Abstract

The present research casts light on the technological development that led to the emergence of nanotechnology and identify its main materials, and the application of their use during the stages of construction and finishing of the building, to achieve sustainability in accordance with global and local regulations. Building facades are exposed to many climate changes that have a negative impact on building materials, which led to search to use building materials with new specifications that give us the sustainability standards, that can face the effects of climate change. Research discusses nanomaterials that can be used in building facades such as (lotus flower effect - photolysis - easy-to-clean surfaces ... Etc.)

Keywords: Nanotechnology, Nanomaterials, Sustainability of building material, Nanotechnology Applications, building facades.

1 Introduction

Since the twentieth century, the world has witnessed a remarkable and unprecedented acceleration in technological development in all spheres of life, one of the most prominent of these developments (nanotechnology). It has led to significant positive changes in all areas and has been positive on the architectural and construction side by exploiting its potential to produce new materials or improve the properties of certain materials, giving buildings multiple possibilities for building sustainable materials that are environmentally friendly. The wide interest in nanotechnology dates from 1996 to 1998 when American World Technology Center undertook an assessment study of nanotechnology research and its importance in all medical, military, computer, agricultural, engineering and other fields. [1].
Many uses of nanotechnology in architecture, from the stages of construction to the finishing stages, it is also creating, smaller, lighter, stronger, materials. Using less raw materials and decrease energy, this technology offers a perfect new way of thinking for the architects according to the various option of it. Buildings facades are affected by exposure to climate changes, the research casts light on to use nanomaterial to solve these problems, and achieve sustainability standards.

2 Research Problem
Climate change adversely affects building facades, due to the poor of existing building materials to resist their various impacts and poor compatibility with sustainability standards.

3 The Importance of Research
The importance of the research is due to use building materials based on nanotechnology with new properties and high performance that treatment the problems in existing building materials.
To reach building facades resistant to climate change and apply sustainability standards

4 Research Objectives
We divide the search into two objectives, it is summarized as follows:
1. The definition of sustainability standards
2. The definition of nanotechnology and its effects on architecture.
3. Nanomaterials building that can be used on building facades and apply sustainability standards

5 Research Methodology
The research will be based on the analytical and descriptive approaches in gathering data on Nanomaterial and its effect on the facades of buildings

6 Sustainability Standards
The trend toward sustainable architecture has emerged in response to the impact of the building sector on primary sources and the surrounding environment, sustainable buildings indicate quality standards, strategies and sustainability initiatives. High levels of efficient use of water and energy sources, adequate land use, site coordination and use of environmentally compatible building materials to achieve the quality of the internal environment and water efficiency, reduce the impacts of buildings during their life cycle and manage solid waste [19]

7 Nanotechnology
The principle of nanotechnology is based on capturing very small atoms of any material and moving it from place to place and then combining it with other atoms to achieve high performance nanomaterial [2].

7.1 Nano Scale
Nano particles have at least one dimension (depth, length, height) that measures between (1-999 NM). Many scientists search for imagining this scale, but we can get this idea by comparison as in (fig 1). The term “nanotechnology” is used as an all-encompassing term for science, technology and engineering conducted at the Nano scale.
Nanotechnology materials and sustainability of building facades 350

level- which involves the control of matter at dimensions between approximately 1 to 100 nano meters (nm) [3].

Figure 1. Show Nano scale area .[4]

7.2 Applications of Nanomaterial in Architecture

Nanomaterials are chemical substances or materials that are manufactured and used at a very small scale. Nanomaterials are developed to exhibit novel characteristics compared to the same material without nanoscale features, such as increased strength, chemical reactivity or conductivity.[ 6]

Nanotechnology can modify the nature of the building and the relationship of our buildings to the user and the environment. At this point we will highlight building materials that used on building facades

7.2.1 Self-cleaning: Lotus-Effect

Figure 2. A microscopic display of a water dropper sits on the surface of the lotus effect[5]

Fig (2) illustrates the idea of the effect of a lotus flower as the surface does not absorb water droplets and therefore these droplets wash away the dust that contaminates the surface. In all areas the lotus effect decreases the cleaning necessity and Surfaces remain clean due to the availability of water. The advantages are self-cleaning and reduced maintenance. [1]

The material achieves reduced the use of raw materials, raising water and improving the quality of the internal environment
We notice from (Fig 3) that the white surfaces are protected against dirt due to a Lotus-Effect coating. Dirt washes off the rough surface when it rains. The self-cleaning function persists five years without needing to be renewed [1].

**Table 1. Commercial Building, Pula, Croatia**

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Rusan architecture, Andrija Rusan, Pula, Croatia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Self-cleaning paint (lotus-effect)</td>
</tr>
<tr>
<td>Date</td>
<td>2006</td>
</tr>
<tr>
<td>Area</td>
<td>745 m²</td>
</tr>
</tbody>
</table>

Photocatalytic self-cleaning is the most commonly used nano function, it reduces the adhesion of dirt on surfaces, (fig 4) explain the concept of this technique is depends on the interaction of light (ultraviolet light) with titanium dioxide (Tio2), so that light is used to activate the material to expel dust [9]. This technique can be used to make glass, self-cleaning membrane and photocatalysis self-cleaning coating (fig 5)

The material achieves reduced the use of raw materials, raising water and energy efficiency and improving the quality of the internal environment.
Table 2. Muhammad Ali Center MAC Louisville, Kentucky, USA

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Beyer Blinder Belle Architects &amp; Planners LLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Hydrotect, Photocatalytic self-cleaning ceramic tiles</td>
</tr>
<tr>
<td>Date</td>
<td>2005</td>
</tr>
<tr>
<td>Area</td>
<td>9000 m²</td>
</tr>
<tr>
<td>Façade</td>
<td>1500 m²</td>
</tr>
</tbody>
</table>

To maintain a consistently good appearance, the ceramic tiles are equipped with a photocatalytic self-cleaning surface coating. In addition, the surface is air-purifying, breaking down pollution and exhaust gases from vehicles and industry in the surrounding atmosphere [13].

Figure 6. Mohamed Ali Center [6].

Due to the high humidity in the area of the Mohammed Ali Center, which is located next to the Ohio River, we notice from (Fig 7) the deterioration of the facades surrounding the Mohammed Ali Center and its facades is not affected [15].

Figure 7(a). The deterioration of the facades surrounding the Mohammed Ali enter[20]

Table 3. Hyatt Regency hotel, Osaka, Japan

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Obayashi company, Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>sky clear coat fabric/TiO₂ photocatalytic self-cleaning</td>
</tr>
<tr>
<td>Date</td>
<td>2001</td>
</tr>
<tr>
<td>Area</td>
<td>50 m²</td>
</tr>
</tbody>
</table>
By using photocatalytic self-cleaning surface, the white of the membrane have lasted long without having to be cleaned regularly [6]

![Figure 7(b). Hyatt Regency Garden Chapel Osaka, Japan][8]

**7.2.3 Easy to Clean (ETC)**

![Figure 8. A comparison of right with ETC coating, ceramic surfaces – left without ETC coating.[6]](image)

ETC surfaces are hydrophobic, making them well suited for facades, ETC surfaces are used in the interior and can also be used in outdoor to protect against weather changes. ETC surfaces are smooth. These surfaces have a force of surface attraction by a decrease in the surface energy, less adhesion. This causes water to be repelled, forming droplets and dropping it [7].

The material achieves reduced the use of raw materials, raising water and improving the quality of the internal environment

**Table 4.** Private residence Erlenbach, Switzerland

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Burkhalter sumi architects, Switzerland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>hydrophobic wood treatment</td>
</tr>
<tr>
<td>Date</td>
<td>2005</td>
</tr>
<tr>
<td>Area</td>
<td>415 m²</td>
</tr>
</tbody>
</table>

The wood has been given a hydrophobic treatment to protect the wood against weathering, Instead of painting wood with a paint-like varnish. The wood is impregnated transparently allowing it to breathe. The hydrophobic coating does not obscure the natural grain of the wood [16].

![Figure 9. Private residence Erlenbach, Switzerland][6]
7.2.4 Antibacterial

It is possible to manufacture surfaces to be germicidal and antibacterial due to silver nano particles. Whether in materials or the form of invisible coatings to which the particles have been added [6]

The material achieves reduced the use of raw materials, raising water and improving the quality of the internal environment.

Table 5. Deutsche Annington Immobilien

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Burkhalter sumi architects, zurich, switzerland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Bioni Perform, antibacterial façade paint</td>
</tr>
<tr>
<td>Date</td>
<td>2004</td>
</tr>
</tbody>
</table>

Figure 10. Deutsche Annington Immobilien and form the bacteria are on the wall (2004) [6]

Figure 11. By using antibacterial materials we observe that bacteria are not formed [6]

7.2.5 Thermal Insulation: Aereogel

Aerogel holds the record as the lightest solid material and was developed back in 1931[10]. The gel appears somewhat cloudy, milky, a globular granulate, translucent and It is a very light aerated foam that consists varies between (95%: 99.9%) of nothing other than air. The remaining foam material is silicon dioxide, it is thermal insulating, acts as a sound insulator and good light transmission [11-12].

Figure 12. Aerogels in combination with glass [9]
The material achieves reduced the use of raw materials, raising water and energy efficiency and improving the quality of the internal environment

<table>
<thead>
<tr>
<th>Table 6. School extension, London, England</th>
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<tbody>
<tr>
<td>Architecture</td>
</tr>
<tr>
<td>Client</td>
</tr>
<tr>
<td>Product</td>
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</tbody>
</table>

The south elevation, a dance studio is located, behind which classrooms, a cafe and the Convention hall. The School extension is clad in translucent 70 mm thick aerogel-filled panels [17].

7.2.6 Anti-Fogging

By using nanotechnology, it is now possible to see clearly without the use of electricity. Due to the coating of nanoscale TiO2, which produces an energy on the surface and therefore better humidity attraction on the surfaces, humidity forms a thin film instead of water droplets. It still settles on the surface but remains hidden, the film is transparent, creating a fog-free pure appearance. The two sides are rife to all anti-fogging variants, condensation itself is not stopped and it remains clear without the need for heating [7]. The material achieves reduced the use of raw materials, raising water and energy efficiency and improving the quality of the internal environment.

7.2.7 Solar Protection

Nanotechnology drove us to give another methods for incorporating electrochromic glass in structures. To change the level of the entry of light starting with one state then onto the next, to change to change from clear to obscure and change back. The electrical vitality wanted to shading the ultra-meager nano covering is negligible. We can utilize photochromic glass superior to utilizing dim glass. Daylight consequently obscures the glass. Nanotechnology offers a vitality proficient methods for sun powered security that can be joined with different glass works, the most extreme element of glass boards is 120*200cm [1]. The material accomplishes decreased the utilization of crude materials, raising water and vitality productivity and improving the quality of the inner condition.
7.2.8 Fire-Proof Glass

The Aerosil material a pyrogenic silicic corrosive utilized for some reasons such the production of flame resistant glass. To expand the necessary span of imperviousness to fire the dynamic pressing material is put between at least one pieces of the glass. Standard items are somewhere in the range of 90 and 380 m² for every gram! The advantages are longer duration of fire resistance, and the slender construction, the light weight of the glass and optical appearance. [6]. The fire-resistant layer extends into a foam form that prevents the fire from spreading and keeps escaping routes available to firefighters and others.

Sandwich constructions made of hemp and straw, Flame-resistant, lightweight building boards, it is an interesting application of coating the product in a transparent cover of glass-like particles, making it waterproof and fire-proof [10]. The material achieves reduced the use of raw materials, raising water and energy efficiency and improving the quality of the internal environment

<table>
<thead>
<tr>
<th>Table 7. DHL headquarters Bonn, Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
</tr>
<tr>
<td>Product</td>
</tr>
<tr>
<td>Date</td>
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<tr>
<td>Area</td>
</tr>
</tbody>
</table>

The 160-meter-high main office tower accommodates more than 2,000 members. The facade of the tower is covered with fire-resistant glass. A fire-proof glass with a particularly slender profile was selected for the project. form, Space, construction and materials are carefully coordinated, resulting in an overall concept [6].

Figure 15. Fire-proof glass

Figure 16. Deutsche Post headquarters [18].
8 Conclusion

1. The principle of nanotechnology relies on capturing nanoparticles of any material, moving it from its original positions to other locations, to incorporate atoms of other materials, which in turn form a crystalline network of nanomaterials with high performance properties.

2. Nanomaterials building can be used in the finishing of building facades, this material is Self-cleaning: Lotus-Effect, Self-cleaning: Photocatalysis, Easy to clean, Antibacterial, Thermal insulation: Aerogel, Anti-fogging, Solar protection and Fire-proof

3. Nanomaterials Building help produce facades to be highly efficient and sustainability. Reducing the use of raw materials, raising water and energy efficiency and improving the quality of the internal environment

9 Recommendations

1. The importance of architects' follow-up on the development of new nano materials related to the architectural and structural aspects, to support sustainability that is compatible with the environment.

2. The importance of highlighting the architect's uses of nanotechnology through building methods and building finishing materials.

References

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