]**

Zeta potential measurement can be carried out using zeta potential analyzer or zetameter.The determination of the zeta potential of a nanosuspension is essential as it gives an idea about the physical stability of the nanosuspension. The zeta potential of a nanosuspension is governed by both the stabilizer and the drug itself. Higher value of zeta potential may lead to deaggregation of particles. Suspension with zeta potential above 30 mv (absolute value) is physical stable. Suspension with a potential above 60 mv shows excellent stability. Suspension below 20 mv are of limited stability, below 5 mv they undergo pronounced aggregation. Positively charged electrostatic stabilizer and is of interest to increase the adhesion of positively nanocrystals to the negatively charged GIT wall thus further enhancing the oral bioavaialabity. Chitosan is a compound which combines the electrostatic stabilization due its positive charge and steric stabilization because of its polymeric nature. That means theoretically it should be the ideal stabilizer because it combines electro static and steric stabilization, together with bioavailability enhancement due to mucoadhesion.

- **Crystalline state and particle morphology [20]**

DSC and powder X-ray diffractometry (PXRD) is performed for the determination of the degree of crystallinity of the particle dispersion. The rate of crystallinity using DSC is estimated by comparison of the melting enthalpy/g of the bulk material with the melting enthalpy/g of the dispersion. Differential Scanning Calorimetry (DSC) is most commonly used for such studies. The X-Ray Diffraction (XRD) is commonly used for determining change in crystallinity and the extent of the amorphous form of drug. The assessment of the crystalline state and particle morphology together helps in the polymorphic or morphological changes that a drug might undergo when subjected to nanosizing.

- **Saturation solubility and dissolution velocity**

The determination of the saturation solubility and dissolution velocity is very important as these two parameters together help to anticipate any change in the in-vivo performance (blood profiles, plasma peaks and bioavailability) of the drug. The investigation of the saturation solubility and dissolution velocity of nanosuspensions reflects the advantages that can be achieved over conventional formulations, especially when designing the sustained-release dosage forms based on nanoparticulate drugs. These are studied in different physiological solutions at different pH. Kelvin equation and the Ostwald-Freundlich equations can explain increase in saturation solubility.

➢ **Stability study**

Stability is dependent on the particle size. As the particle size reduces to the nanosize, the surface energy of the particles will be increased and they tend to agglomerate. The main function of the stabilizer is to wet the drug particles thoroughly to prevent Ostwald ripening and agglomeration of the nanosuspension and form a physically stable formulation by providing a steric or an ionic barrier. Typical examples of stabilizers used in nanosuspensions are cellulosics, poloxamer, polysorbates, lecithin, polyoleate and povidones. Lecithin may be preferred in developing parenteral nanosuspensions.

B. *In Vivo* Evaluation [21]

The *in vivo* evaluation is specific to drug and route of administration. Most common parameters which are generally evaluated *in vivo* are:

- Plasma drug levels were estimated using HPLC-UV Visible Spectrophotometry
- Surface hydrophilicity/hydrophobicity (determines interaction with cells prior to phagocytosis)
- Adhesion properties
- Interaction with body proteins

PHARMACEUTICAL APPLICATIONS OF NANOPARTICLES [22]

Target drug delivery

Nanoparticles can also be used for targeted delivery as their surface properties and *in vivo* behavior can easily be altered by changing either the stabilizer. The engineering of stealth nanosuspensions by using various surface coatings for active or passive targeting of the desired site is the future of targeted drug delivery systems. Targeting of *Cryptosporidium parvum*, the organism responsible for cryptosporidiosis, was achieved by using surface modified mucoadhesive nanosuspensions of bupravaquone. Similarly, conditions such as pulmonary aspergillosis can easily be targeted by using suitable drug candidates, such as amphotericin B, in the form of pulmonary nanosuspensions instead of using stealth liposomes.

Oral drug delivery

The oral route is the preferred route for drug delivery. Oral administration of nanoparticles is a drug delivery strategy, not only to improve bioavailability, but also to target gastrointestinal bacterial and parasitic infections because of improved adhesion properties. Orally administered antibiotics such as atovaquone and bupravaquone are of low oral bioavailability, so it is administered in a larger dose than actually required. Nanosizing of such drugs can lead to a dramatic increase in their oral absorption and subsequently bioavailability.

Parenteral drug delivery

The parenteral route is an invasive route. Nanoparticles can be administered via different parenteral administration routes ranging from intra-articular via intraperitonal to intravenous injection. So the drug either has to be solubilized or globule size below 5 μm to avoid capillary blockage. The current approaches for parenteral delivery include salt formation, solubilization using co-solvents, micellar solutions, complexation with cyclodextrin and recently liposomes. However, there are limitations on the use of these approaches because of the limitations on their solubilization capacity and parenteral acceptability. Despite all these limitations, the parenteral route still retains its value because of its special advantages such as, quick onset of action in case of emergency, reduction in dose of the drug and the ability to target the drug quickly to the desired site of action, especially in the case of severe infections. The parenteral route is often employed as an alternative when the drug is either not absorbed through the gastrointestinal tract or undergoes extensive first-pass metabolism.

Occular drug delivery

Nanoparticles could prove to be vital for drugs that exhibit poor solubility in lachrymal fluids. Suspensions offer advantages such as prolonged residence time in a cul-de-sac, which is desirable for most ocular diseases for effective treatment and avoidance of high tonicity created by water soluble drugs. Their actual performance depends on the intrinsic solubility of the drug in lachrymal fluids. Thus the intrinsic dissolution rate of the drug in lachrymal fluids governs its release and ocular bioavailability. To achieve sustained release of the drug for a stipulated time period, nanosuspensions can be incorporated in a suitable hydrogel base or mucoadhesive base or even in ocular inserts.

Pulmonary drug delivery

Aqueous nanosuspensions can be nebulized using mechanical or ultrasonic nebulizers for lung delivery. Basically the nanosuspensions can be used in all nebulizers. The dispersions can be relatively high concentrated. Due to the presence of many small particles instead of a few large microparticles, all aerosol droplets are likely to contain drug nanoparticles. Budesonide, a poorly water-soluble corticosteroid, has been successfully prepared as a nanosuspension for pulmonary delivery.

Mucoadhesive nanoparticles

Nanoparticles orally administered in the form of a suspension diffuse into the liquid media and rapidly encounter the mucosal surface. The particles are immobilized at the intestinal surface by an adhesion mechanism referred to as "bioadhesion.". The direct contact of the particles with the intestinal cells through a bioadhesive phase is the first step before particle absorption. The adhesiveness of the nanosuspensions not only helps to improve bioavailability but also improves targeting of the parasites persisting in the GIT, e.g., Cryptosporidium parvum. Bupravaquone nanosuspensions have been reported to demonstrate an advantage in TRC- alpha-deficient mice infected with Cryptosporidium parvum oocytes. The bioadhesion can also be improved by including a mucoadhesive polymer in the formulation.

- **Topical delivery**

Drug nanoparticles can be incorporated into creams and water-free ointments. The nanocrystalline form leads to an increased saturation solubility of the drug in the topical dosage form, thus enhancing the diffusion of the drug into the skin.

MARKETED NANO HERBAL DRUG FORMULATIONS[23]

Nanoherbal medicines are prepared from plant extracts or their therapeutically active constituents. Some of the marketed nano herbal medicines are described as below.

- **Breast cream**

St. Herb nano breast cream claims it is a nanocream from Thai herb, *Pereira mirifica*, enriched with phytoestrogens, is used to release the cream in nanosomes. These nanoparticles penetrate straightly deep down to the inner breast skin layers causes development of the lobules and alveoli of the breast fatty tissues as well as maintain collagen in breast, thereby increased size from one to three cups.

Figure 7: Breast cream

- **Hair care shampoo [24]**

Argan oil shampoo is a perfect product made with Nano clusters to give hair a healthy shine. Argan oil is plant oil produced from kernels of Argan tree (*Argania spinosa*) that is endemic to Morocco, is used as the main ingredient. It helps to restore softness, strength and shine to hair and also used to combat dry and brittle damaged hair.

Figure 8: Hair care shampoo

- **Nano Sunscreen lotion [25]**

Natural substances extracted from plants have been recently considered as potential sunscreen resources owing to high UV ray absorption and antioxidant activity. The polymeric nanoparticles were incorporated to the sunscreen lotion. Nanoparticles in the sunscreen do not penetrate the skin.

Figure 9: Nano Sunscreen lotion

- **Berberine-loaded nanoparticles [26,27]**

Developed as fucose-conjugated or chitosan loaded nanoparticle. This was prepared by Ionic gelation method or ionic cross linking method. Used for Nasopharyngeal carcinoma, is a common epithelial malignancy on nasopharynx and also used for eradicating Helicobactor pylori.

Figure 10: Berberine-loaded nanoparticles

- **Nanoparticles of Cuscuta chinensis [28]**

Herb is known as Chinese Dodder, used in Chinese herbal medicine. It is mainly used to treat impotence, ejaculation, premature and frequent urination. It is also used for treating eye problems such as blurred vision and dry eyes. Seeds of Cucuta increase the testosterone level in blood and increases the weight of testicles and there by increases semen production, so used for male infertility. Due to the poor water solubility of major constituents like flavanoids and lignans, its oral absorption is limited. So for increasing solubility it is used as nanosuspension or nanoparticles. Such formulation is having hepatoprotective and antioxidant effects.

Figure 11: Nanoparticles of Cuscuta chinensis

- **Artemisinin nanocapsule [29,30]**

Artemisinin crystals were encapsulated with chitosan, gelatin, and alginate for the purpose of controlled release of the anticancer drug. Prolonged release of drug achieved through self-assembly of poly electrolytes on natural drug crystals.

Figure 12: Artemisinin nanocapsule

- **Paclitaxel loaded nanoparticles [31,32]**
- Paclitaxel is a major anticancer drug isolated from the bark of *Taxus brevifolia Nutt*. (Family-Taxaceae). Because of its very limited aqueous solubility and efficacy, incorporated paclitaxel into nanoparticles, enhanced its antitumoral activity. Paclitaxel loaded nanoparticles were prepared by nanoprecipitation method and by sequential simplex optimization method. Paclitaxel nanoparticles thus enhance stability, sustained drug release and improve bioavailability.

CONCLUSION:

The globalization of trade and market has brought about an integration of different kinds of herbal medicines worldwide. At present, herbal medications or related products in the global market are derived from Chinese herbs, Indian herbs, Arabic herbs, and Western herbs. Nanotechnology is rapidly expanding field with tremendous implication for medicine and cosmetics. The combination of nanotechnology with traditional herbal medicine may provide a very useful tool in designing future herbal medicine with improved bioavailability profile and less toxicity. There are many challenges to the safety and effective use of traditional medicine. But there is huge scope for nanotechnology based herbal medicines. Recent exploration of nanotechnology in biomedical and pharmaceutical science results in successful improvement of conventional means of drug delivery system.

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