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Advance in Biological Research, 2022, 3(1), 8-10
https://www.hillpublisher.com/journals/abr/
ISSN Online: 2635-0319

Herb-Synthesized Antiviral Nanoparticles

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How to cite this paper: Mohammad K. Parvez, Sarfaraz Ahmed, Sakina Niyazi. (2022). Herb-Synthesized Antiviral Nanoparticles. *Advance in Biological Research*, 3(1), 8-10.
DOI: 10.26855/abr.2022.03.001

Received: January 27, 2022
Accepted: February 23, 2022
Published: March 14, 2022

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Abstract

In recent times, nanomedicine has effectively addressed the poor delivery, solubility, absorption or cytotoxicity issues of conventional and herbal drugs. Several herbals or bioactive metabolites because of their ability to efficiently reduce and stabilize metal ions have been exploited as herb-synthesized gold and silver nanoparticles. Outbreaks of pathogenic viruses cause significant morbidity and mortality, worldwide. Of these, the novel SARS-Coronavirus-2 disease (COVID-19) remains the most devastating pandemic ever. In view of this, herbal gold and silver nanoparticles have been developed as antiviral drug-delivery carriers against Human immunodeficiency virus, Herpes virus, Influenza virus, Dengue virus, Chikungunya virus and Hepatitis B virus etc. Notable examples include *Astragalus membranaceus*, *Tinospora cordifolia*, *Phyllanthus niruri*, *Andrographis paniculate*, *Lampranthus coccineus* and *Malephora lutea* synthesized antiviral nanoparticles. Although further studies have shown that such herbal-synthesized nanoparticles could enter the target cells and inhibit virus replication, their interactions with different cell types and the specific mechanism of antiviral activities still remain inconclusive.

Keywords

Nanomedicine, Herbal Drugs, Herb-Synthesized Nanoparticles, Antivirals

1. Introduction

In nanomedicine, nanoparticles or nanocarriers have gained much advancement due to their physiochemical and biological performances over their drug-delivery counterparts [1]. Nanoparticles are nanoscale spacious structures of metallic or nonmetallic materials having extremely small size between 1 to100 nm [2]. Of different types of materials used in nanomedicine, including antiviral drugs, the most common are lipid-, polymer-, carbon-, and metal-based nanoparticles [2]. Notably, their physical properties can be manipulated reversibly and dynamically towards further enhancement of their access to target cells and intracellular compartments, including nucleus [3].

Because, human body contains mostly water, the ability to efficiently deliver hydrophobic drugs is a major issue. In view of this, the materials used in therapeutic nanocarriers should allow efficient delivery of both hydrophobic and hydrophilic drugs to the body [4, 5]. Nonetheless, a potential problem with synthetic nanocarriers is their unwanted toxicity of the type of material used. In addition, inorganic nanomaterial can also be cytotoxic if it accumulates in certain cell organelles. Comparatively, protein based nanocarriers are one of the promising drug-delivery systems, since they occur naturally, and generally demonstrate less cytotoxicity [1].

2. Herbal-Synthesis of Nanoparticles

Although, therapeutic herbs or natural products can easily dissolve in non-polar solvents, they are poorly soluble in

water resulting in their partial absorption when taken orally. These restrictions of herbal drugs can be overcome by their attachment with or encapsulation within appropriate nanomaterials, leading to their significant enhancement in the pharmacokinetics and therapeutic index [6]. In recent years therefore, herbals rich in bioactive phytochemicals have been exploited as green-synthesized gold and silver nanoparticles. Though green synthesis can utilize fungi, algae or bacteria, plant's parts have been widely used for herbal-synthesis of various nanoparticles [7, 8]. Moreover, phytochemicals such as flavonoids, alkaloids, tannins, saponins, and lignans efficiently contribute to the reduction of metal ions and enhance the stability of newly formed green nanoparticles [9]. In addition, such herbal gold or silver nanoparticles have received much interest due to their less bio-hazardous, eco-friendly, cost-effective and easily-scalable properties [10]. In addition, they inhibit the aggregation and agglomeration of the novel metallic nanoparticles by non-hazardous means [9, 11, 12].

3. Viral Diseases and Herbal Antivirals

In the past decades, several cases of emerging or re-emerging viral epidemics and pandemics have led to significant morbidity and mortality, worldwide [13]. The best examples are the Human immunodeficiency virus, Hepatitis viruses, Dengue virus, Chikungunya virus, Zika virus, Ebola virus, Nipah virus, SARS-Coronavirus-1, MERS-Coronavirus and Influenza viruses outbreaks across the globe. Notably, the recently emerged novel SARS-Coronavirus-2 disease (COVID-19) has been the most devastating pandemic ever [14]. Herbal bioactive compounds due to their high chemical-diversity and biochemical-specificity have been extensively studied for their therapeutic potential against different diseases. Of these, various herbal formulations and isolated compounds belonging to different classes such as flavonoids, alkaloids, tannins, saponins, lignans, coumarins, polyphenols, glycosides, and terpenoids have been widely reported for their antiviral efficacies against several pathogenic viruses [15-17].

4. Herbal-Synthesized Antiviral Nanoparticles

Ample of recent studies has suggested that herbal-synthesized silver nanoparticles could also act as effective antiviral drug-delivery vehicles against Human immunodeficiency virus, Influenza virus, Dengue virus, Bovine diarrhea virus, and Foot-and-mouth disease virus [18]. Also, further alterations in such metallic nanoparticles i.e., gallic acid-functionalized gold, multivalent-silver, tannic acid-modified silver, curcumin-modified silver naoparticles have been assessed as potential antivirals [19, 20]. In a previous study, *Astragalus membranaceus* tannic acid-modified silver nanoparticles were found to effectively treat Herpes virus infection [21]. Very recently, extracts of *Tinospora cordifolia*, *Phyllanthus niruri*, and *Andrographis paniculate* has been used to synthesize antiviral silver nanoparticles, which could interfere and block the cell entry of Chikungunya virus [22]. Also, silver nanoparticles synthesized from *Lampranthus coccineus* and *Malephora lutea* extracts have been reported for their antiviral activities against Herpes virus, Influenza virus and Hepatitis B virus [23]. Though further analysis has showed that such green-synthesized nanoparticles could enter the cells and inhibit virus replication, their interactions with various cell types and the underlying mechanism of activities still remain inconclusive.

5. Conclusive Remarks

Herbal products, including their isolated metabolites have ability to efficiently reduce and stabilize metal ions used to synthesize nanoparticles. In addition, herbal-synthesized nanoparticles have excelled as efficient targeted drug-delivery carriers without adding specific ligands, and improved bioavailability, solubility as well as minor or no side-effects. Recently therefore, several herbal-synthesized gold and silver nanoparticles have been developed as effective antiviral formulations against different pathogenic viruses. Although further studies have shown that such herbal-synthesized nanoparticles could enter the target cells and inhibit virus replication, their interactions with different cell types and the specific mechanism of antiviral activities are poorly understood. Further research and development in nanomaterials can allow manipulations in their properties and behavior in a biological environment.

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