SYNTHESIS OF NANOPARTICLES UTILIZING PLANT EXTRACT

Abstract

Nanoparticles (NPs) being used most widely now-a-days, are in verge of developing new methodologies for their preparation. Focusing on the sustainable development goal and understanding the Green Chemistry principles, it is given utmost importance for synthesis of NPs utilising different plant extracts. Here in this chapter, we are discussing on synthesis of NPs.

Keywords: NPs, Green synthesis, Plant extract

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I. INTRODUCTION

In recent days, scientific community focuses on the concept of sustainable development i.e. development of the current necessities without hampering the needs of the future generation [1]. In this regard, methodologies developed with the acceptance of Green Chemistry Principles [2] are the prime goal of the researchers which can lead to the fulfillment of the concept of sustainable development. Presently, nanotechnology has become an emerging area which has immense effect on various fields. NPs have small size and they have commendable physicochemical properties which are clearly diverse from their bulk counterparts [3]. NPs have been synthesized traditionally mostly by chemical methods. Many methods are utilised for the preparation of metallic NPs under various physiological and environment friendly conditions like microwave, so no chemical, electrochemical, ionic liquids, supercritical liquids etc [4]. But most of the methodologies are confronted with the drawback of using toxic chemicals and in the process of synthesis, by-products are generated; moreover, there are some other economic issues related with the process [5]. Because of this, researchers are continuously working on developing new environment friendly, less toxic and economically viable methodologies for NP synthesis. As such, bio-based methodologies utilising different microorganisms like fungi, yeast, algae, bacteria etc, as alternative to the traditional methods, have been developed [6]. Along with these, plant extracts have been extensively explored in recent days because they are easily available, cost effective as well as easy handling [7]. Besides, in the synthesis of NPs, it plays effective role as an efficient stabilizing or reducing agent [7]. These plant extract contain a wide range of phytochemicals, presence of which may act as stabilizing and/or reducing agents in the synthesis process of NPs [8]. Different plant components viz. leaves, roots, stems, fruits, and seeds are extensively utilized for the synthesis of different NPs [9]. Thus, easy to use nature along with the diversity of plants, plant extract mediated green synthesis of NPs is now considered as a commanding technique amongst various biological methods. NPs synthesized utilizing plant extracts have definite size, shape, and composition and they are less harmful to human than that of the NPs synthesized chemically [8].

II. PLANT EXTRACT MEDIATED SYNTHESIS OF NPs

Many more literatures are found regarding the synthesis of NPs utilizing plant extracts. Plant extract means the extracts obtained from different parts of a tree viz. leaf, stem, fruit, root, latex, bark residue, peels of fruits and seeds [9].

Plant extracts mainly contain active ingredients like phenols, terpenoids, quinines, alkaloids, amides, alcohols, flavonoids and proteins which are mainly associated with the process of reduction of metal cations to NPs [10]. Carbonyl, hydroxyl, amine and methoxide basically found in the active ingredients of plant extracts and they are the main functional groups which react with the precursor [11]. Among these ingredients, flavonoids and phenols have the ability to act as stabilizers which prevent the aggregation of as-synthesized NPs [10].

In general, the plant extract mediated NP synthesis involves three main phases viz. I) reduction phase, II) growth phase and III) termination phase. A short summary of these steps is given below [12, 13].

1. In the first phase, which is the reduction phase, the reducing phytoactives contained in the plant extract have the ability to reduce the metal ions to zero-valent metal atoms by transferring electrons.

2. In the second phase, the zero-valent atoms produced starts growing to nanometallic particles of different shapes like triangular, linear, hexagonal, cubic or rod shaped by aggregation.

3. In the final stage, named termination stage, the phytoactive components with antioxidant properties present in the extract help to uphold the stability of NPs by enriching themselves around the NPs.

Some of the active ingredients found in the plant extract are shown in the figure below (Figure 1).

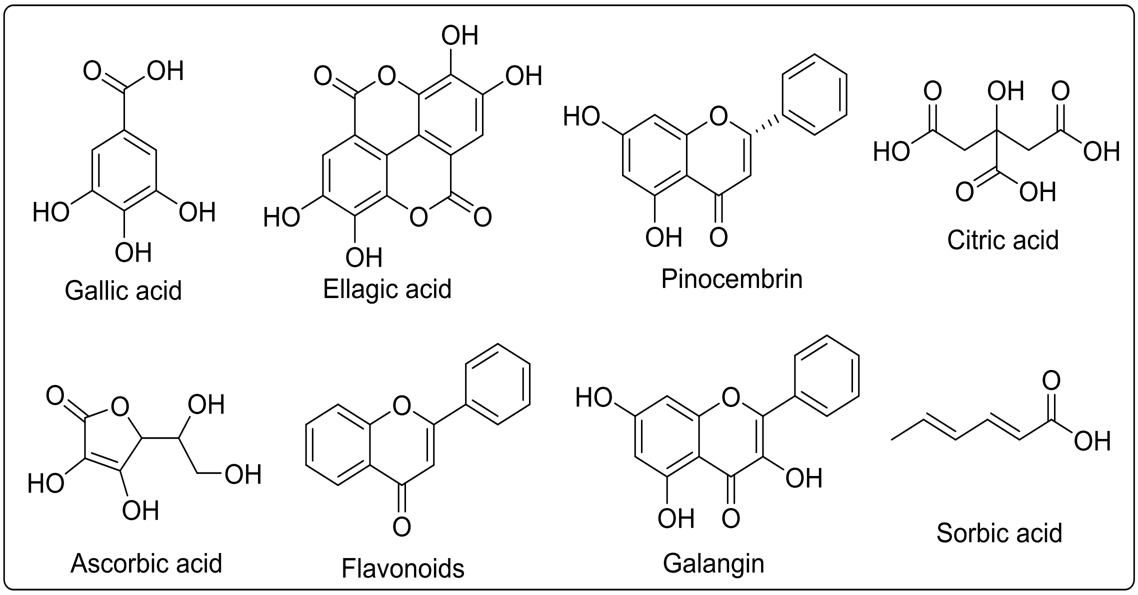

Figure 1: Structures of Some Active Ingredients Present in Plant Extract

III. PLANT EXTRACT IN THE SYNTHESIS OF Pd NPs

In present day, Pd NPs, on account of their high surface area as well as high surface energy, have found immense applications in various fields like organocatalysis, in biosensors, in hydrogen production, in supercapacitors etc [14].

They exhibit excellent catalytic activities in organic transformation reactions. But the synthetic routes of Pd NPs mostly require high temperature, ultra sonication, active reducing agent etc [15], which have been trying to avoid by searching for mild, environment friendly, easy handling methodologies by the scientific community. As such, there is a continuous effort for the development of green methodologies for the synthesis of Pd NPs in one step with least quantity of chemicals utilising environmentally benign plant extracts.

Many literatures are found for the synthesis of Pd NPs utilizing different plant extracts. Some of the reported literatures are listed below in Table 1.

Table 1: Some literatures of Pd NPs Synthesis Utilizing Plant Extract

Plant Extract	Reference
Ocimum sanctum	[5]
Papaya peel	[16]
Pomegranate peel	[17]
Diopyros kaki. leaf	[18]
Banana peel	[19]
Cinnamom zeylanicum bark	[20]
C. Camphora leaf	[21]
Curcuma longa tuber	[22]
Rosa canina fruit	[23]
Pistacia atlantica kurdica gum	[24]
Pectin	[25]
Stachys lavandulifolia	[26]
Oak gum	[27]
Camellia sinensis leaves (black tea)	[28]
Ananas comosus leaf extract (ACLE)	[29]
Moringa oleifera Leaf Extract	[30]

Extensive researches are still going on regarding the plant extract facilitated Pd NPs synthesis.

After synthesis of the Pd NPs, these are characterized by different spectroscopic and analytical methods. Pd NPs are mainly characterized by HRTEM (High Resolution Transmission Electron Microscopy) analysis. Moreover, SEM (Scanning Electron Microscopy) analysis, EDX (Energy Dispersive X-ray) analysis, UV-Visible spectroscopy, FTIR (Fourier Transform Infrared) spectroscopy, PXRD (Powder X-ray Diffraction) analysis, SAED (Selected Area Electron Diffraction) analysis, XPS (X-ray Photoelectron Spectroscopy) analysis etc.

IV. CONCLUSION

Green Chemistry has led to the advancement of new environmentally benign methodologies for the synthesis of NPs. In this regard, it is seen that, the plant extract has a commendable impact on their synthesis due to the presence of different active biomolecules. Utilisation of plant extract retards the use of toxic chemicals required for the synthesis of the NPs and makes the process easy handling as well as economic. Moreover, the NPs synthesized by bio-routes have very good use in medical field. As such, the effective utilization of plant extract for the synthesis of NPs, has become a very good alternative pathway.

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