Green Nano materials -Innovation in interior design, a New Era of Sustainability

Prof. Doaa Abelrahman Mohamed

Professor at interior design and furniture department, Faculty of Applied Arts, Helwan University,Egypt

do_go2010@yahoo.com

Dr.Basma Mohamed Youssef

Lecturer at the Higher Institute of Applied Arts, Fifth district, Egypt

basmaart20005@gmail.com

Abstract:

Two decades ago, nanotechnologies demonstrated various applications in different fields. As a result, an exposure to such particles has been risen dramatically within the last century due to anthropogenic sources of nanoparticles. The wide application of nanomaterials in industry, and products for consumers have raised concerns regarding the potential toxicity of nanoparticles to humans. For this Engineered Nano technology, materials have been proved to be with a great risk on human health and environment. For that reason, we now try to find solutions to manage this risks, for many scientific studies have proved it to be with a great dangerous impact. As an alternative solution, scientists work hard to extract natural nanomaterials from different sources of nature even from (agricultural crops – soil- sand ……..etc.).

The aim of the research is to focus on the potential uses of these extracted natural nanomaterials and study their physical and mechanical properties and applications in interior design and furniture fields, in a way to find Sustainable interior design using design principles such as functionality, and aesthetics and expand the focus to include environmental considerations by choosing materials with low environmental impacts.

The research manipulated three components (Nano cellulose fibers sheets, Nano clays and shellac) together, and studied their structural properties, and the advantages of those green Nano materials for future trends and applications in the field of interior design.

Two properties were examined on the prepared samples on this paper; contact angle and water absorption. For the purpose of mating between green Nano-materials and interior design for use in creating a comfortable environment for humans that can be environmentally friendly.

Keywords:

Nano cellulose sheets – Nano clay –shellac - interior design – wood coating – wall paper.

الملخص :

قبل عقدين من الزمن ، ظهرت تقنيات النانو فى تطبيقات مختلفة لمجالات عدة. نتيجة لذلک ، ارتفع التعرض لمثل هذه الجسيمات بشكل كبير خلال القرن الماضي بسبب تعدد مصادر تصنيعها من قبل الانسان - المنشىء للجسيمات النانوية.

أثار التطبيق الواسع للمواد النانوية في الصناعة وبالتالى فى المنتجات والمستهلكين مخاوف بشأن السمية المحتملة للجسيمات النانوية للإنسان. اما بالنسبة لمواد النانو المصنعة هندسيًا ، ثبت علميا أن مواد النانو المصنعة هندسياً تحوى مخاطر كبيرة على صحة الإنسان والبيئة. لهذا السبب ، يعمل العلماء الآن على إيجاد حلول لإدارة هذه المخاطر و الحد

منها. وكحل بديل ، قام العلماء بجد على استخراج مواد ا ننوية طبيعية من مصادر مختلفة من الطبيعة مثال على ذلک من (المحاصيل الزراعية - التربة - الرمل ..... الخ.)

الهدف من البحث هو التركيز على الاستخدامات المحتملة لهذه المواد النانوية الطبيعية المستخرجة ودراسة خصائصها الفيزيائية والميكانيكية وتطبيقها في مجال التصميم الداخلي والأثاث ، و ذلک بهدف إيجاد تصميم داخلي مستدام يحقق كلا من القيم الوظيفة والجمال ة ي. و يمتد ليشمل الاعتبارات البيئية و ذلک عن طريق اختيار المواد ذات التأثيرات البيئية المنخفضة.

تناول البحث في ثلاثة من المكونات النانونية الطبيعية)ألياف النانو سيليلوز ، وطين النانو والجمالكا(معًا كهيكل بنائى مندمج ودراسة مزايا تلک المواد النانوية الخضراء والاتجاهات والتطبيقات المستقبلية المحتملة في مجال التصميم الداخلي.

ســـيتم فحص خاصـــيتين على العينات المجهزة معملياً اولا :زاوية ا ت للامس ، ثاني أً: امتصـــاص الماء و ذلک لغرض التزاوج

بين مواد النانو الخضراء والتصميم الداخلي لاستخدامها في خلق بيئة مريحة للإنسان وتكون صديقة للبيئة.

الكلمات المفتاحية:
صفائح نانو السليلوز,نانو كلاى,الجمالكا,طلاءالخشب,ورق الحائط

Introduction:

Nanotechnology uses are aimed to be diverse and multifaceted, new materials are emerging with different property characteristics than we are used to working with, or better yet experiencing. As we delve deeper into the uses of nanotechnology, we should begin to ask ourselves what can we do with this technology, at this Nano scale, that we could not do before to solve many of the critical problems that we as people and interior designers face today.

As a result of any new trend which has its advantages and disadvantages, so we must take the advantages of this technology and avoid its disadvantages, for that reason new concept was developed which is called GREEN NANO TECHNOLOGY. *1-*

Green Nano materials are environmentally friendly, Nano cellulose fibers and Nano clays fall under this concept and called green Nano materials, also shellac is considered one of them as well. …..

As interior designers, we thought of a mating business between green Nano materials and interior design by experimentally test physical and mechanical properties of these materials and finding a way to apply them in our interior space to achieve the requirements of interior design process and those people who inhabit such spaces.

SHELLAC:

Shellac is the purified product of the natural material lac (tiny red insect no larger than an apple seed, which drinks the sap of trees, these tiny red insects contain within themselves the ability to make tree sap within their bodies and subject it to chemical changes that are still a mystery to science) which is secreted by the small parasitic insect Kerria Lacca on various host trees in India, Thailand and South-eastern Asia. Shellac is non-toxic, physiologically harmless and therefore listed as GRAS by the FDA.

Shellac is a natural resin that has been widely used as a protective material for wooden artifacts (e.g. furniture, musical instruments), due to its excellent properties.
It should be noted that the composition varies depending on the insects as well as the host tree from which the raw material is obtained.

Fig. Lac bags attached to the branch of a lac tree. Male, female and young lac insect greatly magnified

USES OF SHELLAC:

1- Wooden furniture and musical instruments are usually coated with a protective layer that plays also an aesthetic role, because it so strikingly brings out the beauty of the grains. Enhancement of the appearance of grain where pure white shellac is used, also it is used for hardwood floors.

2- Woodworks prefer shellac because it is easy working and remarkably quick drying, saving labor and expensive time. In addition it is tough, durable and very elastic, so that it provides a perfect undercoating for any other finishes5-

NANO CELLULOSE FIBERS:

Natural fibers can be classified into different types depending upon their origin such as plant fibers and animal fibers. Natural fibers are of different types based on their source of origin from the plant such as leaf (PALF, sisal, banana etc.), bast (kenaf, jute, hemp etc.), fruit (OPEFB, coir) and seed (cotton, kapok). The mechanical properties of natural fibers (kenaf, jute) are found to be comparable with the commercial synthetic fibers, making the natural fibers highly preferable to synthetic fibers in automotive and other high end applications where weight and stiffness are of primary concerns. ***4-***

Natural fibers have many advantages such as renewability, abundance, low density, biodegradability, and last but not least, low cost. Despite this, the applications of these lignocellulose fillers are still limited in industrial practice, in part due to their poor mechanical properties in general—although they have good specific mechanical properties given their low density. ***3-***

NANO CLAYS:

Nano clays are easily available, environment friendly, low cost substances they are fine-grained crystalline materials.

Particle size, surface area, and aspect ratio are highly important characteristics desired in Nano clays. The length and breadth of the particles can range from 1.5µm. to a few tenths of a micron. A small amount of Nano clay exhibits a high surface area; i.e., a Nano clay product is known

with a surface area in excess of 750 m2 /g, which is an approximate equivalent to the area occupied by nine soccer fields. ***1-2-***

EXPERIMENTAL:

Natural white shellac was purchased which is used in wood paints and used without any further purification.

Ethanol (100% EtOH) was used as a solvent for preparing shellac stock solutions.

MONTMORILLONITE (MTM) Nano clay.

Bagasse Nano cellulose fiber sheets where used.

Dissolve shellac in alcohol (ethanol) 100% with constant concentrations 18%. The Nano-clay was divided on the shellac solution respectively with the following percentages: 0.6%, 1.2% and 2.2% for the formation of three different concentrations of shellac solution with Nano-clay for use in covering the sheets of Nano cellulose fiber. The envisaged clay NPs were dispersed in EtOH shellac solution (200 g/L Ultrasonic Homogenizer. The dispersion time was 5 min. with power set at 50%.

All dispersions were used immediately after their preparation in order to avoid any possible NPs precipitation and to provide a good reproducibility for the further tests.

Nano cellulose fiber sheets (5*5*0.1 cm) was emerged in each solution with different concentration twice, also immerged twice in solution of 18% shellac only without clay, and a blank sheet was left as a control, between the two emergent a 24 hours was left.

The obtained samples were labeled as 18% zero clay (1), 18% 0.6(2), 18% 1.2(3), 18% 2.2(4) respectively, we observed from pre experimental tests, that addition of larger amounts of clay NPs to shellac solutions resulted in non-homogeneous dispersions, which were not investigated.

Sample name	Clay percentage	Shellac
1-	Zero clay	18% (constant)
2-	0.6	18% (constant)
3-	1.2	18% (constant)
4-	2.2	18% (constant)

Table represents the name of samples and percentage of clay and shellac in each sample.

A Varity of testing procedures and experimental technique were used in order to characterize all the materials and to evaluate the properties of the corresponding coating on Nano cellulose fiber sheets. They include Contact angle, Color measurements, water adsorption, Tensile strength, UV ageing.

EXPERIMENTAL STEPS:

1- Divided this solvent into 3 divisions in the 1st bottle put o.6% clay, in the 2nd bottle put 1.2% clay, the 3rd bottle put 2.2% clay.

2- After that make 5 samples of cellulose paper then emerge 4 samples in the 4 different concentrations of clay, 1st 0.6, 2nd 1.2, 3rd 2.2, 4th zero clay %.

3- Do measurement tests.

TESTING METHODS:

All the testes were performed at the laboratories of national research center, Dokki, Giza, Egypt. According to test standards methods, all tests on treated Nano cellulose fibers sheets were performed by examining the Combination of natural Nano cellulose fibers with Nano clay and shellac by immerging cellulose sheets in solution of shellac (constant concentration 18%) and Nano clay with different concentrations of Nano clays (0.6 – 1.2 – 2.2) and measuring (Color measurements - Contact angle measurements - - The moisture adsorption).

Contact angle measurements on the samples were taken by *contact angle instrument, model OCA 15EC*.

The moisture adsorption (humidity) this test was carried out by placing the samples in a controlled humidity environment at a constant temperature until equilibrium, they were placed in desiccators containing salt that provided relative humidity level (RH). In particular, RH% level corresponding 98% were obtained by saturated potassium sulphate, the samples were equilibrated at each condition for 17 days at room temperature, they were weighted regularly over the course of 17 days, the weight gain of the samples was recorded and ascribed to the adsorbed humidity.

RESULTS AND DISCUSSION:

Hydrophobic behavior:

The hydrophobic behavior of the investigated shellac/clay NPs materials was evaluated by performing static contact angle measurements on the surface of treated Nano cellulose fiber sheets and moisture adsorption tests on the fully coated sheets.

Contact angle result:

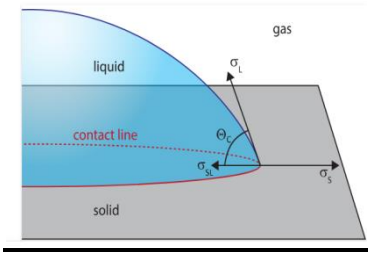


Fig. Contact angle at a solid-liquid-gas contact line

Contact angle measurement:

An equilibrium of vectorial forces dictates the contact angle ΘC at the three phase contact line of a deposited drop. The surface energy of the solid σS acts along the solid surface. The solid-liquid interfacial energy σSL acts in the opposite direction and the surface tension σLof the liquid acts tangential to the drop surface. This can be described by a simple scalar equation,

the Young equation: $\sigma_L \cos\Theta_C = \sigma_S - \sigma_{SL}$ [6]

Contact angle (α) measured on sample no. 2 (SH 18% + clay 0.6%) indicates the highest hydrophobic character (α ≈ 56.05 0). An decreasing of α (about 3.8%) was observed in the case of sample no. 3 (SH 18% + clay 1.2%) , also sample no. 4 (SH 18% + clay 2.2%) the decreasing was (about 6.75%) of the contact angle of the sample no. 2 value, while a sharp decrease was observed in the value of contact angle (α) in sample no.1 (SH 18% + clay zero %), see the Table ,see fig.[7]

Contact angle α	1 SH 18% + clay zero %)	2 SH 18% + clay 0.6%	3 SH 18% + clay 1.2%	4 SH 18% + clay 2.2%
CA left / right 1	40.1	53.8	53	49.8
CA left / right 2	40	58.3	52.4	48.8
Contact angle (α)average	40.05 ±1	56.05 ±3	52.7 ±1	49.3 ±1

Table. contact angle values (α) measured on treated Nano cellulose sheets

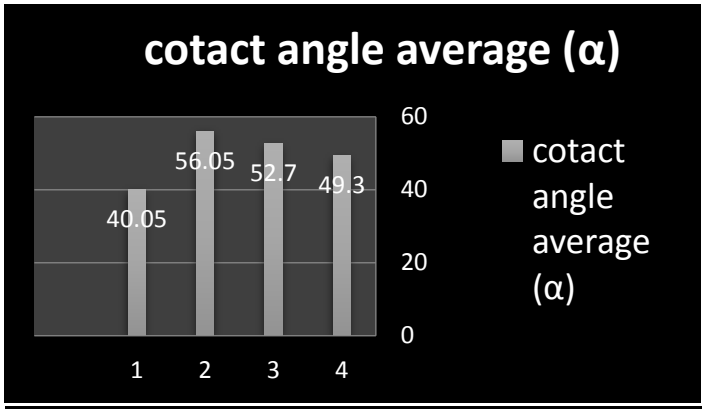


Fig. Variation of contact angle values (α) determined on surface of blank and treated Nano cellulose sheets.

It should be pointed out that contact angle measurements are related to a ‘‘local’’ and ‘‘instantaneous’’ water-repellence behavior (contact angle is usually measured after a very short contact time with liquid water) and should be used with caution to assess the actual hydrophobic properties of a coating or, in general, of a protecting material. Therefore, long-term resistance of the shellac based coatings to water vapor was also investigated by performing moisture absorption tests on fully coated Nano cellulose sheets.

The moisture adsorption:

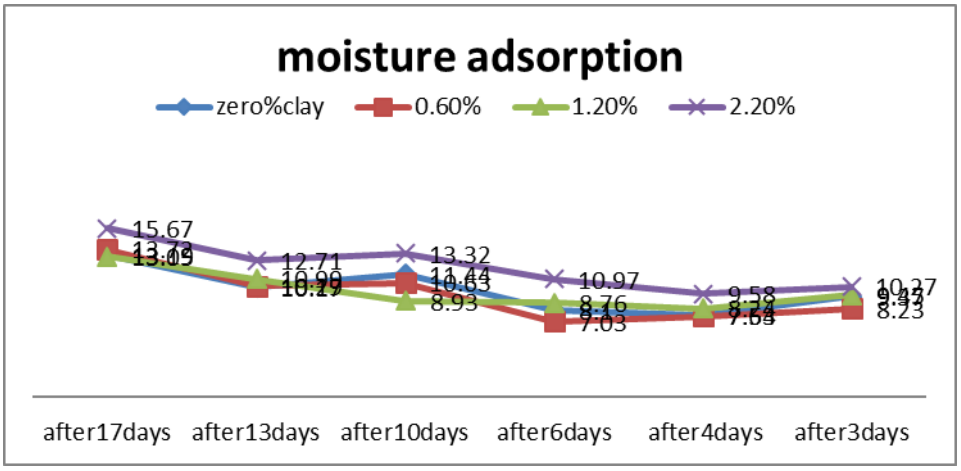
To study the effect of shellac resin matrix and dispersed clay NPs, fully coated Nano cellulose sheets were exposed to controlled humidity environments and the moisture uptake values (calculated as weight increase%) determined after 17-days exposure. The test was performed at relative humidity Level (RH% = 98%), and as expected, the moisture uptake of shellac-coated sheets increased with increasing RH% (from about 10 to 15 %).

Moisture uptake values determined for all sheets coated with shellac/NPs mixtures are almost close in percentage and decrease to those observed for native shellac by about 2.5%.

The behavior of the shellac coating towards water in the vapor phase, is affected by the presence of dispersed clay NPs, that is due to MMT Nano clay has been largely applied to enhance the barrier properties of polymeric materials towards gases (e.g. O2, CO2) and water vapor.

	1	2	3	4
	SH 18% + clay zero %)	SH 18% + clay 0.6%	SH 18% + clay 1.2%	SH 18% + clay 2.2%
after 3 days	10.27	9.45	8.23	9.37
after 4 days	9.58	8.24	7.54	7.63
after 6 days	10.97	8.76	7.03	8.1
after 10 days	13.32	8.93	10.63	11.44
after 13 days	12.71	10.99	10.29	10.17
after 17 days	15.67	13.05	13.72	13.19

Table. variation in the percentage of moisture adsorbed throughout the days of test and Average of moisture adsorption for the 4 samples



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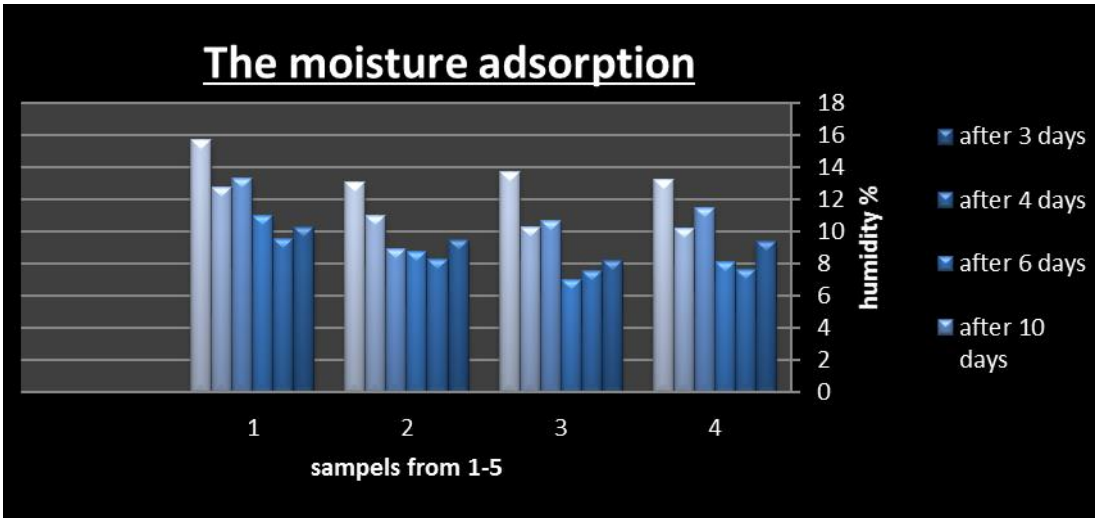


Fig. variation in the percentage of moisture adsorbed throughout the days of test.

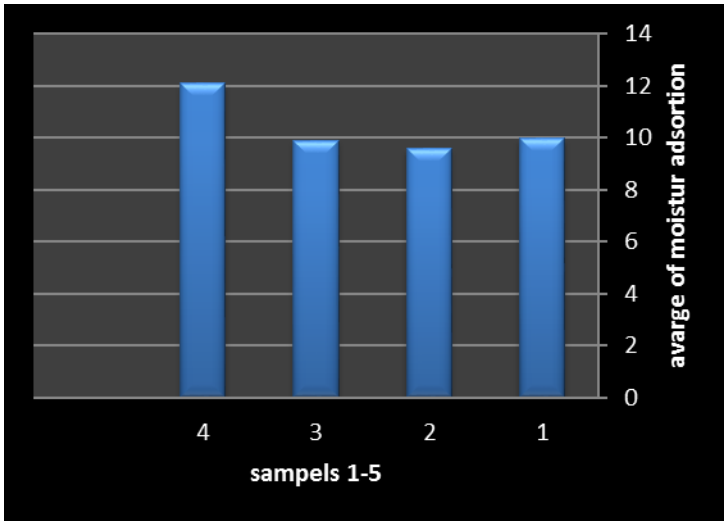


Fig. Average of moisture adsorption for the 4 samples

CONCLUSION:

Final results for Contact Angle Measurements and Moisture Adsorption Test results for treated Nano cellulose sheets:

SAMPLE NAME	Contact angle measurements degree	Moisture adsorption Humidity%
1.	40.05	15.67
2.	56.05	13.05
3.	52.7	13.72
4.	49.3	13.19

Table. shows Contact angle measurements and Moisture Adsorption Test results for treated Nano cellulose sheets

Application on field of interior design and furniture:

Before taking about the application on the field of **interior design and furniture** we must ask some questions and find an answer for.

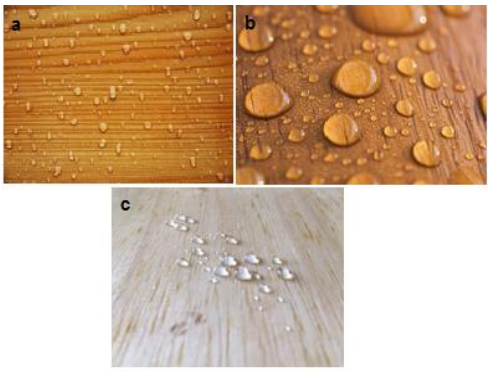
- Why this test (contact angle, moisture uptake) was preformed to Nano cellulose fiber sheets?
- What benefits will come to the field of interior design and furniture due to these tests?

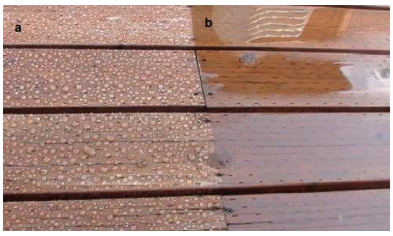
Moisture, rain and cleaning water has a negative impact on interior design materials, accordingly, the interior designer must search for new environmentally friendly materials which help to maintain the natural interior design materials such as wood (manufactured, natural and semi-manufactured), as well as other interior design elements, walls, ceilings and glass, so these materials should be conserved using an environmentally friendly Nano green materials that protect them from the harmful effects of moisture and water.

The role of these materials is not confined only to protection, but it has a role in finding new properties of interior design elements such as self-cleaning. That appears by increasing the value of contact angle measurements.

Based on the research results, Nano cellulose fiber sheets coated with shellac and concentration of clay 0.6% 0r 1.2%, sample no. 2 (SH 18% + clay 0.6%), sample no. 3 (SH 18% + clay 1.2%) considered the best result for Nano green material in the contact angle and moisture measurements. Therefore, it is recommended to the interior designers to use this material as environmentally friendly Nano green material and to benefit from the results of the research and tests.

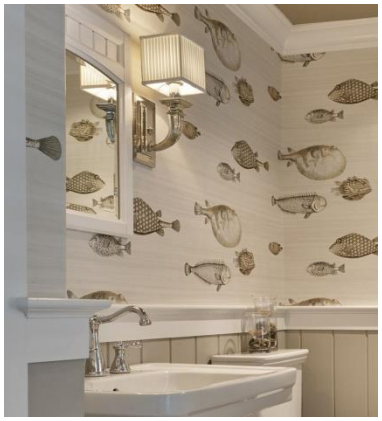
Value added to green Nano material when applied in interior design and furniture field:

<table>
<tr><td rowspan="3">Water repellent and protection against moisture Properties</td><td colspan="2">Elements of interior design in which Nano green materials can be added</td></tr>
<tr><td colspan="2">When added to wood as veneer</td></tr>
<tr><td>Can be added as a veneer to the manufactured wood, Semi manufactured like MDF, with a design work to those veneers to give an aesthetic value to the product and protect the surface of the wood from moisture, water and Scratches.
 
This picture indicates that blank colors can be added to those veneers to give an aesthetic value to the manufactured wood and protect them against water by increasing water repellant property
 
Different Designs can be added to those veneers to give an aesthetic value to the manufactured wood and protect them against water by increasing water repellant property.
 
Natural wood texture can be added to those veneers to give an aesthetic</td><td>Can be added as a transparent veneer or semitransparent to the natural wood to show the beauty of natural wood cutting like oak, beech and pine wood, to protect the surface of the wood from moisture, water and Scratches.
 

a, b& c, Nano green sheets can be used as a veneer when added to natural wood thus increase water repellant property.
 

A &b shows the difference between using Nano green veneers as a coating to natural wood in pic. (a) where it gives water repellant On the contrary in the pic. (b)because Nano green veneer is not applied.</td></tr>
</table>

<table>
<tr><td rowspan="3">Water repellent and protection against moisture Properties</td><td>value to the manufactured wood and protect them against water by increasing water repellant property
 
Damages that water cause to MDF with traditional coating</td><td> 
This picture shows the damages that water can cause to natural wood with traditional coating</td></tr>
<tr><td colspan="2">When added to walls as wall paper</td></tr>
<tr><td colspan="2">It can be used as wall paper with different printed designs, by using green Nano wall paper material instead of traditional wall paper it helps to reduce moisture absorption, which helps to keep the wallpaper longer than damage, especially in coastal areas.
  
Using green Nano sheets as a wall paper in interior spaces like reception or bed rooms, etc… protecting wall papers against moisture and give self-cleaning property
 
Using green Nano sheets as a wall paper in interior spaces in coastal area protecting wall papers against moisture and give self-cleaning property.</td></tr>
</table>

Water repellent and protection against moisture Properties	  *Using green Nano sheets as a wall paper in interior spaces in clinics reception area where specific design pattern can be added to serve the design concept of the space protecting wall papers against moisture and give self-cleaning property.*  *Different colors with different patterns in various interior spaces can use the Nano green material as a wall paper*  *Natural scene can be added by different printing methods to the Nano green veneer and add an aesthetic value to the interior space* 

	Nano green sheets can be used as a wall paper with different designs in upper wall of bath room designs, where it can resist water and moisture  *Pictures shows the harmful effect of water and moister against traditional wall paper, the damages that can be happen which cause shortness of its life time and distortion of aesthetic view*

Table. The use of green Nano materials as an alternative to traditional materials in interior design to give the property of water repellent and self-cleaning, upon the research result.

RECOMMENDATION:

Upon the research results; it is recommended to use Nano green materials (Nano green sheets tested in the research) in the field of interior design as wood veneer either for natural wood or manufactured ones or as a wall paper in a way that fulfill interior design desires. The use of green Nano materials (Nano cellulose fibers and Nano-clays) and natural materials as shellac helps to achieve the principle of sustainability and helps in maintaining the ecosystem, as well as energy saving by eliminating the use of Chemically Manufactured Nanomaterials where they consume a lot of energy when manufactured, also the use of green Nano materials examples (Nano cellulose fibers and Nano-clays) maximized by being applied in the field of interior design and furniture.

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