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Nanotechnology and The Sustainability of Building Facades

تكنولوجيا النانو وتحقيق استدامة واجهات المباني

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Abstract

The Sustainable Development Strategy - Egypt 2030 - represents a step towards improving the quality of daily life and taking into account the rights of future generations Nanotechnology is one of the most important sustainability applications because the materials generated by this technology achieve sustainability goals and standards in that they are environmentally friendly materials and help reduce emissions of harmful substances and extend the life of buildings that directly contribute to the development of architecture.

Public building facilities across the world, including Egypt, are exposed to many climatic changes, which show a negative impact on existing building materials and the maintenance of their finishing, thus requiring the need to address the use of building materials with modern specifications that meet sustainability standards. Building materials that interfere with the manufacture of nanotechnology, with their characteristics and advantages, can counteract the effects of climate changes and address the situation in many regions' buildings.

The study aims to develop the facades of buildings near beaches in coastal cities, identify some of the building materials that are used to finish the facades of buildings in those areas and their vulnerability to the surrounding climatic factors, and identify the nanomaterials that can be used in finishing work to protect the facades from the impact of these factors.

Key Words: *Nanotechnology, Building Facades, Sustainable Development, Climatic Changes, Nano-materials, Sustainability*

1. Introduction

The world has witnessed a marked acceleration of technological progress in all spheres of life since the twentieth century, most notably (nanotechnology), which has led to significant changes in all spheres and is one of the most important areas affected by the development of nanotechnology; Using this technology to produce advanced materials and improve the features of other finishing materials that give the building significant developments through the use of environmentally friendly materials. Interest in nanotechnology began in 1996 and 1998 when the American Center for Global Technology researched nanotechnology and its role in the military, medical, agricultural, engineering and other fields. (Fahd Hemeida, 2010)

Nanotechnology contributes to the establishment and finishing phases. It develops less sized materials and their light and more powerful weight, using less raw materials and

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contributing to reduced energy use. This technology also offers many directions and ways for architects to increase the prospects for creativity, engineering development and many different options. We note that building facades are affected by many climate variability, and research is interested in using nanotechnology to contribute to these problems and achieve sustainability standards.

2. Research Problem

Climate changing badly affects building facades, because of the poverty of finishing materials to hold out their different effects and low alignment with sustainability standards.

3. The Importance of Research

The significance of the study is due to the application of building materials built with nanotechnology as a new property and the forceful achievement in addressing the problems in available building materials. To achieve building facades that are self-contradictory to climate variations and adhere to sustainability standards.

4. Research Objectives

The search is divided into two goals, which are arranged in the following:

1. Clarification of sustainability criteria
2. It is important to consider the effects of nanotechnology on structure.
3. Developing nanomaterials that can be utilized on building facades and adhering to sustainability standards.

5. Research Methodology

The study focused on testing and narrative methods for gathering information on nanomaterials and their impact on the building's facade.

6. Sustainability Standards

The trend towards sustainable architecture has been influenced by the building sector's impact on primary sources and the surrounding environment. Sustainable buildings indicate the presence of quality standards, strategies, and sustainability initiatives. Water and energy sources are utilized at a high level of efficiency, Appropriate land use, site coordination, and use of environmentally compatible building materials are necessary to achieve the standard of the internal surroundings and cost-effective water use, Reduce the impact of buildings during their life cycle and handle solid waste.

7. Nanotechnology

Nanotechnology involves the capture of very small atoms of any material and the movement of them subsequently blending them with other atoms to make high-performance nanomaterials. (Samar Z Moh, 2014)

7.1 Nano Scale

The depth, length, and height of nano particles range from 1 to 999 NM, Despite the desire of many scientists to imagine this scale, we can acquire the same concept by comparing it to (fig 1).The term 'nanotechnology' is used as an all-encompassing term for science, technology, and engineering conducted at the nanoscale level, The control of matter at dimensions that range from 1 to 100 nano meters (nm) (Arafa R, 2017).

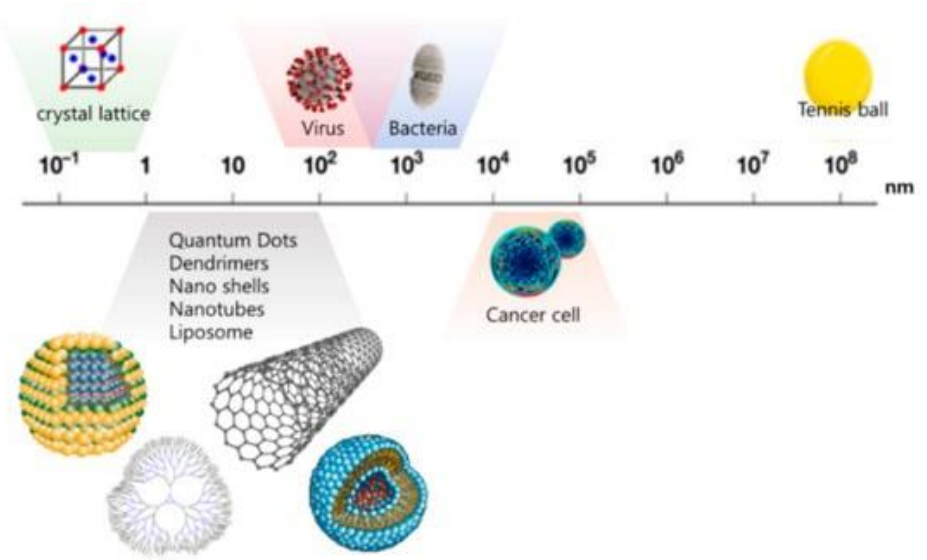

Figure 1. Show Nano scale area (Edwin Nun, Markus Oles and Bernhard Schleick, 2002)

7.2 Applications of Nanomaterial in Architecture

Chemical substances or materials that are manufactured and used on a very small scale are known as nanomaterials. The development of nanomaterials involves exhibiting unique features compared to the same material without nanoscale features, such as increased strength, chemical reactivity, or conductivity. (Leydecker Sylvia, 2008)

The nature of buildings and their relationship with users and the environment can be altered by nanotechnology. At this moment, the building materials used on building facades will be emphasized.

7.2.1 Self-cleaning: Lotus-Effect

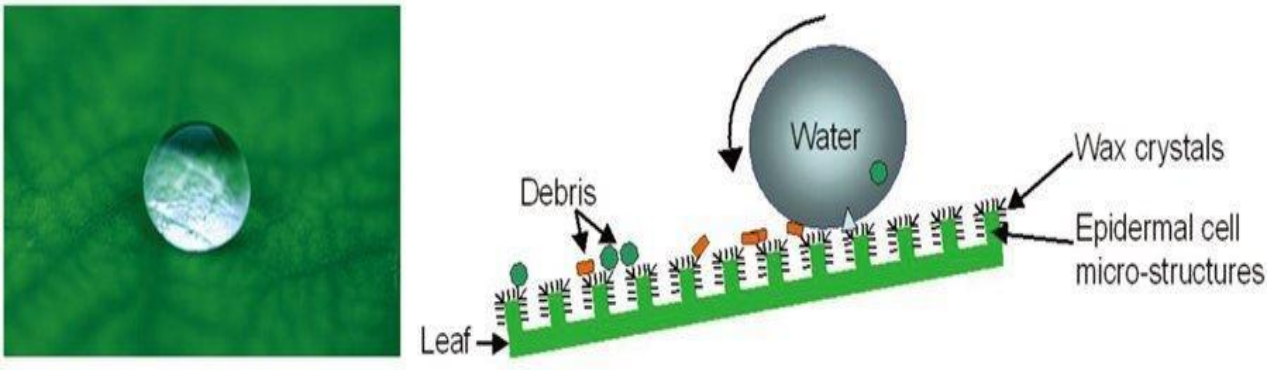

Figure 2. The surface of the lotus effect has a microscopic display of a water dropper (Surface allows self-cleaning)

The surface of a lotus flower is shown in Fig (2) because it does not absorb water droplets, which wash away dust that contaminates it. The lotus effect in all areas decreases the need for cleaning and surfaces stay clean because of the availability of water. The benefits include self-cleaning and less maintenance. (Fahd Hemeida, 2010)

The material results in a decrease in the use of raw materials, an increase in water levels, and a better quality of the internal environment.

Table 1. Building of Commercial at Pula - Croatia

Designer	**Rusan architecture, Andrija Rusan, Pula, croatia**
Area	745 m2

Nano-Material	Self-cleaning paint (lotus-effect)
building	2006

The Lotus-Effect coating protects the white surfaces from dirt (Fig 3) as we can see. The rough surface is washed away by dirt during rain, There is no need to renew the self-cleaning function for five years (Fahd Hemeida, 2010).

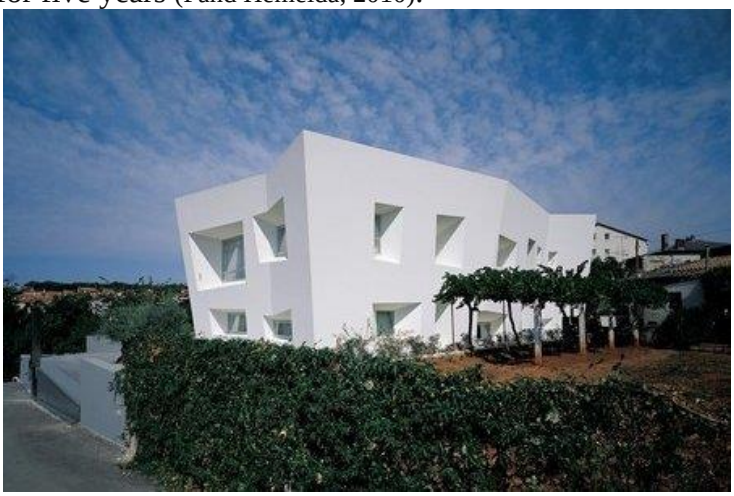

Figure3. Building of Commercial at Pula – Croatia (Leydecker Sylvia, 2008)

7.2.2 Self-cleaning: Photocatalysis

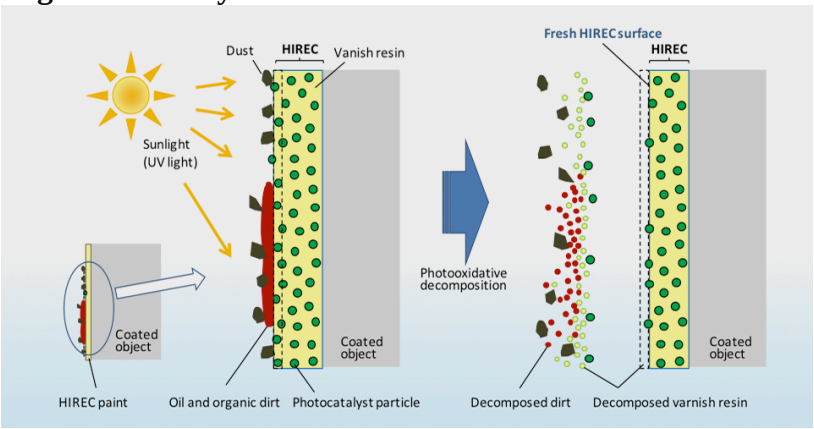

Figure 4. show Photocatalysis concept [9]

The most common nano function is photocatalytic self-cleaning, which reduces dirt adhesion on surfaces. The theory behind this technique (fig 4) is based on the interaction of light (ultraviolet light) with titanium dioxide (TiO2) The material is activated and dust is expelled through the use of light (New photocatalyst shows promise for fuel production). Glass, self-cleaning membranes, and photocatalysis self-cleaning coatings can be made using this technique (fig 5). The material achieves a reduction in the use of raw materials, increases the efficiency of water and energy, and improves the quality of the internal environment.

Table 2. Mohamed Ali center in USA

Designer	**Beyer Blinder Belle Architects& Planners LLP**
Area	1500 m2
Nano-Material	Hydrotect, Photocatalytic self-cleaning ceramic tiles
building	2005

To keep good appearance steady, Photostimulation process is used for self-cleaning to paint the surface of ceramic tile. Furthermore, the surface is able to purify the air by

decomposing pollutants and exhaust vapour from vehicles and manufacturing in the ambient atmosphere (Mohamed Ali, 2007).

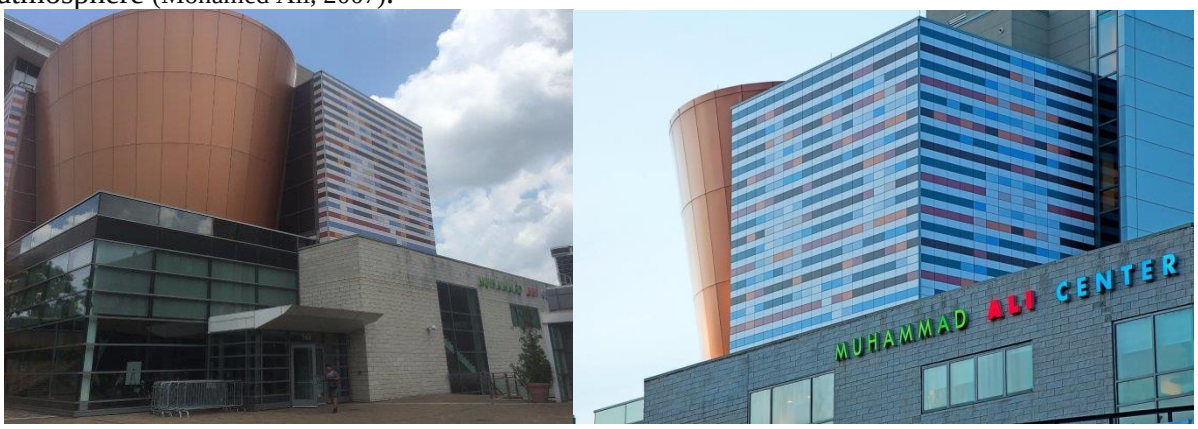

Figure 5 Mohamed Ali Center in USA [13]

Because of the humidity around of the Center area, located nearly Ohio River, we show from (figure 6) the degradation of the facades surrounding Center and its facades was not damaged [15].

Figure 6 . The disrepair of the facades nearby the Mohamed Ali center (Mohamed Ali, 2007)

7.2.3 Easy to Clean (ETC)

Figure 7 . A compare between right with ETC coating and left other (Leydecker Sylvia, 2008)

ETC surfaces are water resistant, manufacture them well suitable for facades, ETC surfaces are utilized in the interior and also be utilized in external to safeguard versus climate . ETC surfaces are soft. These surfaces have a vigour of surface beauty by a decrease in the face vigour, less adhesion. This cause for water to be rejected, shaping droplets and way down (Michael F. Ashby, Paulo J. Ferreira, and Daniel L. Schodek, 2009).

Table 3. Private residence in Switzerland

Designer	**Burkhalter sumi architects, Switzerland**
Area	415 m2
Nano-Material	hydrophobic wood treatment
building	2005

Instead of painting the wood with a paint-like varnish, it has been treated with a hydrophobic treatment to prevent weathering. The impregnation of the wood is transparent, which allows it to breathe. The natural grain of the wood remains intact due to the hydrophobic coating (Faten Fares Fouad, 2012).

Figure 8. Private residence in Switzerland

7.2.4 Antibacterial

Surfaces that are germicidal and antibacterial can be made using silver nanoparticles.Whether it's in materials or invisible coatings, the particles have been added to them. (Leydecker Sylvia, 2008)

The material enables a decrease in the use of raw materials, raises water levels, and enhances the quality of the internal environment.

Table 4. Deutsche Annington Immobilien

Designer	**Burkhalter sumi architects, switzerland**
Area	612 m2
Nano-Material	Bioni Perform, antibacterial façade paint
building	2004

Figure 9. Deutsche Annington Immobilien and form the bacteria are on the wall (2004)

Figure 10. Bacteria not formed when antibacterial materials are used (Leydecker Sylvia, 2008)

7.2.5 Thermal I nsulation: Aereogel

Aerogel is one of the lightest solids and was developed in 1931 (Ritter Axel, 2007). The gel appears fairly cloudy, milky, transparent, which is a light air foam consisting of 95%: 99.9%) of the air. Foam material is silicon dioxide, which is thermally insulating, acting as a sounding insulator and light transmits (Branko Kolarevic, 2003)(Johansen John, 2002). The material reduces the use of raw materials, increases the effectiveness of water and vitality and improves in the internal.

Figure 11. Aerogels in combination with glass (New photocatalyst shows promise for fuel production)

7.2.6 Anti-Fogging

Using nanomaterials now it is possible to see clearly without the need to use electricity. Using a TiO2 nanoscale coating, it contributes to maintaining surfaces without flashing, where moisture forms a thin layer rather than water droplets. It still settles on the surface but remains hidden, and the nano-film is transparent, creating a pure appearance without fog, the condensation itself is not stopped and remains visible without the need for heating (Michael F. Ashby, Paulo J. Ferreira, and Daniel L. Schodek, 2009).

7.2.7 Fire-Proof Glass

Aerosil material is a thermal silicone material and is used for many uses such as the production of flame resistant glass. Or to reduce the spread and blockade of fire, this material is placed through at least one piece of glass.

Fire resistant layer spreads through the foam that contributes to preventing fire spread and keeps emergency corridors available to firefighters and others (Leydecker Sylvia, 2008).

Construction of made sandwiches, flame-resistant construction panels and light weight which are an interesting application for coating the product with a transparent cover of glass-like particles that make it waterproof and fireproof (Ritter Axel, 2007).

Table 5. DHL headquarters, Germany

Designer	**Murphy/Jahn, USA**
Area	90000 m2
Nano-Material	fire proof glass
building	2005

The main office tower is 160 meters tall and employs more than 2,000 employees. The tower facade features a fireproof glass. Fireproof glass has been selected with a particularly slim appearance of this project. (Leydecker Sylvia, 2008)

Figure 1٢. Deutsche Post headquarters (Deutsche Post headquarters, 2014).

8. Conclusion

1. Nanotechnology is based on capturing nanoparticles from any material. Moving it from its original positions to other locations. To incorporate atoms from other materials. Resulting in a crystalline network of nanomaterials with high performance properties.
2. Nanomaterials that can be used for building facade finishing include self-cleaning, Lotus-Effect, photocatalysis, easy to clean, antibacterial, thermal insulation, Aereogel, anti-fogging, solar protection, and fire-proof.
3. Building facades that are both highly efficient and sustainable can be achieved through the use of nanomaterials. The internal environment can be improved by reducing raw materials, boosting water and energy efficiency, and improving the quality of the environment.

9. Recommendations

1. To support sustainable sustainability that is compatible with the environment, architects should follow up on the development of new nanomaterials related to architectural and structural aspects.
2. It is important to emphasize the architect's use of nanotechnology in building methods and finishing materials.

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