

## Low-Emission Interior Design Using Nanotechnology Treated Ropes

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### **ABSTRACT:**

Low-emission design is the latest topic that has spread recently in the fields of architecture and interior design, so it was necessary to pay attention to studying the possibility of reducing emissions, especially in internal spaces, to preserve human health. Here comes the need for the role of the interior designer, considering that the type of materials used in the design has a direct relationship to the percentage of emissions in the interior spaces. It is necessary to use low emission materials treated with nanotechnology as an alternative to harmful materials. In this research, the material for ropes treated with nanotechnology was selected to study its applications in interior design and furniture and its role in reducing harmful emissions in internal spaces.

### **Research Problem:**

There is role of materials treated with nanotechnology in reducing emissions in internal spaces, so it is necessary to raise designer awareness of the importance of nano-tech ropes as eco-friendly material in interior and furniture application.

### **Research Objective:**

- There is an importance of using ropes treated with nanotechnology as a material, whether in interior design or furniture design, as an alternative to harmful materials commonly used.
- Nanotechnology ropes are eco-friendly and low emission materials which are highly recommended to use in internal spaces.

### **Research Methods:**

Analytical Approach  
Projects Analysis / Case Studies

### **Research Limits:**

- Formulation of research aims and objectives.
- Implementing this at the present time keeps pace with the world's trends in confronting the climate crisis.

### **Research Procedural Steps:**

- 1- Nanotechnology Materials.
- 2-Nano Technology Materials which used in interior design.
- 3- The Role of Nanomaterials in Reducing Emissions in Internal Spaces.
- 4- The Fiber Ropes Applications in Interior Design.

- 5- The Importance of Using Nano Technology Treated Ropes.
- 6- Interior Design Using Ropes examples.
- 7-Furniture Design Using Ropes examples.
- 8- Nano Technology Treated Ropes and its applications.
- 9-The practical application.

**KEYWORDS:**

Nanotechnology; Ropes treated with nanotechnology; Eco-Friendly materials; The Carbon footprint.

**المستخلص**

التصميم منخفض الانبعاثات هو أحدث الموضوعات التي انتشرت في الأونة الأخيرة في مجالي العمارة والتصميم الداخلي لذا كان من الضروري الاهتمام بدراسة امكانية تقليل الانبعاثات خاصة في الفراغات الداخلية للحفاظ على صحة الانسان. هنا تأتي الحاجة لدور المصمم الداخلي حيث الاخذ في الاعتبار أن نوع الخامات المستخدمة في التصميم لها علاقة مباشرة بنسبة الانبعاثات في الفراغات الداخلية. إنه من الضروري الاتجاه إلى التوقف عن استخدام الخامات الصناعية واستخدام هذه الخامات المعالجة بتقنية النانو كبديل منخفض الانبعاثات. في هذا البحث تم اختيار خامة الحبال المعالجة بتقنية النانو ودراسة تطبيقاتها في التصميم الداخلي والأثاث ودورها في تقليل نسبة الانبعاثات الضارة كبديل للخامات الصناعية المتعارف عليها. لذا من الضروري الإشارة إلى أهمية استخدام الحبال المعالجة بتقنية النانو كخامة صديقة للبيئة منخفضة الانبعاثات سواء في التصميم الداخلي أو تصميم الأثاث كبديل للخامات الضارة الشائع استخدامها. وبشكل عام فإن استخدام الحبال في التصميم الداخلي والأثاث كمادة له تأثير جمالي ووظيفي أفضل من المواد الأخرى، ولكن يجب الإشارة إلى دور تقنية النانو في تحسين خصائص الحبال التي يمكن الاستفادة منها وتطبيقها. على نطاق أوسع في مجال التصميم الداخلي. يوضح البحث خطوات دراسة مواد تقنية النانو المستخدمة في التصميم الداخليمن خلال:

-الإشارة إلى دور المواد النانوية في تقليل الانبعاثات في الفضاءات الداخلية.

-التعرف على تطبيقات حبال الفايبير في التصميم الداخلي.

-التصميم الداخلي والأثاث باستخدام أمثلة الحبال.

-الحبال المعالجة بتقنية النانو وتطبيقاتها.

-أهمية استخدام الحبال المعالجة بتقنية النانو.

كذلك التأكيد على أهمية تطبيق تقنية النانو في مجال التصميم الداخلي والأثاث وهي الخامات المعالجة بهذه التقنية والتي يمكن أن تشمل جميع عناصر التصميم الداخلي من حوائط واسقف وأرضيات وأيضاً قطع الأثاث. لذا نوصي المصممين باستخدام الخامات المعالجة بتقنية النانو في التصميم الداخلي مع دمجها في عناصر الفراغ كخامات صديقة للبيئة منخفضة الانبعاثات

**الكلمات الرئيسية**

تقنية النانو، الحبال المعالجة بتقنية النانو، الخامات الصديقة للبيئة، البصمة الكربونية

## -Introduction

Nowadays, the essential role of Nanotechnology is enhancing the performance of traditional building materials, both structural materials such as (concrete, steel and wood) and nonstructural materials such as (glass, coating, and Air purification). Towards a multidisciplinary and technical architectural approach. The future of Interior Design has become linked to the effect of materials on the quality of the internal environment, so it is necessary to choose new eco-friendly materials to reduce the percentage of emissions inside the space. In general, the use of rope in Interior Design and Furniture as a material has a better aesthetic and functional effect than other materials, but it must be noted that the role of Nanotechnology in improving the properties of ropes can be benefited from and be applied more widely in the field of interior design.

## 1- Nano Technology Materials

Nanotechnology is the manipulation of matter on an atomic and molecular scale. Generally, nanotechnology works with materials, devices, and other structures with at least one dimension sized from 1 to 100 nanometers and is a key technology for the future. In relation to architecture Nanotechnology enables to create new materials from the molecular level. That is to say it can create a material to meet our demands.<sup>1</sup>

Nanomaterials/nanoparticles/nanostructures, due to their nano size (approximately 1–100 nm) exhibit extraordinary physical, chemical and biological properties. Nanotechnology deals with the design, production, manipulation and application of nano structured materials. Nanotechnology is creating its way in environmental applications and may become the future technology in mitigating climate change.<sup>2</sup>

The use of nanomaterial in architecture and Interior Design will present new opportunities to solve problems by improving significantly the nature of building structure efficiency and the way that buildings relate to the environment. Nanomaterial can expand design possibilities for both Interior and Exterior spaces. Their use can open up new possibilities for sustainable design strategies.<sup>3</sup>

**1-1 Types of Nanomaterials based on dimensions.** Based on the dimension of nanomaterials, they have been classified into various types as shown figure (1)

1-1-1 Zero-dimension nanomaterials (nanoparticles, nanoshells, nanocapsules, nanorings, fullerenes and quasi crystals).

1-1-2 One-dimension nanomaterials (nanorods, nanofilaments, nanotubes, quantum wires, and nanowires).

1-1-3 Two-dimension nanomaterial (discs, platelets, ultrathin films, super lattices, graphene and quantum wells).

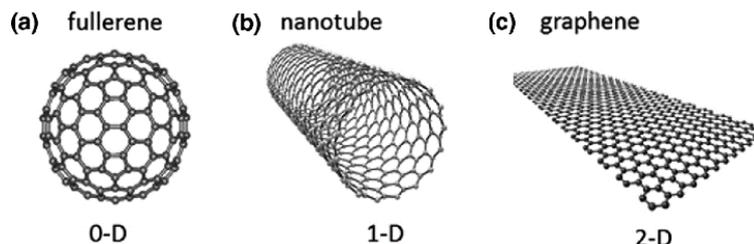


figure (1), Nanomaterials of various dimensions.<sup>4</sup>

## 2-Nano Technology Materials which used in Interior Design

Soon, nanotechnology will become the basis of the future house. As the use of materials treated with nanotechnology has become a necessity for a healthy and clean interior space. figure (2) shows nanotech of the house of the future using different materials such as (nano paints and nano-based wall decoration, anti-bacterial coating, self-cleaning nanotextile curtains, self-cleaning glass, and furniture with carbon nanotubes).

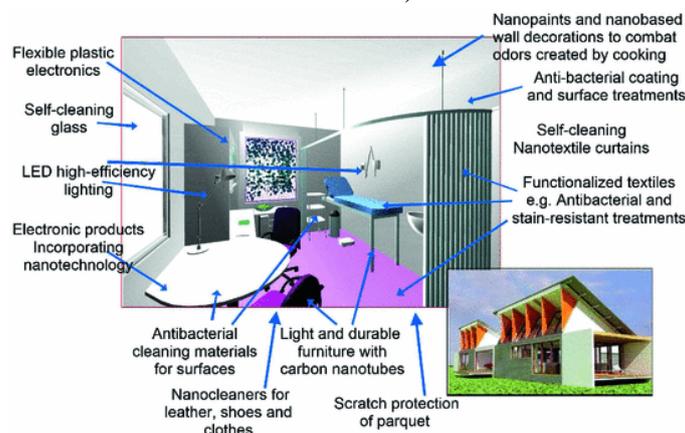


Figure (2): Nano-tech of the house of the future.

### 2-1 Nano-tech materials which used in interior design have many advantages:

- Nanoparticles can be applied to form a very thin “self-cleaning” film on household surfaces which protects from dust.
- Nanoparticle coatings can improve the scratch and wear resistance considerably.
- prevent the formation of bacteria and algae.
- Increasing safety and lowering product costs by reducing maintenance requirements.
- Nanotechnologies enable cost-competitive, sustainable, and effective energy in the house.
- Increased energy efficiency will reduce the electricity bill for the house lighting.<sup>5</sup>

2-2 Some Examples of materials treated with nanotechnology which use in interior design elements (floor, wall, ceiling and furniture).

-Nano-tech Interior Design Floor Materials and Finishing (Wood-Ceramic-Marble-Epoxy). For example, figure (3) shows Carrara Porcelain, this material is a low-cost option that looks just like marble tile with its white background and gray veining.as an antibacterial porcelain with a long-lasting effect and self-cleaning (hydrophobic) material.



Figure (3): Carrara Porcelain, Nano-tech floor material.<sup>6</sup>

-Nano-tech Interior Design Wall Materials and Painting (Wood-tiles-wallpaper-painting). For example, figure (4) shows wall cladding with Nano4-Wood material does not contain silicone or any other harmful chemicals, which has invisible protection against all dirt particles, as well as from sea salt, sunlight, and moisture.



Figure (4): Nano4-Wood, Wall cover nano material.<sup>7</sup>

-Nano-tech Interior Design Ceiling Materials and Coating (Gypsum Board-Glass-Heating Film Sheet)

For example, figure (5) shows Nano-Tech heating film can achieve its maximum efficiency when used as a far infrared radiant heating wall and ceiling covering. The infrared radiation providing a warm feel.



Figure (5): Nano-Tech heating film sheet, ceiling cover material.<sup>8</sup>

-Nano-Tech Furniture Materials

For example, Nanotech matte furniture boards figure (6). With the help of nanotechnology, the surface of the material has not merely been rendered matte, but super-matte. The same effect is

achieved no matter what the color of the material and regardless of whether the surface is horizontal or vertical. At the same time, it is UV-Resistant.



Figure (6): Nano-Tech matte furniture boards, kitchen cabinet material.<sup>9</sup>

### 2-3 Nano-tech materials have specific characteristics:

- Waterproofing
- Anti-bacterial
- Self-cleaning
- Thermal heating

An eco-friendly Nano coating with high hydrophobicity can be put on objects to make them watertight for the long term. The product is anti-corrosive and oxidation resistant, anti-icing, UV resistant, high temperature resistant, and chemical compound resistant. It may be used on various surfaces and has self-cleaning qualities when it rains.<sup>1</sup>

### 3-The Role of Nanomaterials in Reducing Emissions in Internal Spaces

The internal space has IAQ level (Indoor Air Quality) which should be controlled. Nanocomposite membranes are maintaining high IAQ standards, due to structural stability, reusability, and filtration efficiency. Therefore, the resulting polymeric nanofibrous membranes have a high filtration efficiency of removal. Some of nanomaterial has the ability for CO<sub>2</sub> adsorption. Using this nanomaterial, the CO<sub>2</sub> level may be reduced to 50%. The nanocomposite membranes are used for maintaining IAQ through the filtration of reactive oxygen, so Filtration efficiencies are quite high. Removal of aerosol and bacteria from indoor air resulted in a safe IAQ level. Moreover, nanocomposite had no toxic effects on human systems. Hence, polymeric nanocomposite-based adsorbents were efficiently used to remove indoor pollutants.<sup>1</sup>

### 4- The Fiber Ropes Applications in Interior Design

There are two types of fiber ropes with different characterize natural rope and synthetic rope. Table (1) shows the characterizes of each one.

Type	characterizes
Natural rope	<p>Made from natural, eco-friendly products like hemp, cotton, sisal, silk, and other types of natural fibers.</p> <p>It is more secure and does not slip easily when it's knotted.</p> <p>Do not get damaged when exposed to high heat and will burn only when exposed to a flame.</p> <p>Example: cotton ropes</p>

<p>Synthetic rope</p>	<p>Made of materials like polyester, nylon, and polypropylene.                  Its more durable and long-lasting compared to natural ropes.                  Its more elastic and shock absorbent, which makes them perfect for various applications.                  Do not shrink if they get wet.                  less likely to get damaged when exposed to water, UV rays, mold, and mildew.                  Example: polyethylene ropes</p>
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Table (1) The Characterizes of Ropes types commonly used. <sup>1</sup>

2

Natural rope is quite strong; however, it may not be as strong as synthetic rope and can be damaged by water, UV rays, mold and mildew. If it gets wet, a natural rope can shrink and can be quite difficult to work with. However, synthetic ropes production can create hazardous by-products. Also, the synthetic materials are not reusable or renewable. Also heat can cause the rope to melt, which can lessen its strength. Therefore, other materials must be found, such as ropes treated with nanotechnology Which have better characterizes. Most popular ropes which use in interior design ( Dyneema Cord, Hemp Fibre, Jute Fibre, Manilla Fiber, Nylon Braided Cord, Polyester Cord, Polyprop Cord and Sisal Fiber) Figure (7). A wide range of fiber and cord material options with differing diameters and lengths sold in weighted bundles or in measured reels.



Figure (7) Most Popular Fiber Ropes which Use in Interior Design. <sup>1</sup>

3

#### 4-1 Ropes Construction Details

##### 4-1-1 Type of Ropes construction

There are 2 types of ropes – Laid Rope, and Braided Rope.

**Laid Rope:** rope is made in a 3-part process: First, fibers are twisted into yarns. Next, the yarns are twisted together to form strands. Finally, these strands are twisted together to form rope Figure (8)



Figure (8) lid rope construction.

**Hollow Braided Rope:** Braided rope comes in several varieties:

Single braid: consists of 8 or 12 strands that are braided together in a circular pattern figure (9).



Figure (9) single braided rope construction.

Double braid: It has a braided core with a braided sheath around the core. The inner and outer rope both provide strength in bearing load figure (10).



Figure (10) Double braided rope construction.

Natural Rope Materials are primarily used today for decorative rather than functional purposes. There are many ropes Commonly used in interior design: Manila, Jute and Magicians Cotton Cord/Rope.<sup>1</sup>

4

#### 4-1-2 Choosing Rope Thickness

The appropriate thickness for the type of rope required is chosen from among the different types depending on the use in interior design. There are some items that need a large thickness for specific function, such as suspended furniture units, but other decorative purposes may require a smaller thickness, and so on. Figure (11,12) shows examples of the difference in rope thickness in the same type.



Figure (11) Jute rope cord.

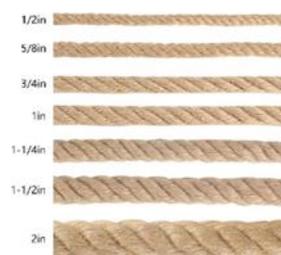


Figure (12) Twisted Manila Rope.

#### 4-1-3 Rope End Finishes

-Soft eye splice ... Also known as a soft loop. This is created by looping the rope back on itself and interweaving the strands Figure (13).



figure (13).

-Hard eye splice .... This is created in the same way as a soft splice. However, a galvanized metal thimble or stainless-steel thimble is inserted into the eyelet Figure (14).



figure (14).

-Whipped end ..... A traditional rope end finish. Flax twine is wound – or whipped – around each end of the rope. It can also be applied to synthetic ropes figure (15).



figure (15).

-Heat set end caps..... This effective finish creates a smooth yet rigid cap on the end of the rope. End caps are more durable than whipping figure (16).



figure (16).<sup>1</sup>

5

#### 4-1-4 Rope Fitting Accessories

Table (2) shows set of metal connectors for fixing and installing ropes of different lengths and thicknesses, which help to achieve any desired design with ropes in interior design.

<b>Rope bracket</b>	 <b>figure 17.</b>
<b>Rope hook</b>	 <b>figure 18.</b>
<b>Rope hook attachment</b>	 <b>figure 19.</b>
<b>Rope snap</b>	 <b>figure 20.</b>
<b>Rope end cap</b>	 <b>figure 21.</b>

Rope terminal end	 <p>figure 22.</p>
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Table (2) Rope Fitting Accessory Types. <sup>1</sup>

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## 5-The Importance of Using Nano Technology Treated Ropes.

In general nano textile materials are used to develop desired textile characteristics, such as high tensile strength, unique surface structure, soft hand, durability, water repellency, fire retardancy, antimicrobial properties, etc. Nanotechnology ropes are eco-friendly and low emission materials which high recommended to use in internal spaces.

### 5-1 Nano Tech Ropes as An Eco-Friendly Material

The most common treatment for rope material is coating with nanoparticle. For example **DryXP** rope is an environmentally-friendly material , Treated with environmentally-friendly DeltaDry™ nano coating for water resistance, which rated as standard of 5% water absorption figure (23) .<sup>1</sup>

7



figure (23) DryXP nano rope.

Another example is the heat resistant **Nano Cord** rope which is small, compact, and ultra-strong. this cord is performing tasks of ropes that are 200% larger in size with UV, Rot, Mildew Resistant figure (24).<sup>1</sup>

8



figure (24) Nano Cord rope.

### 5-2 Nano Tech Ropes as Low Emission Material

Technology of Bio-Based DYNEEMA®, is the first ever bio-based ultra-high molecular weight polyethylene fiber. Which is in fact certified according to the International Sustainability and Carbon Certification (ISCC). So that any rope made with bio-based dyneema directly contributes to reduce CO2 emissions and has a lower environmental impact. For example, Gottifredi Maffioli's Ropes made with Dyneema are ultra-light and float on water, they are resistant to water, chemicals, and UV.<sup>1</sup>

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Another example Gleistein Ropes, the new bio-based Dyneema fibres, which reduce carbon footprint. With high levels of performance these ropes being the world’s first textile rope manufactured using sustainable raw materials made with Dyneema figure (25).

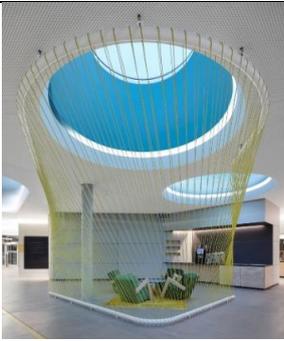


figure (25) Gleistein Ropes.<sup>2</sup>

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## 6-Interior Design Using Ropes Examples

There are many applications of using ropes in interior design with different purposes. (Functional, Decorative or design Accessories). Table (3) shows examples of this applications.

<b>6-1 Interior design with ropes for functional purpose</b>	
<b>6-1-1 Ropes as Room Divider</b>	<div style="text-align: center;">  </div> <p style="text-align: center;">Ex 1: (SAP Innovation Center located in Potsdam, Germany.) Rope partition around a breakout area creates a divide but still allows visibility figure (26).<sup>2</sup></p> <div style="text-align: center;">  </div> <p style="text-align: center;">Ex 2: (The Odessa Restaurant, located in Kyiv, Ukraine) the rope room dividers are used to create a special aesthetic. The ropes also continue as a ceiling installation that travels above different dining areas of the restaurant figure (27).<sup>2</sup></p>
<b>6-1-2 Ropes as Staircase (Bannister Rope)</b>	<div style="text-align: center;">  </div> <p style="text-align: center;">Staircase with rope railing in cross pattern and seasoned wood, Khemka marketing store design, designed by Hitesh Prajapati &amp; Associates interior design company, Chhattisgarh, India figure (28).<sup>2</sup></p>

	 <p><b>Ex2: staircase with colorful rope, family house ,Vienna, Austria figure (29).<sup>2</sup></b></p>
<p><b>6-1-3 Ropes as hanging units</b></p>	 <p><b>Ex1: Oak Manila Rope Hanging Shelving Unit. The rope is hung from hooks installed on the ceiling figure (30).<sup>2</sup></b></p>
	 <p><b>Ex 2: Bed unit suspended by ropes figure (31).<sup>2</sup></b></p>
<p><b>6-2 Interior design with ropes for decorative purpose</b></p>	
<p><b>6-2-1 Rope curtains</b></p>	 <p><b>Ex : Decorative String Curtains Wall Panel.Rope curtains determine the atmosphere of the space they hang in. Because of the bright colours of the ropes, these room dividers make real eye-catchers figure (32).<sup>2</sup></b></p>

<p><b>6-2-2 Rope wall and ceiling covering</b></p>	 <p><b>Ex 1: (The Rope Wave Office in Shanghai) .Rope is used in a wide range of forms in various rooms of the office with it morphing into ceiling in one of the areas while acting as a room divider in other areas figure (33).<sup>2</sup></b></p>
	 <p><b>Ex 2: SUVICHE, a new restaurant in Florida, USA. Decorative design with multi-color handwoven macramé rope mural, wraps around from the ceiling and onto the wall figure (34).<sup>2</sup></b></p>
<p><b>6-2-3 Rope string art</b></p>	 <p><b>Ex1: String wall partition, Ravello Italian restaurant, Four Seasons Orlando at Walt Disney World Resort, USA figure (35).<sup>3</sup></b></p>
	 <p><b>Ex 2: String furniture pieces made of nylon cord, polyester thread and wire make bold new shapes. Craft of weaving rattan and straw are the new trend figure (36).<sup>3</sup></b></p>

<b>6-3 Interior design with ropes as a design accessory</b>	
<b>6-3-1 Ropes Lighting units</b>	 <p><b>Ex 1: Industrial Rope Pendant Lights. The rope used to create an industrial yet creative atmosphere. The rope is hand-knitted, the pendants require LED bulbs figure (37).<sup>3</sup></b></p>
<b>6-3-2 Ropes accessory units</b>	 <p><b>Ex1: Nautical Hampton Round Rope Mirror as twisted Rope Home Decor Art Wall Hanging Mirror figure (38).<sup>3</sup></b></p>  <p><b>Ex2: Boho Macrame Wall Hanging as wall hanging rope accessory figure (39).<sup>3</sup></b></p>
<b>6-3-3 Jute rope Floor Rug</b>	 <p><b>Ex: rope Floor Rug, threads fibers are woven together to make jute fabrics and ropes, used in the production of jute rugs figure (40).<sup>3</sup></b></p>

Table (2) Interior Design Using Ropes Examples.<sup>3</sup>

6

### 7-Furniture Design Using Ropes Examples

The rope is easy to use in many decorative units and various pieces of furniture. There are two important purposes for using ropes in furniture design. Either for the purpose of covering the structure of the piece of furniture with ropes or for the purpose of hanging the piece of furniture. In both cases, the different types of ropes mentioned above can be used.

For example, Outdoor rope furniture. The rope engineered to be strong and durable for outdoor use. The fibers are made with polypropylene which has several qualities that make it perfect for outdoor use. The rope is made to be UV resistant figure (41) .



figure (41) outdoor rope chair.<sup>3</sup>

7

Another example, Rope Table. Unusual little cube ingeniously covered in Manila rope. France, 1970s figure (42).



figure (42) Rope Table.<sup>3</sup>

8

Furniture rope for suspending purpose. Macrame Rope Swing as decorative rope for suspended wooden swing figure (43) .



figure (43) Macrame Rope Swing.<sup>3</sup>

9

## 8- Nano Technology Treated Ropes and its applications

Nanotechnology in textile used to develop desired textile characteristics, such as high tensile strength, unique surface structure, soft hand, durability, water repellency, fire retardancy, antimicrobial properties, etc.

Nano fiber is a continuous fiber which has diameter in range of billionths of a meter. The smallest nano fibers made today are between 1.5 and 1.75 nanometers.<sup>4</sup>

Nanofibers ropes are coated on hollow braided rope which increased the resistance of the membrane to provide high specific surface area. These nanofibers contained numerous advantages such as high porosity. Nano ropes are strong against chemicals and high heat while being flexible and providing mechanical resistance.<sup>4</sup>

1

The characterizes of nano treated ropes are better, so that There are several reasons why we use it in interior design.

Nowadays, the most popular nano ropes are the new synthetic fibers like **Dyneema®** and **Vectran™** which give unlimited possibilities in constructions, office projects and interior design.

Vectran rope which is a polyester fiber made from liquid crystal polymer (LCP) figure (44) . while

Dyneema rope which is an ultrahigh molecular weight polyethylene (UHMWPE) fiber with superior strength properties figure (45). However, it has lower abrasion resistance than Vectran and it absorbs more moisture but provides better flexibility than Vectran due to its softness.



figure (44) Vectran rope.

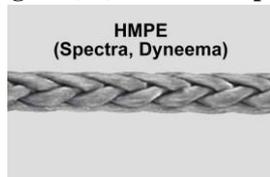


figure (45) Dyneema rope.<sup>4</sup>

2

That is because ropes can be made in almost any color. This makes ropes very decorative, and they give a room an own identity. For example, ropes can be used in making furniture. Ropes are also used in interior architecture to divide a room in multiple zones. We often make rope curtains to use as room divider.<sup>4</sup>

3

Using nano materials for treating fabric materials properties to achieve durability, Antibacterial, UV resistance and self-cleaning. New fabrication and surface finishing methods to employ nanotechnology to inculcate smart and innovative applications.

Table (4) shows classification of nano fabrics treated with enhancing properties.

<b>8-1 Classification of nano tech fabrics with enhancing properties</b>	
<p><b>8-1-1 Ultraviolet-resistant nano cotton fabric</b></p>  <p>figure (46)</p>	<p>The nanomaterials responsive to UV light such as TiO<sub>2</sub> and ZnO are capable to scatter or absorb UV radiations. TiO<sub>2</sub> nanoparticles have been used on cotton as the UV blockers. ZnO nanoparticles have been applied on cotton and polyester fabrics as UV absorbing layer. The results confirm that nano-coated materials on the textile fabrics possess strong UV-blocking capacity, an intelligent and durable fabric as compared to uncoated materials figure (6).<sup>4</sup></p>

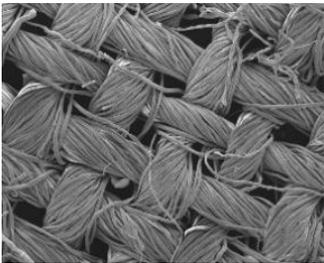
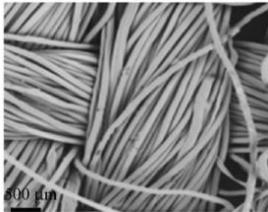
<p><b>8-1-2 Self-cleaning Nano fabric Cu@Cotton and Ag@Cotton</b></p>  <p>figure (47)</p>	<p>Cu@Cotton and Ag@Cotton are nano-enhanced textiles that can spontaneously clean themselves of stains and grime simply by being put under a light bulb or worn out in the sun. When exposed to light, it took less than six minutes for some of the nano-enhanced textiles to spontaneously clean themselves. nanostructures on cotton fabrics can be widely used to create functional textiles for industrial applications with an ability to self-cleaning figure (47).<sup>4</sup></p>
<p><b>8-2 Antibacterial nano fabric</b></p>	
<p><b>8-2-1 Nano silver fiber</b></p>	<p><b>8-2-2 Polyester/Cotton fabric treated with graphene oxide and TiO<sub>2</sub>/SiO<sub>2</sub></b></p>
 <p>figure (48).</p> <p>Nano Silver yarn contains special non-toxic silver which can effectively block the growth of harmful bacterium. After dyeing and finishing fabric made of Nano Silver yarn still has excellent anti-bacteria properties, can be dyed various colors, and has very good color fastness figure (48). Silver molecules are bonded onto the polyester fibre. Silver is well-known for its antibacterial properties. The molecules of silver don't emit into the environment therefore products are environmentally friendly.<sup>4</sup></p>	 <p>figure (49)</p> <p>polyester/cotton fabrics were modified by the combination of graphene oxide (GO) and TiO<sub>2</sub>/SiO<sub>2</sub> to solve the low photocatalytic efficiency, weak antibacterial activity and poor durability of polyester/cotton fabrics figure (49). TiO<sub>2</sub>/SiO<sub>2</sub> enhance the antibacterial rate of composite modified fabrics is over 99% under visible light.<sup>4</sup></p>

Table (4) classification of nano fabrics.<sup>4</sup>

**8-3 (CNT) fiber Rope as nano treated rope application.**

Nanotube has the ability to stretch: one square inch of a "Nanotube Forest" can be spun into more than two miles of yarn without losing any tensile strength. Once elongated, carbon nanotubes can be woven and shaped into a thread-like material. carbon nanotube (CNT) fiber can be combined into larger yarns or ropes which assembled with a braided construction figure (50).



figure (50) (CNT) fiber Rope.

In the conventional rope industries, the most important qualities of the material are all mechanical: the flexibility of the yarn, its tensile strength, its stretchability, etc. Different styles of braided rope have been developed to optimize products for needs of different applications. CNT fiber rope is a product that will eventually be used in some cases for its mechanical strength, and in other cases for its electrical or thermal conductivity.<sup>4</sup>

### 9- Practical application

A proposal to design a separating wall (partition) as room divider made of nanotechnology ropes inside the house as a low-emission alternative to the metallic stainless steel.

Study and analysis show that we can shed light on two points:

First, the importance of using ropes as safe alternative to many materials in interior design and furniture.

Second, the use of ropes treated with nanotechnology in interior design as an alternative to regular ropes to reduce emissions within the interior space.

This research presents a proposal in the Interior Design ropes treated with nanotechnology.

#### 9-1 Stages of Practical Application

9-1-1 Table (5) shows comparison between using each of rope and stainless steel as materials to design room divider partition.

Interior design unit: Room divider partition	
Material 1: Black Polypropylene Braided Rope <sup>5</sup>	Material 2: Black Stainless Steel <sup>5</sup>
 <p>figure (51)</p>	 <p>figure (52)</p>

<b>Details</b>	
 <p style="text-align: center;"><b>figure (53)</b></p>	 <p style="text-align: center;"><b>figure (54)</b></p>
<b>Advantages</b>	
<ul style="list-style-type: none"> <li>- High durability (strength and abrasion resistance).</li> <li>-Low density of textile fibers (only 0.91 g / cm<sup>3</sup>).</li> <li>-Ropes made of PP are light.</li> <li>-Moisture resistance.</li> <li>-Good knot ability.</li> <li>-They retain their softness even in wet environments.</li> <li>-They are not prone to static electricity charge.<sup>5</sup></li> <li>-It is cheap compared to other ropes.</li> </ul>	<ul style="list-style-type: none"> <li>-It is highly resistant to corrosion and staining.</li> <li>-It is easy to maintain.</li> <li>-It is durable and has a long lifespan.</li> </ul>
<b>Disadvantages</b>	
<ul style="list-style-type: none"> <li>-Not the Strongest rope around.</li> <li>-Polypropylene is sensitive to UV degradation and will become weak if left in the sun. Which means it suits indoor purposes.<sup>5</sup></li> </ul>	<ul style="list-style-type: none"> <li>-It can be very expensive.</li> <li>-It is not as durable as some other materials.</li> <li>-It can be difficult to clean.</li> <li>-It is susceptible to scratches and dents.<sup>5</sup></li> </ul>
<b>Carbon footprint</b>	
<ul style="list-style-type: none"> <li>-Compared to traditional rope materials such as nylon or polyester, polypropylene has a lower carbon footprint.</li> <li>-It can actively reduce their carbon emissions and contribute to mitigating climate change.</li> <li>-By using a longer-lasting rope, fewer resources are consumed, leading to a reduced overall environmental impact.<sup>5</sup></li> </ul>	<ul style="list-style-type: none"> <li>-The carbon footprint of metal mining processing . while stainless steel consists of (iron, chromium and, in some cases, nickel) so each one has CO2 emission.</li> <li>-The average CO2 emissions per ton of stainless steel are 0.39 tons. The carbon footprint of steel is near twice the production amount.<sup>5</sup></li> </ul>

**Table (5) Comparison between using each of ropes and stainless steel as materials to design room divider partition.<sup>5</sup>**

**The Results of the Comparison:**

Using ropes material is good low emitting alternative compared with stainless steel in interior and furniture design.

Room divider made from polypropylene rope would be better than another divider made of stainless steel. Which is cheaper, durable, and eco-friendly material to be recommended.

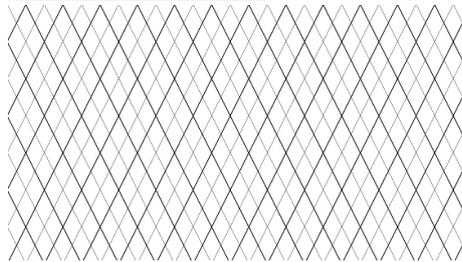
**9-1-2 Design Room divider partition using Nano Rope Material (Carbon fiber rope).**

Material: Galvorn CNT Braided Yarn 1000 microns

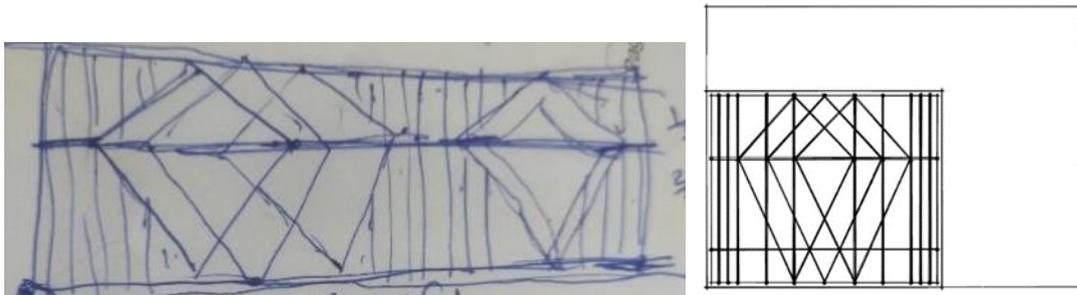


**9-1-3 Design Idea:** Design a partition unit as a divider between the dining and living rooms using ropes treated with nano technology.

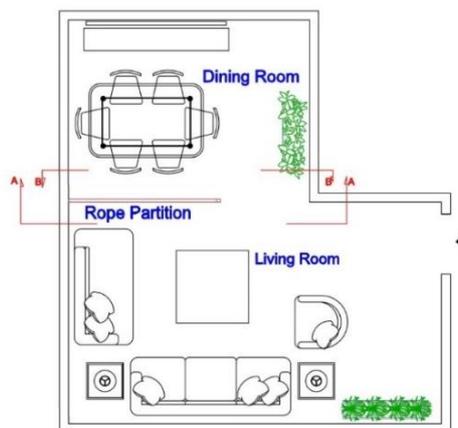
**9-1-4 Design Grid:** Rhombus geometric grid.



**9-1-5 Primary Sketch:** 2.5m\*2m black metal frame with a network of carbon rope attached.



**9-1-6 Final Design:** Rope partition as a divider between two rooms dining and living room. The drawing plan and 2 sections clarify the idea.



Floor Plan



5

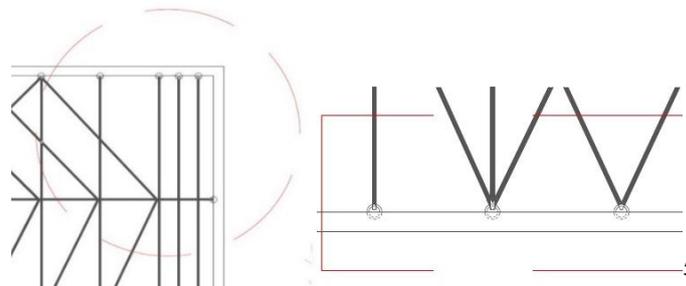
8

### **9-1-7 Construction Steps:**

- The ropes are stretched to form the network shown previously so that the oblique lines of the geometric shape (Rhombus) intersect with the longitudinal straight lines to achieve a dynamic concept.
- Using Rope hook attachment which installed in the frame to be semi-hidden.



### **9-1-8 Details:**



9

**9-2 Application Usage:** Interior Design Room divider ..The overlapping design of the ropes in the design of the room divider gives an illusion of movement and acts as a semi-transparent separator that allows an extension of vision between the two rooms. The aim of the design is aesthetically.

### **9-3 Results:**

- It is clear from the design presented by the researcher that it is possible to replace the usual materials of room divider such as (metal, stainless steel, acrylic and even wood) with a new material such as ropes treated with nanotechnology.
- The importance of using ropes treated with nanotechnology like Carbon fiber in interior design applications to achieve both functionality and aesthetics with low emitting ratio.

## Results and discussion

- The characterizes of Nano treated ropes are several (UV resistance, self-cleaning or antibacterial) which are good reasons to use it in interior design.
- There is an importance of using ropes treated with nanotechnology as a material, whether in interior design or furniture design instead of harmful materials commonly used.
- Nanotechnology ropes are eco-friendly and low emission materials which are highly recommended to use in internal spaces.

## Conclusions

We conclude from this research that there are many applications of using ropes in interior design with different purposes. (Functional, Decorative or design Accessories). Also, using ropes in furniture design. Either for the purpose of covering the structure of the piece of furniture or for the purpose of hanging the piece of furniture. the study of ropes treated with nano technology shows that the Nano-tech materials have specific characteristics like (Waterproofing ,Anti-bacterial, Self-cleaning or Thermal heating) which enhancing fiber ropes usage and make it a good alternative to other materials using in interior design. While the importance of using nanotechnology ropes is their ability to reduce their carbon emissions and contribute to mitigating climate change.

## Recommendation

- The researchers to pay attention to nanotechnology applications, especially in the field of interior design and furniture.
- Designers to use ropes treated with nanotechnology as eco-friendly material in their interior and furniture design.
- Design companies to present modern designs for applications of nano-treated ropes in the field of furniture manufacturing to attract the largest number of customers.

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