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Bio-Nano Fertilizers Preparation Using a Fully-Automated Apparatus: A Case Study of Nano-Selenium

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THE global production of mineral fertilizers suffers from several critics due the serious problems, which penetrated the environment causing direct and indirect troubles for human health. Thus, the sustainable alternative "like bio-nanofertilizers" for the mineral fertilizers, that protects and conserves the environment will be a global aim. The present investigation introduces a simple and a fully-automated technique for producing bio-nano-fertilizers from abundant green materials. These nano-fertilizers were produced using plant extracts as a protocol for the biosynthesis of nanoparticles based-fertilizers. The innovative device can work automatically without human intervention by programming its units to produce homogeneous nanoparticles. Three plant extracts (i.e., *Nerium oleander*, *Azadirachta indica*, and *Cinnamomum camphora*) were selected to produce nano selenium using this device, and the nano-products were further investigated using both zeta potential and transmission electron microscope (TEM). Further investigations including more nano-fertilizers will be published in the future with more details for different kinds of nutrients.

Keywords: Nano selenium, Bio-nanofertilizer, *Nerium oleander*, *Azadirachta indica*, *Cinnamomum camphora*

Introduction

In recent years, several investigations have been undertaken on agro-environmental application of nanomaterials, which has been called agro-nanotechnology (El-Ghamry et al. 2018; El-Ramady et al. 2021; Shalaby et al. 2021). Several applications of nanomaterials in agricultural sector could be broadly classified into nano-pesticides, controlled or slow released nanomaterials/ nanofertilizers, nanomaterials for plantgrowth, and nano-biosensors (Acharya and Pal 2020; Sarkar et al. 2021).There are many promising studies on the use of nanotechnology in fertilizing plants to reduce the amount of fertilizersapplied, maximize their use efficiency, and reduce their potential contamination hazard (Ahmadian et al. 2021; Madzokere et al. 2021).Nanofertilizers play important roles in plant nutrition, whether they are sprayed on vegetable varieties (Salama et al. 2021) or added as soil application (Saleem et al. 2021). Currently, there are hundreds of fertilizer products in the world with their active substance, the nanoparticles of small element oxides, as well as different types of nutrients that the plant greatly needs in the form of nanostructures, which are expected to increase over the next few years (Madzokere et al. 2021). The biological methods for producing nano-fertilizers are considered a sustainable technology for plant nutrition because this method has opened new horizons for minimizing the environmental protection costs and increasing use efficiency of nutrients (El-Ghamry et al. 2018; Mohammadghasemi et al. 2021). Many studies have published about the

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bio-manufactured nanomaterials (Pal 2021; Patel and Pathak 2021) and/or nano-fertilizers from different organic materials or plant extracts.

The interplay between plants and nanoparticles (NPs) has two aspects including their role as nano-fertilizers, nano-growth regulators, nano-pesticides, nano-antimicrobial agents, and nano-biosensors; and using plant materials in the biosynthesis of NPssuch as bio-nano-fertilizerslike CuO-NPs and ZnO-NPs (Hu and Xianyu 2021). Several plant extracts have been used to produce many kinds of nanofertilizers such as moringa (Matinise et al. 2017), banana peels (Hussein et al. 2019), *Rhamnus virgata* (Iqbal et al. 2019), and onion (Gosavi et al. 2020).The biosynthesis of nanofertilizers could be achieved using some micro-organisms (i.e., bacteria, fungi and actinomycetes)and plant extracts(Sarkar et al. 2021). Many leaf extracts were used for producing nano-nutrients, which could be used as nanofertilizers like *Cymbopogon jwarancusa* for the synthesis of FeO-NPs (Irum et al. 2020), *Fragaria ananassa* leaf extract for biogenic synthesis of Cu-, Fe-, MgO-, and ZnO-NPs (Bayatet al. 2021), as well as some plant extracts for nano-pharmacological and bio-medical applications like *Phyllanthus emblica* fruit extract to produce Ag-NPs (Dhar et al. 2021). However, there is an urgent need to find out an automated technology for nanofertilizers synthesis in order to move forward toward the mass production for large-scale applications.

Therefore, this study is an attempt to highlight an innovative apparatus, which could be usedfor the large-scale application of nanofertilizers. Plant extracts could be used in this device for green synthesis of many kinds of nanofertilizers. To the best of our knowledge, it has not been reported about such apparatus in the literature. Several of the potential applications of other biosynthesized nanofertilizers will be published in our future reports.

Materials and Methods

This study wascarried out to find outan eco-friendly technique for biosynthesis of stable metallic particles using plant extracts by reducing the element ions to the nanoparticles comparing withother synthetically or chemically proven materials such as polyvinyl alcohol (PVA), tripolyphosphate (TPP), polyacrylic acid (PAA),Mercaphosocyanic Acid (MSA), Tri-Mercaptoprionic Acid (MPA), etc. As presented in **Fig. 1**, this protocol isan ideal method for preparing environmentally friendly nano-fertilizers.

Conceptualization of the research design

Although there are many physical, chemical and mechanical methods that have been introduced to synthesize nanofertilizer granules, only the biological methods are the most effective and safe to the ecosphere.Therefore, within the biological method, two methods can be used safely (i) biosynthesis using active microorganisms and (ii) phytosynthesisusing plant tissues (plant extracts). Some environmental problems or obstacles should be reduced during the production ofthe nanofertilizers like:

1- The presence of unauthorized places and companies that trade in the products of nano-fertilizer, which has not been subjected to any tests that prove that it is nano.

2- There is a mixing of those who make nanofertilizers, as it uses other non-biological methods, which increases environmental and health risks (Commercial fraud).

3- Steps to manufacture nanoparticles by biotechnology need sequence steps, heating, stirring, exposure to UV rays for fixation, and preparing a salt extract to be converted to nano, etc. These steps require a long time, special laboratories, and concentration of those working on manufacturing it until it reaches the final product. Even in this way, the human factor interferes when re-experimenting again as it must be with the same steps, time, and temperatures, which makes the products with repetition of the synthesis process heterogeneous.

4- The method of synthesis, even in the biological way. The use of plant extracts requires many devices and glass tools and needs a special equipped place for manufacturing (manufacturing plant).

The device and its requirements

The manufacture of nanoparticles is greatly affected by the conditions under study (e.g., concentration of metal ions, temperature, volume of extract used, acidity or alkalinity of the medium, type of addition, and time), where all these conditions must be studied in order to ensure that the nanomaterial appears in the best conditions to overcome any problems. When an experiment has been found, we found it difficult to have the nano-structure, which could be attributed

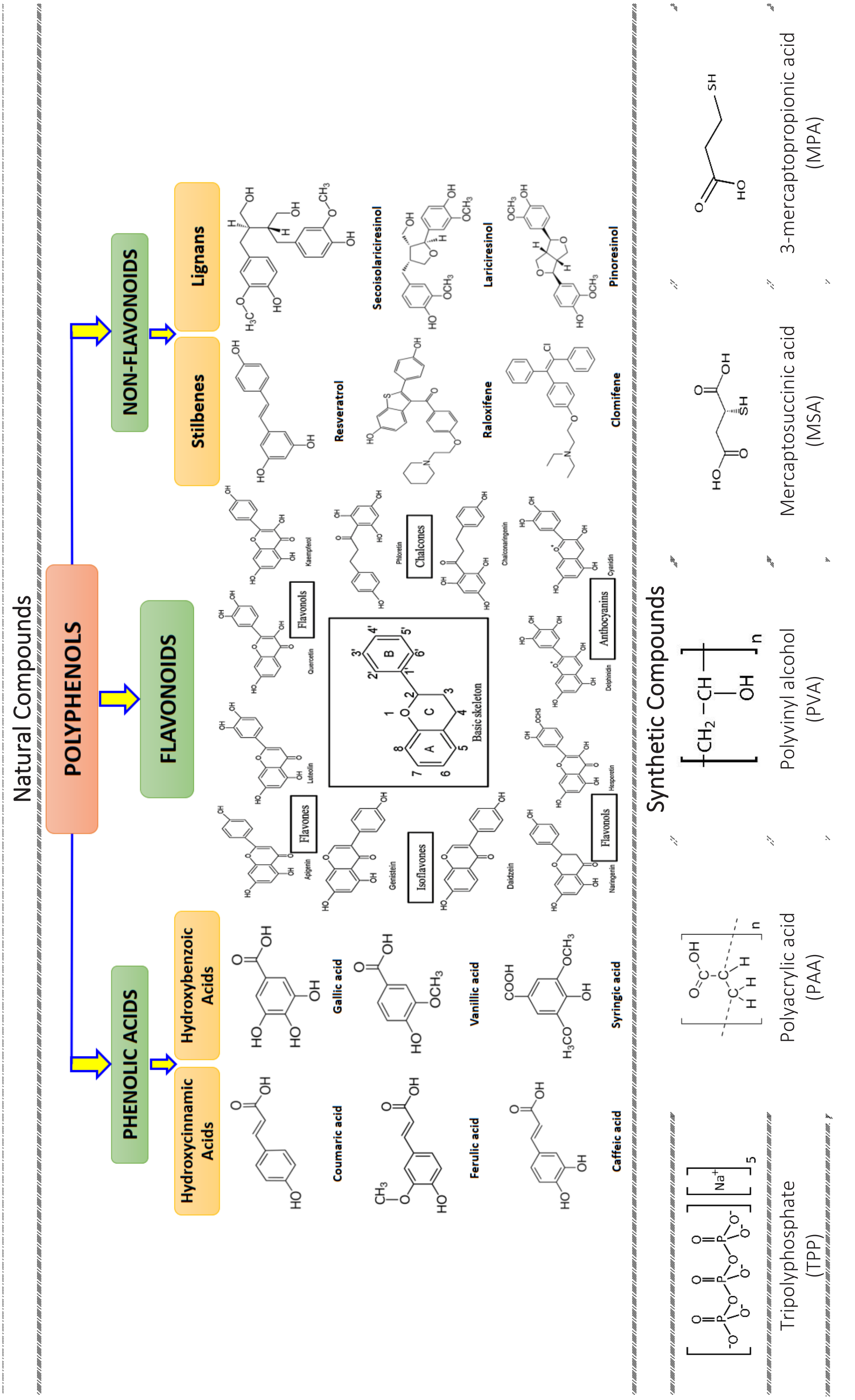


Fig. 1.The comparison between synthetical or chemical methods to produce nanoparticles and the suggested device in this studyfor preparing environmentally friendly nano-fertilizers.

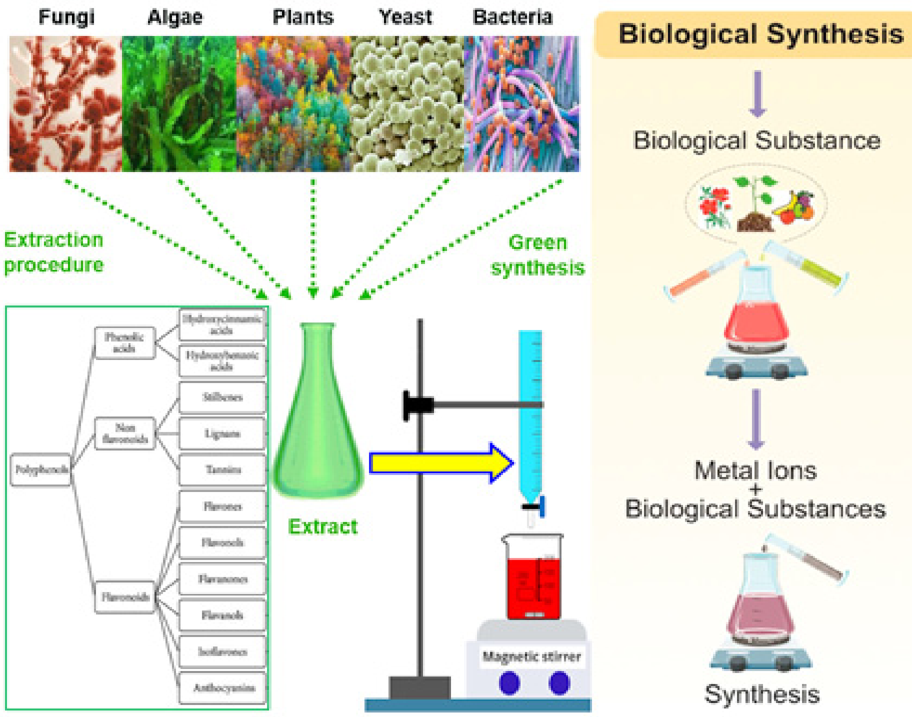


Fig. 2. Schematic diagram of the preparation of green synthetized nanoparticles.

to several reasons such as:

(1)The reaction usually needs to be activated by heat and the solution must be gradually heated in the presence of stirring.

(2) Lack of active substances in the extract. Therefore, the size of the added extract should be increased, concentrated, or replaced with a more effective extract.

(3) The extract may be acidic and the acidity should be adjusted to approximately 7 (neutral medium), or modified to the base if it is not given at function 7.

(4) The time, the reaction period may take more than 24 hours at room temperature, and may be more than an hour in the case of heating.

(5) Exposure to a specific type of radiation, where some elements are required to be exposed to a specific period of time to special rays such as ultraviolet rays, which in turn work to stabilize nanoparticles, research that is continuously chargeless so that the particles repel permanently and do not precipitate.

Apparatus and its description

The used device in the recent study is called **“El-Ghamry and El-Khateeb Bio-Nano Apparatus”,** which is already under evaluation and processing for the official license as a patent from the Academy of Scientific Research and Technology in Egypt.This devicecould be programmed to operate automatically according to the following detailed description (**Fig. 3**):

1. The 1st unit (solvent unit): water used as a solvent to make the plant extract or the appropriate solvent in the work of the plant extract, bearing in mind that this unit can pass a magnetic field to activate the solvent before it reaches the plant residue used to make the extract. This unit referred to in drawing board No. 1.

2. The 2nd unit (metal ions unit): solutions of the ion salt whose elements are to be transformed into a nanostructure are placed – and it is also possible through this unit to add solutions that will modify the acidity of the contents to reach the neutral and this unit referred to in drawing board No. 2.

3. The 3rd unit (extraction unit): in extracting the active compounds, especially many phenols, which are found in all plants, with different proportions and efficacy. With heating during extraction and controlling the temperature and time used for extraction, then an electrical valve opens when extraction is completed automatically to proceed to the next stage. And when the extract is intended to be minimized or used for other purposes, it may come from another hole to

container No. 7.

4. The 4th unit (biosynthesis unit): automatically adding the saline solution to be converted into nanoparticles from the second unit with the plant extract starting to move from the third unit to this unit and control added drop wisely very slowly is necessary in the transition rate of the extract as the increase in the rate of drip increases the size of the grains formed and is more subject to precipitation. Here also the magnetic stirrer works with adjusting the temperature to the appropriate degree for the required period of time before its separation and leaving it to cool down a period of time before opening the electric valve automatically for the exit of the nanometer. It is called a reducing unit in which the ions of salts are reduced to the image of zero-charged granules by means of an electronic oscillation (Resonance hybrid) of the active polyphenol compound, so we get a granule surrounded by polyphenols in the required nanoscale. This unit referred to in drawing board No. 4.

5. The 5th unit (ultra violet radiation unit): After the completion of the previous stage in the fourth unit, the electric valve is automatically opened to enter the nanometer solution on filters to purify it. Then it is exposed to UV bulbs to fix it and not to accumulate. So that it is continuously chargeless and in a constant repulsion state so that it does not precipitate. Then, via an electrical lock after a specified time, it automatically opens to exit to the next stage. This unit referred to in drawing board No. 5.

6. The 6th unit (product storage unit): which is the sixth unit, that receives the final product from the nanoparticle produced in the form of a biomass nanoparticle that can be stored until it is used as a bribe at addition or ground rates. This is after taking a sample from it to make the required tests, whether in terms of the diameter of the produced nanoparticle or the concentration of the granules in the solvent. This unit referred to in drawing board No. 6.

7. The7th unit(extract container): the plant extract can be emptied into container No. 7 if it is necessary to obtain the plant extract for other uses. This container referred to in drawing board No. 7.

8. The 8th unit (solvent container):the solvent can be emptied into vessel No. 8 if it is necessary to

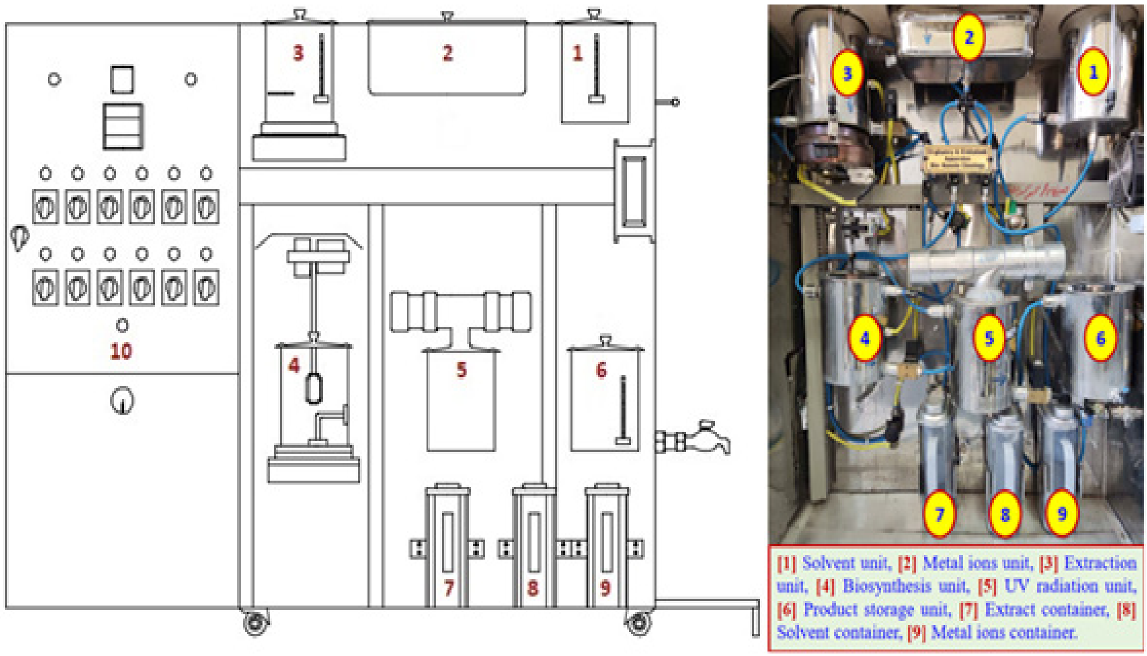


Fig. 3. Integrated device (from 6 automatic programmed units, 3 storage containers and 1 control panel) to manufacture nano-fertilizer using device of "El-Ghamry and El-Khateeb Bio-Nano Apparatus".and this device includes graphics from 1 to 10.(1)Solvent unit with or without magnetization, (2)Salt storage unit, (3) Extraction unit with heating and filtering, (4)Biosynthesis unit with stirring and heating, (5) Anchorage unit with or without UV use, (6) The volume of the final product after filtration, (7) A filtered plant extract storage container, (8) Magnetic or non-magnetic solvent storage container, (9) Excess storage container of saline, and (10)Automated control panel.

change the solvent used or to obtain magnetic water for other uses. This container referred to in drawing board No. 8.

9. The 9th unit (metal ions container): the saline solution can be disposed of by opening it to vessel No. 9 if it is assumed to use another solution or to wash the unit. This bowl, referred to in drawing board No. 9.

10. The 10th unit: automated control panel.

Extraction of active ingredients and synthesis of metal nanoparticles

This device could be used for the extraction of active ingredients and synthesis of metal nanoparticles using some plant extracts (i.e., *Nerium oleander, Azadirachta indica* and *Cinnamomum camphora*).Extraction of the selected plants was prepared according to the previously reported method of Dent et al. (2013) with a slight modification tofit the newly invented creative device namely “El-Ghamry and El-Khateeb Bio-Nano Apparatus”. Accurately, 100 g of plant powder was extracted using 1L of distilled magnetized water performed at 70°C for 2 hours on an extraction unit. The extract was then transferred to the synthesis unit. Metal nanoparticles were eco-friendly synthesized using the method reported by Devasenan et al. (2016). Aqueous solution of metal salt (1L, 1mM) was prepared using distilled water and added drop wisely very slowly to the same volume of prepared plant extract under stirring.After the complete addition of the metal aqueous solution, the mixture was stirred for an extra two hours at room temperatureaccording to El-Zayat et al. (2021). The synthesized nanoparticles were then transferred to the irradiation unit. The mixture was subjected to UV irradiation using reduction factor lamp (Vilber Lourmat-6. LC, France) at wavelength (λ=254nm) for 20min according to Supraja et al. (2013). The synthesis nanoparticles were then filtered through Whatman no. 1 filter paper (Whatman International Ltd., Kent, UK) and stored at −18°C further experimental uses.

Extraction of active ingredients

Extraction of the selected plants was prepared according to the previously reported method (Dent et al. 2013). Accurately, 10 g of plant powder was extracted using 100ml of distilled water performed at 60°C for 30min on a horizontal water bath shaker (Memmert WB14, Germany). The extracts were then filtered through Whatman no. 1 filter paper (Whatman International Ltd., Kent, UK) using a Büchner funnel and the filtrates were adjusted to 100ml in volumetric flasks with appropriate distilled water. The extracts were stored at −18°C further experimental uses.

Synthesis of metal nanoparticles

Metal nanoparticles were eco-friendly synthesized using the method reported by Devasenan et al. (2016). Aqueous solution of metal salt (20ml, 1mM) was prepared using distilled water and added drop wisely very slowly to the same volume of prepared plant extract under stirring, after the complete addition of the metal aqueous solution, the mixture was stirred for an extra two hours at room temperature (El-Zayat et al. 2021). The mixture was subjected to UV irradiation using reduction factor lamp (Vilber Lourmat-6. LC, France) at wavelength (λ=254nm) for 20min according to Supraja et al. (2013).This device has been tested to produce some metal nanoparticles like nano-Se using some plant extracts as mentioned in the following sections.

Biosynthesis of nanoparticles using plant extracts

For evaluation the device “the El-Ghamry and El-Khateeb Bio-Nano Apparatus”, some plant extracts were used to produce nanoparticles or nanofertilizers based on the active substances in the extracts. These active substances have the ability biologically to reduce the salts ions and convert them into nanoparticles, so they try to accumulate, but soon the adsorbent materials are adsorbed on their surface, their surface stabilizes, their energy is reduced and the nanoscale is maintained, which is the second role of effective compounds with biological extracts. These compounds are often polyphenols and their different sections, which have a mechanism depends on the kind of plant extracts and differs from each other chemically, according to the ratio and quality of these compounds. The surface coverage also makes the nanoparticles of the element less susceptible to oxidation and hence be antioxidant qualities.

Physicochemical characterization of the engineered nano-fertilizers

Three different plant extracts, i.e., oleander(*Nerium oleander* L.), neem (*Azadirachta indica* L.) and camphor tree (*Cinnamomum camphora*L.) were used to produce the biological nano-Se(i.e., nanofertilizer)using the apparatus in the current study. The physical properties and chemical structure (i.e., particle’s size, shape, surfacenature, crystal structure, and morphological data of the prepared nanoparticles) were identified as conveyed by El-Zayat et al. (2021), using Transmission Electron Microscope or TEM (JEOL TEM-2100, Tokyo, Japan) connected with a CCD camera with voltage of 200 kV. Each sample of synthesized metal nanoparticles was prepared by involving a suspension of the sample on copper-coated carbon grids and the solvent was evaporated slowly before recording the TEM images at the Electron Microscope Unit, Mansoura University, Egypt. The surface charge of the prepared selenium nanoparticles in the suspension was characterized by applying Zeta potential technique using (Malvern Instruments Ltd. Zeta Potential Ver. 2.3, Kassel, Germany) according to Bhattacharjee (2016) at the Electron Microscope Unit, Mansoura University, Egypt. The process is significant for studying the surface nature of nanoparticles, and the stability of these particles can be expected to last for long-term periods (Honary and Zahir 2013). The source of Se in this study was selenium dioxide (SeO_2, Merck Schuchardt OHG, Germany). The leaves of investigated plants were collected from their authentic habitats at Mansoura University Gardens, Mansoura, Egypt. The leaves were air-dried in the shade, away from the sun light, so that it could be crashed into small pieces by hand.

Zeta potential analysis technique was applied for defining the nanoparticle's surface charge in the *Nerium oleander, Azadirachta indica* and *Cinnamomum camphora* aqueous extract solution. The surface charge of nanoparticles could attract a thin layer of ions with the opposite charges on the surface of nanoparticles. The zeta potential magnitude referred to the stability of the particles in the solution. The technique was used as a reference of the stability of the particles, in which the values of zeta potential between ±10 mV will tend the particles to a rapid agglomeration in the absence of steric factor, while zeta values in the range ±60 mV have excellent stability. The negative sign for zeta potential values indicated the net charge of the scattered is negative. The negative sign of zeta value was recorded above the isoelectric point of each sample. The values of zeta potential were recorded in the range of ±100 mV. The greenly synthesized metal nanoparticles were scanned by zeta potential analysis using Malvern Instruments Ltd Zeta Potential Ver. 2.3.

Results and Discussion

There is no doubt that this era is the era of the scientific and technological boom, in which the chain of technological development continues quickly and with utmost accuracy. There are no limits to the human imagination and aspirations. Many studies and research have appeared in recent years that dealt with the introduction of one of the most accurate techniques that are now frequented by our ears, which is nanotechnology.This very accurate technology is used in all areas of life including agricultural, medical and industrial sectors (Tahir et al. 2021). Nanotechnology has a lot of inventions in the biological and medical fields, sustainable water treatment (Tom 2021), studying the primary components of cells, and knowing their properties, using magnifying microscopes, as well as in the pharmaceutical industry (Sahu et al. 2021), microscopic injection, study of DNA, and pandemic diseases like COVID-19(Hasanzadeh et al. 2021).

Nanomaterials are also used to cover traditional fertilizers as nano-coated fertilizers to facilitate their absorption and increase their efficiency.Many nanomaterials could be also used as an alternative to traditional fertilizers or as bearers of its components has many advantages (Yu et al. 2021).These advantages may include increasing the ability to control the direction process, and increasing the plant response to nanoparticles due to their easy entry into cells because they are smaller in size, have greater area and its surface, consequently, its permeability and effectiveness (Madzokere et al. 2021). Theuse of nanomaterials in fertilization programs is an effective alternative to traditional fertilizers as it achieves many advantages due to its use in smaller quantities, and its high stability under different conditions, which increases the ability to store it for longer periods, which brings many benefits to the plant and the environment.Nanofertilizers could be also applied for better crop production under normal conditions (Pitambara et al. 2019) and-or stressful environments (Ahanger et al. 2021), improving the availability of plant nutrients (Madzokere et al. 2021), and sustainable agriculture (Basavegowdaand Baek 2021).

In the current study, green nanotechnology using some plant extracts *via* the "El-Ghamry and El-Khateeb Bio-Nano Apparatus". has been evaluated through the biosynthesis of nano-Se as shown in the following sections.

Green nanotechnology

Thegreen nanotechnology isconsidered developing clean technologies, which mainly aim to reduce environmental products and human health risks associated with the manufacture of nano-products and to encourage the replacement of existing products with potential new nanoscale products that are more eco-friendly in the long-run (Dutta and Das2021).Green nanotechnology has two goals including the producing nanomaterials and nano-products without harming the environment or human health, and producing nanotechnologies that provide solutions to environmental problems (García-Quintero andPalencia 2021). This is by using the existing principles of green chemistry and green engineering to make nanomaterials and nanoscale products without toxic industrial chemical ingredients.In addition to making eco-friendly nanomaterials and products, for example, nanoscale films can separate products with a required chemical reaction.Among the techniques of green nanotechnology is the technology of creating nanostructures biologically, using either microorganisms or plant tissues by making a plant extract, and they are the most widespread in the medical and agricultural field (**Fig. 4**).

Characterization ofmetal nanoparticles

Transmission Electron Microscope

The synthesized selenium nanoparticles usingplant extracts of*Nerium oleander, Azadirachta indica* and *Cinnamomum camphora* were characterized by TEM implementation at higher spatial resolution at 200 nm (**Fig.5**). The technique was applied to study the chemical, and physical properties of the formed nanoparticles, as well as the surface morphology. The process was run for characterization of the samples in accordance to Otunola et al. (2017) to study the size, shape, surface, and crystal structure of the selenium nanoparticles. The morphological particles appeared clearly in the scan, in which it provided the size distributions, shapes, and aggregations of the nanoparticles. The selenium nanoparticles appeared to be spherical shapes with particle sizes ranging from 64.25 – 79.55 nm for *Nerium oleander,* 63.61 – 95.63 nm for *Azadirachta indica* and38.94 – 95.94 nm for *Cinnamomum camphora*. The agglomeration and/or aggregation assessment indicated that the selenium nanoparticles are regularly distributed in the scanned image. Accordingly, the selenium nanoparticles appeared to be more effective with a smaller sizes and large surface area when applied, also provided high potency of the sample more effective than the original extracts of *Nerium oleander, Azadirachta indica* and *Cinnamomum camphora*.

Zeta potential

The results of the screened selenium nanoparticles of the aqueous extracts of *Nerium oleander, Azadirachta indica* and *Cinnamomum camphora* for their zeta potential presented in

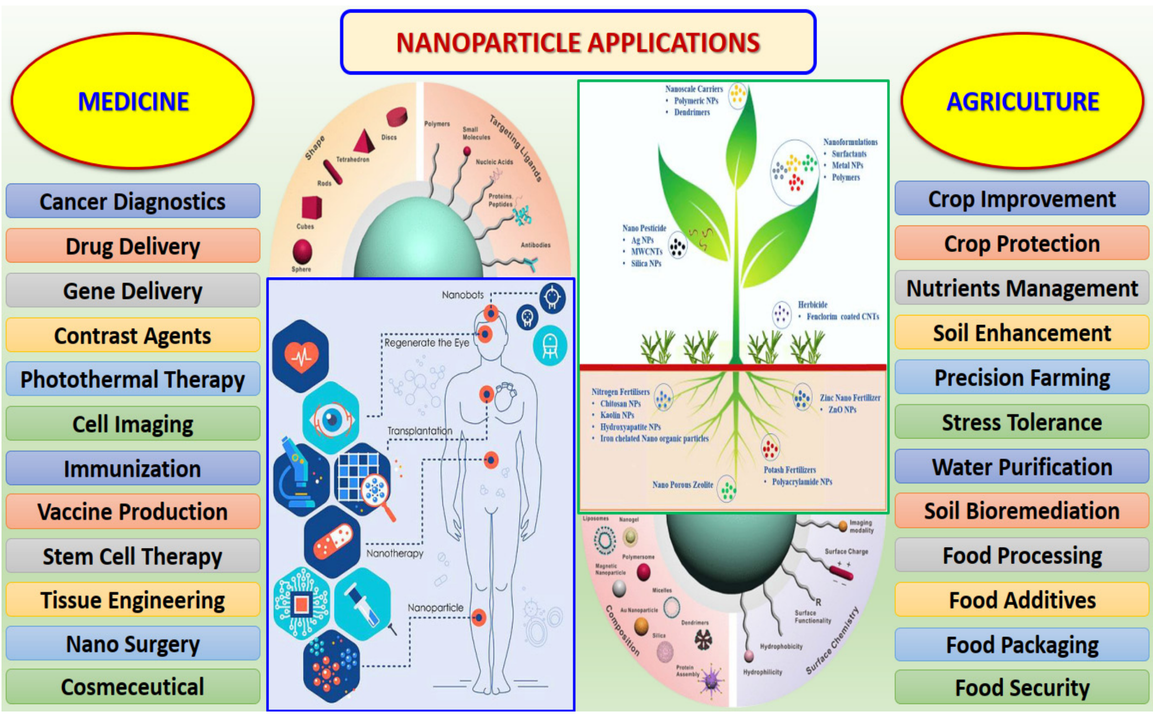
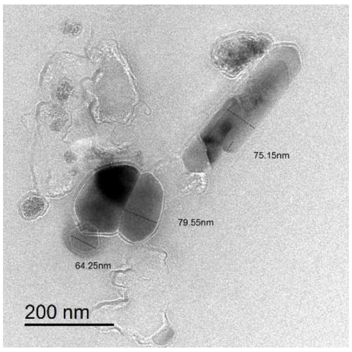
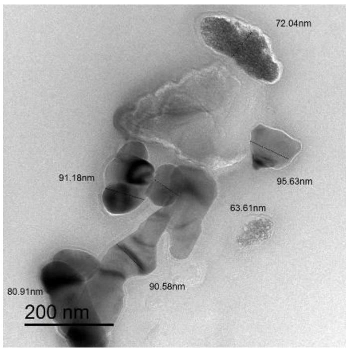


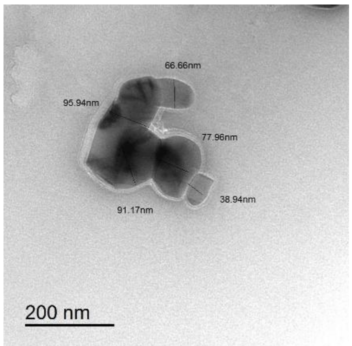
Fig. 4. Different applications using the biological synthesis.



(A)- TEM micrographs and size distributions for selenium nanoparticles synthesized by *Nerium oleander* extract at 200 nm magnification value



(B)- TEM micrographs and size distributions for selenium nanoparticles synthesized by *Azadirachta indica* extract at 200 nm magnification value



(C)- TEM micrographs and size distributions for selenium nanoparticles synthesized by *Cinnamomum camphora* extract at 200 nm magnification value

Fig.5. TEM micrographs of the selenium nanoparticles prepared from the extracted using the(A)*Nerium oleander,*(B) *Azadirachta indica* and (C) *Cinnamomum camphora.*

			Mean (mV)	Area (%)	St Dev (mV)
Zeta Potential (mV):	-11.1	Peak 1:	-11.1	100.0	3.94
Zeta Deviation (mV):	3.94	Peak 2:	0.00	0.0	0.00
Conductivity (mS/cm):	1.61	Peak 3:	0.00	0.0	0.00
Result quality :	Good				

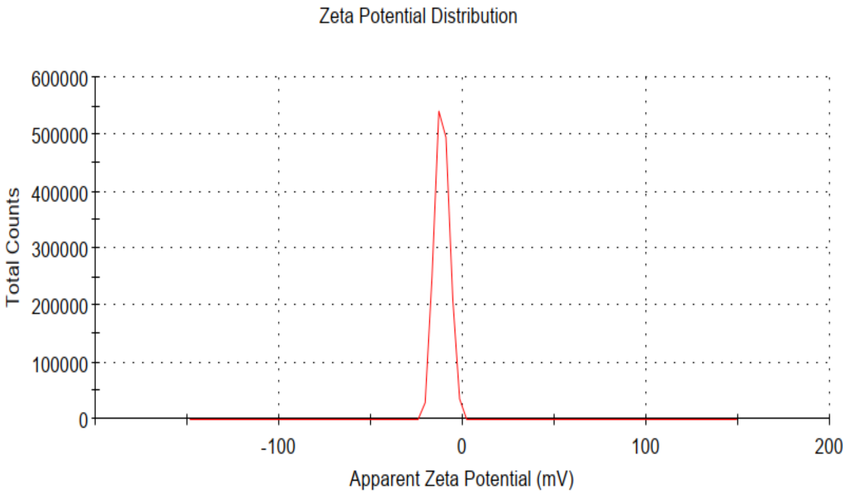


Fig.6a. Zeta potential of the nano selenium synthesized by *Nerium oleander* extract.

			Mean (mV)	Area (%)	St Dev (mV)
Zeta Potential (mV):	-23.0	Peak 1:	-23.0	100.0	4.68
Zeta Deviation (mV):	4.68	Peak 2:	0.00	0.0	0.00
Conductivity (mS/cm):	0.903	Peak 3:	0.00	0.0	0.00
Result quality :	Good				

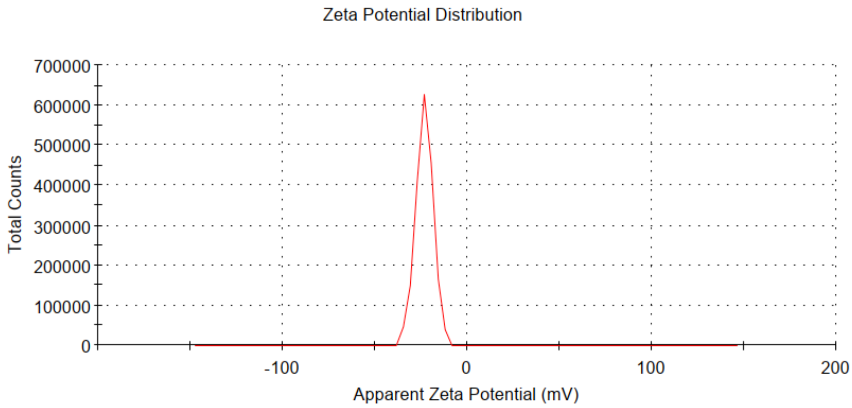


Fig.6 b. Zeta potential of the nano selenium synthesized by *Azadirachta indica* extract.

			Mean (mV)	Area (%)	St Dev (mV)
Zeta Potential (mV):	-12.5	Peak 1:	-12.5	100.0	5.45
Zeta Deviation (mV):	5.45	Peak 2:	0.00	0.0	0.00
Conductivity (mS/cm):	1.81	Peak 3:	0.00	0.0	0.00
Result quality :	Good				

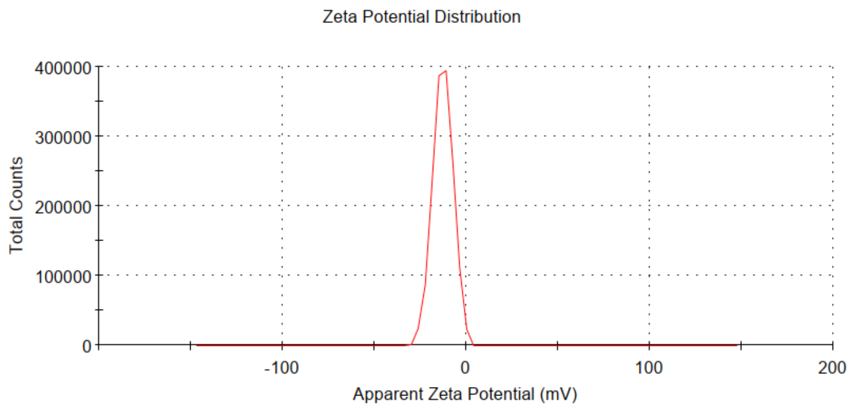


Fig.6c. Zeta potential of the nano selenium synthesized by *Cinnamomum camphora* extract.

Fig. (6a, b, and c).The samples have values at -11.1, -23.0 and -12.5 mV, with zeta deviations at 3.94, 4.86 and 5.45 mV, and conductivity at 1.61, 0.903 and 1.81 $mScm^{-1}$, for of *Nerium oleander, Azadirachta indica* and *Cinnamomum camphora* respectively, in which excellent stability of the particles complemented with zeta values larger than ±60 mV as specified by Honary and Zahir (2013).

Discover a new technique for green synthesis of stable metal nanoparticles, many scientific experiments have already been conducted to use many solvents of different polarity, from water to ether, including mixtures of solvents, with and without the operation of the magnetization unit of the solvent to extract many effective natural compounds from plants, various plant parts, medicinal herbs, food spices, algae, bi-products. for use in the bio-reduction of many metal salts such as silver, selenium, zinc, iron and copper instead of any artificial or chemical stabilizers such as polyvinyl alcohol (PVA), tripolyphosphate (TPP), polyacrilic acid (PAA), mercaptosuccinic acid (MSA), 3-mercaptopropionic acid (MPA), etc. Under various biosynthesis laboratory conditions to reach optimal conditions for biosynthesis from solvent, pH and temperature, as well as control the extraction time, reaction time and exposure to UV radiation.

Conclusions

The production of nano-fertilizers on the large-scale is of important issue for many countries, which already started to establish a such protocol. In the current report, a successful attempt for production many kinds of anno-fertilizers have been achieved through developing an apparatus can manufacturenano-products or nano-fertilizers. This apparatus could be considered as the nucleus of a factory on a production scale in large quantities. This apparatus can be also used for scientific research because its accurate that operates automatically to make tests for the synthesis of nanoparticles using plant or organic extracts and test many saline solutions for many elements. This system could also produce magnetic water that can use as a solvent for the saline solutions. This device can be developed to use in industry on a large scale to produce nanoparticles of many elements using plant extracts and in an automatic way of controlling time, heat, mixing and stirring. This work has opened many questions in the field of nano-fertilizers such as to what extent this apparatus can share in solving the global problem of mineral fertilizers by saving the sustainable nano-fertilizers?Is this device having the ability to produce all kinds of nano-fertilizers particularly "nano-nitrogen fertilizers"?Is the production of nano-fertilizers using this devise is economic and what about its efficiency?For answering these previous questions, further investigations including more nano-fertilizers will be published in the future with more details for different nutrients.

Ethics approval and consent to participate This article does not contain any studies with human participants or animals performed by any of the authors.

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