# Nanotechnology: Between smart architecture and the preservation of the Sustainability

# تكنولوجيا النانو : بين العمارة الذكية والحفاظ علي الاستدامة

**Assoc. Prof. Dr. Wael Seddik moustafa**
Associate Professor in Architecture- Dep.
Faculty of Engineering, Mansoura University

**Assoc. Prof. Dr. Mohamed Saad Attwa**
Associate Professor in Architecture- Dep.
Faculty of Engineering, El-Azhar University.

**Dr. Magdy Qassem**
Associate Professor in Architecture- Dep.
Faculty of Engineering, El-Azhar University

**Eng. Haitham Emad el- din Morsy**
Ademonstrator in Architecture- Dep.
Higher Institute of Engineering and Technology

## Abstract:

Nanotechnology appeared as a result of global cooperation in the field of advanced technology in the twenty-first century this manipulation in the articles on the Richter nanotechnology had revolutionized the contemporary technology we have in all aspects of life, in particular in the different concepts of the design of the materials and methods of construction.

therefore search wanted to clarify the most important methods and materials and processors used techniques of nanotechnology which contribute to increasing the capacity of its buildings to provide energy exploitation of optimal exploitation, therefore focused research study in an attempt to reach some of materials manufacturing by nanotechnology in which access to the best sustainable design of buildings is compatible with modern technology.

The study aims at research to attempt to clarify the ability of technology including reached of science and modern technology and its impact on the architectural thought and understanding of the basics to take advantage of the positive aspects which seriously contribute in raising environmental efficiency, as the study focuses also develop axes to develop materials used in construction to make them more sustainability

## الملخص :

ظهرت تكنولوجيا النانو كنتيجة للتعاون العالمي في مجال التكنولوجيا المتطورة في القرن الواحد والعشرين وهذا التلاعب في المواد على مقياس النانو قد أحدثت ثورة في التكنولوجيا المعاصرة لدينا في جميع جوانب الحياة، ولا سيما في المفاهيم المختلفة لتصميم المواد وطرق البناء.

ولذا أراد البحث توضيح أهم الأساليب والمواد والمعالجات المستخدمة بتقنيات النانو تكنولوجي والتي تساهم في زيادة قدرة مبانيها على توفير واستغلال الطاقة الاستغلال الأمثل ، ولهذا ركزت الدراسة البحثية في محاولة للوصول لبعض المواد المصنعة بتكنولوجيا النانو والتي نستطيع من خلالها الوصول الي افضل تصميم مستدام للمباني متوافق مع تكنولوجيا العصر.

وتهدف الدراسة البحثية إلي محاولة توضيح قدرة التكنولوجيا بما وصلت إليه من علوم وتقنية حديثة وتأثيرها على الفكر المعماري وفهم معطياتهم إلي الإستفادة من جوانبها الإيجابية والتي تساهم جديا في رفع الكفاءة البيئية لمبانيها، كما تركز الدراسة أيضا إلي وضع محاور لتطوير المواد المستخدمة في البناء لجعلها اكثر استدامة

*Keywords*; Sustainable design, Nano technology, Nano materials.

## 1- Introduction

Construction technology witnessed several recent breakthroughs in the development of construction materials, stressing the invitation to the sustainability of the construction in order to what is happening on the negative impacts on the system and achieve environmental sustainability of these buildings.

Architectural Innovation did not depend on traditional methods of design, aesthetics and function, but the percentages Arrived in contemporary creativity to integrate science and technology in modern architecture, whether on the level of design or construction or implementation or construction materials, which aims to achieve the best product seeks for and the well-being of the building and well-being and comfort of user environment and sustainable resources,

In spite of the steady expansion in the areas of use, but it still faces some obstacles and difficulties Today, researchers are trying to overcome in the attempt to eliminate those obstacles.

The architecture is a reflection of people's civilization and the spirit of the age, now this age witnesses intellectual shifts in the architectural field. But with the continuance of technological development the architecture affects badly on the society from many aspects such as:

1. The increasing of sick buildings phenomenon and pollute the environment
2. The inability of our architectural structure to play the role assigned to it to achieve full sustainability concepts.

Perhaps the emergence of these environmental problems make the architects think about a better future with sustainable architecture, hence it emerged making ourselves ask:

- Can we develop the solar cells through Nano technology and make it more sustainable?
- Can nanomaterials be compatible with the future architecture and which take into account the maximum preservation of the environment standards?

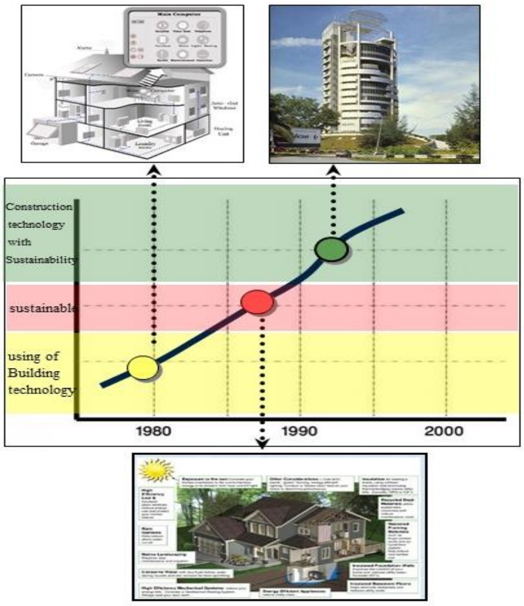



Fig 1: seeking to integrate science and technology of modern construction with the principles of sustainability
Source: researcher

## 2- Sustainable design:(2)

The concept of sustainable design can be summarized as a design which seeks to reduce the negative effects on the environment, and health insurance, and comfort of the occupants of the building, and this leads to improve the building performance and achieve the basic objectives of sustainability such as reduction of nonrenewable resources consumption and reduce waste materials.

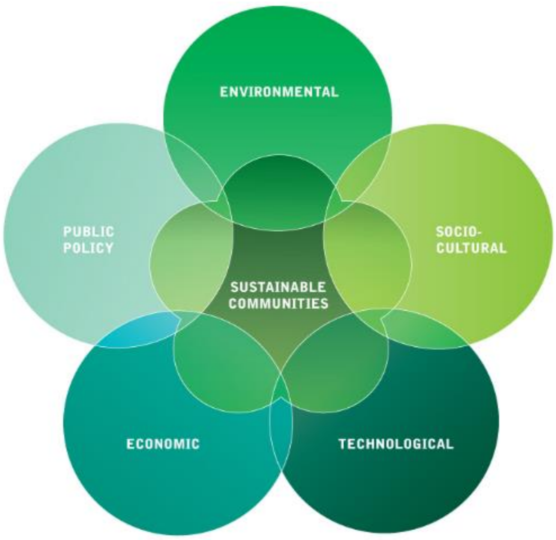



Fig 2: Technology and environmental preservation of the most important domains to reach a sustainable societies
Source: www.nslw.org_large.png

### 2.1- Executive formula to achieve the principles of sustainability: [2]

In order to achieve the principles of sustainability in architecture a lot of pioneers of sustainability in architecture, professionals and academic organizations try to achieve Executive formula of sustainability to make it available and intangible ,So they summarized it in the following tables:-

#### 2.1.1- Pre-Building Phase: Manufacture [4]

| | | |
|---|---|---|
| 1 | **Waste Reduction** | The waste reduction feature indicates that the manufacturer has taken steps to make the production process more efficient, by reducing the amount of scrap Material that results.<br>This scrap may come from the various molding, trimming, and finishing processes, or from defective and damaged products. For products with this feature, scrap materials can be reincorporated into the product or removed for recycling elsewhere.<br>Some industries can power their operations by using waste products generated on-site or by other industries. These options reduce the waste that goes into landfills. |
| 2 | **pollution Prevention** | The pollution prevention feature indicates that the manufacturer has reduced the air, water, and soil pollution associated with the manufacturing process, implying measures that exceed the legislative minimums required of manufacturers.<br>These reductions may be achieved through on-site waste processing, reduced emissions, or the recycling of water used in the manufacturing process. Environmentally sound packaging is another pollution prevention feature, as the way in which a product is packaged and<br>shipped affects the total amount of waste generated by the product |
| 3 | **Recycled Content** | A product featuring recycled content has been produced partially or entirely Of post-industrial or post-consumer waste.<br>The incorporation of waste materials from industrial processes or households into usable building products reduces the waste stream and the demand on virgin natural resources. |
| 4 | **Embodied Energy Reduction** | The embodied energy of a material refers to the total energy required to<br>Produce that material, including the collection of raw materials. Any revision of a manufacturing process that saves energy reduces the embodied energy of the material.<br>A conventional material with a high embodied-energy content can often be replaced with a low-embodied-energy material, while still using conventional design and construction techniques. |
| 5 | **Use of Natural Materials** | Natural materials are generally lower in embodied energy and toxicity than man-made materials. They require less processing and are less damaging to the environment. Many, like wood, are theoretically renewable.<br>When low- embodied-energy natural materials are incorporated into building products, the products become more sustainable. |

#### 2.1.2- Building Phase: Use [4]

| | | |
|---|---|---|
| 6 | **Reduction in Construction Waste** | Many building materials come in standard sizes, based on the 4' x 8' module defined by a sheet of plywood. Designing a building with these standard sizes in mind can greatly reduce the waste material created during the installation process.<br>Efficient use of materials is a fundamental principle of sustainability.<br>Materials that are easily installed with common tools also reduce overall waste from trimming and fitting. |
| 7 | **Energy Efficiency** | *Energy efficiency* is an important feature in making a building material environmentally sustainable.<br>Depending on type, the energy efficiency of building materials can be measured with factors such as R-value, shading coefficient, luminous efficiency, or fuel efficiency.<br>The ultimate goal in using energy efficient materials is to reduce the amount of artificially generated power that must be brought to a building site. |

| | | |
|---|---|---|
| 8 | **Water Treatment/ Conservation** | Products with the *water treatment/conservation* feature either increase the quality of water or reduce the amount of water used on a site. Generally, this involves reducing the amount of water that must be treated by municipal septic systems, with the accompanying chemical and energy costs.<br>This can be accomplished in two ways: by physically restricting the amount of water that can pass through a fixture (showerhead, faucet, and toilet), or by recycling water that has already entered the site.<br>Graywater from cooking or hand-washing may be channeled to flush toilets.<br>Captured rainwater can be used for irrigation. |
| 9 | **Use of Non Toxic or Less-Toxic Materials** | *Non- or less-toxic materials* are less hazardous to construction workers and building occupants. Many materials adversely affect indoor air quality and expose occupants to health hazards.<br>Some materials, like adhesives, emit dangerous fumes for only a short time during and after installation; others can reduce air quality throughout building's life. |
| 10 | **Renewable Energy Systems** | *Renewable energy systems* replace traditional building systems that are dependent on the off-site production of electricity and fuel. Solar, wind, and geothermal energy utilize the natural resources already present on a site.<br>Components that encourage daylighting, passive solar heating, and on-site power generation are included in this category. |
| 11 | **Longer Life** | Materials with a *longer life* relative to other materials designed for the same purpose need to be replaced less often.<br>This reduces the natural resources required for manufacturing and the amount of money spent on installation and the associated labor.<br>Durable materials that require less maintenance produce less landfill waste over the building's lifetime. |

### 2.1.3- Post-Building Phase: Disposal [4]

| | | |
|---|---|---|
| 12 | **Waste Reduction** | Reusability is a function of the age and durability of a material. Very durable materials may outlast the building itself, and can be reused at a new site.<br>These materials may have many useful years of service left when the building in which they are installed is decommissioned, and may be easily extracted and reinstalled at a new site. |
| 13 | **Recyclability** | *Recyclability* measures a material's capacity to be used as a resource in the creation of new products.<br>Steel is the most commonly recycled building material, in large part because it can be easily separated from construction debris with magnets.<br>Glass can theoretically be recycled, but is difficult to handle and separate at a demolition site |
| 14 | **Biodegradability** | The biodegradability of a material refers to its potential to naturally decompose when discarded. Organic materials can return to the earth rapidly, while others, like steel, take a long time.<br>An important consideration is whether the material in question will produce hazardous materials as it decomposes, either alone or in combination with other substances. |

## 3- Nanotechnology: [1]

There are many and varied definitions of the term nanotechnology show by experts, researchers, and most of these are close and are similar definitions in terms of content and the concept and the private and public so it can be summarized in the following concept: "is the search and control or control article internal environment at the atomic scale or molecular by restructuring and the arrangement of atoms The constituent particles, and dealing with structures sizes between 1 and 100 nm in the design, production, characterization and applications of materials and structures and systems are distinct and unique "operations.

## 3.1- Nano materials

Nano materials show many terms for many global organizations are as follows:

Table 1: multiple terms of the various bodies of nanomaterials: (coordinated by researcher)

| | |
|---|---|
| ISO standard[5] | Materials with nanometer scale after an external and an internal or surface with nanometer-scale structures.[5] |
| The Commission of the European Union for the Scientific competent emerging health risks[8] | Related materials after the external one or more or internal architecture can be new properties appear compared to the same material without nanoscale features or some form of material that is composed of parts of a separate function, and have many of them and one or more a scale of 100 nm or less.[8] |
| The European Union re-drafting of the new law for food[5] | Any material made with after an external one or more scale of 100 nm or less or is composed of discrete functional parts internal or superficial and her after one or more scale of 100 nm or less, including environmental and blocks and compounds that can scale more than 100 nm but retain the characteristics of the nanoscale.[5] |
| American Chemistry Council (ACC)[8] | Material nanometer manufacturer (Engineered Nanomaterial) is any material of a one-dimensional size or dual, or triple made between 100 nm in the usual, and notes that the nanometer scale or 100 nm is not a dividing line (Bright Line) and the data available to the materials outside this range may be value, and the intervention of spherical fullerenes in this range although the size of less than 1 nm.[8] |

## 3.2- Nano materials science: [1]

Nanomaterials are not simply another step in the miniaturization of materials.
They often require very different production approaches.
There are several processes to create nanomaterials, classified as „top-down" and „bottom-up". Although many nanomaterials are currently at the laboratory stage of manufacture, a few of them are being commercialised.
Below we outline some examples of nanomaterials and the range of nanoscience that is aimed at understanding their properties. As will be seen, the behavior of some nanomaterials is well understood, whereas others present greater challenges

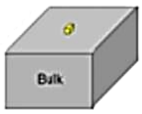
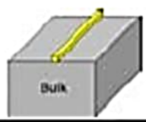
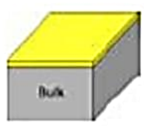
| Nanomaterial Dimension | Nanomaterial Type | Example |
|---|---|---|
| All three dimensions < 100 nm | Nanoparticles, Quantum dots, nanoshells, nanorings, microcapsules |  |
| Two dimensions < 100 nm | Nanotubes, fibres, nanowires |  |
| One dimension < 100 nm | Thin films, layers and coatings |  |

Fig 3: Nanomaterials categorized based on their dimensions
Source: Nano material science, Nanotechnology, (2009)

## 3.3- The important functional characteristics of nanomaterials

### 3.3.1- Self-cleaning: Lotus-Effect: (9)

This is one of the best-known means of designing surfaces with nonmaterial.
The name "Lotus-Effect" is evocative, conjuring up associations of beads of water droplets, and therefore the effect is often confused with "Easy-to-clean" surfaces with photo catalysis, which is also self-cleaning.
Self-cleaning surfaces were investigated back in the 1970s by the botanist Wilhelm Berthelot.
He examined a self-cleaning effect that can be observed not only in Lotus leaves.
They exhibit a microscopically rough water- repellent (hydrophobic) surface, which is covered with tiny knobbles or spikes so that there is little contact surface for water to settle on.
Due to this microstructure surfaces that are already hydrophobic are even less wettable.

The effect of the rough surface is strengthened still further by a combination of wax (which is also hydrophobic) on the tips of the knobbles on the Lotus leaves and self-healing mechanisms, which results in a perfect, super-hydrophobic serf cleaning surface.

Artificial "lotus surfaces", created with the help of nanotechnology, do not as yet have any self-healing capabilities, but they can offer an effective means of self-cleaning when properly applied.
The Lotus-Effect is most well suited for surfaces In all areas not subject to mechanical wear and tear, the Lotus-Effect drastically reduces the cleaning requirement and surfaces that are regularly exposed to water remain clean.
The advantages are self-evident: a cleaner appearance and considerably reduced maintenance demands.

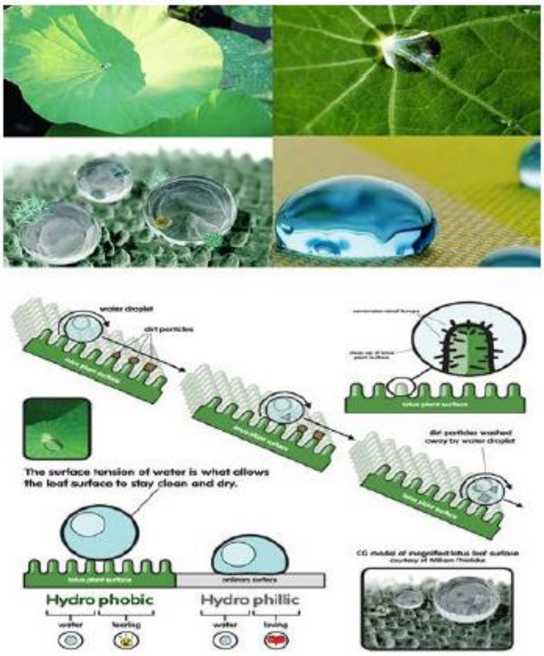



Fig 4: The nature of the outer surface of the water repellent lotus leaf.
Source: www.ryannygard.com

Fig 5: Wood can be given an extremely water-repellent self-cleaning surface.
Source: www.understandingnano.com

## 3.3.2- Self-cleaning: Photo catalysis: (6)

Photocatalytic self-cleaning is probably the most widely used Nano-function in building construction. There are numerous buildings around the world that make use of this function.

Its primary effect is that it greatly reduces the extent of dirt adhesion on surfaces. It is important to note that the term “self-cleaning ” in this context is misleading and does not mean, as commonly assumed , that a surface need not be cleaned at all. The interval between cleaning cycles can, however, be extended significantly, a fact that is particularly relevant in the context of facility management.

Fewer detergents are required, resulting in less environmental pollution and less wear and tear of materials. Likewise reduced cleaning cycles lead to savings in personnel costs and the fact that the dirt adheres less means that it is also easier to remove.

A further advantage is that light transmission for glazing and translucent membrane is improved as daylight is obscured less by surface dirt and grime. Energy costs for lighting can be reduced accordingly

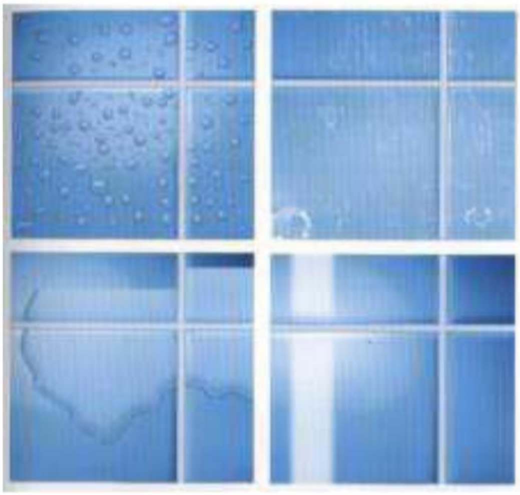


Fig 6: Before & After: On conventional tiles, water forms droplets that dry leaving behind dirt deposits. On the hydrophilic surfaces of photocatalytic tiles, water forms a film that runs off taking any loose dirt deposits with it.
Source: Nano Materials in architecture, Interior architecture and Design

For the function to work, UV light present in normal daylight is sufficient to activate the photocatalytic reaction. Organic dirt on the surface of a material is decomposed with the help of a catalyst – usually titanium dioxide which has been used in all kinds of products. At a nanoscale dimension, titanium appears no longer white but transparent, and it's also hydrophilic. Photocatalytic surface coatings are often applied to façade panels made of glass or ceramics or to membranes.

As the self-cleaning effect doesn't function without water, eaves should be designed so that they do not prevent rainwater or dew from reaching the façade. It is also necessary in glazing to abstain from the use of silicon-based seals because the oils they contain transfer to the glass and are incompatible with the surface coating, rendering it partially hydrophobic and resulting in unsightly streaking.

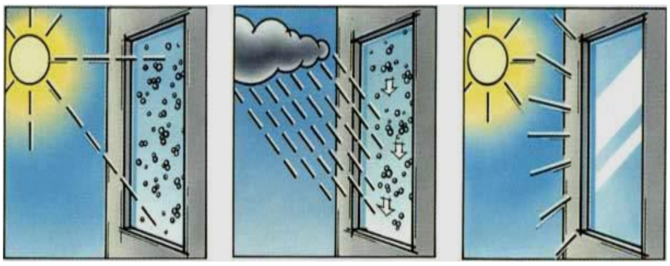


Fig 7: The diagram shows the basic process: Organic dirt & grime is broken down and “decomposed”. Until now UV light, such as present in sunlight, is necessary to initiate photo catalysis.
When water impacts on the surface, it spreads to form a film washing away the loose dirt
Source Nano material science, Nanotechnology

### 3.3.3- Antibacterial: (1)

Photocatalytic surfaces have an antibacterial side Effect due to their ability to break down organic substances in dirt. With the help of silver nanoparticles –for its antimicrobial properties, it is possible to manufacture surfaces specifically designed to be antibacterial or germicidal.
Various products are already commercially available and the product palette ranges from floor coverings to panel products and paints to textiles with an innovative finish that renders them germ free.

Fig 8: Operation theatre interior shows the green antibacterial tiles
Source: www.understandingnano.com

The antibacterial effect of silver results from the ongoing slow diffusion of silver ions. The very high surface area to volume ratio of the nanoparticles means that the ions can be emitted more easily and therefore kill bacteria more effectively. The antibacterial effect itself is also permanent – it doesn't wear off after a period of time.
As the use of disinfectants in health care cannot yet be avoided, it is important that coatings and materials are proven to withstand standard disinfections. In addition, it is also advisable to equip surfaces with an anti-stick function to prevent the buildup of a bio-film of dead bacteria from which new bacteria could eventually grow.

Fig 9: Nano scalar silver particles contained in the glaze applied to ceramic sanitary installations lend it antibacterial properties
Source: www.understandingnano.com

### 3.3.4- Easy-to-clean (ETC): (3)

So-called easy-to-clean (ETC) surfaces are water- repellent and accordingly are often confused with other self-cleaning functions such as the Lotus-Effect.
However, unlike the latter, easy-to-clean surfaces are smooth rather than rough. These surfaces have a lower force of surface attraction due to a decrease in their surface energy, resulting in reduced surface adhesion. This causes water to be repelled, forming droplets and running off. Easy-to-clean surfaces are therefore hydrophobic, and often also oleo phobic. This function is used for coating ceramic sanitary installations and shower cubicle glazing. Wood, metal, masonry, concrete, leather as well as textiles are likewise candidates for hydrophobic coatings.
Easy-to-clean surfaces are less susceptible to dirt accumulation (―dirt- repellent‖).
The benefit: stress-free and easy cleaning saves time and costs.

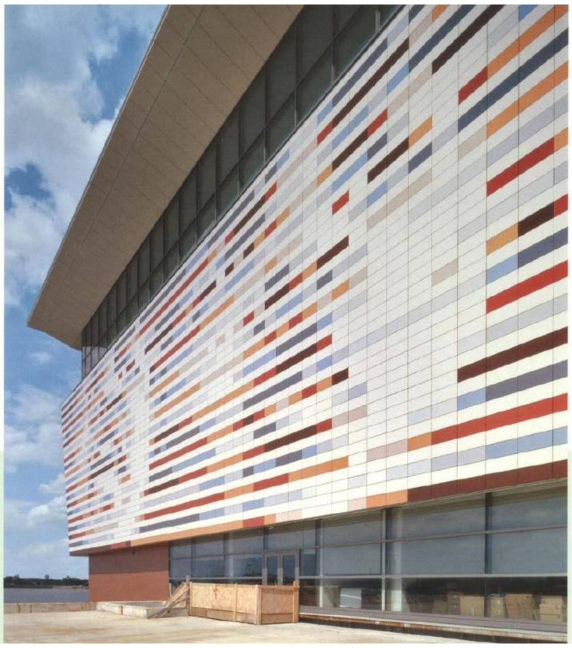


Fig 10: Exterior façade of Mohamed Ali kylie-center
Source: www.forbes.com

Water droplets are not always beneficial and can have disadvantageous effects: the drying time is correspondingly longer and this should be taken into consideration for particular areas of application. It is therefore necessary to consider where and how the easy-to-clean function should best be employed; it is that droplets dry individually, leaving behind dirt residues

Fig 11: A comparison of ceramic surfaces – left without ETC coating, right with ETC coating.
Flexible ETC ceramic wall coverings, similar to wallpapers, can withstand direct exposure to water, such as that in a shower cubicle thanks to their highly Water-repellent surface.
Source: www.forbes.com

## 4- Conclusion:

The construction technology based on the use of nano materials in the construction, with many important and which was one of the most important outcomes of the major technologies in the twenty-first century changes, which led to providing many opportunities and find many solutions to environmental problems such as resource conservation, reduce pollution, raise the internal environment of buildings efficiency and reduce maintenance costs, which can clarified to the following examples

### 4.1- The difference between the using of nanomaterials and conventional materials in buildings:

Fig 12: The difference between using ordinary paints and paints made by nanotechnology and the impact of environmental factors after 224 days
Source: www.edgecryojetics.com

## 4.2- The difference between the using of nanomaterials and conventional materials;

**Table2: comparison between Nano ceramic tiles and conventional ceramic tiles**: (3) (coordinated by researcher)

| | **Nano-material ceramic(3)** | **Conventional material ceramic(3)** |
|---|---|---|
| **Applications** | | |
| Contract flooring | √ | x |
| Decorative elements | √ | √ |
| Sanitary wet rooms | √ | √ |
| Veneer | √ | x |
| Wall coverings in exteriors | √ | √ |
| Wall coverings in interiors | √ | √ |
| **Markets** | | |
| Construction | √ | √ |
| Home , lifestyle & personal care | √ | √ |
| Print , paint & coating | √ | x |
| **Advantages** | | |
| Antibiotic | √ | x |
| Breathable | √ | x |
| Durability | √ | √ |
| Easy to clean | √ | √ |
| Environmental friendly | √ | x |
| Flame-resistant | √ | √ |
| Flexible , easy to process | √ | x |
| Impact – resistant | √ | x |
| Easy of mobility | √ | x |
| Scratch- resistant | √ | x |
| Svoc free | √ | x |
| Uv – resistant | √ | √ |
| Waterproof | √ | √ |

## 5- Recommendations

The research paper demonstrated the need to use nanotechnology in solar cells because of the lifting of qualification and the preservation of the sustainability of those buildings at the same time, however, it is still the urgent need for necessary to continue to scientific research in this area to reach the best product of the least cost in order to achieve the purpose of access to sustainable design at the top of the inefficient and cheaper

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