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Original Article

A Review on Herbal Drug Nanotechnology

Suraj Kedar*, Divya Palande, Aradhya Sase, Bhavesh Mohape, Pravin Gaykar, Pratiksha Sonawane

Siddhis Institute of Pharmacy, Nandgaon Murbad Thane 421401

ABSTRACT

The purpose of the review is to discuss nanotechnology in herbal medicine as well as nanomedicine. Herbal treatments have been used extensively since ancient times and are recognized by both patients and medical experts for their strong beneficial effects and lower risk of adverse effects when compared to conventional treatment. An introduction to nanomedicine, the application of nanoparticles in herbal medicine, the challenges facing nanotechnology, and various herbal nanomedicine formulations are covered here. To address the shortcomings of the traditional drug delivery method, the evaluation focused on a new approach that can increase patient compliance and decrease the need for repeated dosages. Additionally, it showcases recent developments in nanomedicine that have been influenced by nanotechnology, including nanoparticulate systems. The drug's improved bioavailability and efficacy are also noted in this assessment. It will be possible by using natural elements to create innovative pharmaceutical compositions. NDDS is a useful drug that reduces dosage frequency, enhances bioavailability, and minimizes adverse effects. One innovative method of delivering medication is nanotechnology. The study also shows that nano-sized ingredients for herbal medicines might be employed in the future to increase pharmacological activity while reducing side effects and dose needs. During the course of treatment, nanosystems can administer the active component at a high enough concentration to guide it to the targeted location of action. These conditions are not met by conventional therapy. The article discusses the many nano herbal medications and cosmetics that are currently on the market, as well as the traits, advantages, and disadvantages of nano drug delivery systems. Additionally, because of the complexity of manufacturing nanotechnology-based therapeutics, generic drug companies may find it difficult to quickly produce identical medications. In order to address these issues, drug delivery based on nanotechnology is gaining popularity as an alternate method of improving treatment outcomes by altering the chemical and physical properties of antiviral medications.

Keywords: Nanoparticles, Nanotechnology, Nanomedicine, Future Prospective, Toxicity, Nano Herbal Formulation, Nanosupension, Microemulsion, Liposomes, Liquid Crystalline System, New Approches And Challenges

INTRODUCTION

First of all, from ancient times, medicinal diseases have been treated using herbal products and therapies. Unlike the commonly utilized allopathic approach, herbal medicines include thousands of ingredients that work together to cure the current situation. Phytotherapeutics need a systematic technique to disperse the components throughout time in order to increase patient compliance and avoid repeated dosing. Throughout human evolution, many populations have known about and used plants as herbal remedies, starting when man first learned to choose plants for nourishment and to treat illnesses. Since the dawn of civilization, people have used natural products and herbal remedies to treat illnesses. Unlike common allopathic treatments, herbal medicines include thousands of distinct substances that work together to combat disease. Making lozenge and bias shapes as tiny as possible—between 1 and 100 nm—is the aim of the applied science and technology discipline known as nanotechnology. Recently, the monitoring, control, opinion, and treatment of natural systems using nanotechnology has been referred to as "nanomedicine."[1] The nanocarriers were made with safe ingredients including lipids, polysaccharides, and synthetic biodegradable polymers. A herbal medication's effectiveness depends on the coordinated action of several active ingredients, since each one enhances the therapeutic benefit through a synergistic effect. Each active component plays an important part and is

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related to the others. Nevertheless, most herbal treatments still have an uncontrollable characteristic that lowers bioavailability and raises systemic concurrence, requiring repeated administration or more sophisticated therapy, which makes them unsuitable for therapeutic usage. The development of nani lozenge shapes (polymeric nanoparticles), nanospheres and nanocapsules, liposomes, proliposomes, solid lipid nanoparticles, and nanoemulsions provides several advantages for herbal remedies in the field of phytoexpression study. These advantages include improved stability, defense against toxins, increased bioavailability, improved pharmacological exertion, optimal distribution of towel macrophages, extended delivery, and defense against physical and chemical deterioration. Therefore, there is a natural possibility that the nanoscale drug delivery systems included in herbal remedies would alleviate the weariness and prostrating problems associated with produced drugs. [15] Nowadays, a sizable portion of the populace in many nations still receives their medical treatment through complementary therapies, despite the pharmaceutical industry's promotion and encouragement of allopathic medicine growth. Medicinal herbs are the source of many of these practices. However, the therapeutic use of these natural resources—which are mostly utilized by those who cannot afford other treatments—has significantly decreased as a result of global economic, political, and social developments. [8]

NANOPARTICLES:

Nanoparticles produced by various physical or chemical processes and certain attributes. It is believed that nanoparticles are the main component of nanotechnology. Recent years have seen a significant focus on the synthesis of environmentally acceptable nanoparticles that don't produce hazardous waste. This is only possible through safe biological synthesis methods, which are an alternative to conventional physical and chemical methods. In contrast to the production of gold and silver nanoparticles, the bulk of the use of herbal and therapeutic plant extracts has been in the creation of stable nanoparticle dispersions. More specifically, the design and manufacturing of materials at the molecular and atomic level is known as nanotechnology. The creation of structures up to several hundred nanometers in size by both top-down and bottom-up engineering of individual components is referred to as nanotechnology. [15]

CHARACTERISTICS OF NANOPARTICLES:

1.The solvent-particle surface interaction is sufficiently strong to overcome density variations, making nanoparticle suspensions possible.

2. Janus particles are very helpful for stabilizing emulsions since they are half hydrophilic and half hydrophobic nanoparticles. [15]

Need of nanopaticals in herbal medicines:

1. Nanoparticles increase patient adherence by enhancing medication delivery, safety, effectiveness, and selectivity. reduces the negative impact. demonstrates passive targeting to the disease's site of action without the need of a particular ligand component. [14]
2. Nanoparticals can deliver a high concentration of the medication to the intended disease location because of their unique size.
3. Because of its compact size, exhibit greater penetration.
4. Nanoparticles can make herbal medications more soluble, which will improve their effectiveness.
5. The nanoparticles tiny size increases their surface area, which facilitates better blood solubility. [21]
6. It lessens the negative effects and toxicity. [1]

Need for novel drug delivery system:

Not enough of the herbal drugs will enter the circulation because of the stomach's very acidic pH, which will cause many of the substances to crumble and the liver to bio transform other chemicals. Should the drug not reach the afflicted location in the optimal amount and with the least amount of efficacy, there will be no therapeutic benefit. [18] Nanocarriers will transfer the optimal amount of medication to the site of action while avoiding all obstacles, such as the liver's metabolism and the stomach's acidic pH, when used in conjunction with herbal remedies. They will also extend the drug's circulation into the bloodstream due to their tiny size. [1]

Application of nanotechnology:

1. Drug delivery systems and drug development are advanced by nanotechnology.
2. Herbal medications that use nanotechnology may have lower dosage levels.
3. It gives the product more stability.
4. It demonstrates improved patient acceptance.
5. It will contribute to the repeatability of treatment efficacy.
6. It improves solubility and, thus, efficacy.
7. Nanotechnology helps increase the bioavailability of drugs. [1]

Nanomedicine:

The use of nanotechnology in medicine is known as "nanomedicine." It covers diagnosis, treatment, monitoring, control, and sickness prevention. The physicochemical properties of the Nano formulation change the pharmacokinetics (i.e., absorption, distribution, elimination, and metabolism), indicating that it would be able to cross biological barriers more easily.[23] Resolving toxic properties in the environment and human body is one area that nanomaterials can help with.[16]

ADVANTAGES:

1. Cutting-edge treatments with less invasiveness
2. Quicker, smaller, and more sensitive diagnostic tools
3.The total cost-effectiveness of illness management procedures and medical therapies
4.A nanomedical technique can help with unresolved medical difficulties like cancer.
5. longer lifespans accompanied by decreased incidence of illness and death. [1]

Impact of nanomedicine on health care:

Both improving results and repairing harm to organs and tissues are possible with the application of nanotechnology in medicine. It has the potential to revolutionize the human sector in the future. Nanotechnology will be used to improve drug delivery and heal damaged organs, two of today's most pressing medical issues. Nanotechnology may be used for both in vitro and in vivo research and applications.

Future prospective:

Worldwide, studies on natural products and herbal remedies have been carried out. Numerous institutions are developing herbal remedies for the drug delivery system, both in terms of introduction and clinical trial situations. The sole need is to improve the mechanisms that guarantee the same drugs are given to the body as boluses at the appropriate locations without interfering with therapy. A solution that would both relieve side effects like toxins and hypersensitivity responses and fortify the shell from the outside is unquestionably important and desirable. [17] The use of herbal nanoparticles to carry cancer drugs might eventually be intriguing to certain implicit exploratory groups, and the results would be visually arresting. [1]

Toxicity issues:

The safety of Nano pharmaceuticals should not be overlooked, despite the fact that they may provide countless opportunities for drug delivery to treat and diagnose a variety of diseases. Materials designed to be nanoscale may undergo changes in their physicochemical and structural properties, leading to a variety of material interactions that could ultimately have toxicological effects. [1]

Recent Development:

Nanoparticles in drug delivery systems can be utilized to efficiently distribute medications needed to treat a range of illnesses, including cancer. Among the various herbal nanomedicines that have lately evolved include carbon nanotubes, solid lipid nanoparticles, phytosomes, nanomicelles, self-nano emulsifying drug delivery systems, nanofibers, liposomes, dendrimers, ethosome nanoemulsions, and nanosuspensions. To a lesser degree, their estimating factors, difficulties, and possibilities are also discussed. [1]

Herbal Formulations: Need for Nano- Sized Delivery System:

A nanoscale delivery system is necessary for natural remedies because Nano-sized herbal delivery systems were selected to address the drawbacks of traditional herbal drug delivery systems for the following reasons:

They seem to be able to transport significant amounts of drugs to receptor sites because of their special size and loading capacity. The use of nano formulation can improve drug delivery, potency, and safety by delivering herbal medication straight to a particular organ. They enhance retentivity and penetration, which means that because of their small size, they may more easily cross the barrier and are more likely to stay because of insufficient lymphatic drainage, as in tumors. In addition to being used to assist tailor the drug, nanoparticles can be used to make herbal medications more soluble. [15]

Techniques of Nano Herbal Formulations:

The techniques commonly used for the Nano formulations are:

· High-pressure homogenization method
· Complex coacervation method
· Co-precipitation method
· Salting out method
· Nano precipitation method or solvent displacement method
· The solvent emulsification diffusion method
· Supercritical fluid method
· Self-assembly method. [15]

Nano Herbal Formulations:

Plant extracts or the active components of plants are used to make a variety of nano-phytomedicines. A nanomedication delivery system lowers toxicity and adverse effects while increasing bioavailability. Directions for some of the commercially available Nano natural medications are as follows:

1. Nano formulation of Curcuma gel [2]

· Formulation: Nanocapsules
· Active ingredients: Curcumin, turmeric.
· Applications: Better immunity, Better Brain health.
· Activity: Better Inflammatory response.
· Preparation process: Self-assembly procedure.
· Administration route: Oral.

2. BiotinSesbania Grandiflora [3]

· Formulation: Sesbania Grandiflora tablets
· Active ingredient: Sesbania Grandiflora powder.
· Application: Reduce hair fall, Damaged hair repair
· Biological activity: Dietary supplement vitamin B7
· Preparation process: Emulsion solvent evaporation method.
· Administration route: oral.

3. Quercetin Nano capsules [4]

· Formulation: Quercetin capsules.
· Active ingredient: Quercetin
· Application: Immune health, Dietary supplement.
· Biological activity: Anti-oxidant.
· Administration route: Oral.

Prospects of Nano Herbal Formulations:

Herbal treatments can address the issues with pure herbal medicines and boost pharmacological action. However, a number of challenges remain before clinically effective medications may be used in this field. Testing new methods to control how nanomaterials interact with biological systems and affect their activities is one of the major challenges to transforming these technology into therapeutics. Newer challenges in the development of medicine delivery systems based on nanotechnology include the ability to scale up procedures that quickly bring novel therapeutic techniques to market and the potential for creating a multifunctional system to meet various biological and therapeutic requirements. [5] New therapeutic opportunities and difficulties have arisen as a result of the development of engineered nanoparticles with important biomedical uses. The foundations of innovative nanomedical devices that will be used for drug delivery and discovery are probably going to be particle-free. Since nanoparticles may have toxicological consequences, study is being done on them. Since particulate matter nanoparticles have already harmed the biosphere, care should be taken to prevent intentionally created nanomaterials from creating any new environmental risks. The use of herbal remedies in nanotechnology will increase its potential for the treatment of several chronic diseases and health benefits, as it has rapidly produced attractive pharmaceutical medicines that will enhance people's health. The importance of the existing medication delivery system will grow as a result of nano carriers. The idea of creating externally controlled nanorobots and nanodevices for tissue diagnostics and healing has generated a lot of interest. Nevertheless, this field of study is still in the future

and has not yet materialized. It is crucial to take into account the possible hazards that nanomedicines might provide to both people and the environment in addition to their potential advantages. To evaluate the potential acute or long-term toxicity effects of novel nanomaterials on people and the environment, extensive and prolonged research is required. Furthermore, as nanomedicines gain popularity, more research is required to guarantee their affordability. Finally, as was previously mentioned, the regulation of nanomedicines will keep evolving in step with the development of nanomedicine applications. [15]

Nanotechnology-Based Drug Delivery System for Phytochemical Compounds:

According to the study, 70% of plant-based active compounds are hydrophobic. In order to prevent and treat diseases effectively, phytonutrients must be consumed. Lipid- and polymer-based delivery strategies are among the delivery methods that might boost the bioactivity of phytochemical compounds. Additionally, the use of nanotechnology provides a technological foundation for modernization as well as a solid roadmap for TCM development in the future.

Nanosuspension:

Pure drug crystal plus a polymer for consistency are the sole ingredients in nanosuspension (NS). The produced nanosuspensions showed good stability and enhanced absorption of flavonoids, and they dramatically reduced blood glucose levels. The nanosuspension consists only of submicron colloidal dispersions of medication nanocrystals [19]. Because stabilizers surround it, it is one of the most promising techniques for delivering active chemicals that are poorly soluble. [22]

Microemulsion:

Initially semi-transparent and titrated until clear, a microemulsion (ME) is a fluid system made by titrating a simple emulsion with a medium chain alcohol, like hexanol or pentanol [19]. In MEs, an oil is dissolved in an aqueous medium (or vice versa) that contains a surfactant, either with or without an appropriate cosurfactant. These emulsions are transparent. Under these circumstances, a thermodynamically stable system is produced, with internal phase droplets that have nanoscale (nm) dimensions. When active ingredients are dissolved in the oil or aqueous phases, they may be transported in the microemulsions. Following the drug's separation from the dissolving media via a membrane or interface, which has to be translated to regulate the release into the environment, MEs are reservoir systems. These systems can link or associate molecules of various pharmacological groups to enhance their solubility, modular stability, or bioavailability profile. They also offer a dimensionally constrained environment with proprietary features. In addition to offering prolonged action, microemulsified systems can also increase the solubility and stability of medications. This includes targeting specific body tissues or organs and delivering active ingredients with varying levels of hydrophilicity or lipophilicity within the same formulation. [22]

Liposomes:

A liposome is an area of aqueous solution that is encircled by a hydrophobic barrier that prevents the dissolution and accumulation of lipids by hydrophilic solutes. Both hydrophilic and hydrophobic molecules can enter liposomes because hydrophobic substances can dissolve into the membrane. Amphiphilic chemicals make up the majority of artificial membranes, also known as liposomes [20]. Liposomal lipid-like bilayers are advanced nano-carriers for drugs since they include drugs enclosed in a hollow section. [22]

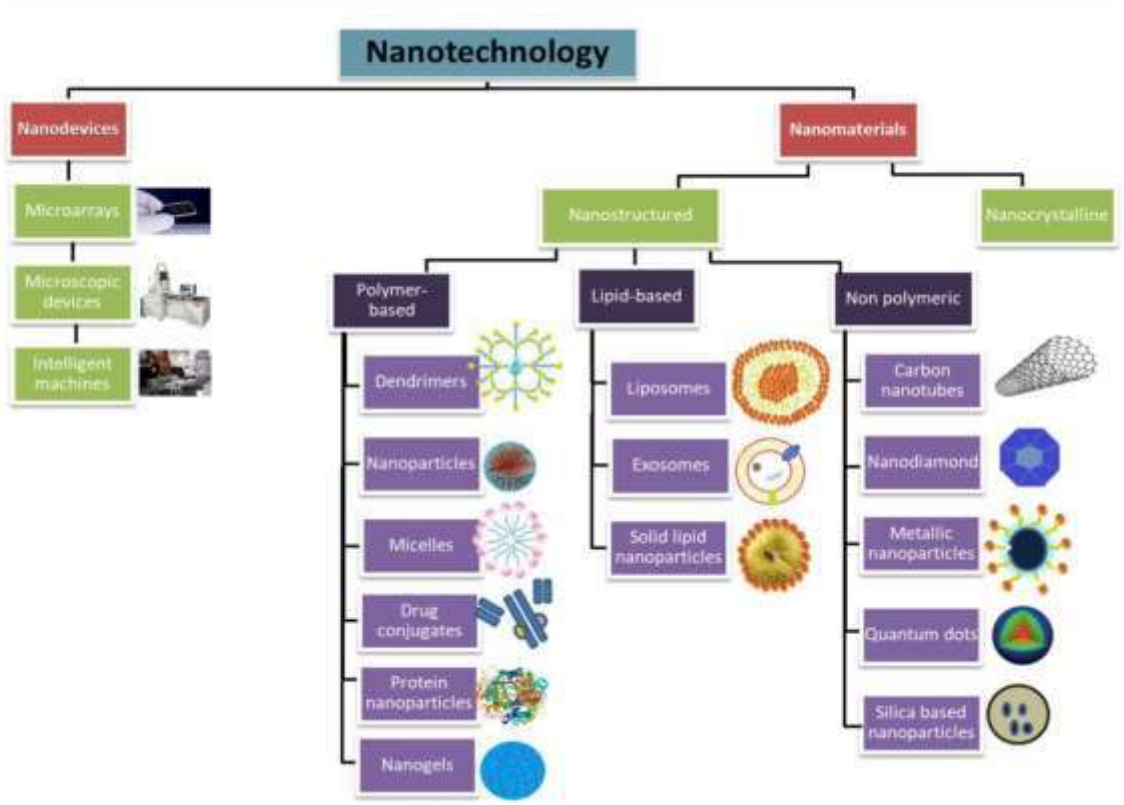

Figure 1: NPs based drug delivery systems [6]

Polymeric Nanoparticles:

Researchers are now more interested in the nanotechnological processes involving medicinal plants, and they have created a number of novel delivery systems, such as polymeric nanoparticles. These materials offer a regulated medication delivery alternative since they are composed of biodegradable and biocompatible polymers. Due to their ability to be targeted, polymeric nanoparticles are a viable formulation for drug delivery systems. [8] Colloidal systems called polymeric nanoparticles serve as vectors to regulate drug release by directing it to particular sites. Polymeric nanoparticles can enhance absorption of the active ingredients, lower the therapeutic dosage, and increase the solubility of constituents as compared to traditional formulations. Additionally, because nanoparticles are stable, non-toxic, nonthrombogenic, nonimmunogenic, noninflammatory, do not activate neutrophils, and do not interact with the reticuloendothelial system, they are beneficial when utilized in blood. Polymeric nanoparticles can occasionally be employed as cell surfaces or to access particular tissues. [11] Depending on their intended use and payload, polymeric nanoparticles can be created in a variety of ways. These particles are composed of biodegradable polymers, either synthetic or natural. Since natural materials often offer additional benefits, including the capacity to carry many active ingredients using the same carrier, extend residence duration in the body, offer a sustained release method, and lessen adverse effects, they are favored. Because particle diameters are less than 1 μm, nanoscale systems are also referred to as submicrometer. Researchers are drawn to them because they provide a number of therapeutic benefits in several domains, such as improved therapeutic impact, site specificity, and routes of administration. Certain standard formulations may have adverse effects when taken orally, and the stomach's acidic pH encourages the breakdown of active ingredients. Polymeric nanoparticles may lessen these issues. Nanoparticles regulate the release of active ingredients in ophthalmic delivery, improving ocular bioavailability and minimizing adverse effects. [12] Polymeric nanoparticles may effectively preserve medications with diameters ranging from 10 to 1,000 nm. They can manifest as nanospheres (NSs) or nanocapsules (NCs); the composition and structural arrangement of these structures vary. The active ingredient in nanocapsules can either dissolve in the oily core or be adsorbed to the polymeric membrane,

which encloses the oily core. The sole material used to create nanospheres is polymeric, which retains or adsorbed the active ingredient. Some polymers, such as poly-L-lactic acid (PLA) and copolymers with glycolic acid (PLGA), have previously been widely employed for polymeric nanoparticles, despite the growing quest for novel polymer types. [13]

Liquid Crystalline System:

As evidenced by their ease of efflux, liquid crystals are a unique phase of condensed structures that exist in a state halfway between that of an isotropic liquid and a crystalline solid. Mesophases, which can be cubic or hexagonal in LCs, are states of matter that lie between solids and liquids. The two major categories of LCs are lyotropic liquid crystals (LLCs) and thermotropic liquid crystals (TLCs). There is a temperature at which the liquid crystal transforms into an isotropic liquid, and TLCs have temperature-dependent liquid-crystalline phases. The chemical that creates the mesophase is their primary component. Functional unit micelles are aggregates made up of amphiphilic molecules that are present in LLCs. Temperature, solvent, and concentration all affect the formation of mesophases; in some cases, micelles can self-organize to form extremely complex structures. [8] Because of their persistent and advantageous characteristics, LCs can chaperon physiologically active principles that are often inactive due to degradation processes or unfavorable interactions with lipid membranes at the active site. LCs maximize contact time at the target site and successfully encourage an interaction between the drug and a particular target site that was previously inaccessible. By enabling entrance into the cell and fostering connections between the active molecules and cell membranes, LC components enhance pharmacological activity. [7] Many researchers are working to develop a safe, effective, and dependable medication delivery method for illness treatments. Additionally, given a chosen administration route, drug delivery systems should package medications to ensure equal distribution, giving priority to the optimal drug-receptor interaction and minimizing adverse effects. It would thus be very beneficial to find a system that satisfies each of these requirements. One possible option is a drug delivery system based on LC. [9] Vegetable oils are among the best plant components for creating LC systems due to their advantageous qualities, which include low molecular weight and low viscosity. Because vegetable oils have a lower occlusion than mineral oils, they can penetrate the skin more deeply and allow for a higher loading of therapeutic chemicals. [10] Products derived from natural sources have been utilized recently to create high-tech cosmetics and nanostructured medication delivery systems. Since there are no reports of using these compounds in LCs for therapeutic purposes, the scientific community is being encouraged to develop new LC systems as drug vehicles in order to support crucial, essential elements like the chemical/physical stability of herbal compounds and their bioavailability. [8]

New Approches And Challenges:

Herbal medication delivery systems using nanoscale particles have the potential to improve biological activity and solve issues related to plant medicines. However, there are still a lot of obstacles in the way of implementing clinically effective treatments in this area. One of the main obstacles to converting these technologies into treatments is the testing of new techniques to regulate how nanomaterials interact with biological systems. The viability of scale-up procedures that swiftly introduce novel therapeutic approaches to the market and the potential for multifunctional systems to satisfy a number of biological and therapeutic needs are two new challenges in the development of nanotechnology-based drug delivery systems. Probing the effectiveness of nanoparticle targeting and meeting international requirements for their toxicological and biocompatibility are a few more novel issues. [8]

CONCLUSION:

According to the present study, there are several exciting opportunities for using nanotechnology in herbal treatments. Nanotechnology has great potential since it can transform poorly soluble and poorly absorbed drugs. uses a novel medicine delivery technique to enhance patient compatibility and avoid repeated dosing of herbal substances. Drug delivery has undergone a revolution thanks to the combination of nanotechnology and herbal medicine, which has made it possible to create innovative formulations with enhanced bioavailability, targeted distribution, and decreased toxicity. Herbal extracts and bioactive

substances have been effectively delivered by nanocarriers like liposomes, nanoparticles, and dendrimers, increasing their therapeutic efficacy. Additionally, the use of nanotechnology has enhanced the stability and solubility of herbal compounds, making it easier to employ them for a variety of illnesses, such as diabetes, cardiovascular disease, and cancer. Additionally, the application of nanotechnology and natural products has created new opportunities for the creation of safe and efficient therapeutic agents. All things considered, the combination of nanotechnology and herbal medicine has enormous potential for creating novel cures for a range of illnesses.

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