Research & Reviews in Biotechnology & Biosciences
Website: www.biotechjournal.in
Volume-8, Issue No: 1, Year: 2021 (January-June)
DOI: http://doi.org/10.5281/zenodo.5118434

ISSN No: 2321-8681
Review Paper
PP: 148-156
Peer Reviewed Journal

Ayurveda and nanotechnology: an integrative approach

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Article History

Received: 15/04/2021
Accepted: 08/06/2021

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ABSTRACT

Ayurveda originated centuries ago taking roots from the Indian subcontinent. Since the Samhita period, metals and minerals are used as medicines in Ayurveda in a fine powder form called 'Ayaskriti' and around 7th century AD techniques were developed which resulted in even more fine particles called 'bhasma'.[1,2,3] On the other hand, nanotechnology is a newly found branch of science

which deals with the study and use of structures which are between 1 nanometre and 100 nanometre(nm) in size, where 1 nanometre is a billionth(10^-9) part of 1 metre. For a structure to be considered as a nanoparticle at least one of its dimensions should be in the range of 1 nm to 100 nm. However, integration of the discoveries in nanotechnology and various Ayurvedic medicines and formulations can help overcome the problems which caused the reduction in the use of Ayurvedic methods.

This review entails promising discoveries made in the field of nanotechnology inclining towards usage nanocarrier aids and how they will help develop Ayurvedic medicine. Various nanoparticle synthesis methods which take leads from Ayurveda and quality assessment of such products are also discussed. Furthermore, the development of plant derived medicine using nanotechnological aids (nanophytomedicines) are mentioned as a success in integration of the aforementioned 'historical' and 'new' knowledge. And lastly, safety concerns raised due to the unique properties of the engineered nanomaterials (ENM) are discussed briefly.

Keywords: Ayurveda, bhasma, nanotechnology, nanoparticles, nanophytomedicines, nanocarriers

INTRODUCTION

To make sure a system holds true for several hundreds of years and even after, it should be easily adaptable and should have not only areas of modifications but also improvement. If such an "open to changes" system exists, only then it would be able to make a strong appeal to the entire world otherwise it would be shunned off and/or only be recognised as an ancient knowledge which cannot be adapted by the modern world.

Even though Ayurvedic formulations are unique in many ways and differ in dosages from today's medicine, certain processes and products do resemble techniques and sciences that were lately discovered, like nanotechnology. With the new discoveries in the field of nanotechnology and drug delivery systems, Ayurvedic products can

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be modified such that they can be adapted by the modern world.

Bhasma- nanomedicine of Ayurveda

The Metals and Minerals are heavy, nonabsorbable and toxic substances. But in Ayurveda, 'Ayaskriti' is used as Medicine which is fine powdered form of metals [1,2]
With the development 'Marana' technique the metals and minerals are converted into an even more fine form called 'Bhasma' Bhasma is defined as powdered form of a substance obtained by calcination [1,6] Being converted into such fine powder, makes bhasma more absorbable, therapeutically most effective and least or nontoxic form of medicine[1,3]
Ayurvedic concept explains this change in qualities as a result of the procedures(Samskara) that reduce the size of the metals and minerals into the very fine bhasma. The procedures include 'Shodhana', 'Bhavana' and 'Putapaka'.[1] A three step procedure is shown in Figure 1.[16]

The quality of Bhasma is based on the marana drugs that are added and are categorised as 'Shresta Bhasma'(best quality), 'Madhyama Bhasma', 'Kanishta Bhasma' and 'Durguna Bhasma'.[1,4] Tests like Varitara, Rekhapurnatwa, Lochanaanjana Sannibhaand Apunarbhava are given in the Rasashastra for the assessment of good quality Bhasma.[1,5]

After microscopically analysing the bhasma particles, it was found out that that they fall under the range of nanoparticles[Figure 2] [1] When any dimension of a substance is below 100 nm it can be considered as a nanoparticles. Hence confirming that bhasma is indeed a nanomedicine [1]

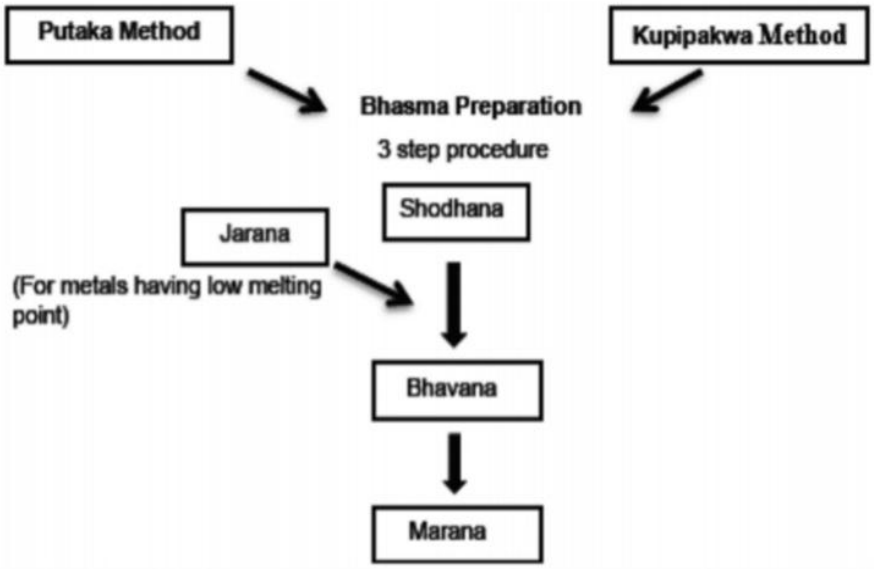

Figure 1: Bhasma preparation [16]

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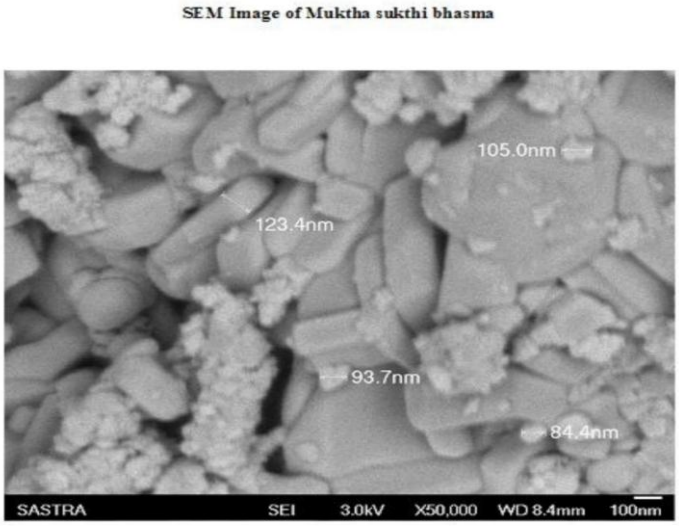

Figure 2: SEM image of Muktha sukhti bhasma[1]

NANO CARRIERS

It is evident that Ayurvedic medicines are often plant based. Many such herbs which are used as medicines are on the verge of extinction and hence there administration in high doses is not advisable as it would lead to their extinction. Rauwolfia serpentina, Gloriosa superba, and Strychnos nux vomica are included in the Red List by IUCN.But if the drugs are incorporated into nanocarriers, thus reducing their dose without compromising the desired effect it is possible to not endanger them at large.[7] High dose, Poor bioavailability, Repetitive administration and Stability issues are deemed to limit the usage of Ayurvedic drugs and formulations.[7,8]

Incorporation of drugs in nanocarriers will ensure targeted drug delivery if for example they are conjugated with specific antibodies against the characteristic component of the target area.[7,11] To ensure that the dose is slowly administered or to control its release, the nanocarriers can be made such that they slowly degrade and there time of release can be controlled by making them stimuli reaction such as pH sensitive or temperature sensitive.[7,11] **Advantages of using nanocarrier aid:[7,12]**

Targeted drug delivery

Convey most extreme measure of medication to the site of activity by passing all barriers. Reduce repeated dose administration

Solubility enhancement.

Increased bioavailability.

Protection from toxicity.

Enhancement of pharmacological activity.

Some commonly used nanocarriers are:[7,9,10]

Liposomes.[Figure 3]

Solid lipids nanoparticles.[Figure 4]

Dendrimers.[Figure 5]

Polymeric nanoparticles.

Silicon or Carbon materials.

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Magnetic nanoparticles.

Nano emulsions.

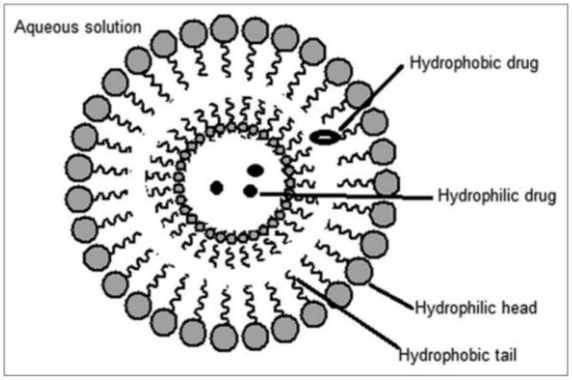

Figure 3: Liposome [21].

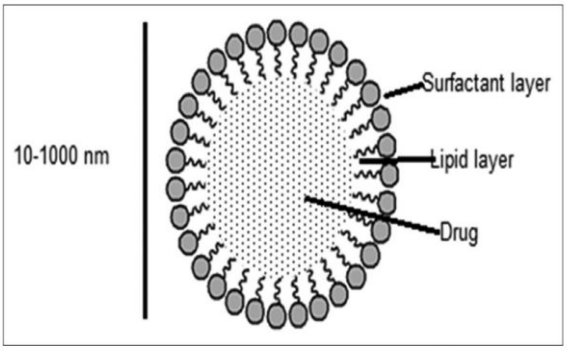

Figure 4: Solid lipid nanoparticles [22]

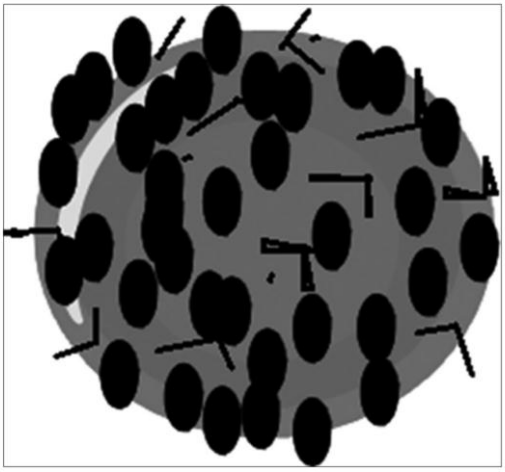

Figure 5: Dendrimers [23]

APPLICATION OF NANOTECHNOLOGY IN HERBAL MEDICINES

Nanophytomedicines Nanophytomedicines are prepared from active phytoconstituents or standardized extracts. Use of Nanophytomedicine improves efficacy and bioavailability While it also decreases the side effects and toxicity of administered drugs.[13] An example for improved bioavailability can be nanocurcumin. Curcumin, is a hydrophobic polyphenol which is derived from the rhizome (turmeric) of the herb Curcuma longa and nanocurcumin is a polymer-based nanoparticle of curcumin. Curcumin may have anti-inflammatory, antioxidant, antiarthritic and anticarcinogenic activity as suggested by in vitro and animal study. Curcumin being poorly soluble in water and its intense staining colour stand as major problems. One more disadvantage is that it has low bioavailability as it is metabolised quickly. This problem is overcame by encapsulating the tiny particle of curcumin in oil cavity surrounded by membrane. This

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encapsulation aids in better absorption and slows down the release in blood streams, resulting improved and enhanced bioavailability.[13,14]

Using aloe vera extract with aid of nanotechnology-Use of aloe vera is aloe vera extract for skin care is widely known. But the application is limited as, according to Japanese scientists, the aloe Vera extract is unable to cross stratum cornium. Penetration of such hydrophilic compound into skin is highly suppressed by a barrier of stratum cornium which is water impermeable which is composed of protein rich nonviable cells and intercellular lipid domain. Increasing dose is not an appropriate solution as it could lead to inflammation. For enhanced penetration they have investigated liposome containing Aloe vera from soybean lecithin. After preparing Aloe vera containing liposome, which had diameter less than 200 nm, in vitro test has been performed using human skin fibroblast and epidermal keratinocytes. Study reveals that cell proliferation rate has been significantly higher with the liposomal Aloe vera than non-encapsulated.[13,15]

Safety concerns

The properties of nanoparticles which at the same time making them unique, important in industrial and medical applications also raises safety concerns. The nano forms have unique properties in terms of magnetic, catalytic, optical, electrical, and mechanical attributes when compared to their non-nanobulk forms[17], indicating that a compound in nano form should be considered as a new compound.[16]

Even though Bhasma is considered to be reduced or non-toxic form form of the metals and minerals, incidences of adverse effects are have occurred. These are assumed to be due to noncompliance to the traditional methods and guidelines of 'Ayurveda Rasayana Shastra'.[16,18,19,20]

Following are the details of Ayurveda Rasa Shastra prescribed tests of a Bhasma Sanskrit equivalent, Physical characteristic Description

Visishta Varnotpatti, Specific colour

There is a specific colour for each Bhasma. If there is an alteration in the colour it is suggested that the Bhasma is not made properly, since a particular metallic compound is formed during Bhasma preparation and every chemical compound possesses a specific colour

Rekhapurantva, Fineness to enter finger ridges

Bhasma particles should be of minimum size so that it can be easily absorbed and assimilated in the body. It should be so fine that it should be able to fill the furrows of finger tips. A little amount of Bhasma is rubbed in between index finger and thumb to observe whether the particles can fill furrow of finger tips

Varitaratva, Lightness to float in water

The test is based on the law of surface tension. Little amount of Bhasma is taken in between index finger and thumb, after which it is sprinkled slowly on stagnant water surface from a short distance. If its properly incinerated, the Bhasma shall float on the water surface

Gatarastva, Tastelessness

Properly incinerated Bhasma of a metal should be of particular taste. It indicates transformation of particular metallic taste to compounds of specific taste

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Nischandratva, Lustrelessness

The Bhasma must not be shiny before therapeutic application. Luster or shine is a character of a metal. After proper incineration the luster of the metal should not remain. Therefore, Bhasma is observed under bright sunlight, for assessing whether luster is present or not. If luster is present, it still needs further incineration

Anjanabhatva, Smoothness

Anjana (collyrium) is smooth in character and it doesn't create any irritation when applied. Properly incinerated Bhasma should be smooth and should not create any irritation to the mucous membrane of the gastrointestinal tract

Apunarbhavtva, Permanence

Apunarbhavtva means incapability to regain original metallic form. For this test Bhasma is mixed with equal quantity of Mitra Panchaka (seeds of Abrus precatorius, honey, ghee, borax and jiggery) and it is sealed in Sarava Samputa (earthen pots), thereafter similar grade of heat used for preparation of particular Bhasma is applied and on self-cooling product is observed

Niruthatva, Irreversibility

It is to test the inability to regain metallic form of metallic Bhasma. In this test Bhasma is mixed with a fixed weight of silver leaf, kept in earthen pots and similar grade of heat is applied and after self-cooling, weight of silver is taken. Increase in weight of silver indicates improperly prepared Bhasma. Following Figure 6 shows different methods of preparation of conventional nanoparticle (as opposed to bhasma preparation methods mentioned earlier).

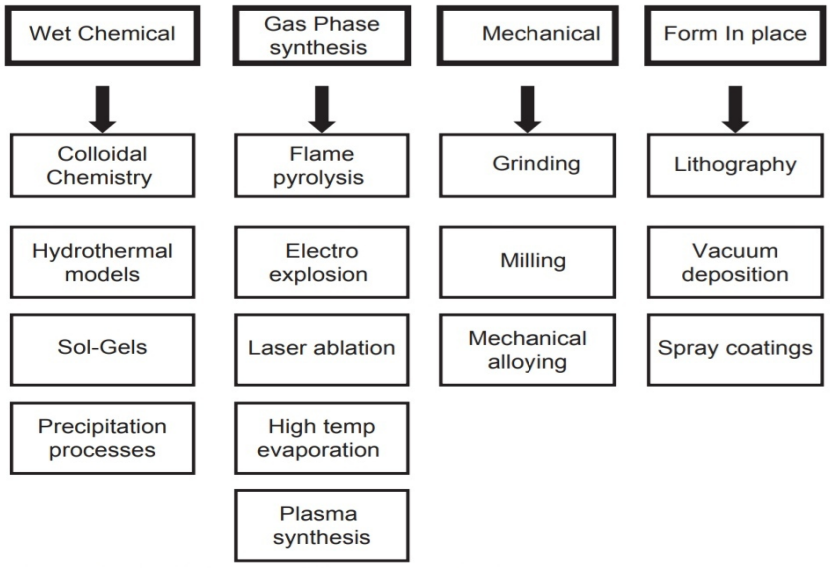

Figure 6: Methods of making nanoparticles[16]

DISCUSSION

Ayurvedic formulations mainly have metals, minerals and plant extracts (or derivatives) as starting materials. As spoken of earlier, there are a lot of endangered plant species which are on the red list but have great medicinal applications.[13] If the Ayurvedic standards are accepted and practiced all

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over the globe, due to the high dosage requirements, these resources (endangered plants) would be depleted within the blink of an eye. According to studies, using these herbs with the aid of nano carriers will greatly reduce the dose size while having the same therapeutic effect and potency.[13] This in fact is a great application of nanocarriers and will immensely help develop the drug delivery systems for Ayurvedic formulations. We hereby insist that research should be carried out in this particular direction and nano forms of more already existing medicinal herbs in Ayurveda should be discovered, even those which are not endangered right now as they might be in the future.

Adaptation of Ayurveda in European food[24]

According to Professor Ian Norton, Chemical Engineer at the University of Birmingham, there are certain reasons due to which Ayurvedic ingredients have not been integrated into European food, the reasons are as follows:

• Lack of sufficient scientific research and safety studies-Even though there is lack of scientific research and proof, it is evident that Ayurvedic formulations are indeed effective as no such system would last for several decades without being effective.[24]But there is a need for safety studies as mentioned earlier, so as to obtain approval from the concerned authorities.

• Second problem is that addition of Ayurvedic compounds will change the "tatse" of the food-Ayurvedic compounds are known to taste unpleasant. In addition to that, inclusion of these products directly might make the food more spicy and sour this most European consumers won't be able to handle it. But this problem can be easily overcome as we saw earlier that the Nano forms of the herbs can become tasteless and even other methods like nanoparticle entrapment can mask the unwarranted change in the taste hence their inclusion won't affect the original taste of the food.[24]

• Extended storage time -this problem concerns the fact that Europe and other developed countries consume industrially processed food products (like canned food) having longer shelf life on the other hand Ayurvedic compounds are known to be unstable thus there is an increased chance of losing the properties over long storage periods. According to Professor Norton and his team, Nanoparticles can be used to encapsulate sensitive bioactive compounds within Nano-compartments to protect them from degradation due to exposure to heat, light, oxygen, pH and other factors.

CONCLUSION

Ayurveda was practiced hundreds of years ago in India when the term "nanotechnology" didn't even exist. But, medicines like bhasma show resemblance to nanoparticles(size of bhasma particles fall under the range of nanoparticles).

Ancient knowledge can be revived by the aids of new technology. Thus with the aid of nanotechnological discoveries, Ayurvedic formulations can be modified such that they appeal to a much broader spectrum and be accepted worldwide.

Nanocarriers and Drug delivery systems will revolutionise the applications of Ayurvedic medicine as it would help increase the bioavailability, enable targeted delivery and the reduce the dosage administration.

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lack of scientific proof can be overcome by carrying out research on the Ayurvedic formulations (and subsequently modifying if possible). As the integrated/aided products would be considered novel, safety tests and compatibility research should be focused.

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