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The Impact of Nanotechnology on Exterior and Interior Finishing Materials in Hospitals

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ABSTRACT:

This research deals with nanotechnology and its impact on the external and internal finishing materials in hospitals, as it sheds light on the remarkable recent development in the field of technology, which led to the discovery of nanotechnology, which was adapted in the field of architecture and finishing, which led to the emergence of many different nanotechnologies, which can Increasing the performance of buildings economically and environmentally in general, and for hospitals, which are among the most energy-consuming buildings in particular. These technologies include self-cleaning technology, air purification technology, easy-to-clean surfaces, anti-bacterial surfaces, anti-fog surfaces, anti-reflective surfaces, nano-treated wood, and nano thermal insulators, then the researcher discussed a comparison between some international hospitals that contain nano-finishing materials and a local hospital that relies on traditional finishing materials. The comparison showed the superiority of nano-finishing materials over their traditional counterparts in both economic and environmental aspects, as they were distinguished by their long-life span, reduced carbon dioxide emissions, reduced maintenance work and energy consumption, and thus reduced operating costs, which in hospital buildings reach approximately seven times the cost of their construction.

KEYWORDS: Nanotechnology - Self-cleaning - Air Purification - Anti-Bacterial - Hospitals - Running Costs.

I. INTRODUCTION

Nanotechnology is one of the modern technologies that still needs a lot of research and studies, which also, as many nanoscale research centers have mentioned, is the technology of the next era, meaning we can call our next era a "nanoscale", and the widespread interest in this technology goes back to some period. Between 1996 AD to 1998 AD, when the American Global Technology Assessment Center (WTEC) conducted an evaluation study of nanoscale research and its importance in technical innovation. The study concluded with the most important points that nanotechnology has a great future and will herald a huge leap in many areas of industrial, medical engineering, and agricultural life[1], In the field of transportation, aviation, space research, water purification, and many important vital fields.[2]

The idea of this technique is summarized in rearranging the description of the atoms and molecules of the material next to each other in different formations, and of course, the more the atomic and molecular arrangement of the material changes, the more its resulting properties change to a large extent, which produces materials with distinctive properties, and from here scientists can avoid some unwanted properties For example, rearranging the atoms in coal enables us to obtain diamonds, as well as sand. Rearranging its atoms with the addition of some elements enables us to manufacture computer chips...and so on, and for this reason countries compete with its scientists and capabilities in producing those materials and

products that cannot all be counted because they are increasing and developing rapidly.[3]

Nanotechnology was able to open a new world in the field of architecture and finishing, which led to the use of the best natural resources, as new materials were produced that work on self-cleaning, air purification, easy-to-clean, anti-bacterial, anti-fog, anti-reflective, and thermal insulation, all of which work to increase lifespan and save energy. Reducing operating costs and reducing the need for maintenance and cleaning[4], and we will explain them as follows:

II. RELATED WORK

2-1 Self-Cleaning Technology:

Self-cleaning technology is one of the nanotechnologies in architecture and it has more than one method, including Lotus Effect and Photocatalysis, which is a technique used in glass and coatings, and these two technologies look similar, but each one of them has its own way of achieving its purpose.[5]

2-1-1 Self Cleaning Technique – Lotus Effect:

Lotus-Effect Self-Cleaning uses "Hydrophobic" surfaces, and the designation "Lotus Effect" is one of the best-known meanings for surface design with this technology.[5] The meaning of the "lotus effect" appeared in 1970 by the German botanist Wilhelm Barthlott and a researcher at Heidelberg University, where he placed a slice of the lotus leaf under the electron microscope, as shown in figure (1). What he saw is almost a reversal of a common axiom that says, "If you want to keep something clean, make its surface smooth." On the surface of the leaf at a nanoscale, they are very small and very fine bumps that form a very special roughness, and the secret of the miracle of the lotus leaf lies[6], and the idea came that when water drops fall on the surfaces of the leaves of the plant, they clean it without getting wet, and hence the effect of " Lotus leaf "in the emergence of the name "Self-Cleaning Lotus-Effect". Perhaps what the water drops were doing in cleaning the leaves of plants is nothing but a technique for creating and making a very accurate manufacture of the leaf surfaces of the plant itself, **it has two water-repellent surfaces:**

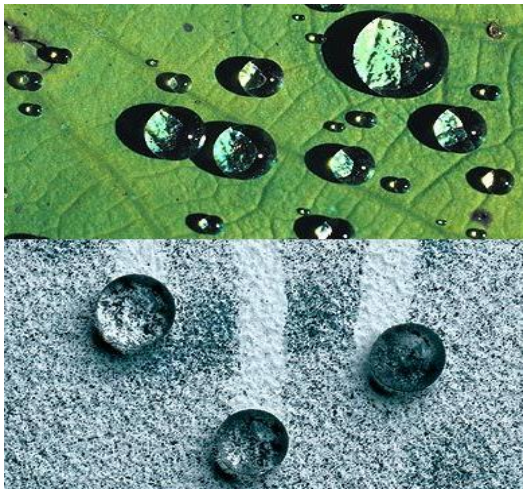

Figure (1) illustrates the idea of the self-cleaning technique of the lotus effect, which shows that the surface contains nanoscale models that carry water droplets, which in turn take the dust with them and fall.[5]

A waxy layer that prevents water from penetrating its tissue, and **a nano-rough layer** formed by the tiny protrusions, between which are also trapped in tiny burrs of air. Each small drop of water from dew or rainwater rolls on it, so the minute drop is joined to the minute droplet to form a bigger and bigger drop, and roll the large, completely rounded drops on the surface of the paper, taking with it all that struck this surface of dust or dirt or other[7], as shown in Figure (2).

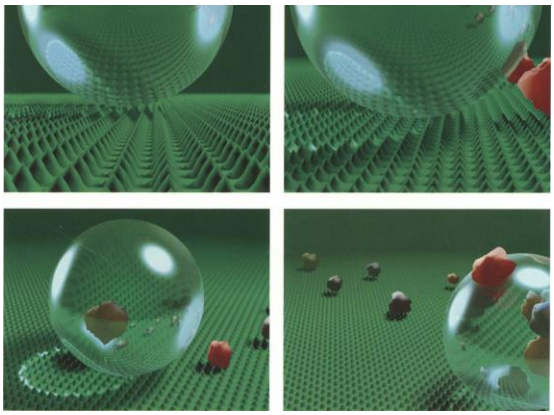

Figure (2), microscope snapshots, showing water droplets cleaning the sinuous surface of the lotus leaf.[4]

2-1-2 Self-Cleaning Technology - Photocatalysis:[8]

Photocatalysis - Self-Cleaning technology uses hydrophilic surfaces, so that water flows on the surface, taking natural or organic soil and slipping

with it, and this technology is used in many countries, such as Japan, for example, where the term "Photocatalysis" is the term used. The idea of this technique, as shown in Figure (3), is summarized in the following:

- Hydrophilic Surface
- Adhesive dirt is broken down and lines
- Washing the dirt on the surface with a torrent of water "A water film washes dirt away"
- UV light and water are required.
- Reduces maintenance requirement

Figure (3) shows that when the building's exterior glass is exposed to sunlight, air and rainwater, the self-cleaning technology "Photocatalysis" works very efficiently to reduce sunlight ingress, resist air, and expel rainwater.[9]

2-1-3 Examples of buildings in which the self-cleaning technique was used:

The Ara Pacis Museum Project:

Table (1) shows the data of The Ara Pacis Museum[5]

Architect	Richard Meier & Partners, NYC, USA
Client	Comune di Roma, Rome, Italy
Manufacturer	Sto
Location	Rome - Italy
Completion	2006
The finishing material	white lacquer
Technology	Self-Cleaning Technology (Lotus Flower Effect)

Description of the building and the technologies used:

It is an antiquities project that contains an entrance with a gallery and is planned in the form of a square, the main building contains a conference hall and cultural meetings and a restaurant, and the building contains a part completely covered with glass, and it is protected against the influences of the surrounding environment, the building is coated with a layer of paint developed with a self-cleaning technique to maintain the white color It is shown in Figure (4), the building's original color, the Meier's character in Rome, which of course did not last long in a heavily polluted city like Rome.[10]

Figure (4) shows the bright white paint used to upgrade the building's exterior facades, developed with a self-cleaning technique that works to preserve the purity and clarity of color in the heavily polluted city of Rome.[10]

A- **MSV Arena Soccer Stadium Project:**

Table (2) shows the data for The MSV Football Stadium Project[5]

Architect	ar.te. plan, Burkhard Grimm, Michael Stehle, Dortmund, Germany
Client	MSV Duisburg
Manufacturer	Pilkington Deutschland AG/Pilkington Group
Location	Duisburg - Germany
Completion	2004
Area	18000 m^2
The finishing material	Nano glass
Technology	Pilkington Active, photocatalytic self-cleaning glass

Description of the building and the technologies used:

It is a football stadium located in the middle of urban gatherings and it was built in nearly a year and the stadium has a capacity of 30,000 fans. More than 15,000 square meters of concrete, about 3,500 tons of reinforced concrete and 30 solid columns were used. As for the used grass, its area is 7,500 square meters and is heated from the bottom, and the project also contains On a giant display screen with an area of 40 square meters, glass and aluminum were used as cladding for the facade with an area of 1500

square meters and a width of 120 square meters, and a "photocatalytic" self-cleaning technique was used in the glass, which also works on protection from sunlight and also has noise isolation[5], as shown in figure (5).

Figure (5) shows the glass facade of the building from the outside and the inside, which works with self-cleaning nanotechnology, as well as noise isolation and protection from sunlight.[11]

2-2 Air Purifying Technology:

Although the air cannot be completely purified, nanomaterials make improving air quality possible. It can dissolve air pollutants and unpleasant odors. Using nanotechnology, odors can be chemically broken down into their harmless components, and despite the possibility of improving air quality, this does not make it ideal, there are other factors that control air quality such as oxygen content and relative humidity.[5]

2-2-1 Example of a building using air purification technology:

A- Expo Milano - Italy Pavilion:

Table (3) shows the data for The Milan Expo Building - Italy Pavilion[12]

Architect	Nemesis and Associates
Location	Milan - Italy
Completion	2015
Area	26,949 m^2
The finishing material	nano-cement containing white titanium dioxide particles
Technology	TX MilIenium, TX Active, photocatalytic cement that purifies the air

Description of the building and the technologies used:

The building consists of irregularly shaped white facades interspersed with openings, as shown in Figure (7), and the facades consist of a mixture of cement and titanium dioxide, as the building captures the nitrogen oxide polluting the air and converts it into inert salts that reduce the levels of fog in the atmosphere when Rain falls, and the building consumes 40% less energy than traditional buildings that are similar in size, and does not produce any pollutants, and it was designed with the concept of urban forests, and this appears in the design of the façades, which helped create a unique geometric texture that evokes random intertwining branches that harmonize light and shade He emphasized the sculptural style of the building, with glass canopies above the building.[12]

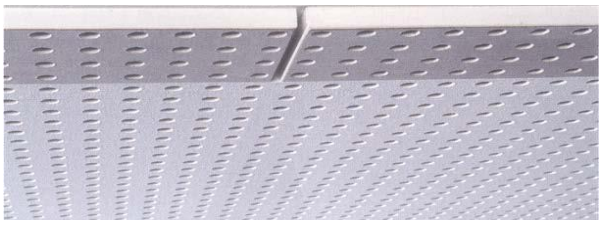

Figure (6) shows a roof made of nanomaterials with air purification technology.[5]

Figure (7) shows the building of Expo Milano 2015 - The Italy Pavilion, which consisted of white, irregularly shaped façades, punctuated with openings, and the façades were made of a mixture of cement and titanium dioxide.[13]

2-3 Easy-to-Clean Technology (ETC):[5]

The easy-to-clean surfaces are smooth surfaces, their energy is low, which leads to a decrease in adhesion to the surface, and this makes them repellent or waterproof surfaces, so water forms drops on the surface that escape quickly and

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thus wash away dirt, and it is anti-oils and oil products, the difference between it and the self-cleaning technology by photocatalysis is that the former does not need sunlight and ultraviolet rays to work, which makes it suitable for bathrooms. Easy-to-clean technology can be used on surfaces outside the building, but it may work efficiently on ceramic and glass products in bathrooms and partitions surfaces in bathrooms, wood, metal, concrete, and leather Textiles, in general, this technology is less prone to dirt because it repels dirt and the benefit is easy cleaning, saving time and maintenance costs.

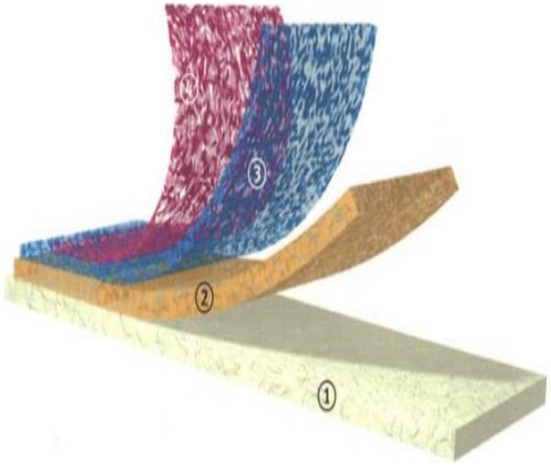

Figure (8) shows a piece of marble with ETC paint on it.[5]

Figure (8) shows a piece of marble with ETC paint on it. It is fireproof and has a water repellent and easy-to-clean surface. The product consists of four layers:

1- Reinforced layer of flexible polymer a flexible polymer matting as backing.
2- A layer of colored ceramic coloured ceramic material is applied.
3- Optional layer for color or other optional printing.
4- "ceramised topcoat".

2-3-1 Example of a building Use a technique easy cleaning:

A- Science to Business Center Nanotronics & Bio Project:

Table (4) shows the data of The Research Center for Science and Business Project.[5]

Architect	Henn Architekten, Munich, Germany
Client	Degussa, Creavis
Manufacturer	The company was called Degussa and now Evonik
Location	Marl - Germany
Completion	2005
The finishing material	Nano ceramic
Technology	Easy-to-clean technology with ccflex nanoceramic wall covering

Figure (9) Science to Business Center Nanotronics & Bio[5]

Figure (10) shows the distinctiveness of these surfaces with their vapor permeability and water repellency properties. They are easy-to-clean surfaces, as they can only be cleaned with a small amount of water.[5]

Description of the building and the technologies used:

The facades of the building were designed to be transparent, as it reflects the principle of the founding company, and nanoceramic was used in many interior decorations in wall cladding, and in bathrooms.[5]

2-4 Antibacterial Surfaces Technology:

Anti-bacterial nanomaterials are produced in the form of paint or spray or films placed on the surface or as a primary factor in filtering water and air inside the interior space of the building, and the United States Environmental Protection Agency stated that ($ 1 billion annually) is spent to produce anti-bacterial compounds, fungi and germs. , And these compounds contain approximately 275 active ingredients, which may spread to the environment, leading to many risks to the environment, and concerns about the spread of these components in the internal space of buildings, which harms human health, and they were used in hospitals, whether in purifying air, water or For floor surfaces in operating rooms and all internal spaces of the hospital.[9]

Figure (11) shows the surfaces on which the bacteria and viruses may be present as a result of touching them by patients.[13]

2-4-1 Example of a building using anti-bacterial roof technology:

Housing Estate project:

Table (5) shows the data for The Housing Estate project in Duisburg [5]

Architect	Joachim Osterland, Essen, Germany
Client	Deutsche Annington Immobilien
Manufacturer	Bioni CS
Location	Duisburg - Germany
Completion	2004
Technology	Antibacterial façade paint

Figure (12) shows the facade of the building, which shows the accumulation of bacteria.[14]

Description of the building and the technologies used: [5]

It is a residential building located in the German city of Duisburg. Fungi, bacteria, algae, some pollutants, and fumes from factories accumulate on its facades, which leads to distortion of the building's facades. In the past, the facades were treated with a silicone coating containing a mixture of insulating and fungicide materials, but after only two years, fungi, bacteria, and algae re-accumulated again, which necessitated re-treatment of the facades again, which leads to an increase in maintenance costs, because when using Like the previous materials, it will need to be reused every two years.

A solution was developed by the Fraunhofer Institute for Chemical Technology in cooperation with the paint manufacturer, using a nano-coating of silver nanoparticles with an average size of 10-15 nanometres (its molecules are chemically stable), and with antibacterial properties. It dissolves bacteria and fungi and prevents them from growing, and therefore does not need to wash the interface or treat it again for several years, and after treating it with antibacterial nano-coating, there is no accumulation of bacteria, fungi and algae on the interface, as shown in Figure (13), which classifies it among Environmentally friendly materials, as this limits the use of strong chemicals that are harmful to the environment.

Figure (13) shows the building after being treated with an anti-bacterial nano coating.[14]

2-5 Anti-fogging Coating:

It was old to maintain surfaces without condensation of water that must be exposed to continuous heating, and using nanotechnology, the coating was made with a very thin layer of titanium dioxide Tio_2, which behaves as energy, as it dissolves water droplets and fog into an invisible thin layer, and this coating is used in glass facades and mirrors , as shown in Figure (14), and in air-conditioned rooms in tropical regions, which are anti-evaporation coatings and can also be used in plastics, and there are many nanomaterials that have this feature, but there is always better In a specific field, there are (AVM) industries the "G-40 Nano 2000" anti-fogging product made of nano-silica, and the product can be used on any surfaces without the need for ultraviolet rays such as titanium oxide, which enables it to be employed inside the building.[15]

Figure (14) shows a pane of glass, half of which is left side of normal glass and the right half of anti-fog glass.[5]

2-6 Anti-reflective coatings:

The anti-reflection coating shown in Figure (15), is used in buildings, especially in the interior spaces of exhibitions and museums, to display exhibits or antiques in a protective glass box. The anti-reflective prevents such reflections on the glass to make the box as if it does not exist, and silica dioxide nanospheres are used in the anti-reflection nano-coating with a size of 30-50 nm, and the thickness of the coating on the surface of the glass is 150 nm and reduces light reflection from 8% to 1%, and anti-reflective coating is widely used as it is used in **television screens**, mobile phone screens and computer screens, and was also used in solar collectors to prevent the reflection of solar rays.[16]

Figure (15) shows a glass plate in which the circular area has been coated with an anti-reflective nano-coating, while the rest of the plate has not been coated.[17]

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2-7 Wood Treated with Nanotechnology:

Nano technology was used in the wood material, where the wood particles were collected and rearranged, making it more bonded and stronger than the natural material, and nano-sensors were invented to locate the fungi and wear points to treat them. The Super Hydrophobic nano coating uses the "Lotus-Effect", which repels water in the form of droplets without leaving any trace of water when sliding, as shown in Figure (16), and this technology allows the wood not to rot and water to penetrate inside it. In order not to lose its hardness, and nanotechnology has improved the properties of wood to address many defects such as combustibility and does not bear stresses like concrete.[18]

Figure (16) shows the surface of wood treated with a layer of water-repellent nano coating.[19]

2-7-1 Example of a building using Wood Treated with Nanotechnology:

Aspen Art Museum (AAM):

Table (6) shows data for the Aspen Museum of Art project.[20]

Architect	Shigeru Ban
Manufacturer	Hunter Douglas Architectural (Europe), Parklex Prodema,
Location	Aspen, Colorado, United States of America
Completion	2014
Area	33,000 m^2
Technology	Wood treated with ultra-hydrophobic nano-coating "Lotus Effect"

Description of the building and the technologies used:[20]

The Aspen Museum of Art is the first permanent museum of architecture in America, and the architect created a sequence specific to the site that takes into account the views of the surrounding mountains and the function of the building as a museum of art, as shown in Figure (17), and to open to the outside where visitors can appreciate The museum's beauty is inside, and the project's architect aims to pressure companies to design more nano-coated wooden structures, which is characterized by its strength, hardness and endurance like concrete, environmentally friendly, lightweight, low cost, flexible and acceptable Shaping, easy to clean, highly resistant to weather, temperature and UV rays. The building's exterior was covered with a woven mesh of braided laminate made of Prodema, as shown in Figure (18), a mixture of resin and paper; It exists as a middle layer between two layers of wood lacquer, and the two sides of the corner are clad in this way, which is somewhat like the "Mashrabiya".

Figure (17) shows the Aspen Museum of Art building and its affiliation with the surrounding nature. It also shows the use of wood treated with nanotechnology in making the ceiling of the last floor of the building.[21]

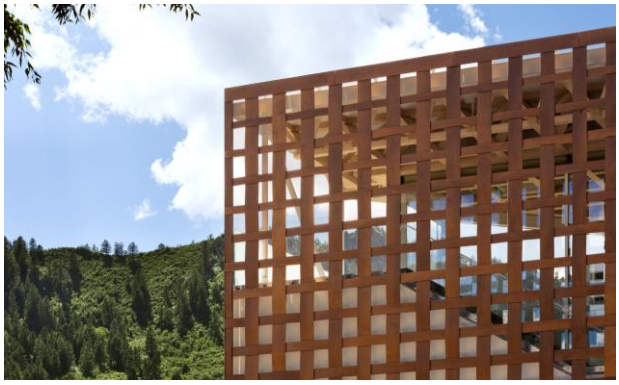

Figure (18) shows the covering of the building's exterior with a mesh woven from braided wooden sheets.[22]

Figure (19) shows vacuum insulation panels (VIPs) of different shapes and sizes.[25]

2-8 Thermal Insulation by Nanotechnology:

Nano insulators are more efficient than conventional insulators by about 30%, and the use of nanomaterials in insulation is a very promising step due to its properties (volume to surface area ratio), and nanomaterials in insulation may be confined between solid plates, or be in the form of films weak, or in the form of paints.[23]

2-8-1 Vacuum insulation panels (VIPs):

The nano vacuum insulation boards are characterized by the maximum thermal insulation and the minimum insulation thickness, they are suitable for providing very good thermal insulation with a thickness less than traditional insulation boards such as polystyrene materials, and it has a thermal conductivity factor less than (5-10) times that of traditional insulation, and its thickness Only 25 mm, and it is used in the inner and outer walls of its thin thickness, and its life span ranges (from 30 to 50) years of operating time, and it does not need periodic maintenance, and it contributes to reducing carbon dioxide and nitrogen emissions.[24]

2-8-2 Aerogel:

It is a substance with wondrous properties known as “Frozen Smoke or Blue Smoke”, and it is prepared from sodium silicate and consists of 5% solid and 95% air. Its density is not more than 3 mg/cm3. It has a high ability to thermal and sound insulation and to provide natural lighting and is used to fill various types of cavities between glass panels, and therefore it is suitable for use in the outer shell of the building, as it helps reduce heating and cooling costs because it is transparent and helps light transmit well. The lightest solid material made by man.[26]

Figure (20) shows the transparent material of the aerogels.[27]

2-8-3 Thin-Film Insulation:

It is a sheet of stainless-steel nanofibers, used in thermal insulation of glass, and helps absorb infrared rays, which helps reduce the temperature of interior spaces by 2-3 degrees compared to traditional materials, which leads to rationalization of energy consumption. in buildings.[24]

Figure (21) Describes the thin films used in thermal insulation of glass.[28]

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Table (7) shows a comparison between the types of nano-thermal insulation in terms of properties and specifications.[24]

Insulation type	Features and specifications
Vacuum Insulation Panels (VIPs)	- Coefficient of thermal conductivity at 25 degrees up to (0.0035 W/m2 Kelvin). - The thickness of the panels (8:35 mm). - Density (240-280 kg/m2). - Provides 10% of the total area of the building due to its low thickness. - Operating time (30-50 years).
(Nanogels) Aerogel	- Decrease in thermal conductivity: U-Value (0.28 W/m2 K). - Sound insulation reduces transmitted noise. - Weight reduction (60:80 kg/m3) - UV resistance. - Natural light transmittance up to 75%. - Water and moisture repellent and high temperature resistant.
Thin-Film Insulation	- Transmitted visible light 61% - Blocks 97% of infrared rays and 99% of UV rays. - Reduces the heat permeable to the interior space by 2-3 degrees Celsius compared to traditional materials.

2-8-4 Example of a buildings using Thermal Insulation by Nanotechnology:

Sonnenschiff centre:

Table (8) shows the data for Sonnenschiff Centre[5]

Architect	Rolf Disch, Freiburg, Germany
Manufacturer	Solarsiedlung GmbH
Location	Frinborg - Germany
Opening	2006
Area	6,500m^2 residential and commercial floor area
Technology	Vacuum insulation panels (VIPs)

Figure (22) shows the Sonnenschiff Residential Commercial Centre, which was designed to be a sustainable and environmentally friendly building.[29]

Description of the building and the technologies used:

This Center is located in Freiburg, Germany, where it is exposed to sunlight during the summer period, which increases the need to consume electrical energy for cooling.

The complex was designed to be a sustainable and environmentally friendly building, where solar panels were used on the roof, and VIP insulated nano panels on the facade of the building, in order to achieve energy efficiency as these panels are more effective compared to other insulating materials.[5]

Krishna P. Singh Center for Nanotechnology:

Table (9) shows the data for Krishna P. Singh Center for Nanotechnology[30]

Architect	Weiss/Manfredi
Manufacturer	Guardian Glass, Sempergreen, JE Berkowitz, Walker Glass
Location	University of Pennsylvania - Philadelphia - Pennsylvania - United States of America
Opening	2013
Area	7020m^2
Technology	Nanogel insulating material - Self-cleaning - Anti-bacterial - Scratch-resistant

Figure (23) shows the building's glass facades that are self-cleaning, anti-bacterial, anti-scratch, and have high thermal and acoustic insulation (nanogel).[30]

Description of the building and the technologies used:

This Center is located at the University of Pennsylvania in the United States of America, and the building was built to contain state-of-the-art laboratories including sterilization and treatment rooms with an area of 10,000 square feet that are located around a central courtyard, which helps to see the outside views and make scientific activities highly visible, and 6,500 square feet of simulation units It also contains 12,000 square feet of vital public spaces, conference rooms, and a multi-purpose hall. The Nanotechnology Center brings together researchers from the faculties of (Engineering, Science, Applied Sciences, and Arts), in order to facilitate interaction between faculty members, students and researchers across different disciplines, and between the university and the city.

In this project, self-cleaning and anti-bacterial nano glass facades were used, and nanogel sheets with high thermal performance were used in the building facades, which thickness reaches 7-12 mm, and they work on thermal and sound insulation at a very high rate, where the thermal conductivity coefficient reaches "U-Value" is less than 5.0 W/m2 Kelvin, and these facades are characterized by saving 20% of daylight without glare, and the transmittance of natural light reaches 88%, and nanomaterials have also been used in the internal and external walls with anti-scratch, All this leads to energy savings and lower operating costs for the building. [31]

Figure (24) shows some of the interior spaces of the building, whose walls were used nano-anti-scratch technology.[30]

2-9 Comparative Analytical Study:

We will conduct a comparative analytical study of some of the foreign hospitals where nano-developed finishing materials are used and compare them with an existing local hospital where traditional finishing materials are used, to determine the extent to which nano-developed finishing materials are superior to their traditional counterpart in economic, environmental, and aesthetic dimensions.[4]

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2-9-1 Examples of international hospitals that have applied some of the above-mentioned nanotechnology:

The Gea González Hospital Specialty Tower:

Table (10) shows the data for The Gea González Hospital Specialty Tower.[32]

Architect	German team of designers from Elegant Embellishments Company
Manufacturer	Elegant Embellishments, Germany
Location	Mexico City - Mexico
Completion	2013
Hospital main facade area	2500m^2
Design Element	External facades
Technology	Air purification by using plates composed of cement and titanium dioxide TiO_2

Figure (25) shows The Gea González Hospital Specialty Tower.[33]

Description of the building and the technologies used:[32]

The Mexican capital, "Mexico City" is famous for its air pollution. Therefore, the facades of the hospital were designed to reduce the impact of pollution, using panels consisting of cement and titanium dioxide, and it consists of concrete designed specifically to reduce the impact of pollution. These panels extend in the facade for more than 100 meters, and have the capacity to reduce the impact of pollution through direct exposure to the sun and give a formation with a unique aesthetic appearance, titanium dioxide is very important because it has the ability to self-clean surfaces from unclean particles, and to get rid of water using "super hydrophilic" that forms on the surface of concrete and maintain On the appearance of the external form of the buildings, and the resulting concrete is white and retains this whiteness permanently.

The Alcoa World Alumina team has unveiled building panels capable of reducing the impact of pollution and used in the chemical reaction between titanium dioxide and sunlight, where it captures polluting nitrogen oxide in the air and turns it into dissolved salts. On the walls when it rains.

The building panels produced by Elegant Embellishments in Berlin-Germany are completely covered with a dense layer of titanium dioxide as a pigment that acts as a catalyst for chemical reactions when exposed to sunlight. When sunlight touches special slabs of bricks, it interferes with the chemical process, the reaction that turns mononitrate into less harmful substances such as calcium nitrate and water as well as carbon dioxide and titanium dioxide does not change and does not weaken its effectiveness over time but remains effective forever.

Figure (26) shows the facades of the hospital in which brick panels are used with air purification technology and the reduction of pollutants, which also serves as a canopy for the facade of the hospital.[34]

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Hospital in Goslar- (Operating Room):

Table (11) shows the data of the "Hospital in Berlin" project.[5]

Architect	Schweitzer + Partner, Braunschweig
Client	Harz Clinics, Goslar
Manufacturer	Agrob Buchtal Architectural Ceramic, Deutsche Steinzeug AG
Location	Goslar - Germany
Completion	2005
Design Element	Floors and Walls
Technology	The ceramic units contain Photocatalysis "Tio_2" coating and anti-bacterial

Figure (27) shows the use of nanoceramic anti-bacterial and anti-fungal in the operating room in the hospital.[35]

Description of the building and the technologies used:[5]

All floors and walls of operating rooms, rooms and corridors in the hospital were paved with Photocatalysis and anti-bacterial surfaces, in order to reduce the spread of infection and reduce risks, especially in operating rooms, and the architects went to reduce the number of spacers between ceramic tiles and reduce the weaknesses in which bacteria and fungi collect and paint them Anti-bacterial nano-coating, all of which simplifies and minimizes
maintenance costs.

Hospital in Berlin - (Patient Room):

Table (12) shows hospital patient room data and materials used.[5]

Architect	100% interior Sylvia Leydecker, Cologne, Germany
Client	succidia Verlag
Location	Berlin - Germany
Completion	2006
Materials Used	
Design Element	**Product**
The Room's Floor	antibacterial floor covering
Bathroom Floor	Subway with Ceramic plus treatment (easy-to-clean)
Room Walls	air-purifying wall paint
Bathroom Walls	Jasba Centino with ETC treatment

Figure (28) shows the room's interior furnishings, which are treated with anti-bacterial technology and purify the indoor air from any pollutants.[5]

Figure (29) shows the use of anti-bacterial floors and wood to keep the room clean from bacteria and microbes.[5]

Interior Appliances and Furnishings	Product
Mirrors	ccflex, water-repellent, scratch-resistant and vapour
Toilet	easy-to-clean WC
Light Switches	AS 500 antibacterial, antibacterial light switches
Table	antibacterial wood varnish
Textiles	air-purifying textiles
Upholstery Fabrics	antibacterial and dirt-repellent upholstery fabrics

Figure (30) the use of easy-to-clean, anti-scratch and anti-steam surfaces in the bathrooms of patient rooms in order to save maintenance costs and not to condense water vapor on the mirrors.[5]

Description of the building and the technologies used:[5]

This room shown in Figure (23) is an ideal model of a patient room within a hospital. The design concept here is based on five main pillars: function, comfort, design, orientation, and luxury. The general concept includes proposals for the design of the patient room (bed, bathroom, and hall), material, shape, and color.

Anti-bacterial floors were used, as well as wood coated with anti-bacterial varnish, anti-bacterial upholstery fabrics were used to keep it clean, light switches are exposed to bacteria and microbes and thus have been treated similarly, and air-purifying materials (textiles or wall paint) were used to protect against air pollution, Finally, surfaces that are easy to clean, anti-scratch and anti-steam were used in bathrooms and toilets.

2-9-2 A case study of a local hospital using traditional finishing materials in its design elements:[4]

The field study is based on an attempt to analyze and evaluate the current situation of the finishing materials used in terms of performance, so that we can know the extent to which these materials achieve economic and environmental factors, which are very important when designing hospitals, which helps us solve some problems that hospitals in Egypt suffer from, such as wasting money In the maintenance work as a result of the poor performance of the finishing materials used, especially since there is basically a deficit in the budgets of maintenance and operation work in most hospitals, which leads to a lack of maintenance, cleaning and sterilization work, which leads to the transmission of infections and diseases.

A- **Case study of Boulaq El Dakrour General Hospital:**[4]

A field study was conducted for Boulaq El-Dakrour Hospital, located in Plot No. 01, Canal El-Zomor - Boulaq El-Dakrour Center - Giza Governorate - Egypt. It is a public hospital that serves thousands of people annually. Unfortunately, the people of this center and the neighboring areas seek help from a lot of medical negligence, which violates their rights to provide a sanctuary. A safe and comfortable medical facility to provide them with medical service at an acceptable level.

Despite the Egyptian leadership's keenness to build and establish a medical system that preserves the health of Egyptians and provides them with good medical service, there is still a dark part of the Egyptian medical system, which is represented by government hospitals, especially Boulaq Dakrour General Hospital in Giza.

The design elements of the hospital and the finishing materials used in it:

We will display and analyze the finishing materials used in the design elements of the hospital

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(external facades - Floors - Walls - Ceilings - Doors and windows) through the following tables:

Exterior Facades:[4]

Table (13) shows an analysis of the finishing materials used in the hospital's exterior facades.

Image	Analysis
	**The shots of the hospital's exteriors show the following:** A- The spread of moisture in most parts of the facade due to the use of separate air conditioning units, and the failure of a drainage path to collect the water leaving the air conditioning units, which causes water to fall on the surface of the facades throughout the work period. B - Poor selection of finishing materials, as paints were used, which are not resistant to moisture and rays, which helped in the emergence and spread of moisture clearly. C- As a result of the increase in population density and the overloading of the sewage network, this led to a rash of public sewage and thus the spread of this water in the streets and roads. The atmosphere also impedes the movement of passers-by, including patients, doctors, visitors, and others, and distorts the visual view of the building and the surrounding area. **Based on all the above, we conclude the following:** A- The finishing materials used are not considered environmental, economic, design and aesthetic factors because of being traditional materials that are not resistant to weather factors, which makes them appear modestly aesthetically, and makes them need maintenance and cleaning work. b- The severe neglect by hospital officials in the periodic maintenance of the building and the necessary treatments for it, which led to the deterioration of the health, environmental and visual condition of the building, whose main function is to treat patients.

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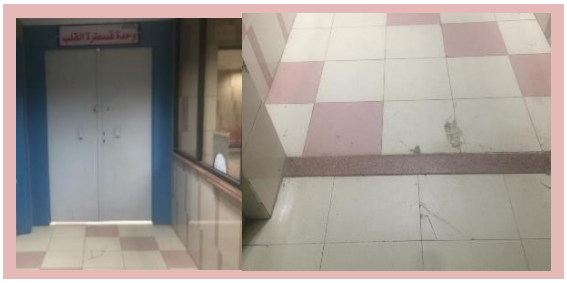
Flooring:[4]

Table (14) shows an analysis of the finishing materials used in the floors of the hospital.

Floor	Department	Image	Analysis
Ground Floor	Emergency		**The main corridor** **Flooring:** ceramic tiles The image shows the appearance of fractures in some ceramic tiles, some of which are not completely, and it shows the hospital's neglect in the necessary treatment and maintenance for these parts.
			**Minimal intervention room** **Flooring:** ceramic tiles The image shows the appearance of fractures in some ceramic tiles, some of which are not completely, and it shows the hospital's neglect in the necessary treatment and maintenance for these parts.
			**Detection and diagnosis room** **Flooring:** ceramic tiles The image shows the appearance of deterioration and fractures in some ceramic tiles, which were treated with cement mortar instead of being replaced with usable tiles.
			**main staircase** **Flooring:** Granite and marble tiles The image shows the crushing of the granite slabs used in the staircase, and their edges are broken, and they are not replaced or treated by maintenance officials, with the presence of cracks in the floor with ceramic tiles that have been treated with cement materials, and this treatment is wrong and incorrect.
			**Cardiac catheterization unit** **Flooring:** ceramic tiles The image shows the presence of cracks in some ceramic tiles, and the lack of interest in treating the floor and replacing the broken tiles with others.

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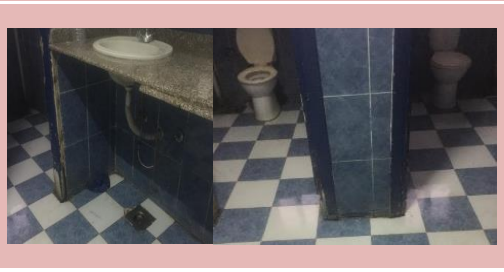
First Floor	**Intensive Care Unit - Ophthalmology Department**		**Reception and waiting area** **Flooring:** ceramic tiles The figure shows the erosion and crushing of most ceramic tiles. The figure also shows the treatment of these defects by filling the broken spaces with cement mortar, and this is a very poor treatment.
			**The main corridor** **Flooring:** ceramic tiles The figure shows the presence of some cracks and cracks in some ceramic tiles that were not treated by replacing them with others.
			**Bathrooms** **Flooring:** ceramic tiles The image shows the neglect of the hygiene factor, where water and dirt accumulate, which results in the formation of bacteria and microbes.
	Intensive Care Unit – Cardiac Department		**Department entrance and waiting area** **Flooring:** ceramic tiles The figure shows the presence of some cracks and cracks in some ceramic tiles that were not treated by replacing them with others.
			**The main corridor** **Flooring:** ceramic tiles The figure shows the presence of some fractures in some ceramic tiles that were not treated by replacing them with others.
Second Floor	**Vascular Surgery Department**		**Department entrance and waiting area** **Flooring:** mosaic tiles The figure shows the presence of some fractures in some tiles, as it was treated by filling the voids with cement mortar. This treatment is primitive and completely unsuitable.

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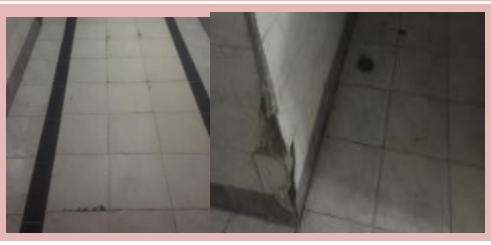
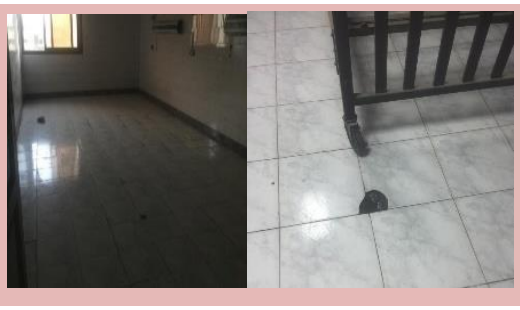
	**Doctors' residence** **Flooring:** mosaic tiles The floor appears poorly due to the use of mosaic as a finishing material, and moisture appears in it, which spreads bacteria.
	**The main corridor** **Flooring:** ceramic tiles The figure shows the presence of some fractures in some ceramic tiles that were not treated by replacing them with others.
	**Head of Department** **Flooring:** ceramic tiles The figure shows the ceramic floors shown here in this space well.
	**The head of the department's toilet** **Flooring:** ceramic tiles The figure shows that the ceramic floor appears poorly in terms of hygiene, as the floor appears dirty, which helps the formation of bacteria and microbes.
	**Some patient care rooms** **Flooring:** ceramic tiles The figure shows the presence of some fractures in some ceramic tiles that have not been treated by replacing them with others, as well as the lack of attention to general cleanliness.
	**Bathrooms** **Flooring:** ceramic tiles The figure shows the lack of attention to general cleanliness, as the floors appear very rough, which spreads bacteria and microbes.

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Interior Walls:[4]

Table (15) shows an analysis of the finishing materials used in the hospital's walls.

Floor	Department	Image	Analysis
Ground Floor	Emergency		**Reception and main corridor** **Walls:** ceramic tiles The picture shows the extent of the deterioration of the ceramic tiles, as we see some tiles are eroded and have fractures, and it shows the hospital's neglect of the necessary maintenance work.
			**Minimal intervention room** **Walls:** ceramic tiles The ceramic tiles under the wash basin appear poorly, as some tiles appear broken and dirt and bacteria form on them. The figure shows the hospital's lack of interest in making the necessary treatments and maintenance to prevent the formation of fungi and bacteria harmful to public health.
			**Detection and diagnosis room** **Walls:** ceramic tiles The picture shows the appearance of deterioration and fractures in some ceramic tiles, while others do not exist, and the cement mortar appears below it, and this helps in the formation of bacteria, fungi, and the presence of insects, and this indicates the hospital's lack of attention to the maintenance and treatment factor.
			**main staircase** **Walls:** paint The picture shows the poor appearance of the paint because of moisture and because of the fingerprints of patients and users of the building. The lower parts of the wall that are exposed to moisture have been treated with cement materials, and this treatment is wrong, and its general shape is very bad.

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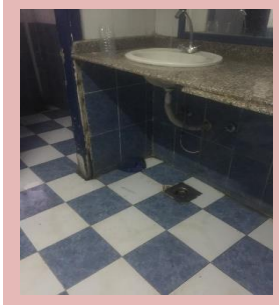
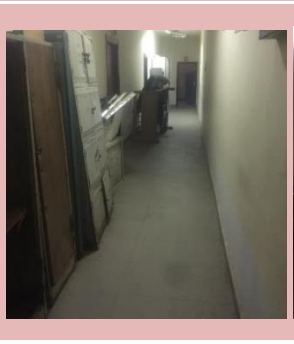
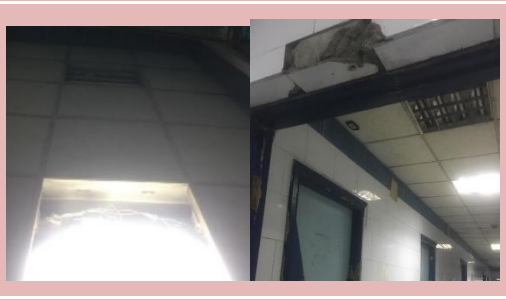
			**Cardiac catheterization unit** **Walls:** ceramic tiles The walls here appear in good condition and are visually acceptable, unlike most of the interior walls that will be analyzed.
First Floor	**Intensive Care Unit - Ophthalmology Department**		**Reception and waiting area** **Walls:** ceramic tiles The figure shows the appearance of many broken and smashed ceramic tiles, especially at the edges of the entrance opening, all of which need to be replaced.
		 	**The main corridor** **Walls:** ceramic tiles The figure shows the poor appearance of the walls, where some tiles appear broken and corroded to the point that bricks appear under the cement mortar, which helps in the formation of bacteria, microbes, and the spread of insects.
		 	**Bathrooms** **Walls:** ceramic tiles The two pictures show the lack of good insulation and neglect of general hygiene, as the walls appear in the corners and the edges of plastic, due to the use of water and the spread of moisture, which leads to the presence of bacteria and fungi and damages public health.
	Intensive Care Unit – Cardiac Department	 	**Department entrance and waiting area** **Walls:** ceramic tiles The figure shows the presence of some cracks and cracks in some ceramic tiles that were not treated by replacing them with others.

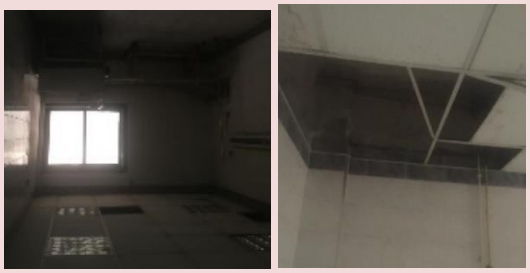
		 	**The main corridor** **Walls:** ceramic tiles The image shows the appearance of deterioration and fractures in some ceramic tiles, while others do not exist, and the cement mortar appears below it, and this helps in the formation of bacteria, fungi, and the presence of insects, and this indicates the hospital's lack of attention to the maintenance and treatment factor.
Second Floor	**Vascular Surgery Department**	 	**Department entrance and waiting area** **Walls:** paint The figure shows the extent to which the paint is affected by moisture and erodes, especially at the lower part of it because of washing the floors, and skirts should have been placed in this part to protect the paint from moisture as much as possible.
		 	**Doctors' residence** **Walls:** paint Painted walls, on which dirt is spread, appear somewhat badly because of handprints that have left dirt on them, and there is moisture under the wall, all of which works on the spread of bacteria and microbes.
		 	**The main corridor** **Walls:** ceramic tiles The figure shows the presence of some fractures in some ceramic tiles, which makes them appear poorly, and therefore must be treated by replacing them with others.

			**patient care room** **Walls:** ceramic tiles The image shows the appearance of deterioration and fractures in some ceramic tiles, while others do not exist, and the cement mortar appears below it, and this helps in the formation of bacteria, fungi, and the presence of insects, and this indicates the hospital's lack of attention to the maintenance and treatment factor.

Ceilings:[4]

Table (16) shows an analysis of the finishing materials used in the hospital ceilings.

Floor	Department	Image	Analysis
First Floor	Intensive Care Unit - Ophthalmology Department		**Reception and waiting area** **Ceiling:** suspended metal slabs The figure shows the hospital's lack of interest in treating or maintaining the suspended tiles, as we find that some of the tiles are not in their place as their place appears exposed, and others are either broken or moisture spreads.
			**The main corridor** **Ceiling:** suspended metal slabs The figure shows the presence of spotlights without a glass cover to protect these headlights and reduce glare. It also shows the presence of some broken and smashed ceramic tiles covering the concrete beam.
			**patient care rooms** **Ceiling:** suspended metal slabs The figure shows the hospital's lack of interest in treating or maintaining the suspended tiles, as we find that some tiles are not in their place, as their place appears exposed, and others are broken.

	Intensive Care Unit – Cardiac Department		**waiting area** **Ceiling:** suspended metal slabs We note from the figure that some tiles are not located in their place as their place appears exposed, and others are broken. We also note the presence of lighting headlights without a glass cover to protect these headlights and reduce the glare of lighting.
			**The main corridor** **Ceiling:** suspended metal slabs The figure shows the presence of lighting headlights without a glass cover to protect these headlights and reduce glare. It also shows moisture and dirt spread on most of the tiles that need maintenance and treatment.
			**patient care rooms** **Ceiling:** suspended metal slabs The figure shows the hospital's lack of interest in treating or maintaining the suspended tiles, as we find that some tiles are not in their place, as their place appears exposed, and others are broken.
Second Floor	**Vascular Surgery Department**		**Department entrance and waiting area** **Ceiling:** suspended metal slabs We note from the figure that some tiles are not located in their place as their place appears exposed, and we note the presence of lighting headlights without a glass cover to protect these headlights and reduce the glare of lighting.

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Doctors' residence

Ceiling: whiteness plaster

We notice from the figure a crack in the concrete ceiling that reaches the iron rails, and we notice that the headlights are coming out of the places where they are installed as if they will fall to the ground, and they appear without a glass cover to protect these headlights and reduce the glare of the lighting, and this indicates that the hospital does not care about the maintenance and treatment factor.

The main corridor

Ceiling: suspended metal slabs

The figure shows the presence of lighting headlights without a glass cover to protect these headlights and reduce glare and shows one of the tiles with a crack in the middle, and shows the moisture and dirt spread on most of the tiles that need maintenance and treatment.

Head of Department

Ceiling: suspended metal slabs

The figure shows that the suspended tiles are not well fixed in their places, and the headlights are without a glass cover to protect these headlights and reduce glare.

patient care rooms

Ceiling: suspended metal slabs

We note from the figure that some tiles are not in their place, as their location appears exposed, and others are not well installed in their places. It also shows moisture and dirt spread on most tiles that need maintenance and treatment. We also note the presence of lighting fixtures without a glass cover to protect these headlights and reduce Illumination glare.

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			**Meeting Room** **Ceiling:** suspended metal slabs We notice from the figure that some tiles spread moisture and dirt, which need maintenance and treatment. We also note the presence of a headlight without a glass cover to protect it and reduce glare.
			**inner corridor** **Ceiling:** suspended metal slabs We notice from the figure that most of the tiles are not in their place, as their place appears exposed, and we notice that the lighting headlights come out of the places where they are installed as if they will fall to the ground, and this indicates that the hospital does not care about the maintenance and treatment factor.

Doors and windows:[4]

Table (17) shows an analysis of some doors and windows of the hospital. **Source:** researcher.

Floor	Department	Image	Analysis
Ground Floor	Emergency		**Minor intervention room & Examination and diagnosis room** The figure shows the presence of circular fractures on the surface of the door leaf, as well as the presence of erosion in the throat and door leaf that may be due to direct contact of patients' beds with it, which makes the door appear visually distorted, and exposes it to the formation of bacteria and microbes.
First Floor	**Intensive Care Unit - Ophthalmology Department**		**The Main Corridor** Shown here is the door of the main corridor of the department in a completely deteriorated condition, where a layer of corroded paint appears on I t and wood appear under it, which may be exposed to moisture, which leads to the formation of bacteria and fungi.

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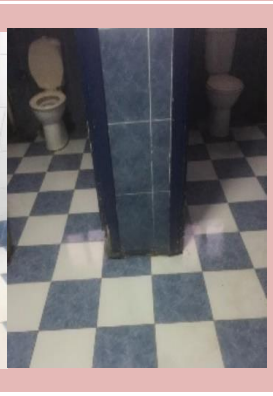
		 	**patient care rooms** The figure shows the presence of corrosion in the throat and door sill, and we note the treatment of some fractures in the doors by placing a piece of wood over the broken hole, and this is a primitive and poor treatment, which shows the door in a visually distorted way, and exposes it to bacteria and microbes.
		 	**Bathrooms** The figure shows the presence of large fractures at the bottom of the door, as well as the presence of corrosion in the throat and door leaf and shows the spread of moisture in the lower parts of the interior doors because of the spread of moisture, which in nature works to rot wood and the spread of bacteria and fungi.
	Intensive Care Unit – Cardiac Departme nt		**Department entrance** The figure shows the deterioration of the condition of the door of the main corridor of the department, where a layer of paint appears corroded and wood appears beneath it, the lower part of which has been exposed to moisture, which leads to the formation of bacteria and fungi.
		 	**patient care rooms** The figure shows the presence of fractures in the lower part of the door, as well as the presence of erosion in the throat and door leaf, which may be due to direct contact of patients' beds with it, which makes the door appear in a visually distorted form, exposing it to the formation of bacteria and microbes.
			**waiting area** The window here appears very badly, as we notice that the wire layer that protects the vacuum from entering insects is corroded, and it needs maintenance by replacing it with a new piece.

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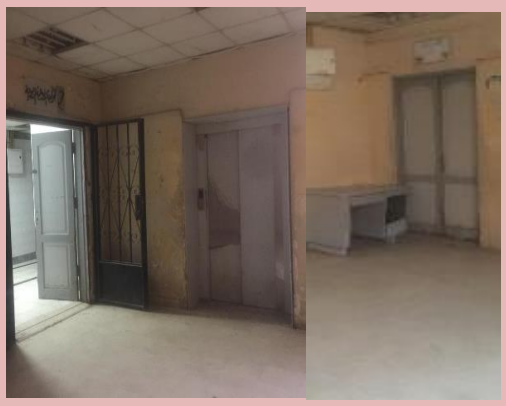
			**Store** The figure shows the presence of major fractures and scratches in the door and shows the presence of corrosion in the throat and door leaf, which shows the door in a visually distorted way, which shows the severe neglect of the hospital in the work of maintenance and the necessary treatments.
Second Floor	**Vascular Surgery Department**		**Main Staircase** The ventilation and lighting windows of the main staircase appear very badly, as dust and dirt resulting from weather factors accumulate on the surfaces of the glass, which does not contain any treatment technology, unlike the absence of some glass sashes from the foundation, and moisture spreads on the walls around it.
			**Department entrance and waiting area** The figure shows the deterioration of the elevator door that has been treated incorrectly. It also shows the erosion of the paint layer and the presence of many scratches on the bottom of both the main door of the entrance to the department and the main door of the urology department, which led to the formation of bacteria because of moisture.
			**Doctors' residence** The figure shows the deterioration of the condition of the main door of the doctors' residence, especially the lower part of it, where a layer of corroded paint appears and wood is exposed under it, which has been exposed to moisture, which leads to the formation of bacteria and fungi.

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Some patient care rooms

The figure shows the presence of erosion in the throat and door leaf, which may be due to direct contact of patients' beds with it, which makes the door appear visually distorted, and exposes it to the formation of bacteria and microbes.

Bathrooms

The figure shows the erosion of the paint layer in the lower parts of the doors because of water, which led to the appearance of wood, which rotted due to its constant exposure to moisture, which led to the formation of bacteria and fungi inside these doors.

The general manager and his bathroom

The figure shows the presence of corrosion in the door throat and some scratches in the door leaf, which makes the door appear visually distorted, and exposes it to the formation of bacteria and microbes because of the spread of moisture, especially in the bathroom door.

A summary of what was clarified and analyzed in the previous design elements for some departments of Bulaq
El-Dakrour General Hospital:[4]

1- Most of the design elements are exposed to moisture, which leads to the spread of bacteria, fungi, and others.
2- Corrosion, crushing and spreading of scratches in most of the design elements such as floors, walls, ceilings, doors, and windows.
3- The spread of dust and dirt on the whites, paints, and glass of the exterior facades.
4- Dirt and trash spread in many internal spaces of the hospital.

The result:[4]
We conclude from all the previous points that:

1- The hospital's lack of maintenance, treatment, and hygiene in general, which are among the most important factors in hospital buildings to maintain the general health of patients and to maintain the general appearance.
2- Poor selection of finishing materials that are suitable for hospital buildings, which should and preferably be resistant to (moisture, bacteria, fungi, scratching, friction, and fire), self-cleaning materials and easy-to-clean materials used in toilets and bathrooms, and materials that purify the air from any pollutants.

Based on what was explained and analyzed in the previous examples of global hospitals and Boulaq
Al-Dakrour General Hospital, we will present in the following table a comparison between these international hospitals and Boulaq Al-Dakrour General Hospital in terms of the finishing materials used in the various design elements, in order to demonstrate the superiority of the hospitals that used different nanotechnology in Its external and internal finishing materials differ from their Egyptian

counterparts, which relied on the use of traditional finishing materials for all their design elements.[4]

Table (18) shows a comparison between hospital buildings in which nano-processed finishing materials were used and Bulaq El-Dakrour General Hospital in which traditional finishing materials were used, and the impact of this on the economic and environmental dimensions, where (■) indicates to (achieved), (⁕) indicates to (achieved to some extent), and finally (□) indicates to (not achieved).[4]

Dimensions	Factors	Hospital			
		The Gea González Hospital Specialty Tower in Mexico City - Mexico	Hospital in Goslar - Germany	Hospital in Berlin - Germany	Bulaq El-Dakrour General Hospital in Giza - Egypt
		Technology			
		Air purification by using plates composed of cement and titanium dioxide "Tio_2"	The ceramic units contain Photocatalysis "Tio_2" coating and anti-bacterial	Multiple Nanotechnologies	Traditional finishing materials not treated with any technology
Economic	Reduce maintenance and use costs	■	■	■	□
	Rationalization of energy consumption	■	■	■	□
	Increase lifespan	■	■	■	□
	Reduce the use of raw materials	■	■	■	□
	material quality	■	■	■	□
Overall evaluation		■	■	■	□
Environmental	Internal Air Quality	■	■	■	□
	Using Natural Materials	■	■	■	□
	thermal insulation	⁕	⁕	■	□
	acoustic isolation	■	■	■	□
Overall evaluation		■	■	■	□

Based on this comparison resulting from the study and analysis of these hospitals, it became clear to us that the three international hospitals, namely: Gia Gonzalez Specialized Hospital in Mexico City, Mexico, and a hospital in Goslar, Germany (operating room), and a hospital in Berlin (patient room), outperform Bulaq El Dakrour General Hospital in both economic and environmental factors, as these hospitals achieved all economic and environmental factors, and on the contrary, Bulaq General Hospital did not achieve any of these factors in any of its design elements.[4]

2-9-3 Adapting the techniques to the horizontal plan of the patient's room to raise their performance:

Based on what the researcher analyzed about some nanotechnologies at the beginning of the research and clarifying the extent of their ability to achieve the economic and environmental factors of buildings in general, and based on what was analyzed for international hospitals that apply nanotechnology and materials to some of their design elements and compare them with a local hospital that relies on traditional finishing materials, We can now know the nanomaterials used in the design elements of the external and internal spaces of hospital buildings, which we will clarify on the design elements of a patient room to raise the performance of this room in particular and thus hospitals in general, economically and environmentally[4], as shown in Figure (22):

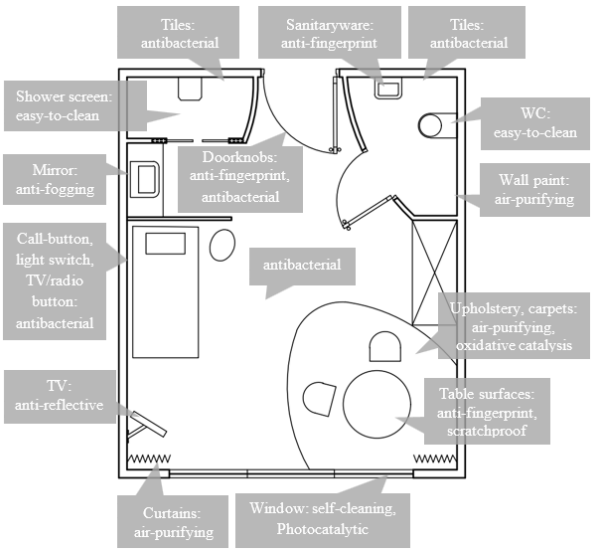

Figure (31) shows a horizontal plan of a patient room in a hospital showing the techniques and nanomaterials used in each element of the room.[5]

A- Analysis of the techniques used in the patient's room:[4]

We will analyze the above-mentioned techniques in the horizontal plan of a patient room in terms of their use in the appropriate design elements for them and find out what is the result of using this technology on the room in particular and on the hospital in general, economically, and environmentally, as shown in the following table:

Table (19) shows the techniques and nanomaterials used for the design elements of a patient room and their purpose.

Technical	Design Element	Result
Self-cleaning (Photocatalysis)	**the window**	- Reduce dirt - Reducing the consumption of raw materials - Reducing maintenance costs - Improving visibility and increasing the purity of the light entering the interior space - Reducing the costs of energy consumption used in lighting - Reducing the energy consumed in air conditioning works by 10%-20%
	walls	- Improving air quality

air purification	**Furniture and carpets** **Curtains**	- Providing a healthy environment for the interior space and preventing the spread of infection - Reducing CO_2 emissions
Easy-to-Clean	**bathroom floor** **toilet**	- It is dirt repellent, which leads to easy cleaning, saving time and maintenance costs
Anti-Bacterial Surfaces	**room floors** **the doors** **room door** **Call button, light switch, TV/radio button**	- Keeping surfaces clean of accumulated bacteria and fungi - Providing a healthy environment for the indoor space - Reducing the use of strong chemical cleaners - Reducing maintenance and renewal costs
Scratch Resistant Coatings	**dining table surfaces**	- Reduce cost and maintenance work - Raising the aesthetic aspects as a result of maintaining the shape without scratches
Anti-fog and anti-vapor coating	**Mirror**	- Protecting the mirror and glass panels from evaporation and condensation of water vapor on them, which helps to improve the user's vision
Anti-reflective coating	**TV screen**	- Prevents light reflection, which helps the patient to watch TV without any reflections of light on the screen that hinder vision

III. EXPERIMENTAL RESULTS

1- Nanotechnology is one of the most powerful technologies that mankind has reached, because it has changed the standards and concepts of physics, chemistry, engineering, and other sciences.

2- Nanotechnology enables us to obtain distinct and unique products that are employed in different applications, by relying on the restructuring and arrangement of the atoms and molecules that make up the material.

3- Various nanotechnologies have provided new finishing materials with unique properties that may be an alternative to traditional materials, as they reduce maintenance costs and energy consumption, improve the aesthetic appearance of buildings, reduce the phenomenon of visual distortion, and increase the sustainability process, which will change the architectural design concept of engineers in terms of creativity and think about using external and internal finishing materials.

4- Nanotechnology and materials help in reaching a set of solutions to many problems that were difficult to solve using traditional techniques and materials, as it became possible to use white color to paint the facades of buildings in highly polluted areas without turning gray, and also the facades can be used Self-cleaning glazing reduces the heat load, in addition to saving electrical energy consumption in buildings.

5- The architect's decision to choose the appropriate finishing materials has a big role in its suitability for the concept of rationalizing energy consumption and reducing the costs of its use and maintenance.

6- The use of nanotechnology and its materials will create a new generation of architects who realize that the building has a spirit and language as it preserves the spirit of the building and its lasting beauty and prolongs its life span.

7- Maintaining the cleanliness of the internal space and its design elements from accumulated bacteria, microbes and germs using anti-bacterial technology.

8- Providing a healthy environment for the internal space and preserving the integrity of the ecosystem by reducing the amount of carbon dioxide emissions in the environment, by using air purification technology.

9- The use of nanotechnology and materials in hospital buildings raises their efficiency economically, environmentally, healthily, and aesthetically.

IV. RECOMMENDATIONS

1- The level of architects should be made aware of modern technologies in general and nanotechnology in particular.
2- The need for the architectural designer's interest in knowing and choosing the finishing materials developed with nanotechnology and used in the spaces of hospital buildings, internally and externally in particular, and the rest of the buildings in general.
3- Studying the nanotechnology curriculum at the university stage as an optional curriculum or adding it as part of the building materials course.
4- Research bodies should pay attention to research in the field of nanotechnology to create new materials that contribute to solving environmental, economic and design problems of buildings.
5- The need for the state to establish factories that prepare and produce nanomaterials and produce building and finishing materials developed with this technology instead of importing them from abroad.
6- Institutes specialized in building research and science prepare the so-called Egyptian code for nanoscale
building materials.
7- The state has introduced building models applied to nanotechnology within its large-budget national projects and under the auspices of state institutions.

V. CONCLUSION

Finishing materials treated with nanotechnology are very much superior to their traditional counterparts in environmental, and economic dimensions when they are used in buildings in general and in hospitals in particular.

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