Herbal Medicine and Nanotechnology: Formulation and Evaluation

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ABSTRACT

The utilization of herbal medicines has roots in human evolution, evolving alongside the selection of plants for food and therapeutic purposes. Despite the historical shift towards allopathic medicines in the Western world, herbal drugs persist in the pharmaceutical industry, boasting known effects and minimal side effects. Notably, traditional medicinal practices remain crucial for basic health needs in developing countries, as highlighted by the World Health Organization. Concurrently, nanotechnology has emerged as a revolutionary field, particularly in drug delivery systems. Nanoformulations offer enhanced properties such as improved permeability, solubility, bioavailability, and therapeutic action compared to conventional preparations. This abstract provides an overview of common nanoformulation systems, including polymeric nanoparticles, metallic nanoparticles, and magnetic nanoparticles, showcasing their diverse applications and benefits. Furthermore, it presents a comprehensive evaluation methodology for nanoparticle formulations, encompassing physicochemical properties, drug content determination, stability studies, and in vitro release assessments. By amalgamating herbal medicine with cutting-edge nanotechnology, this abstract underscores the potential for novel drug delivery systems to advance therapeutic efficacy and patient outcomes.

Keywords: Herbal medicine, Nanoparticle formulations, Characterization techniques, Evaluation methods.

1. INTRODUCTION

Herbal medicine, also known as botanical medicine or phytotherapy, is a holistic approach to healthcare that utilizes plants and plant extracts for healing and wellness. With roots tracing back thousands of years across diverse cultures worldwide, herbal medicine embodies a rich tapestry of traditional knowledge and modern scientific understanding. Throughout history, societies have relied on the therapeutic properties of herbs to address a wide array of health concerns, from alleviating symptoms of common ailments to supporting overall vitality and longevity. Ancient healing systems such as Traditional Chinese Medicine, Ayurveda, and Native American medicine have all incorporated herbal remedies into their practices, recognizing the profound impact of plants on human health [1].

In contemporary times, herbal medicine continues to thrive, fueled by a growing interest in natural and sustainable healthcare alternatives. Herbal preparations come in various forms, including teas, tinctures, capsules, salves, and essential oils, offering versatile options for addressing individual health needs and preferences. One of the key strengths of herbal medicine lies in the synergy of bioactive compounds found within plants, which can exert diverse therapeutic effects on the body. These compounds may include phytochemicals, antioxidants, vitamins, minerals, and other nutrients, working in concert to support optimal health and balance.

While herbal medicine holds great promise for promoting wellness and addressing health challenges, it's essential to approach its use with knowledge, caution, and respect. Each herb possesses unique properties and potential interactions, and individual responses can vary based on factors such as dosage, preparation method, and personal health history. Knowledge and use of plants as herbal medicines has occurred in various populations throughout human evolution, beginning when man was learning to select plants for food, and to relieve ailments and diseases. Herbal medicines were gradually replaced by allopathic medicines in the 2nd half of the western world. Nowadays, herbal drugs dwell in a leading position in the pharmaceutical industry as their effects are known and side effects are very negligible. According to the World Health Organization, 80% of people in developing countries depend on traditional medicinal practices for basic health needs [2].

Nano-size particle or nanoparticle is a spacious class of materials that enclose particulate substance which has not as much of 100 nm in size. It is a well-known field of research of this century and it has a wide range of revolutionary developments in the field of nanotechnology such as treatment, monitoring, diagnosis, and control of biological systems. The major drawbacks of conventional are nonspecific, lack of solubility, and inability to enter inside the cells which offer a great opportunity for nanoparticles to play significant roles. [3]

2. COMMON NANOFORMULATION SYSTEMS LOADED WITH HERBAL ACTIVE INGREDIENTS

Nanotechnology is one of the input novel drug delivery methods under examination, with nanoformulation attention to have a wide variety of benefits in contrast with conventional preparations of plant constituents, which include improved permeability, solubility, bioavailability, therapeutic action, stability [4].

3. POLYMERIC NANO PARTICLE

The polymeric nanoparticles (PNPs) are prepared from biocompatible and biodegradable polymers in size between 10-1000 nm where the drug is dissolved, entrapped, encapsulated or attached to a nanoparticle matrix. The field of polymer nanoparticles (PNPs) is quickly expanding and playing an important role in a wide spectrum of areas ranging from electronics, photonics, conducting materials, sensors, medicine, biotechnology, pollution control and environmental technology [5]. Nanocapsules are systems in which the drug is confined to a cavity surrounded by a unique polymer membrane, while nanospheres are matrix systems in which the drug is physically and uniformly dispersed. Some natural polymers includes: Chitosan Gelatin Sodium alginate Albumin. Synthetic polymers are Polylactides(PLA) Polyglycolides(PGA) Poly(lactide co-glycolides) (PLGA)Polyanhydrides [6].

4. METALLIC NANO PARTICLES

Metal nanoparticle is used to describe nanosized metals with dimension (length, width and thickness) range between 1-100 nm. Metal nanoparticles are widely used due to their characteristic features such as large surface enriches, provides specific electronic structure between molecular and metallic states and process a large number of low coordination sites [7].

5. MAGNETIC NANOPARTICLES

Magnetic Nanoparticles have been synthesized with number of different compositions and phases including pure metals like CO, Fe and Ni, metal alloys such as FePt, CoPt. Using magnetic nanoparticles particle size of approximately 3 nm can be obtained. The size of particles will be hundreds of atoms which enable us to make recording media of up to 1 Tb/in2 in recording density which can be achieved by correctly organizing the particles [8].

Nanoparticles formulations and their pharmacological actions

SL No	Herbal Drug	Nanoformulation	Uses	Method of synthesis
1	Curcumin	Anticancer	Potent Anticancer and Antitumor.	Wet-milling technique.
2	Paclitaxel	Antineoplastic	Acts against several tumours, Ovarian and breast cancers.	Nanoprecipitation.
3	Berberin	Anticancer	Inflammationand several cancers.	Emulsion, Ionicgelation.
4	Camptothecin	Anticancer	Potentanticancer	Encapsulated with Hydrophobically modifiedglycol.
5	Ginkgo biloba	Alzheimer'sdementia	Acts against loss of memory, thinking, language, behaviour.	Combination of Dryand wet process.(Gas-phaseand liquid- phase grinding)
6	Triptolide	Anti-arthritis	Inflammatory and autoimmune diseases, especiallyfor	Nanoencapsulation

			rheumatoid arthritis.	
7	Salvia miltiorrhiza	Anti-hyperlipidaemia	Cerebrovascular diseases, Improve bloodstas is.	Phospholipidcomplexloaded
8	Quercetin	Anti-oxidant	Potentanticancer	Gelatinandchitosanloaded.
9	Breviscapine	Anti-cardiovascular	Cerebrovascular and Cardiovascular diseases also against pulmonary fibrosis.	Lipidencapsulation.
10	Naringenin	Antioxidant,Anti-inflammatory.	Acts against several tum ours and hepatoprotective.	Nanoprecipitation.
11	Dodder	Antioxidant	Acts against carcinogenesis and ageing also used as hepatoprotective.	Nano precipitation.
12	Silymarins	Hepatoprotective	Severalliverdiseases, breast cancer.	Cold homogenization.
13	Genistein	Antioxidant	Usedincardiovascular diseases, breast and uterine cancer also in osteoporosis.	Nanoemulsion and chitosan micro sphere.
14	Centellaasiatica	Anxiolytic	Actsasanti-anxiety, alsousedin leprosy, cancer, syphilis and allergy.	Ionic gelation.
15	Annualmug wort	Antimalerial	Also used for Asthma	Hydrophilic encapsulation.

6. EVALUATION METHODS:

6.1. Physicochemical Properties

Nanoparticles are generally characterized by their size, morphology and surface charge, using advanced microscopic techniques such as scanning electron microscopy (SEM), transmission electron microscopy (TEM) and atomic force microscopy (AFM). Electron microscopy techniques are very useful in ascertaining the overall shape of polymeric nanoparticles, which may determine their toxicity [9].

Scanning electron microscope: SEM micrographs have a large profundity of field acquiescent; they can give a characteristic three-dimensional appearance, useful for understanding the surface structure of a sample. For SEM characterization, nanoparticles solution should be first converted into a dry powder, which is then mounted on a sample holder followed by coating with a conductive metal, such as gold, using a sputter coater. The sample is then scanned with a focused fine beam of electrons. Under vacuum, electrons generated by a source are accelerated in a field gradient [10].

Dynamic light scattering: Currently most popular method of determining particle size is photon-correlation spectroscopy (PCS) or dynamic light scattering (DLS). A shining monochromatic light (laser) onto a solution of spherical particles in Brownian motion causes a Doppler shift when the light hits the moving particle, changing the wavelength of the incoming light [11].

Transmission electron microscopy: The sample preparation for TEM is complex and time consuming because of its requirement that sample should be ultra-thin for the electron transmittance. The nanoparticles dispersion is deposited onto support grids or films. To make nanoparticles withstand the instrument vacuum and facilitate handling, they are fixed using either a negative staining material, such as phosphor tungstic acid or derivatives, uranyl acetate or by plastic embedding. TEM image provides the details about the size distribution and particle distribution of nanoparticles over the proposed shelf-life period [12].

6.2.Drug content Determination by UV-Visible Spectroscopy

A sample is placed between a light source and a photodetector . The intensity of a beam of UVvisible light is calculated before and after the transitory through the sample. These measurements are compared at every wavelength to specify the sample's wavelength-dependent spectrum. The data is classically plotted as absorbance as a function of wavelength [13].

6.3. Stability Studies

Zeta potential: The ZP, also termed as electrokinetic potential, is the potential at the slipping/shear plane of a colloid particle moving under electric field. Zeta potential is an assessment of the efficient electric charge on the nanoparticle's surface, quantifying the charges. When a nanoparticle has a web surface charge, the charge is a screen by the concentration of ions of contradictory charges close to the nanoparticle surface [14].

Encapsulation efficiency: The study aims to determine the encapsulation efficiency of the drug into the carrier. The sample was diluted with an organic solvent and sonicated in an ultrasonic bath for 30 min to extract drug. The resulted mixture was centrifuged for 10 min at suitable rpm and analyzed by HPLC or UV [15].

Surface plasmon resonance: Every nanoparticle has its unique resonance absorption wavelength. The resonance condition is established when the frequency of light photons matches the natural frequency of surface electrons, oscillating against the restoring force of positive nuclei [16].

Atomic force microscopy (AFM): By using this method can create a topological map of a sample and which is mainly based on the forces between the tip and the surface of the sample. AFM offers ultra-high resolution in particle size measurement and is based on a physical scanning of samples at sub-micron level using a probe tip of atomic scale [17].

In-vitro release: In-vitro release of herbal drug from the carrier was investigated using the dialysis bag method. Regenerate cellulose membranes were used to hold the carriers and permit the dispersal of the herbal drug into the discharge medium. The drug-loaded carrier was deposited into the dialysis membrane and placed in release medium under optimized temperature and rpm. A definite period interval samples were withdrawn and replaced with the same medium. Finally, the release was quantified by spectroscopy methods [18].

Acoustic methods: The technique determines the particle size by measuring the attenuation of sound waves and applying the physical equation. The oscillating electric field twisted by the charged particle, progress under the direction of acoustic energy, which can be identified to afford information on the surface charge [18].

7. CONCLUSION

Nanoparticles currently have a highly attractive raised area or a diverse range of biological applications. The foregoing shows that nanoparticulate systems have immense potentials, being able to alter poorly soluble, poorly absorbed, and labile biologically active material into capable delivery drugs.

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