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Using Nanomaterials to Improve Water Desalination Processes or Purify Water from Pollution.

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ABSTRACT

Wastewater has taken a growing role as a global problem, in terms of both its increase and its treatment, recycling or reuse. Wastewater contains suspended and dissolved particles, hydrocarbons, various organic materials, and heavy metals. Reusing wastewater is impeded by the task of removing pollutants before it can flow into any natural body of water. Water treatment has been accomplished in several ways, including secondary materials, however, the manufacture of nanomaterials is expensive, and has the undesirable effect of metals, used in the manufacturing of most nanomaterials, such as silver, gold, etc. In this work, environmentally benign, low-cost natural nanomaterials were synthesized, and their efficacy in wastewater purification was evaluated by utilizing a natural nanomaterial derived from plant leaves. (Schanginia aegyptiaca).

The dried and ground leaf extract was centrifuged, filtered, and then dried. The resulting material was examined by Atomic Force Microscope (AFM) and X-ray Diffractometer (XRD) to ensure it was nanoscale and to determine the type, number, size, and properties of the resulting material. A 1:1 dilution of the secondary material was made, and the dissolved oxygen, pH, total dissolved solids (TDS), electrical conductivity (EC), salinity, and turbidity were calculated before and after adding wastewater for (15), 30, 45, and (60) minutes. Jar test experiments showed that the Nano-extract of the tartar plant showed the best removal of salts, EC, TDS, and turbidity, with a percentage of 82.61%, 80.48%, 80.60%, and 52.83%, respectively, after 60 minutes, while the function The acidity was unchanged, while the dissolved oxygen doubled to 121.80%. The results prove the possibility of manufacturing a natural nanomaterial that is easy to prepare, low-cost, and has a wastewater treatment effect.

KEYWORDS

Nanotechnology, Nanoscience, Control of atoms and molecules, Schanginia aegyptiaca

1. INTRODUCTION

Nanotechnology is the most significant development in the latter half of the twentieth century, according to all experts and researchers, as it captured the attention of all universities, institutes and scientific institutions. The most important and exciting areas in physics, chemistry, biology as well as many other fields is nanotechnology and it is currently at the forefront. This has brought great hope that in the near future technological changes will occur in many applications due to revolutions in science.

Consequently, in order to give a clear idea on this technology, we simplified the basic concepts and principles of nanotechnology and gave an explanation about the tools, using a scientific terms: nanoscience, nanotechnology and nanoscale, as well as its relevant history and the differences between the scientific terms of nanoscience, nanotechnology, and nanoscale. (We then mentioned nanoparticles and the ways to prepare them.) We then concluded by explaining why, and why so widely, people are interested in this technology, and why it will have the future (it will again!).

1-1 Basic Concepts in Nanotechnology

Thirty years ago, nanoscience and nanotechnology did not exist in universities, institutes, centers and others in scientific circles. Nevertheless, the philosophical and theoretical basis of nanoscience and nanotechnology, had been formed on the famous lecture by the famous physicist Richard Feynman called "There's ample space at the bottom," articulated during a notable assembly of the American Physical Society at the California Institute of Technology (Caltech) on December 29, 1959. This lecture, which foresaw the future of human technology, specifically in the field of the possibility of manipulating and controlling atoms and molecules individually, referred philosophically to the possibility of achieving precise devices and machines that he called "Nano-scale machines," which in turn will enable scientists to manufacture devices and machines that become smaller and smaller as this technology advances and when we reach the stage where we can control atoms and molecules individually.

In 1965, this great Nobel Prize winning scientist also stated that matter at the nanoscale, with a small number of atoms was behaving differently than when it is tangible in size. He also noted that one could develop a method for moving atoms and molecules independently for some time and eventually reaching the desired size. Many physical concepts change at these levels. For example, gravity becomes unimportant, surface tension and van der Waals attraction become more important. Scientific research on the specialization of matter on the nanoscale, he said, would have a radical influence on the life of man.

It is worth noting that Richard Feynman did not use the term "nanotechnology" to describe this future technology, but rather described it as the technology of directly controlling individual atoms and molecules. He said in Scientific American magazine, "The implication is that the principles of physics, as far as I can see, do not contradict each other."

The idea of controlling things atom by atom (and nanotechnology) will radically change our lives for the better. Machines and robots built atom by atom and no more than one micrometer in diameter will eliminate cancer cell by cell and store billions of bytes of information in a space no larger than the head of a pin.

The term ‘nanotechnology’ came into being in 1974, in a lecture given by a Japanese professor from Tokyo University of Science, where ‘nanotechnology’ was referred to mean micro machines. Speaking in his paper which was published at the Japan Society for Precision Engineering, he said nanotechnology depending on the process for separating, merging, and remaking materials at a single atom or molecule. Around this same time, many scientific concepts came out with one another in the scientific circles and the manual displacement of some metal atoms at the nanoscale, the idea of the quantum dots and the smaller than myriads of vessels that can be capturing one or even many of the electrons. In 1981, IBM scientist Gerd Binnig and Heinrich Rohrer invented the scanning tunneling microscope (or STM) in early 1981. This device images atoms, molecules, and structures at nanoscale with high resolving power. The two scientists were awarded the Nobel Prize in Physics in 1986 for their invention of this microscope, which led to a clear and significant boom in theoretical and practical research related to the analysis, study, and manufacture of nanostructures of many materials in many fields. In 1986, the term "nanotechnology" first appeared in scientific circles, after which Eric Drexler published his famous book "Engines of Formation: The Coming Age of Nanotechnology." After that, the term "Nanotechnology" took on a larger scope to include, in addition to the industrial handling of atoms and molecules, all dimensions of scientific production on both the theoretical and applied sides of materials with nanoscale dimensions, "nanomaterials," whose dimensions range from 0.1 nanometers (the atomic dimensions) to 100 nanometers (the nanoscale).

Several years later (in 1990), the physicist D.M. Eigler at IBM Laboratories succeeded in moving atoms using a scanning tunneling microscope (STM) by writing the first atomic message "I-B-M" consisting of 35 X e atoms on the surface of Ni (110). This treatment opened a new field for the possibility of assembling single atoms together, as well as building precise nanostructures using the STM device, and this led to a major scientific revolution in this technology.

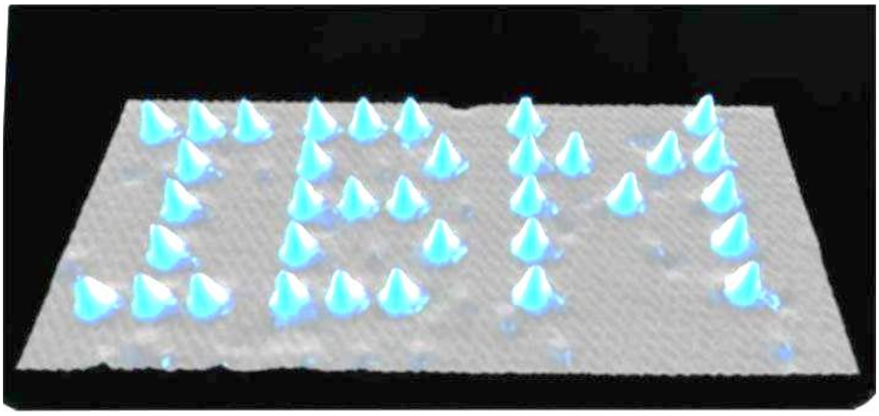


Figure (1-1): The first resulting atomic treatment by writing the messages I- B-M - consisting of 35 X e atoms on the surface of Ni (110) material.

1-2-1 Nanomaterial Manufacturing:

In the production of nanomaterials, diminutive size is not the paramount objective. Additional qualities and aspects pertain to nanomaterial manufacturers:

1 - Material size: The dimension is crucial when engaging with nanomaterials. For instance, when silicon nanoparticles measure 1 nanometer, they emit a blue hue; conversely, at 3 nanometers, they emit a red hue. This contrasts with materials in their natural condition, when size is insignificant and their characteristics remain same regardless of size.

2 - Material shape: The manufactured substance must possess a distinct, homogeneous configuration. When the configuration of the material alters, its characteristics transform.

3 - Dimension distribution: The dimensions of the manufactured material must be well aligned. Is the distribution uniform or non-uniform, and is it consistent or unstable?

4 - Material composition: The chemical composition of the synthesized nanomaterial must be uniform.

5 - Degree of agglomeration: Are they apart or in proximity? The nanomaterial must remain non-agglomerated. Should this occur, the material's qualities will alter.

There are two main methods for manufacturing nanomaterials, as follows:

A. **Top-down:** With this method, smaller forms are made from bigger ones by a step of eroding some parts to get smaller scales. Thus, it begins with a certain, tangible size of that material under study and decays in size until reaching the secondary scale.

B. **Bottom-up:** This is accomplished by assembling smaller components, such as individual atoms and molecules, to create a bigger and more intricate system. These procedures are predominantly chemical and are distinguished by the diminutive size of the results (one nanometer).

2-1- Applications of Nano industry in water purification:

Nano filtration is a novel membrane filtration technique frequently employed with low total dissolved solids (TDS) waters, including freshwater surface and groundwater, to separate and eliminate polyvalent ions of heavy metals such as excess iron and manganese, as well as to remove suspended matter from certain natural organic substances and synthetic organic compounds.

Nano filtration is also increasingly used in food industry applications, including dairy products and the demineralization process. According to the definition of Nano filtration, it involves the use of special membranes with pores around 2 nanometers. This distinguishes it from other types of filtration membranes used in ultrafiltration and micron filters to separate dissolved substances from a solution. These membranes follow the reverse osmosis method used in seawater desalination, i.e., separating dissolved salt from water, making it fresh. Reverse osmosis uses high pressures of up to 60 atmospheres.

Fine filters are used, and the pressures are low. The membrane materials are mostly used to water, where they are used when their thermal properties and stability are met. nano filtration is a type of technology, that is cross between ultrafiltration and reverse osmosis, where the pore size is about 2 nanometer Nano filtration membranes tend to be designated by what is referred to as the molecular weight cut off, not the size of a single pore. It usually has a molecular weight cut-off less than 100 atomic mass units. This limit is expressed in terms of the unit Dalton where the mass is the mass of 1 proton or 1 neutron. The pressure in secondary filtration is of about 3 MPa, which is much less than the pressured applied in reverse osmosis. This tremendously reduces the treatment cost. Nevertheless, scaling or increased sedimentation and filter cake formation (which increases the transit time of filtration) and fouling (the formation of fungal growth and rot) still affects the membranes of the Nano filter. Due to this, these membranes still use anti scalants and anti rot additives.

Water suitable for drinking and human use are scarce countries, such as many developing countries. But nanotechnology may hold a solution for this. Nano filtration is used to filter water sources from the presence of contaminants, and such filtration is also utilised in the process of desalination. As demonstrated in a recent study in South Africa, numerous experiments have been conducted using polymeric or polystyrene Nano filtration in combination with reverse osmosis for treating contaminated groundwater. By incorporating nutrients into the water, the researchers ultimately attained the requisite quantities of dissolved solids for drinking water in these experiments, resulting in the generation of drinkable water. It is noteworthy that implementing nanofiltration techniques in poor nations to enhance their access to safe drinking water is a cost-effective alternative to conventional water treatment systems. Despite the ability of many emerging nations to incorporate new technology into their economies independently, challenges such as elevated costs diminish their capability to pursue these initiatives.

2-2 Nanotechnology in Water Treatment:

This enables the production of novel nanomaterials through nanotechnology, which involves the manipulation of matter at the nanoscale (1-100 nanometers), applicable for the remediation of contaminated surface water, wastewater, and water affected by toxic metal ions, inorganic and organic compounds, and microorganisms. Consequently, several nanomaterials exhibiting significant efficacy against harmful contaminants are currently undergoing rigorous study and development for application in water treatment.

2-3 Schanginia aegyptiaca:

It is a genus of plants belonging to the Amaranthaceous family of the Caryophyllaceous order. It is an annual summer weed that reproduces by seeds and grows wild in lands affected by salinity . The stem is erect and branched from the base, hard, smooth, and free of hairs. The average plant height is 80 cm. The leaves are thread-like and scattered, green, without veins, fleshy in texture, juicy, and sour in taste. The flowers are green, clustered on the branches and stems. The seeds are small, black, and slightly hard. Among its ancient uses were as a medical disinfectant, as a hand wash after meals, and also as food for livestock.

Figure 2: A picture of the Schanginia aegyptiaca plant.

3- MATERIALS AND METHODS:

3-1 Preparation of the Nanomaterial Extract:

Schanginia aegyptiaca is a wild plant whose leaves were collected The leaves From the Rajiba area in Hindiya, Karbala, Iraq were rinsed several times with plain water and then with distilled water to brush out any dust. These were then air dried and oven dried at 60°C until constancy of weight. Next, they were ground in a German stainless steel grinder. The nanomaterial was extracted as 'Nano powder' (with researcheres extraction method), and were sieved through a 0.02 mm sieve. The nanomaterial was made into an aqueous solution with deionized water at a ratio of 1:1 and stored in the refrigerator until required.

Work was done in the Nano production laboratory in Mashhad, Iran.

3-2 Nanomaterial Examinations:

3-2-1 Atomic Force Microscopy (AFM):

Denotes a high-resolution imaging technology capable of analyzing minute variables or characteristics comparable to the dimensions of the atomic lattice in actual space. This method is typically referred to as a scanning probe microscope.

3-2-2 X-ray diffractometer (XRD) Examination:

The UV-vis spectrum demonstrates that atomic electrons absorb radiant energy and shift to elevated energy levels, exhibiting distinct characteristics in the absorption area of the spectrum.

The Chemistry Analysis Center (CAC) laboratory was engaged to perform tests on the plant extract to verify its nanoscale characteristics and to ascertain the kind, quantity, dimensions, and qualities of the resultant material.

3-3 Collection of wastewater samples:

Wastewater samples were collected treatment plant, from the main sedimentation tank.

From the heavy water treatment plant in Karbala, Iraq. Initial tests were performed on the water samples. A German-made WTW multi meter was used after calibrating it to measure pH, electrical conductivity (EC), salinity, and dissolved oxygen (DO). An EPA device was also used to measure WTW turbidity, made in Germany by the LaMotte nephology meter.

Table 1: Average values of initial tests for wastewater.

Tests	Values
Salinity	2.3mmols/cm
EC	4.35mmols/cm
TDS	2.78 mg/l
PH	7.98
O2	1.79 mg/l
Turbidity	26.8 NTU

4- RESULTS:

An efficacious nanomaterial was derived from the leaves of the Schanginia aegyptiaca plant. Tests were performed to verify the resultant material, its attributes, and its ancillary qualities.

4-1 XRD Test

The distinctive characteristics of the spectrum of reflected white light indicate that the electrons of the atoms absorb radiant energy and transition to higher energy levels. The chromophore, in which the part does cause a conformational change of the molecule in absorption region of biological molecules used to capture or detect the light energy. From Figure 3, from the results, it’s noted that the largest peak was given at the

The nano-copper level indicates that the material is nanoparticle-based, as seen by a distinct peak in the secondary copper absorption spectrum (Figure 3).

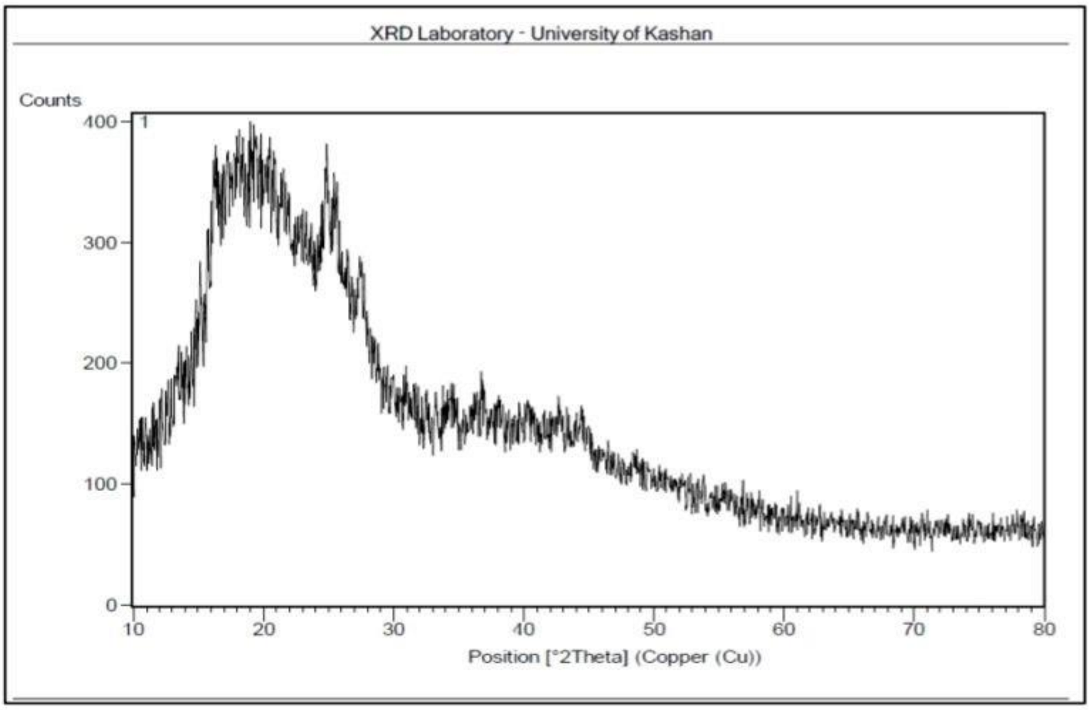


Figure 3 Identifying the active nanomaterial by XRD measurements of the nanomaterial

4-2-1 AFM Examination:

Atomic Force Microscopy (AFM) is a high-resolution imaging technology that functions in actual physical space and can examine features at the scale of atomic lattices. The scanning probe microscope is commonly designated by this approach. This microscope produces three-dimensional surface feature maps of the surface.

dimensional 3D Topographical Maps of Surface

1 - Nanomaterial Measurements:

In Figure 4, AFM measurement results of the three dimensional secondary material achieve the homogeneity. For Figures 5 and 6 in which show the particle heights of the secondary material as two and three dimensions, the value of the right most readout (38.2) nm was the highest. The lower and upper values of the size of the nanomaterial are stated. The plate shaped shape of the secondary material with a length of 0.783 nm and width of 12.9 nm, are results. The nanomaterial in use was from 20 nm to 30 nm frequency.

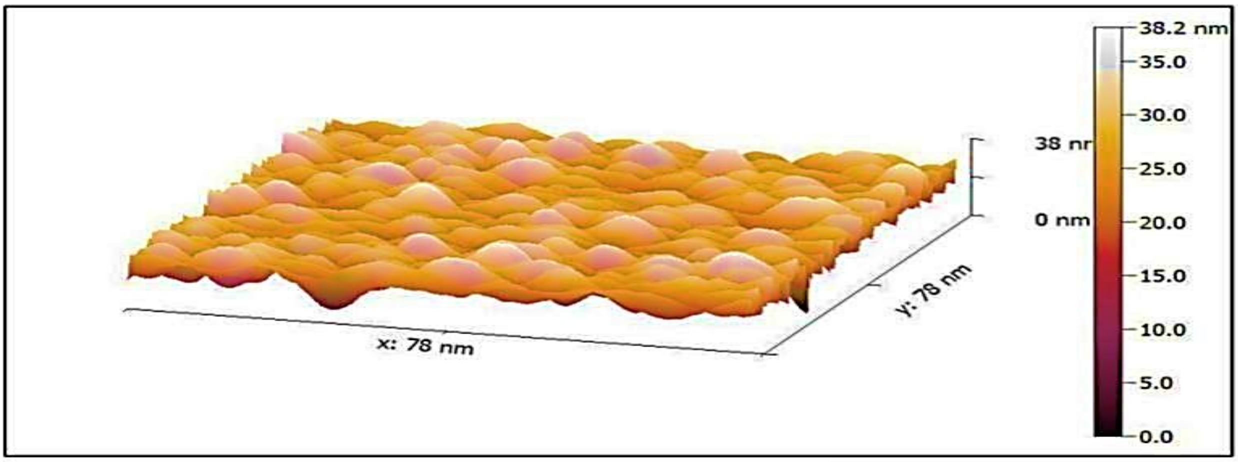


Figure 4. A 3D image of the secondary material using AFM

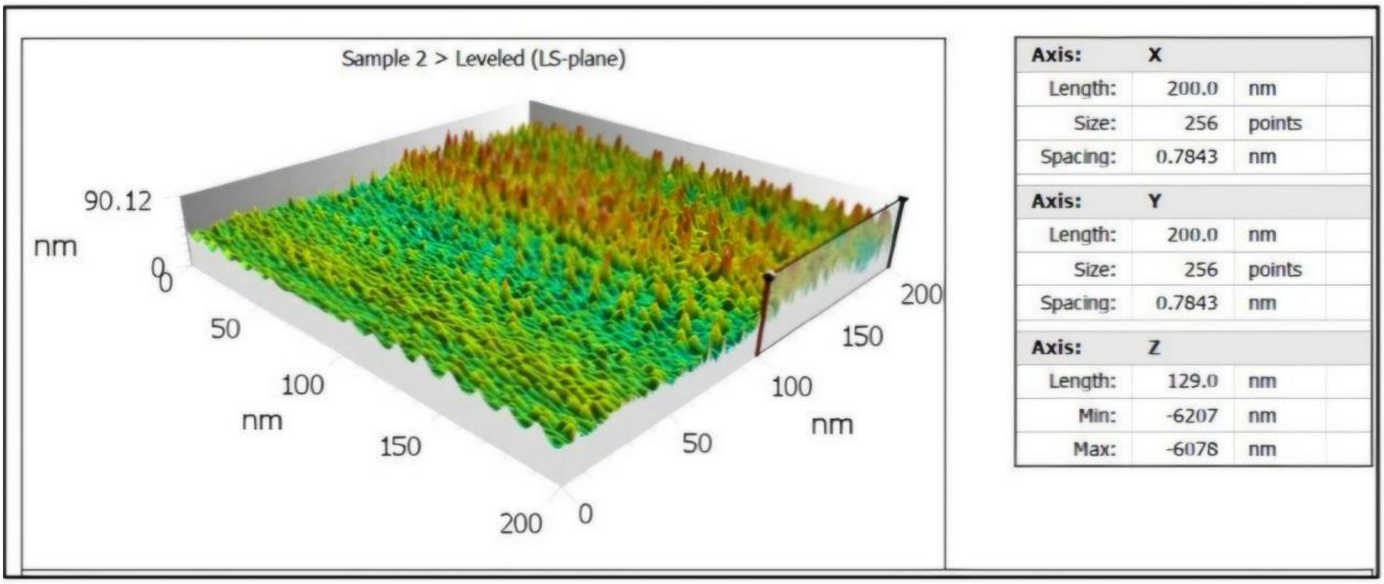


Figure 5: A two-dimensional image of the secondary material by AFM showing the lower and upper boundaries.

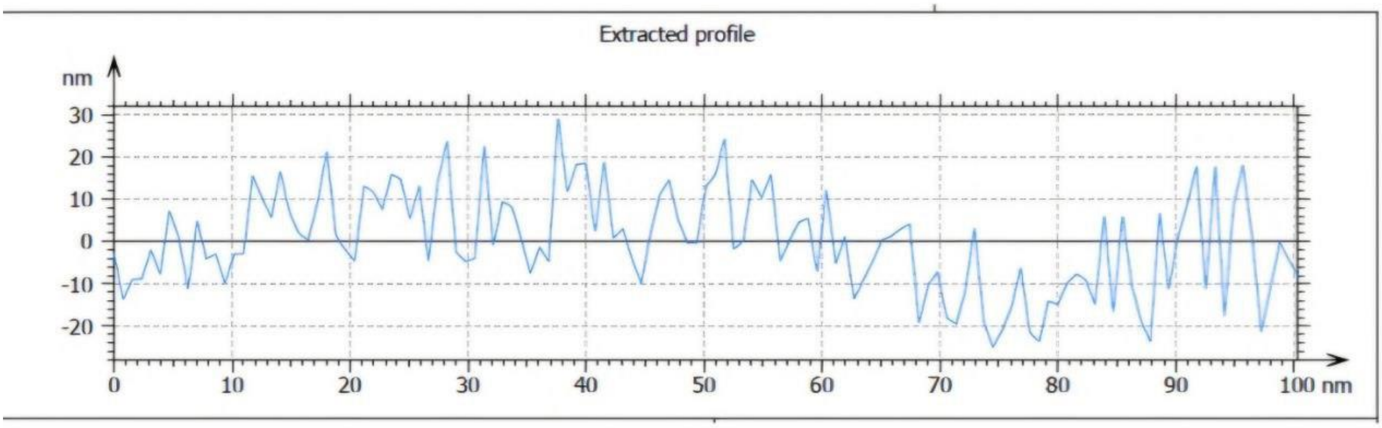
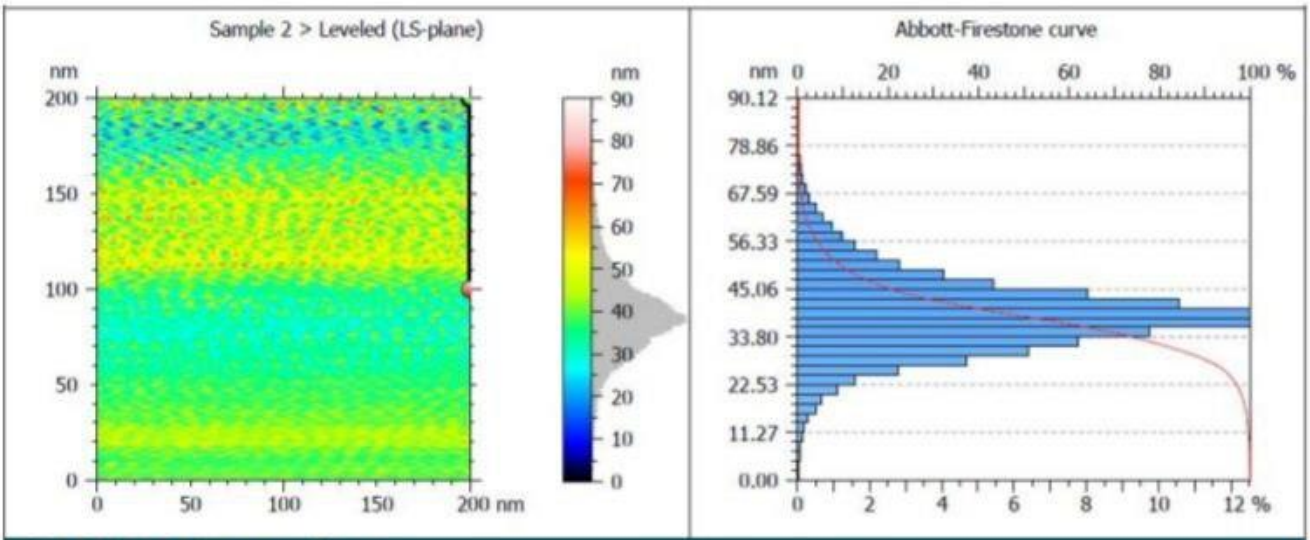


Figure 6: A 3D AFM image of the secondary material showing the secondary material sizes.

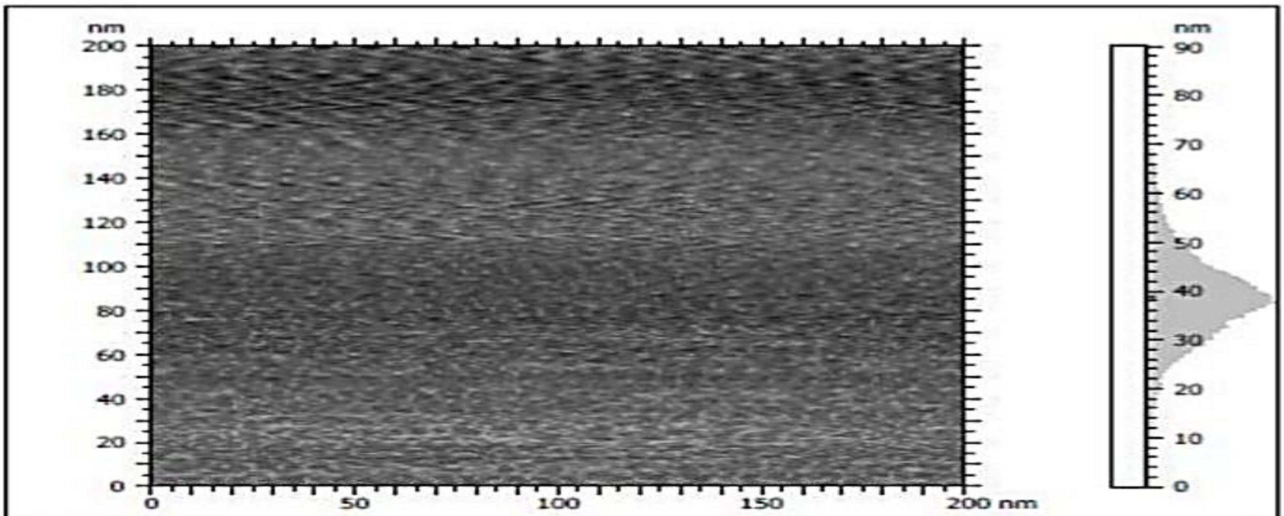
2. Secondary material size ratios and number of atoms:

The results of Figure 7 show the normal distribution of atom sizes, where the lowest size is 11.27 cubic nanometers, the highest size is 67.59 cubic nanometers, and the average size is 45.06 cubic nanometers. The distribution percentages of nanoparticle sizes are presented, correspondingly. The mean diameter of the secondary particles was 45.06 nm, with diameter distributions comprising 12% at 45 nm, 80% at 56.33 nm, and 8% at 22.56 nm, as seen in Figure 7. The majority of the nanoparticles have a size of 38.99 and a number of 782, which covers 46.86% and a density of 1.95 parts/square nanometer, Figures 9 and 10.



ISO 25178 - Primary surface			
Sq	9.168	nm	Root-mean-square height
Sz	90.12	nm	Maximum height
Sa	6.810	nm	Arithmetic mean height
Sdr	970.0	%	Developed interfacial area ratio

Figure 7. A 3D image of the secondary material using AFM showing the sizes of the nanomaterial.



Information		
Method	Threshold detection	
Threshold 1	38.99	nm
Number of particles	782	
Coverage	46.86	%
Density	1.955e+10	Particles/mm²

Parameters	Projected area	Z-maximum
Unit	nm²	nm
Particle #1	167.2	74.61
Particle #2	23.44	69.00
Particle #3	41.84	75.31
Particle #4	99.48	74.00
Particle #5	243.2	74.79
Particle #6	170.5	78.85
Mean	24.16	47.74

Figure 8. A 3D image of the secondary material using AFM showing the sizes of the nanomaterial.

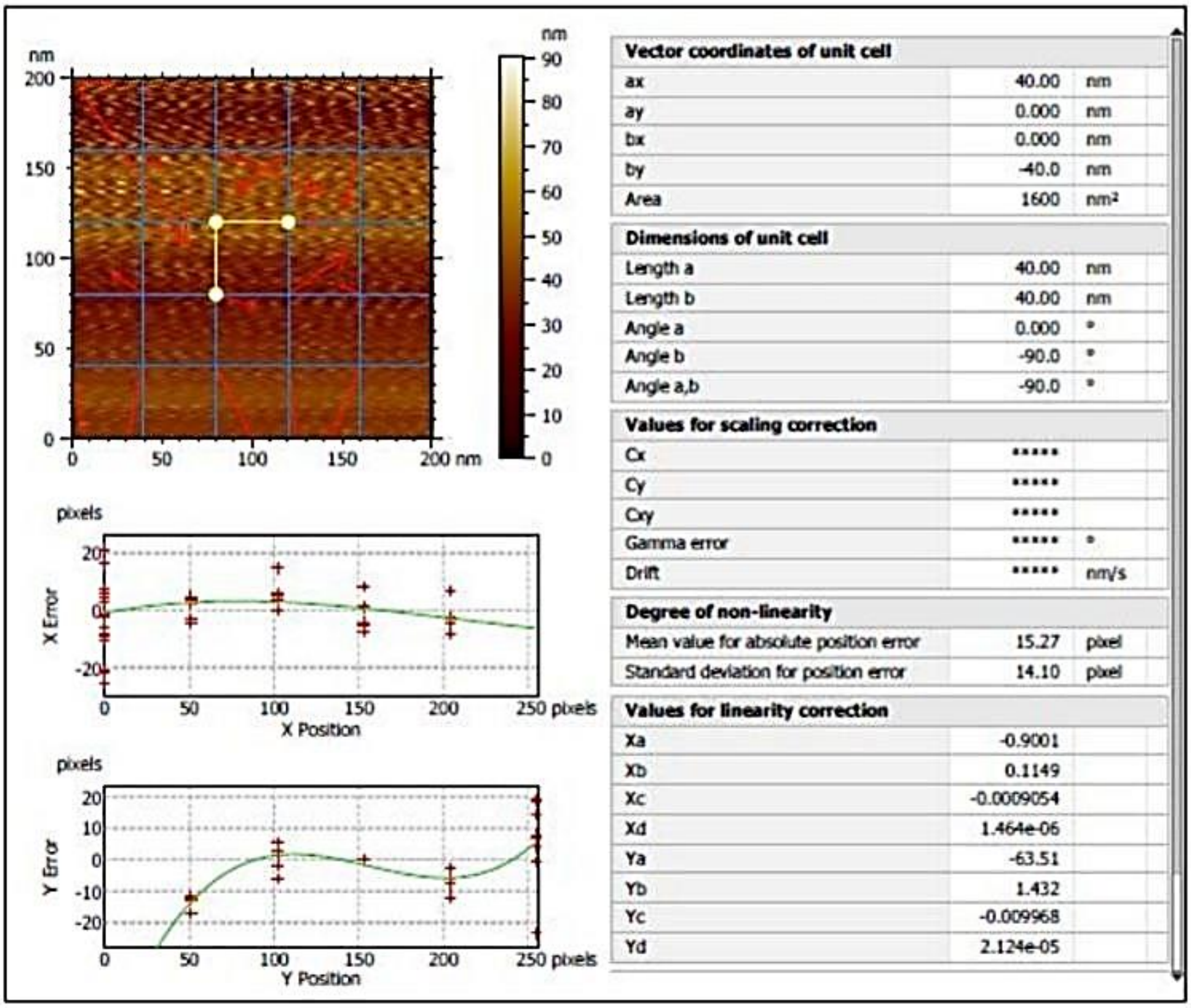


Figure 9: Particle distribution within the Nano sample.

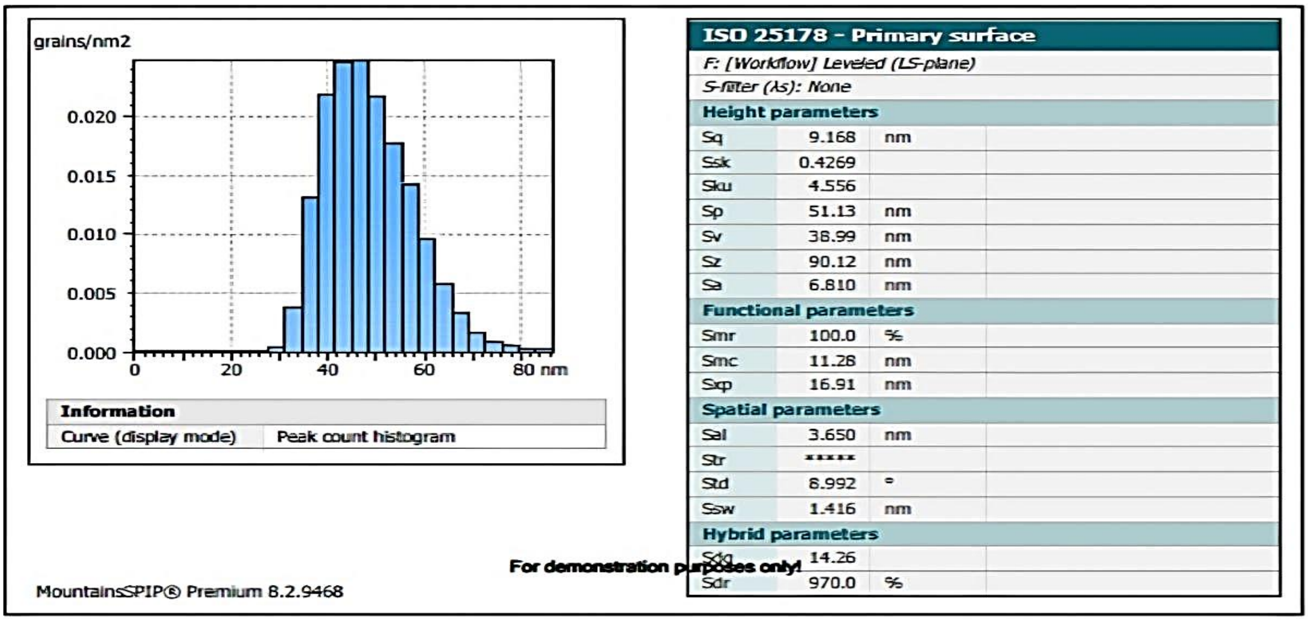


Figure 10: Peak count histogram: number of atoms per square nanometer and relative diameter distribution.

4-2-2 Application of the nanomaterial to wastewater purification:

Wastewater purification 15 minutes after adding the secondary material

The results of Table 2 show that the secondary material removed 34.78% of the salts, 37.71% of the electrical conductivity, and 37.78% of the total dissolved matter. The pH did not change much, and the dissolved oxygen value increased by 103.93%. However, the turbidity increased by 93.30%.

Table 2 Effect of the nanomaterial on wastewater purification 15 minutes after the test.

Parameter	Primary parameter	After adding	Reoval percentage%
Salinity(mmols/cm)	2.3	1.5	34.78
EC(mmols/cm)	4.36	2.72	37.71
TDS(mg/L)	2.79	1.74	37.78
PH	7.99	8.30	2.77
O_2 (mg/L)	1.80	3.70	103.93
(NTU) Turbidity	26.90	51.90	93.30

4-2-3- Wastewater purification 30 minutes after adding the secondary material:

The results of Table 3 show that the secondary material removed 56.09% of the salts, 65.06% of the electrical conductivity, and 73.40% of the total dissolved matter. The pH did not change much, and the dissolved oxygen value increased by 107.26%. Turbidity decreased by 32.10%.

Table 3: Effect of the secondary material on wastewater purification 30 minutes after the test.

Parameter	Primary parameter	After adding	Reoval percentage%
Salinity(mmols/cm)	2.3	1.01	56.09
EC(mmols/cm)	4.36	1.53	65.07
TDS(mg/L)	2.80	0.76	73.40
PH	7.99	7.10	11.29
O_2 (mg/L)	1.80	3.73	107.30
(NTU) Turbidity	26.90	18.30	32.10

4-2-4- Wastewater purification 45 minutes after adding the secondary material:

The results of Table 4 show that the secondary material removed 60.87% of the salts, 75.64% of the electrical conductivity, and 74.84% of the total dissolved matter. The pH decreased by 13.79% but remained within neutral, and the dissolved oxygen value increased by 119.60%. Turbidity decreased by 43.70%.

Table 4: Effect of the secondary material on wastewater purification 45 minutes after the test.

Parameter	Primary parameter	After adding	Reoval percentage%
Salinity(mmols/cm)	2.3	0.9	60.87
EC(mmols/cm)	4.36	1.07	75.64
TDS (mg/L)	2.80	0.71	74.84
PH	7.99	7.80	13.79
O_2 (mg/L)	1.80	3.95	119.60
(NTU) Turbidity	27.01	15.12	43.70

4-2-3- Wastewater purification 60 minutes after adding the secondary material.

The results of Table 5 show that the secondary material removed 82.61% of the salts, 80.48% of the electrical conductivity, and 80.60% of the total dissolved matter. The pH decreased by 4.14% but remained within neutral, and the dissolved oxygen value increased by 121.81%. Turbidity decreased by 52.83%

Table 5: Effect of nanomaterial on wastewater purification after 60 minutes of test.

parameter	Primary parameter	After adding	Reoval percentage%
Salinity (mmols/cm)	2.3	0.4	82.61
EC (mmols/cm)	4.36	0.87	80.48
TDS(mg/l)	2.80	0.57	80.60
PH	7.99	7.69	4.16
O_2 (mg/l)	1.80	3.99	121.81
(NTU) turbidity	26.90	12.68	52.83

CONCLUSIONS:

1. The potential of leaves of the Schanginia aegyptiaca plant for producing nanomaterials. The leaves of this plant are also a wild plant tolerant of stressful environmental conditions that accumulate salt within them. Such an application can be made on poorly drained soils, where water management in irrigation is poor, in agriculture due to soil depletion or excessive use of fertilizers, pesticides etc. or in purifying wastewater.
2. The experiment achieved reductions of 82.61% in salts, 80.48% in electrical conductivity, 80.60% in total dissolved solids, and 52.83% in turbidity, respectively.
3. The production of a natural, easily prepared, and economical secondary material might be highly beneficial in regions deficient in appropriate agricultural water resources. This is the method for mitigating wastewater risk and treating it prior to river discharge.

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