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Green Synthesis of Zn-Ag Nanocomposites via Tamarindus indica Leaf Extracts for Antimicrobial Applications

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Abstract: The Synthesis of mental oxide nanoparticles has emerged as a burge ongoing field of research due to it's promising applications in advance in technological frontiers. Particularly the utilization of biologically derived nano materials has gained significant traction with in realm of nano technology Tamarindus indica plant extract has demonstrated efficacy as a viable precursor for the synthesis of silver nano particles. Tamarindus indica being a locally abundant plant boasts a rich composition of essential amino acids and vitamins .This investigation presents the biosynthesis of mental oxide nano particles using an aqueous extract derived from Tamarindus indica

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INTRODUCTIONNanotechnology is a new and developing technology that has revolutionized every scientific sector. This technique is used in the fields of materials science, biomedicine, electronics, and optics. 1. Nanotechnology works with nanoparticles, which range in size from 1 nm to 100 nm. 2. Its auxiliary domain One of the finest fields for determining chemical activity at the atomic, molecular, and super molecular levels (size 1–100 nm) is nanochemistry. 3. It has several uses in a variety of industries, including electrical, agricultural, and medical. 4. Because of the many different applications for nanodrug delivery, nanomedicines are becoming more and more popular. 5. Due to its wide uses in a variety of sectors, including water treatment, cosmetics, medical, and engineering, to mention a few, metal and metal oxide nanoparticles have been the focus of much research in recent years 6. The nanosized materials have been a significant topic in the

area of applied and fundamental sciences. Since nanomaterials vary in size and form from bulk materials, their unique physicochemical characteristics have drawn a lot of interest. 9. Pharmaceuticals, medical devices, and energy systems (composite propellants) employ nanoparticles of aluminum to replace lead primers in artillery, among other applications. For instance, titanium dioxide nanoparticles are mostly used as photocatalysts and adsorbents in consumer goods like sunscreens, as well as catalysts in chemical engineering and sterilizing, whereas aluminum nanoparticles are employed in explosive combinations. 10. The antibacterial properties of certain metal oxides, such as ZnO and AgO, have been investigated by several organizations. One of the numerous multipurpose inorganic nanoparticles, Ag NPs have a wide variety of uses due to their intense UV and IR adsorption, strong antibacterial activity, and chemical and physical durability. 11. Because of their antibacterial qualities, silver and zinc oxide nanoparticles have been considered a potential means of preventing infectious disorders. 12. Particulate inorganic and organic matter have a significant impact on the behavior of dissolved metals in natural bodies of water. The ability to bind metallic ions from solution is present in hydrous metal oxides, clays, humic compounds, and biota.

13. Over the last several years, there has been a significant growth in the global awareness of medicinal plants. According to estimates from the World Health Organization (WHO), 80% of people in underdeveloped nations get their main medical treatment from traditional medicine, which mostly consists of plant-based medications. 14. The necessity to look for additional sources of antibiotics has been made even more urgent by the increasing prevalence of multidrug resistance in pathogenic bacteria. In traditional medicine, the plant Tamarindus indica is used to cure colds, fevers, stomach disorders, diarrhea, jaundice, and as a skin cleaner 15. Tamarindus indica is used to produce dawwa, or porridge, which is often taken during pregnancy and is a high source of zinc (16). Both gram-positive and gram-negative bacteria are susceptible to the wide range antibacterial action of Tamarindus indica extracts 17. Incorporate T. indicus activity into various extracts.

MATERIALS AND METHODS The botanical material was gathered in the Botanical Garden.

Mysore and verified at the University of Mysore's DOS in Botany. The culture media utilized in bacteriological investigations were acquired from HIMEDIA labs and included Zn (NO3) (99%, Sigma chemicals, India) and AgNO3 (99.9%, Sigma Aldrich, India).

Tamarindus indica plant extract preparation: After being repeatedly cleaned with distilled water and sliced into little pieces, 20g of leaf was put in an RB flask with 200mL of deionized water, heated for one hour at 60° C, and then allowed to cool to room temperature. After passing the extract through Whatmann no. 1 filter paper, a brownish aqueous extract was produced, which was then kept at 4°C to be used later to create the nanoparticles.

Creation of Ag-Doped and Pure Zinc Oxide Nanoparticles Using the Co-Precipitation Method: After stirring 30 milliliters of the aqueous plant extract for 30 minutes, the temperature reached 60 to 70 degrees Celsius. 3M zinc sulphate (0.1 ml) was added. The pH of the aforementioned solution was kept at 10 by adding 8 milliliters of NaOH while stirring constantly. At this stage, a white precipitate formed, which is thought to be the source of the pure compound (undoped ZnNPs). The precipitate was collected, centrifuged, the supernatant was removed, and the precipitate was cleaned with ethanol and water to get rid of impurities. The final sample was then dried in a hot air oven for 12 hours at 60 degrees Celsius. With a few slight adjustments, the same procedure was used to create the doped nanoparticle. In a nutshell, 30 milliliters of plant extract were collected and agitated till it reached 60 to 70 degrees Celsius. After adding 3M of zinc sulfate and 2mL of 0.05 M AgNO3, the mixture was constantly agitated, and NaOH was added to maintain the pH. It was seen that the hue changed to brown. The resulting precipitate was let to stand at room temperature. After removing the supernatant and repeatedly washing the precipitate with deionized water and then ethanol, the sample was dried in a hot air oven set at 60 degrees Celsius for 12 hours.

Description: At the University of Mysore's Centre for Material Science and Technology, synthesized pure ZnO and ZnO-Ag doped nanomaterials were studied. PXRD investigations were conducted utilizing the Rigaku smart lab-II, $2\theta = 10°–80°$, with a step size of 0.0001 deg and Cu Kα radiation at $\lambda = 0.154$ nm. external appearance and

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The Hitachi S-3400 N Scanning Electron Microscope with an associated EDS was used to determine the elemental composition. The surface functional groups were identified using a Perkin Elmer infrared spectrophotometer. Using a Microtrac Zeta analyzer, DLS was used to determine the produced nanoparticles' particle size. A UV-visible spectrophotometer was used to record the nanomaterials' diffuse reflectance UV-visible spectra (DRS).
Antibacterial Properties of Tamarindus indica's Pure and Ag-Doped ZnO Nanoparticles: Using antibiotic discs, the antibacterial activity of pure and Ag-doped zinc nanoparticles was assessed.

Diffusion test 18. Microbial type cell culture and gene banking (MTCC) provided the pure microbial culture. Bacillus subtilis (MTCC 441), Escherichia coli (MTCC 433), Pseudomonas aeruginosa (MTCC 1934), and Salmonella typhi (MTCC 98) were the microbes employed in this investigation.
MTCC 3160 Staphylococcus aureus 19.

RESULTS AND DISCUSSION:

Powder X-ray Diffraction Studies: The University of Mysore conducted the XRD analysis. X-ray diffraction (XRD) is primarily used to determine the intensity, average size, lattice parameters, and gain size in polycrystalline blocks.

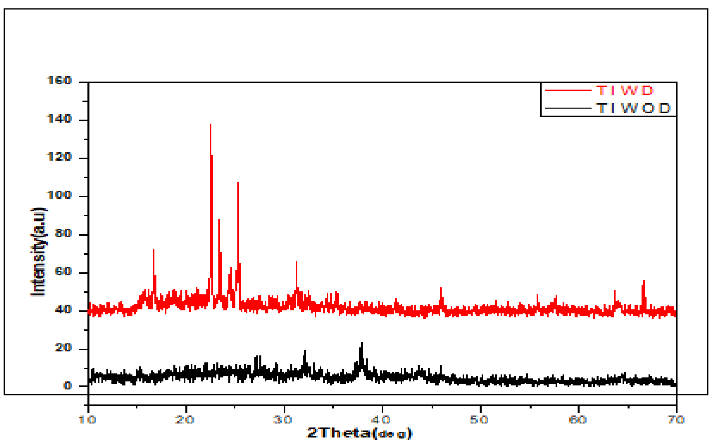

FIG. 1: CHARACTERISTIC SPECTRUM OF XRD PATTERN ANALYSIS OF *TAMARINDUS INDICA* PLANT WHICH CONTAINS BOTH DOPED AND UN-DOPED METAL OXIDE

Bragg's law was used to examine the graph above. The XRD pattern of the metal oxide that was generated from Tamarindus indica leaf extract is shown. It is evident from the AgO NPs diffraction peaks that the material is very crystalline. The step size of the sharp and thin diffraction peaks that show at around 2 is 0.02 and they begin at 10 and conclude at 70.

Particle size Determination using DLS:

Five seconds is the speed. The crystalline nature of the Pur Zn and Ag doped nanoparticle is shown by the diffraction peaks on the XRD graph. The pure Zn nanoparticle had a peak at 2θ angles of 15.39o, 27.64o, 32.2o, 32.23o, 37.95o, and 45.7o. Six diffraction peaks 20 are clearly seen in the peak above.

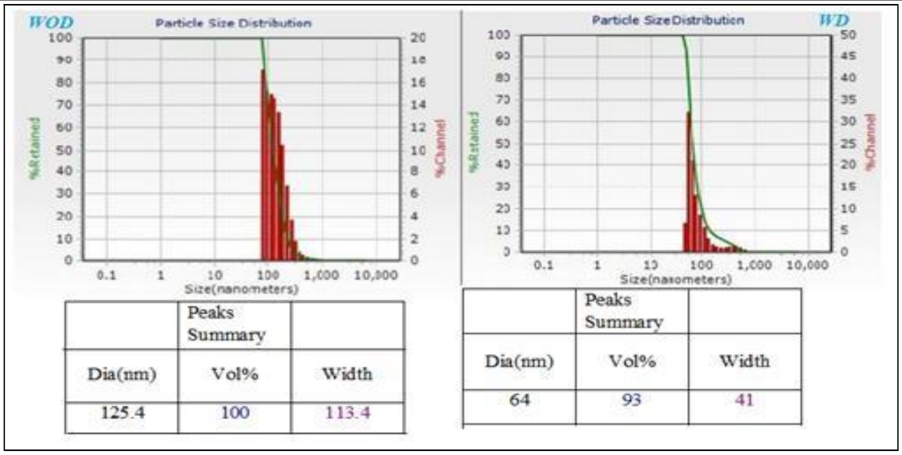

FIG. 2: CHARACTERISTIC SPECTRUM OF DYNAMIC LIGHT SCATTERING PATTERN OF *TAMARINDUS INDICA*

Scanning Electron Microscope:

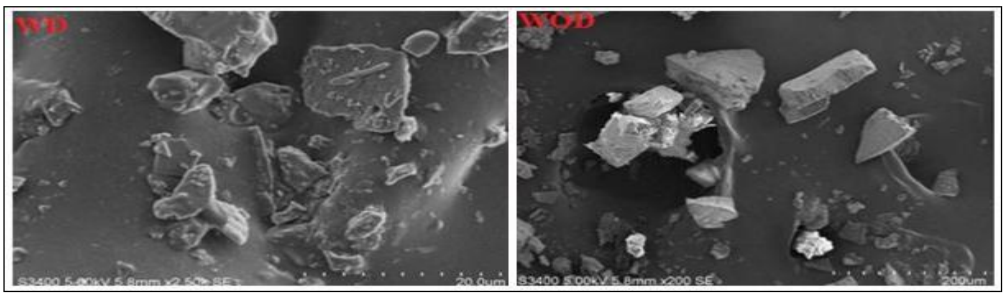

FIG. 3: CHARACTERISTIC SPECTRUMS OF SCANNING ELECTRON MICROSCOPE WERE WE INVESTIGATE THE ACHIEVABLE RESOLUTION OF BOTH DOPED UN-DOPED METAL OXIDE OF *TAMARINDUS INDICA*SEM analysis was used to examine the AgNPs' size and structure. Nanocrystals with a spherical form and somewhat well-dimensioned range of 200µm were found by SEM investigation. The Ag-Doped ZnO and ZnO

Eneregy Dispersive X-ray Studies:

The morphology of the nanoparticles reveals a spherical particle above the Zn nanoparticle and a rod-shaped ZnO.

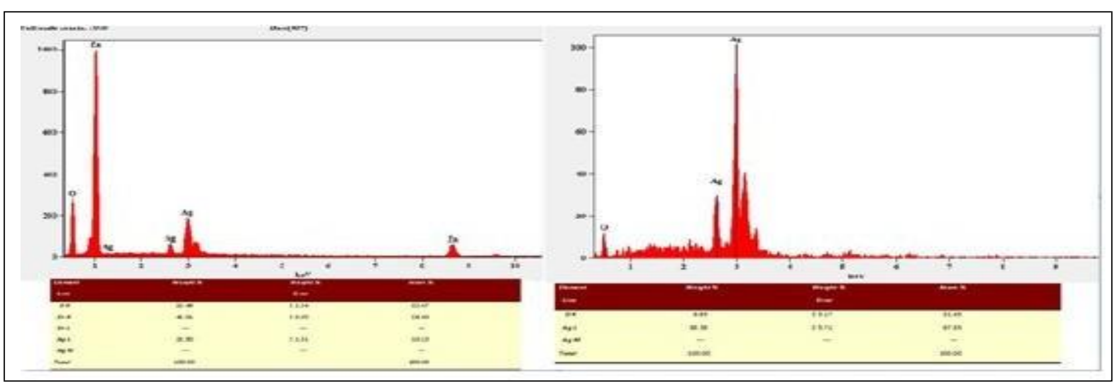

FIG. 4: CHARACTERISTIC SPECTRUM OF AN ENERGY DISPENSSIVE X-RAY SPECTROSCOPY ANALYSIS OF *TAMARINDUS INDICA* PLANT EXTRACT. THIS CONTAINS BOTH DOPED AND UN-DOPED METAL OXIDE

Antibacterial Activity
Disc Diffusion Method:

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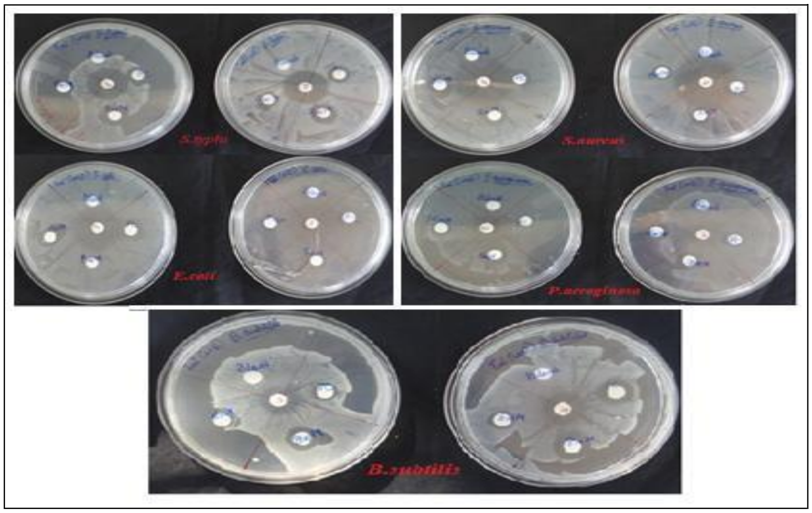

FIG. 5: ANTIBACTERIAL ACTIVITY OF DOPED AND UN-DOPED METAL OXIDE OF *TAMARINDUS INDICA.* ZOI AS OBSERVED IN *A. SALMONELLA* TYPHI, *B STAPHYLOCOCCUS AUREUS, C. ESCHERICHIA* COLI, *D. PSEUDOMONAS AERUGINOSA* AND *E. BACILLUS SUBTILIS*

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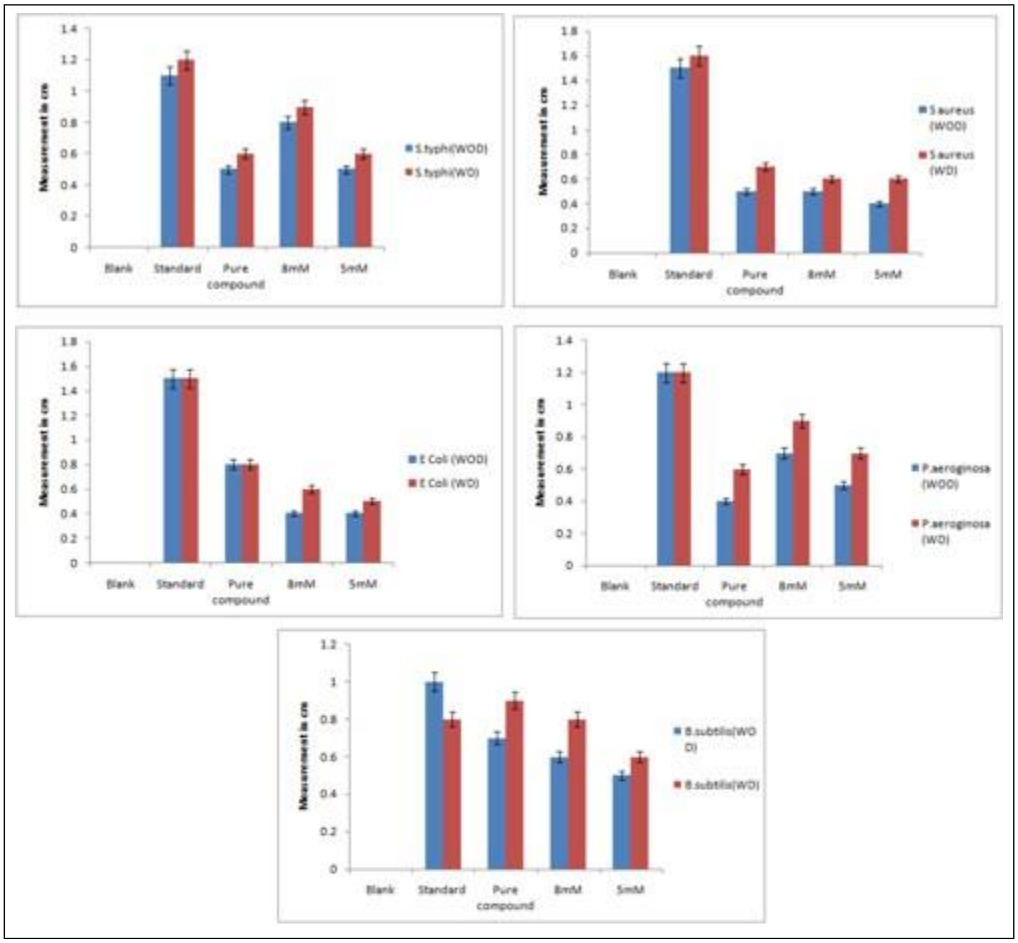

FIG. 6: EFFECT OF DOPED AND UN-DOPED METAL OXIDE OF *TAMARINDUS INDICA* ON SURVIVAL OF A. *SALMONELLA TYPHI,* B *STAPHYLOCOCCUS AUREUS,* C. *ESCHERICHIA COLI,* D. *PSEUDOMONAS AERUGINOSA* AND E. *BACILLUS SUBTILIS.*

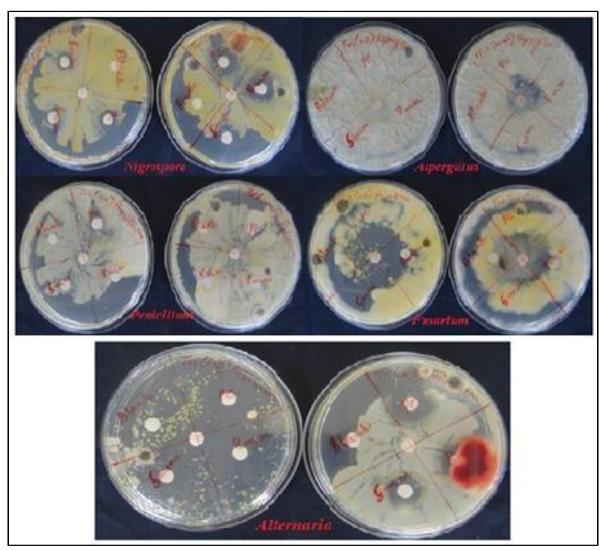

Figure 6 tests the antibacterial properties of Tamarindus indica's doped and un-doped metal oxide against S. typhi , B. subtilis, S. aureus, P. aeruginosa, and E. coli.

All examined bacterial strains were susceptible to the antibacterial effects of both doped and un-doped metal oxides. It was discovered that doped metal oxides have more bactericidal effects than un-doped metal oxides.

Salmonella typhi (9mm), Staphylococcus aureus (6mm), Escherichia coli (6mm), Pseudomonas aeruginosa (8mm), and Bacillus subtilis (10mm) all exhibited a notable zone of inhibition when exposed to Tamarindus indica doped metal oxides, whereas the zone of Salmonella typhi (6 mm), Staphylococcus aureus (4 mm), Escherichia coli (6 mm), Pseudomonas aeruginosa

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(8 mm), and Bacillus subtilis (10 mm) 5 showed reduced inhibition.

Antifungal Activity:

FIG. 7: ANTIFUNGAL ACTIVITY OF DOPED AND UN-DOPED METAL OXIDE OF *TAMARINDUS INDICA.* ZOI AS OBSERVED IN *A. NIGROSPORA, B. ASPERGILLUS, C. PENICILLIUM, D FUSARIUM* AND *E. ALTERNARIA* SPECIES

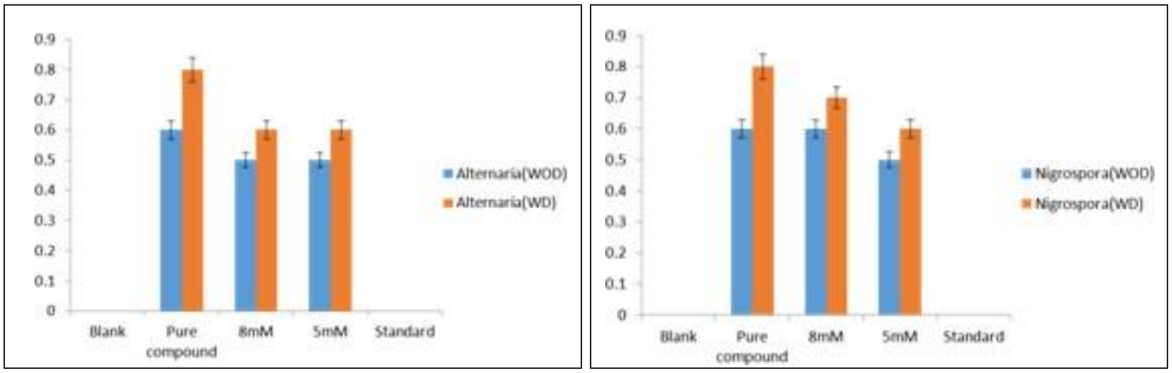

FIG. 8: GRAPHICAL REPRESENTATION OF THE EFFECT OF DOPED AND UN-DOPED METAL OXIDE OF *TAMARINDUS INDICA.* ZOI AS OBSERVED IN *A. NIGROSPORA, B. ASPERGILLUS, C. PENICILLIUM, D FUSARIUM* AND *E. ALTERNARIA* SPECIES

Figure 8 tests the antifungal properties of Tamarindus indica's doped and un-doped metal oxide against the species Nigrospora, Aspergillus, Penicillium, Fusarium, and Alternaria. Only Nigrospora and Alternaria species were susceptible to the antifungal effects of both doped and un-doped metal oxides. When compared to un-doped metal oxides, both doped metal oxides have superior antifungal activity.

CONCLUSION: The present work used the green technique of T. indica co-precipitation to manufacture Zn doped Ag nanoperticles. The size of Zn-doped synthesized nanoparticles was measured to be between 64 and 70 nm, whereas that of non-doped NPs was between 120 and 124 nm. Additional methods for characterizing the produced NPs included XRD, FTIR, SEM, TEM, EDX, AFM, and DLS. Both Gram-positive and Gram-negative bacteria have been shown to be susceptible to the antibacterial activity of the produced ZnO NPs. Salmonella typhi, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, and Bacillus subtilis were among the bacterial strains that were inhibited by the antibacterial activity of Ag-doped and undoped ZnO nanoparticles. by Doped metal oxides produced using Tamarindus indica exhibit more antibacterial activity than un-doped metal oxides, and their development was comparable to that produced using previous techniques. However, only strains of Nigrospora and Alternaria were susceptible to the antifungal effects of both doped and un-doped metal oxides; no impact was seen on other species that competed with commercial treatments that were even more effective than colloidal silver. Tamarindus indica-synthesised doped metal oxides have more antibacterial activity than un-doped metal oxides.

created from the Tamarindus indica plant. It would be interesting to examine the biocidal activity of the resulting nanoparticles and attempt the manufacture of AgNPs using pure flavonoids.

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