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Employing Nano-Titanium Dioxide Laser Coating in Local Materials used in Interior Spaces, Palm Leaves (Barhi) Model

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Abstract

Nanotechnology is considered one of the most important modern technologies used in interior design, which has contributed to improving the specifications of the materials used and their applications. The research problem can be summarized in the following question: What is the importance of employing nano-titanium dioxide laser coating in local materials used in interior spaces? The research aims to use nano-coating as a means to improve the specifications of palm leaves used in the interior designs of some traditional Iraqi homes and cafes. Given that titanium dioxide (Tio2) is a compound with good properties, being a non-toxic, cheap and stable substance in addition to having optical properties, titanium dioxide was used in this study to coat palm leaves (Barhi) and deposit them with different thicknesses by pulsed laser deposition, which is considered a deposition method. It is fast and suitable for producing homogeneous layers of different thicknesses on the materials to be coated. The results showed that the use of titanium oxide nanoparticles increased the resistance and durability of the paper compared to uncoated paper. Laser coating also contributed to controlling the thickness of the nano-coating layer.

Increasing the thickness of the nano-coating layer leads to an increase in the resistance of the Barhi palm leaf to the compressive forces applied to it. The maximum endurance strength of the leaf coated with titanium dioxide through the experiments of this research was (14 KN) with a nano-thickness of (195) nanometers.

Keywords: *local raw materials, nanotechnology, interior spaces.*

Introduction

As a result of the restrictions and limitations that the interior designer suffers from in using materials with traditional specifications, the need has become present to use modern technologies and employ them in interior design and provide opportunities for the designer to communicate his ideas, designs, and creativity without being bound by the specifications of the materials he uses, which imposed specific designs on him. Nano technologies have contributed greatly to Improving the specifications of materials included in the designs of interior spaces, including specifications (mechanical, physical, and chemical), as well as sensory specifications that are related to perception.

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The research aims to use nanoscale titanium dioxide to improve the specifications of local raw materials by adopting pulsed laser coating by depositing the nanomaterial on the surface of the used newspaper with different thicknesses. Titanium dioxide has specifications and properties that have increased its use in the field of environmental protection. It also possesses optical properties because it is affected by ultraviolet rays present in Sunlight, which stimulates it optically and causes it to interact with pollutants adhering to the surface and works to decompose them and thus remove them easily simply because rain falls on them, which increased its use in self-cleaning. The Barhi palm tree is considered one of the most important types of palm trees commonly used in the Iraqi atmosphere due to the quality of the dates produced from it. Therefore, it is It is grown in abundance in Iraq, which provides a local raw material (palm leaves.) in large quantities that requires research into improving its specifications and thus its use in interior spaces.

The research aims to introduce nanotechnology using titanium dioxide to improve the specifications of Iraqi Barhi palm leaves to activate its use in interior spaces.

Research problem and the need for it

1-1 Research problem: What is the importance of employing nano-titanium dioxide laser coating on local materials used in interior spaces?

1-2 The importance of the research: Employing the use of nanotechnology to paint the surface of Barhi palm leaves and improving its specifications by coating it with titanium dioxide nanoparticles for use in interior spaces.

1-3 Research objective: Improving the specifications of local raw materials by introducing nano-coating technology to the surfaces of Iraqi Barhi palm leaves.

1-4 Research limitations:

1- Objective limit: Employing nano titanium dioxide laser coating on local raw materials used in interior spaces (Barhi palm leaves) as an example.

2- Spatial limit: Iraq - Baghdad - University of Technology, Nano Research Center and Central Technical University, laboratories of the Technical College of Engineering

3-Time limits: 2022-2023

1-5 Definition of terms:

1- Local raw materials are sustainable natural raw materials before they are manufactured and can be obtained locally and vary according to the nature of the region and its environmental conditions (1)

2- Nanotechnology: It is a branch of science and technology that deals with materials and processes on the nanometer scale (one nanometer is equivalent to one millionth of a millimeter), in which materials and objects can be manufactured at the atomic and molecular level. The nanoscale includes dimensions of (1-100) in length.) nm

Applications of nanotechnology include many fields, such as medicine, electronics, energy, etc. Its importance lies in the fact that it provides the possibility of improving performance, reducing size and weight, and saving energy consumption in devices and products (2)

3- Interior spaces: It is a closed space separated from the outer space by a group of material elements and determinants that give the architecture its shape, define a part of the endless extended space, and establish the coordination of the closed space. These material elements determine the main general characteristics of the inner space, such as its area, height, and the style of its openness and closure. It is considered the basic unit in the interior design process that reflects a set of perceived and physically embodied

relationships that have a specific form and meaning, known as systems expressing functional, aesthetic, and psychological goals [3].

Basic concepts of nanotechnology

It is not known when humans first used the same substance. Nano size, and it is not possible to determine a specific era or age. for the emergence of nanotechnology, the concept of nanotechnology was used for the first time in 1876 AD when the physicist James Clerk Maxwell conducted a mental experiment called "Maxwell's Demon". An idea was born. Controlling the movement of atoms and molecules. He was followed by the scientist Richard Fehman in 1959, when he said, "...that matter at nanoscale levels and with a small number of atoms...behaves differently from its state when it is at a tangible size." In 1974, the name nanotechnology appeared through the definition of the Japanese scientist Norio Taniguchi. Norio Taniguchi said: "Nanotechnology is based on the processes of separation, fusion, and reshaping of materials using a single atom or molecule." Discoveries continued and interest in nanotechnology research increased, and new devices were discovered that helped in the development of the spread of nanotechnology and its entry into all areas of life. In 2000, the United States of America announced the National Nanotechnology Initiative (NNI), which made nanotechnology a national strategic technology. In 2003, the secrets of this technology and its control over the world of nanomaterials were discovered [4].

Nano concept

The term "nano" is derived from the Greek word Nanos, which means dwarf. It is defined as a precise and extremely small metric unit equivalent to one thousandth of a millionth of a meter, which is equivalent to ten times. The unit of atomic measurement known as the angstrom, which can only be seen under an electron microscope. This unit is used to express the dimensions of the diameters and measures of atoms and molecules of composite materials and microscopic particles such as bacteria and viruses [2].

Nanomaterials:

It is a distinct category of advanced materials that can be produced such that their dimensional scales or the dimensions of their internal grains range between 1-100 nanometers, and they may be natural or manufactured organic or inorganic materials. These materials behave differently from traditional materials [4].

Properties of nanomaterials:

a. The relative increase in surface area. Nanomaterials have a larger surface area when compared to the same materials in a larger area. This makes the materials more chemically active and affects their strength or electrical properties. Nano materials have become used as catalysts.

b. Quantum effects: They begin to control the behavior of matter in the nanoscale, because these materials are no longer subject to the laws of classical physics due to their small dimensions that are close to atomic dimensions. Therefore, they are subject to the laws of quantum physics, which is reflected in their properties. Among them are the ability to change color, transparency, great hardness, and great ability to conduct and insulate. [5]

Interior design and nanotechnology

The entry of nanotechnology into the field of architecture and interior design has given wide freedoms and opened a door for architects and designers who seek to innovate and overcome architectural and design problems through two main methods:

a . Material Design for the Architect and Interior Designer (Nanomaterials)

This term refers to the ability of architects and designers to access molecules and control the shape of materials, which provide a huge amount of building materials to deal with and control their properties to produce nanomaterials, in addition to the possibility of integrating the building's load-bearing structure with the external and internal walls, which affects the decisions of architects. And designers and their design choices, and also gives new horizons to implementers in achieving everything that was impossible [6]

B. Nano devices and tools in interior design

Nano technology in architecture and interior design provides new nano devices that enable building elements to transform it into a building with a facade with the ability to transform the building so that it has the ability to sense the surrounding environment and output data to provide a response between internal spaces and external conditions, in addition to simulating living systems, producing Designs that interact better with human senses[6]

Nano interior design

Nano interior design is the merging of nanotechnology with interior design by affecting architectural and design methods and materials to produce interactive spaces for the environment surrounding humans. Nanotechnology offers a number of applications in architecture and decoration by changing the way architects and interior designers think about the shapes of interior spaces. Nano-based interior design for raw materials and materials depends on the following:

A- Natural raw materials and materials: They are natural materials coated with nano-membranes to maintain their natural shape and color without being affected by surrounding weather factors.

B- Raw materials and manufactured materials that are manufactured with specifications similar to those of natural materials using modern technologies such as nanotechnology to obtain these specifications [7]

The impact of nanotechnology on interior design products

Nano technology has contributed to facilitating the task of the interior designer to develop his design ideas and choose materials with much better specifications than traditional materials. This has allowed the interior designer to easily deal with materials of various required specifications and at low cost. It has paved the way for design ideas and innovations without the restrictions and limitations imposed by the use of traditional materials, and trends can be identified. General Nanotechnology in the field of interior design includes:

The first trend is changing the architectural and design thinking of the interior space: where the architect and interior designer now choose the building materials that he will rely on in his design before starting to plan his project, and they cooperate with the builders to produce materials that serve his design, which works to remove the obstacles facing the interior designer's thought [6].

The second trend is the emergence of new architectural forms and space features:

Nanotechnology applications were integrated, resulting in an architectural form and interior space, which was achieved through:

- Flexible, lively and high-rise architectural forms
- Design shapes and interior spaces characterized by high dynamism
- Future biological architectural forms that harmonize nature and man [6]

Properties and disadvantages of palm leaves

For the purpose of using local materials and palm leaves in particular, the properties of the palm leaves should be known. To contribute to diagnosing the possibility of improving its specifications, allowing the designer to benefit from these specifications and the possibility of improving them to obtain a better design, we list below some important properties of the palm leaves and for the purpose of identifying the properties of the leaves. Its specifications must be identified and compared with the types of wood used in interior design. Given the widespread use of beech wood, we list below some of the physical properties of the leaf, compared to beech wood.

Physical properties of palm leaves[8]

Specific weight

The specific gravity of palm leaves of different types ranges from (0.51) to (0.79) with an average of (0.66). The corresponding value for beech wood was (0.65).

Bending tests:

The value of the modulus of elasticity in bending for all types tested ranged between (1185) to (1514) kN/cm2.

While the value of the modulus of fracture in bending was approximately 14 kN/cm2, while in beech wood it was 13.7 kN/cm2.

Compressive resistance tests

The resistance value of palm leaf samples to compressive stresses ranged between 4.6 kN/cm2 to 8.9 kN/cm2, and the corresponding value for beech wood was 7.4 kN/cm2

Resistance of palm leaf samples to tensile stresses

The resistance value of palm leaf samples to tensile stresses ranged from 4.8 to 11.3 kN/cm2, and the corresponding value for beech wood was 9.7 kN/cm2.

The most important disadvantages of the grain material:

Palm trees are always affected by many pests, the most important of which is the red palm weevil, or what is called (the palm leaf borer), which makes it fragile and easy to break and fragment. To protect it, it is treated with a solution consisting of 3 cm pesticide per liter of kerosene.

It is infected with some types of fungi and parasites that lead to its rotting

Wood and palm leaf material

The wood of the date palm tree is one of the important organic materials in the marshes region, as this tree is one of the perennial trees that has been found since ancient times in the Mesopotamia region. Its wooden parts have been used in construction and various craft industries, including the manufacture of beds, seating chairs, and mats woven from the palm fronds that it uses. Local residents use it in covering floors and other crafts that they use in their livelihood, in addition to the fact that its fruits are an important food substance, and the most important chemical components of its stem are cellulose and hemi-cellulose, and what remains is lignin and other compounds.

The practical side

Due to the widespread cultivation of the Barhi palm tree in Iraq and the wide availability of its raw materials in various regions of Iraq, especially the southern ones, samples of Iraqi Barhi palm leaf raw materials were selected in this research.

The samples were examined to determine their chemical compositions, and Table (1) shows the components of the sand

Table (1) shows the components of Barhi palm leaves (results from the Department of Agricultural Research / Ministry of Science and Technology)

Sample number	Sample type	Humidity%	Fats%	Fibers%	ash%	Nitrogen%	Protein%
1	Palm leaves	8.32	1.196	45.31	1.33	0.8253	5.1583
2	Palm leaves	17.26	1.200	55.60	1.82	0.6354	4.0225
3	Palm leaves	10.75	1.084	40.20	0.96	1.0218	6.3868

The results showed a high percentage of fibers compared to the rest of the components. It is also noted that there is a relative difference between the three samples, as these samples were chosen from different Barhi palm trees and in different regions, and the results are considered relatively acceptable. For the purpose of preparing the palm tree samples according to the required sizes and coating them with the nanomaterial, the samples were cut into cylindrical shapes. Diameter (20 mm) and length (20.40 mm).

Preparation of nanomaterial

In this research, the material (nano-titanium dioxide) (Tio2) was used, manufactured by Changsha Santech Company, with a purity of (99.8%) and a rate of (nm5+30). The nanopowder was placed after weighing it with a sensitive balance with a high accuracy of up to (0.001) grams to obtain a weight of (3.5) grams, with allowances for increases and decreases of (0.005) grams, where the powder is then compressed with a pressure of (490 bar) for five minutes to ensure the consistency of the powder and to obtain cylindrical samples with a diameter of (20 mm) and a length of (20 mm). Figure (1) shows the piston used for pressing Nanoscale samples.

(A) shows the configuration and weight of the nanomaterial (photo by the researchers)

(B) shows the compression of the nanomaterial to the required dimensions (photo by the researchers)

Laser device used:

The Q-Switched Nd-YAG Laser device, shown in Figure (2), deposits the nanomaterial on samples of Barhi palm leaves for the purpose of coating them.

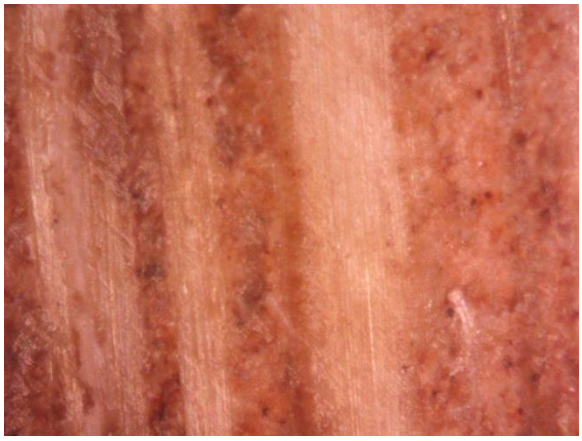
Figure (2) shows the laser device used (Q-Switched Nd-YAG Laser) (Photo by the researchers)

In this device, the laser pulse energy can be changed from (196 to 1000) millijoules, with a pulse repetition rate from (1 to 6) Hz, with a basic wavelength of (1064) nanometers, and using a local size of the nozzle head of the laser radiation arm (1) mm. The variables can also be controlled according to For the experiment to be conducted. The nanomaterial is deposited on the newspaper samples in a container designated for this purpose, emptied of air, and connected to the laser device. The laser system is outside the vacuum container. The vacuum container is also connected to a special pump through which the air flow is controlled and emptied.

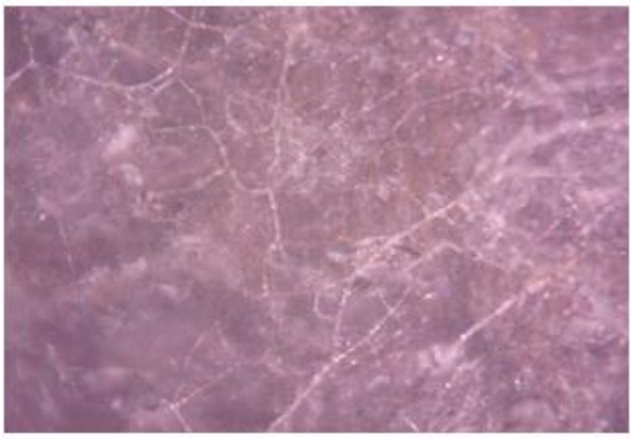
Nano coating of palm leaves

The palm leaf sample is placed on the substrate designated for it and at a distance of (2) cm from the nanomaterial, which in turn is placed in the mold designated for it and in the vacuum chamber at an angle of inclination of (45) degrees to ensure the effectiveness of the laser beam on it. Then the vacuum chamber is closed, the vacuum pump is turned on to obtain a vacuum of air, the required variables are determined in the laser device, and the laser beam is turned on and projected onto the nanomaterial.

When the nanomaterial is ionized, it rises and deposits on the surface of the paper. After the deposition process is completed, the rays, the laser device, and the vacuum pump are turned off, and the coated sample is extracted. The previous steps are repeated to obtain models coated with different paints and according to the required thickness. Figure (3) shows the microscopic structure before and after using the nanomaterial.



A Shows a microscopic image of a Barhi palm tree before it was coated with the nanomaterial



B shows a microscopic image of a Barhi Barhi palm leaf after titanium dioxide coating

Increasing the effect of the laser beam incident on the nanomaterial leads to an increase in the amount of nanomaterial removed, as its deposition on the newspaper samples increases, which means an increase in the thickness of the nano-coating on the samples. It has been found that changing the wavelengths of the laser and the pulses of the laser device used (Rami Salar) clearly affects the thickness. Nanomaterial: As the pulses of the laser device increase, the rate of separation of the nanomaterial increases, and thus the rate of its deposition on the newspaper samples and the thickness of the paint layer. The pulses of the laser device were changed by (200, 250, 350) pulses, with the wavelength used constant (532) nanometers, and a laser power per unit area of (237.47). Joules/cm The results were as shown in Table (2).

Table No. (2) shows the change in thickness with a change in the number of pulses and with a constant wavelength and laser power

Sample number	Number of pulses	Thickness (nm)
1	200	125
2	250	160
3	300	195

Results and discussion

Experiments were conducted to compare the resistance of the paper coated with titanium dioxide nanoparticles to the uncoated paper, and the pressure device shown in Figure (3) was used.

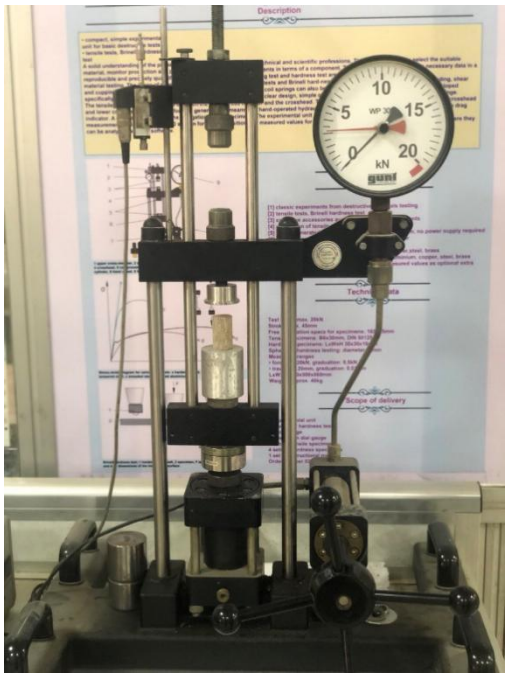


Figure (3) shows the pressure device used to measure the resistance of the newspaper samples used (photo by the researchers)

The results showed that the coated palm leaf has a higher compressive resistance than the uncoated palm leaf, as the nanomaterial, as a result of its interaction with the surface particles of the leaf, contributed to preventing the leaf particles from being subjected to the applied compressive force and gave them greater resistance. The results also showed that by increasing the thickness of the nano-material, the resistance of the leaf increases. The reason for this is that increasing the thickness allows the nanomaterial to homogenize and penetrate better than a smaller thickness, and thus gives the leaf a greater ability to resist the compressive force applied to it. The results obtained and shown in Table (3) and Figure (4) show that the highest compressive strength of the sample is not The coating before failure was (8.51 KN), shown in Table (1-3) and the curve is Figure (1-5), while the highest resistance of the thickness (125 nm) was (9.7 KN), shown in Table (2-3) and Figure (2-5). The thickness (160) nanometers is (10.64 KN), shown in Table (3-3) and Figure (3-5), and the thickness (195) nanometers is (14 KN), shown in Table (4-3) and Figure (4-5).

Table (3) shows the resistance of palm leaf samples coated with nanomaterial and uncoated with different thicknesses

1		2		3		4	
Displacement(mm)	Force (kn)	Displacement(mm)	Force (kn)	Displacement(mm)	Force (kn)	Displacement(mm)	Force (kn)
0	0	0	0	0	0	0	0
0.29	0.71	0.31	0.8	0.75	0.91	0.64	1.1
0.45	1.48	0.5	1.6	0.89	2.49	0.71	2.55
0.58	2.45	0.7	2.55	0.96	4.35	0.8	4.51
0.69	3.47	0.8	4	1	5.39	0.85	5.51
0.78	4.28	0.81	4.31	1.1	7.32	0.92	7.4
0.92	5.53	1	7.3	1.22	8.44	1	8.65
1	6.33	1.45	9	1.38	9.6	1.3	11.5
1.16	7.07	1.5	9.3	1.71	10.71	1.65	14
1.31	7.86	1.7	9.6	2.76	10.32	2.69	13.6
1.94	8.36	1.98	9.65	3.35	10.64	3.27	13.45
2.72	8.43	2.8	9.7	4.54	10.54	4.47	13.1
3.55	8.51	3.62	9.4	5.54	10.33	4.51	12.8
4.44	8.37	4.6	9.1	5.78	9.26	5.7	12.3
4.71	7.5	4.8	8.95	5.8	8.25	5.75	12
4.83	6.73	4.93	7.5				

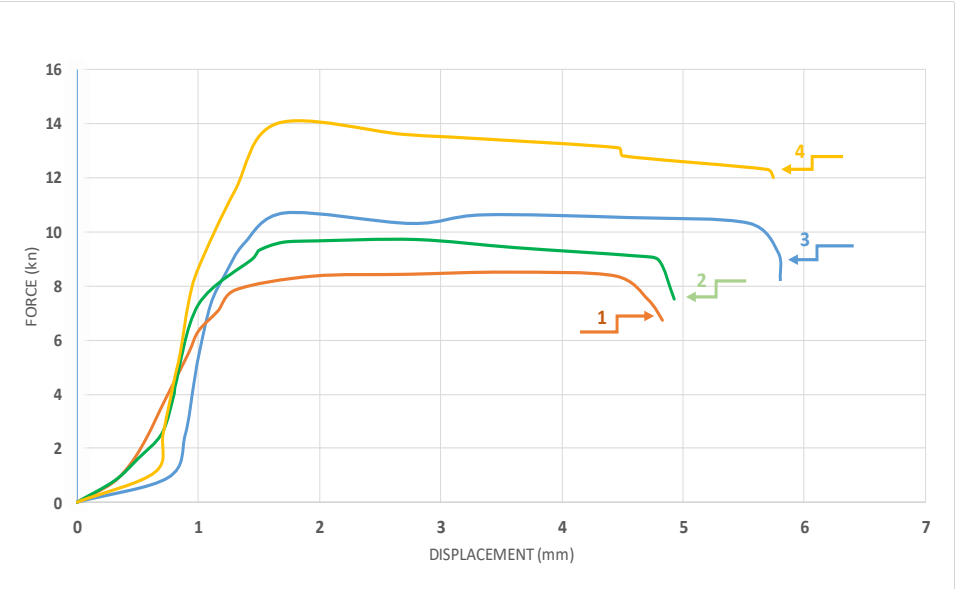


Figure (5) shows the effect of the thickness of the nano-layer (titanium dioxide) on the amount of applied pressure force

The results showed that the use of nanomaterial to paint the leaves of Barhi palm trees has increased the durability and resistance of the leaves to the pressure placed on them, in addition to the fact that this material is characterized by its transparency, which allows the interior designer to obtain the same color, aesthetics, and specificity of the leaves and improve its specifications that the designer needs in setting the appropriate visions for his design. The results also showed that Increasing the thickness increases the resistance and durability of the paper to the force applied to it. The reason for this is that increasing the thickness creates a more homogeneous nano-coating layer that overlaps with the surface layer of the paper, which increases its resistance to the pressure applied to it.

Conclusions

1- The results showed that the use of laser coating of Barhi palm leaves, using titanium oxide nano-material, increased the resistance and durability of the leaf compared to uncoated leaves. Laser coating also contributed to controlling the thickness of the nano-coating layer.

2- Increasing the thickness of the nano-coating layer leads to an increase in the resistance of the Barhi palm leaf to the pressure forces applied to it. The maximum endurance strength of the leaf coated with titanium dioxide through the experiments of this research was (14 KN) with a nano-thickness of (195) nanometers.

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