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Essential oil mediated synthesis of silver nanocrystals for environmental, anti-microbial and antioxidant applications

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ABSTRACT

Our quest for a green, non-toxic and environmentally benign synthetic design for the fabrication of metal nanoparticles has led to the use of essential oil present in plant parts as the bioreductant. In this report, silver particles at nanoscale have been synthesized using essential oil present in the leaves of *Coleus aromaticus* at physiological pH and at 373 K. UV–vis spectra of the colloid display strong plasmon bands centred around 396–411 nm, characteristic of silver nanoparticles. Comparative studies of the FTIR spectra of essential oil and silver nanoparticles reveal the involvement of terpenes and their phenolic derivatives in reduction and subsequent stabilization. TEM micrographs and XRD pattern show the formation of 26 and 28 nm sized face centred cubic structured crystalline nanospheroids with intermittent formation of nanorods. The phytosynthesized silver nanoparticles are found to be effective in degrading hazardous organic pollutants including methyl orange, methylene blue, eosin yellowish and para nitro phenol within a span of a few minutes. Dose dependant antibacterial activity of the biogenic nanosilver against pathogenic Gramme-negative *Escherichia coli* (ATCC 25922) and Gramme-positive *Staphylococcus aureus* (ATCC 25923) has been portrayed through agar-well dispersion method. The antioxidant activity including antiradical activity and reducing power have been depicted through superoxide radical scavenging activity, hydroxyl radical scavenging activity, hydrogen peroxide scavenging activity, nitric oxide scavenging activity, DPPH assay and reducing power activity involving the reduction of ferric ion.

1. Introduction

Designing protocols for the fabrication of nanomaterials has always remained a tedious task among researchers, as the scenario over the ages demanded environmentally benign synthetic routes. This prompted the exploitation of readily available bioresources including algae, bacteria, fungi and plants for the synthesis of materials in the nano regime. These natural nanofactories are excellent alternatives to conventional physical and chemical approaches owing to their non-toxicity, cost-effectiveness and enhanced production of the nanomaterials. Plants that are enriched in antioxidants possess remarkable potential to hyperaccummulate and reduce heavy metals, one of the striking causes of their choice as the biofabricator. Phytosynthesis of metal nanoparticles (NPs) has been regarded as being much more advantageous over other biological methods due to the easy availability of the reductant and the rapid formation of stable NPs with diverse morphology [1]. Biomolecules including polyphenols, saponins, proteins and terpenoids present in plants play active role in reduction of inorganic metal ions and their consequent stabilization.

Earlier works in this field include the use of extracts of plant parts as the reducing and capping agent. However, recent years have witnessed a deviation from this approach in an attempt to make in depth studies on the potential of this bioresource. Bioactive silver (Ag) nanospheroids have been synthesized [2] using aqueous latex extract of *Calotropis gigantea* L. The NPs fabricated by the protein fractions in the latex have been suggested as a promising material in nanodrug formulation. Saponin isolated from *Trianthema decandra* has been used [3] to synthesize bioactive Ag NPs with spherical morphology. Pedicellamide isolated from the petroleum ether extract of dried leaves of *Piper pedicellatum* has also been used for the synthesis of catalytically active silver nanoparticles [4]. Works have been further extended for the utilization of plant derived natural polymers including natural rubber [5], chitosan [6], gum acacia [7] and the hydrocolloid, gum kondagogu [8]. As a refined phytosynthetic protocol, essential oils present in leaves of cashew [9] and nutmeg [10] have been recently reported as efficient green materials for the synthesis of metal NPs.

Coleus aromaticus, an aromatic perennial herb, known for its bioactivity is of supreme significance in modern medicine. Being antilithic, antispasmodic, cathartic and a stimulant, the leaves of *C. aromaticus* are used in the treatment of asthma, gonorrhoea, piles, headache and wounds [11]. Previous reports reveal, the essential oil fraction enriched in carvacrol, thymol and eugenol to be the main cause for the bioactivity

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