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Applications of Nanotechnology (Nanomaterial) in Raising the Efficiency of Photovoltaic Cells (Lotus Effect)

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Abstract

One of the most important problems facing the work of photovoltaic cells is the problem of contamination of the cells with Dust that is deposited on them by the wind. By; studying this phenomenon, It was found that the performance rate of photovoltaic cells decreases by a large percentage of up to 80%, and with the development of research in the field of nanotechnology and nanomaterial, scientists were able to reach a technique a new method addresses these negative effects of the work of photovoltaic cells, which is the property of not attaching Dust to the surface of the cells, similar in its work to the surface of the polished lotus plant, where raindrops slip on the surface of the girls. From; this phenomenon, scientists were able to devise the work of advanced cells, which falls within the scope of the study of (bio mimicry) the study of biology.

Keywords: contamination, Dust, pollution, nanomaterial, lotus plant, bio mimicry

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1. Introduction

The importance of scientific research and recent discoveries has great effects on the development of materials, especially building materials, and examples of these materials are photovoltaic cells. Until; scientists came up with a new technique, which is the technique of polishing smooth surfaces, which is a phenomenon of nature, and scientists reached this feature by studying nature simulations, it was possible to reach a technique to raise the efficiency of the surfaces that make up the photoelectric cells.

1.2. Research Problem

The problem of the presence of Dust, as scientific research has proven that more than 80% of the effectiveness of solar panels is lost if the device that receives sunlight is not cleaned for a month. Public; health problems have identified using this technique. Environmental; issues associated with generation of liquid and solid waste during cell raw materials cutting, cleaning, and solar cell processing and assembly. The; x-Si photovoltaic industry has embarked on waste minimization programs. Achieved; through successful efforts at laboratory and manufacturing scales to reduce waste.

1.3. Research Hypotheses

The research assumes that the development in nanotechnology sciences in the field of producing new materials, improving the properties of materials, and changing them contributes to improving the efficiency of photovoltaic cells Through a change in the characteristics of the photovoltaic cell material due to the possibility of Dust not sticking to it, and thus raising the efficiency of its work in converting solar energy into an electric current. Achieving the sustainability principles, in terms of rationalizing energy consumption and benefiting from renewable energy sources.

2. Methodology

It has observed over a period of time that problem of photovoltaic cells is directly affected by their exposure to dust and dust flying from the air, and thus their efficiency decreases by a large percentage. And through scientific research through science of simulating nature, it noticed that lotus plant has a very polished surface so that nothing sticks to it, even water droplets slide on it without sticking to it, and therefore this technology can be applied in many fields, and most important of these fields is field of photovoltaic cells through nanotechnology research, scientists have been able to produce photovoltaic cells with a smooth surface similar to surface of lotus plant, so that dust or environmental factors do not stick to it, and thus efficiency of work of cells is raised by a large percentage, which has a large economic return.

2.1. Introduction (Method)

With the increase of technology usage, humankind's quality of life is increasing, too. As a result of this, all over

the world energy consumption and greenhouse gas (GHS) emissions are increasing dramatically. Currently, the worldwide use rate of fossil fuels, which is the primary cause of carbon emissions, is approximately 80% [1]. Besides, the power sector contributes 38% to this [2]. Although, many countries promote renewable energy sources for healthy generations. Therefore, especially the installation of solar plants in the world has been increasing. Also, the trend in energy technology is shifting to PV panels. More than half of the renewable energy resource installed (56%) in 2018 are solar plants. Although it is very difficult to know the total electricity produced by countries with PV panels, it is an easy way to measure data from PV plants. It is estimated that 670TWh of electricity produces with the 512.3GW PV facility established all over the world in 2018. Even though its popularity has increased so much, the efficiency achieved through the panel is still around between percent 15-20% [3-4]. In addition to the efficiency of the panel due to its internal structure, it also affects the efficiency of environmental factors. Because the areas where the panels are installed are environments that are exposed to physical effects.

Some of these factors summarized as: situation of the geographical area where the panel is installed (because it affects the temperature, humidity, wind, shade and dust on the panel), the angle of sunlight and the distance of the water because it is necessary to clean PV panels [5]. There are lots of studies conducted by many researchers about the experimental efficiency of the PV panels. In the light of these studies, we have the opportunity to access much valuable information. When the sunlight comes from a 90-degree angle on the PV panels the temperature of the modules rises because solar radiations are absorbed by the PV. This is the reason why the panel efficiency is reduced by 10% to 25% [6]. In addition, the cloudiness of the sky decreases the production of electricity due to reduce the solar radiation reach on the PV panel, too [7-8]. Also, it permanently decreases its efficiency in moisture penetrating into the panel [9-10]. Generally, despite PV panel performance studies conducts to measure the efficiency of the panel, environmental parameters such as dust, shading, wind speed, installation tilt angle of the panels have a large effect on the efficiency and power productivity of PVs [11].

In the literature, dust particles are defined as particles smaller than 500 microns [12]. The nature of these particles is varying to a great degree, as they may occur via divergent natural sources in the atmosphere, and the particles may include cells, organic matters, clay, sand, ash, etc. [13-14]. Efficiency decreases of PV panels caused by dusting. When looked at studies in the literature accumulated dust on the PV's causes a significant reduction of efficiency output of the panels. A study conducted by researcher's shows that the PV panel output efficiency decrease between 8-12% per month depends on accumulated dust. Another finding in the same study is that there is a relation between wind speed and relative humidity on the performance of the panels [15]. In the same way, due to accumulated dust, performance of the PVs has been decreased by nearly 13% in Abu Dhabi, UAE [16]. In addition, performance decreases have been calculated due to daily dust exposure in different parts of the world. Daily dusting losses are occurs consecutively between 0-05% in Libya, Limassol, Nigeria and CA, 0.5-1 in Abu Dhabi and Kuwait, 1-1.5% in Bangladesh and Saudi Arabia [16-23]. Also, there are lots of studies to determine accumulated rate of dust on the panels depends on installation locations, rate of precipitation, atmospheric dust concentration, etc.

In this study focus on the effect of dust on the efficiency of PVs in term of produced electrics and prediction of the output voltage at a panel with ANN. The ANN are used for decades in practical engineering problems the data of different sized powder particles distributed homogeneously on the panel has been collected by an infrared sensor at a certain time to train in NN Tool. To doing this, four different dust particles were chosen such as; (-75), (+75/-105), (+105/-250), and (+250/-450). The "-" symbol means smaller particles than the following number and "+" means bigger particles than the following numbers, too. The surface of the panel was covered by different types of dust particles and each of the particles selected 20g. Additionally, NN Tool was used in Matlab to predict the output voltage of the PVs depend on the dust. In MATLAB, 5 different data sets were prepared with 60% training and 40% test rates in NN Tool randomly. Generally, researchers only get power data from a panel in terms of the covered panels with dust. However, in this study was taken periodically reflected light data to use in NN Tool with together linear motor and photodiode, too. Due to this, the novel method was used in this study.

2.2. Experimental Setup

First of all, the dust samples were collected near the agricultural. In the second stage, to separate micro size scale of dust particles was performed sieve analysis by the Department of Geological Engineering. The sieve analysis (also called gradation) is used as an exact method to determine the particle size distribution depending on the fine and course of dust. The sands, crushed rock, clays, granite, feldspars, coal, soil from organic or nonorganic granular could be analyzed with this method. Although this method is simple, it is used to determine size particle distribution commonly in civil engineering and chemical engineering. Besides this, to observe relation between dust particles size and efficiency of the panel experimental setup has prepared. a). The experimental setup consists of step Motor, step motor driver, one-meter ball screw, microcontroller, power supply and photodiode. Reason of used the photodiode is observation to reflection of the light on the panel. Arduino UNO control card has been used as a microcontroller. The Arduino has 10-bit analog reading resolution so input signal data vary from between 0 and 1023. It's writing resolution value is 8-bit so output signal data could be max 255. In addition, the speed of the step motor was adjusted soft.-wise, approximately 5mm per second. The distance of the photodiode sensor from the surface is about 3 cm. lastly, the study started inside the laboratory by scattering dust particles. In table 1 the PV panel characteristic has given been collected for each different size of dust particles and it is called number of samples in figures. Fig.3 is shown platform to perform experimental studies.

2.3. Test Procedure

In order to investigate the efficiency of the PV panel which exposed to from dust particles a 40-Watt SUNNY polycrystalline panel has been placed under a 1000W/$m2$ halogen lamp solar simulator. The reason of chosen halogen lamp is why it is an artificial source that produces wavelengths closest to sunlight. The solar simulator has been placed perpendicular to the PV panel with the distance of 80 cm .To obtain measuring data includes current-voltage curves

of the clean and dirty panel, a resistor which is values 100 ohms,1000Watt has been used as an electronic load. Dust particles were separated into four micro sizes groups with Sieve method such as: (-75), (+75/-105), (+105/-250), and (+250/-450). Additionally, each of group parts divided 20gr. The reason of choose 20 g in this study is the best result given in terms of coverage on surfaces of PV panel when compared 5g, 10g, and 15g dust mass. Thus, 5 different data sets have been prepared for use at NN Tool in MATLAB with the aim of %40 training and %60 test. The clean PV panel data have been used twice. One of the data is in training part, same data have also used in prediction part. Sensor data obtained with a microcontroller and graphs were drawn on the MATLAB platform. The PV panel gives maximum 24-volt output, depends on light intensity. However, at the microcontroller analog pin operating voltage is maxed 5-volt. In order to overcome this situation, voltage divider circuit established and converted into a suitable input signal for microcontroller.

The sampling frequency was selected as 10 Hz in the data acquisition card. Totally 30 data have the panel was carefully cleaned before making observations for each data set. After that, dust particles have been homogeneously sprinkled on the panel. This study, conducted from total 5 different case studies. Data sets are divided into two groups for use in NN Tool and they were chosen randomly. The first group is the training part which has been used training to neurons with a back propagation learning rule, the second group is the test part which has been an observation of the success rate of training. The indicator of the performance criterion is the low error rate. The Tansig transfer function was used for the first layer and Purelin transfer function was used for the second layer, too. The tansig function's dynamic range is [-1 1] and the function shows a nonlinear change, in this range depending on the neuron total input. Although the Purelin function has a similar dynamic range, its output neuron linearly changes according to the input neurons varies. The reason of choosing Tansig-Purelin function was the give best result when compared different variations (Tansig-Logsig, Logsig-Purelin). Also, in literature Tansig-Purelin functions is the most commonly used technique for activation in terms of average number of iterations and number of networks that learn-based in ANN. Besides this, Leven berg-Marquardt (LM) algorithm preferred due to stability and speed it provides in training of artificial neural networks.

3. Results and discussion

It is noticeable from Fig.4 that ANN structure with 3 inputs, 3 output and 8 neurons interlayer. In validation performance graphs given Mean Squared Error (MSE) of Artificial Neural Network model for training, validation (check), and test steps. It is clear that from figure the model has best validation performance equal to 3.3134 at epoch 4. The PV panel is affected significantly by dust particles. This study indicated that how particle sizes affect voltage output of the panel and to make inferences easily with use of NN tool in MATLAB. This study is also important in terms of being a comparison of the measurement of the radiation from dirty panels and their efficiency. There is a strong correlation between radiation from dirty panels and producing voltage. Radiations have obtained by photodiode sensors. It used as a data set in ANN in range of 0-5 by scaling. Additionally, this Matlab tool is a very promising method to estimate efficiency loss due to dusting. This method could be used to determine the solar power installation locations. For example, by the Turkish State Meteorological service dust transport estimation is made every day. In light of these data, average efficiency losses can be calculated with this method.

3.1. Clean solar panel

Caption: Dust that accumulates on solar panels is a major problem, but washing the panels uses huge amounts of water. MIT engineers have now developed a waterless cleaning method to remove dust on solar installations in water-limited regions, improving overall efficiency.

Caption: The new system uses electrostatic repulsion to cause dust particles to detach and virtually leap off the panel's surface, without the need for water or brushes Solar power is expected to reach 10 percent of global power generation by year 2030, and much of that is likely to be located in desert areas, where sunlight is abundant. But the accumulation of dust on solar panels or mirrors is already a significant issue- it can reduce output of photovoltaic panels by as much as 30 percent in just one month- so regular cleaning is essential for such installations But cleaning solar panels currently is estimated to use about 10 billion gallons of water per year — enough to supply drinking water for up to 2 million people. Attempts at waterless cleaning are labor intensive and tend to cause irreversible scratching of the surfaces, which also reduces efficiency.

Now, a team of researchers at MIT has devised a way of automatically cleaning solar panels, or mirrors of solar thermal plants, in a waterless, no-contact system Z could significantly reduce dust problem, they say. New system uses electrostatic repulsion to cause dust particles to detach and virtually leap off panel's surface, without need for water or brushes. To activate system, a simple electrode passes just above solar panel's surface, imparting an electrical charge to dust particles, which are then repelled by a charge applied to panel itself. System can be operated automatically using a simple electric motor and guide rails alongside of panel. Research described today in journal Science Advances, in a paper by MIT graduate student Sreedath Panat and professor of mechanical engineering Kripa Varanasi. After we confirmed effect of dust on photovoltaic panels, we review in this section how nanotechnology can raise efficiency of photovoltaic cells to reduce effect of dust on them.

3.2. Lotus Effect in Nanotechnology

The term "lotus effect" refer to water repellency and self- cleaning, seen in graphic mode as a drop that is kept on a surface instead of being absorbed. Origin of this expression has to do with a flower, known as "lotus flower", which is a scientific mystery because it has not possible to discover why it does not get wet. Hydrophobic characteristic of the lotus flower has imitated for useful effects of human life, being one of main tasks of nanotechnology research. Lotus effect has reproduced on various surfaces, such as wood, plastic, glass, metal and stones including absorbents, textiles, etc, through chemical products of technological innovation. Impact of these achievements has beneficial in business, domestic and personal sectors, since it generously contributes to extend life of different materials, improve their appearance, and avoid constant investment in maintenance and cleaning. For example, a car can be perfectly protected in body and windshield, extending durability and avoiding fogging on rainy days; liquid repellency in textiles is very useful.

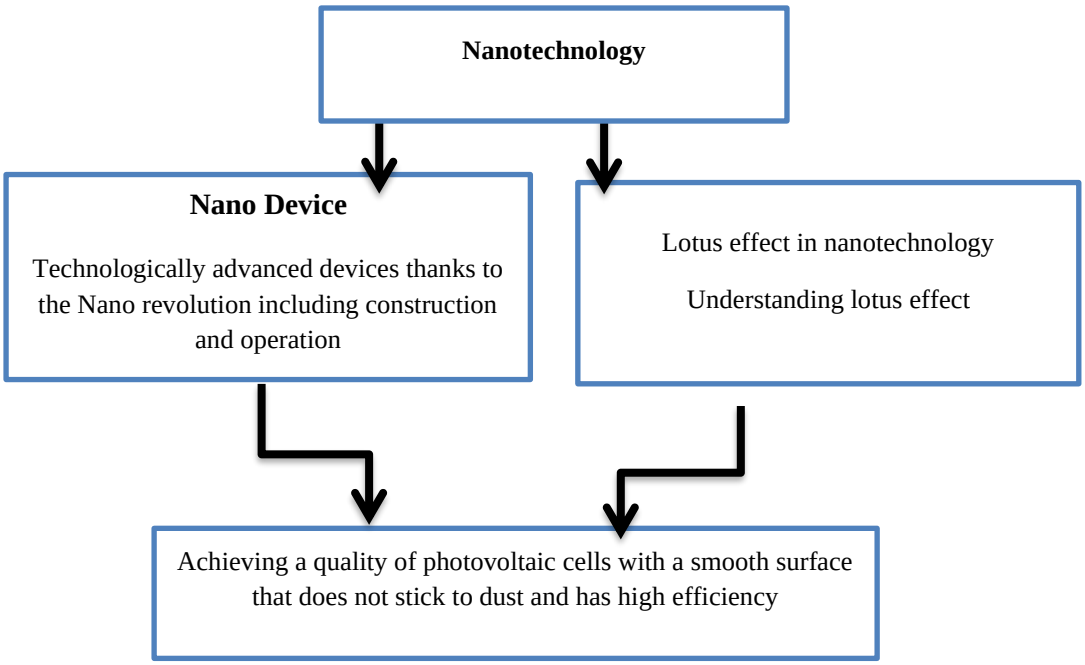

Figure 1: This shape show the relationship by nanotechnology and efficiency of photovoltaic cell

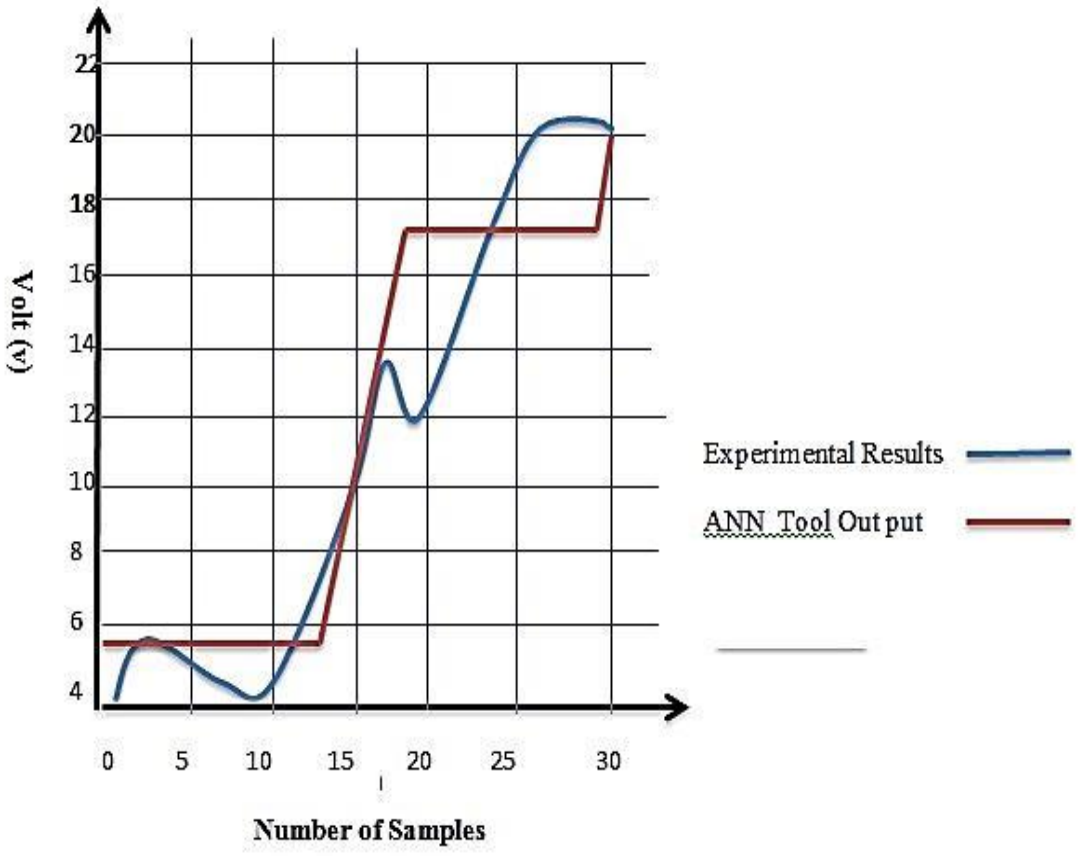

Figure 2: The output of clean pv with covered 75 micrometer dust particles

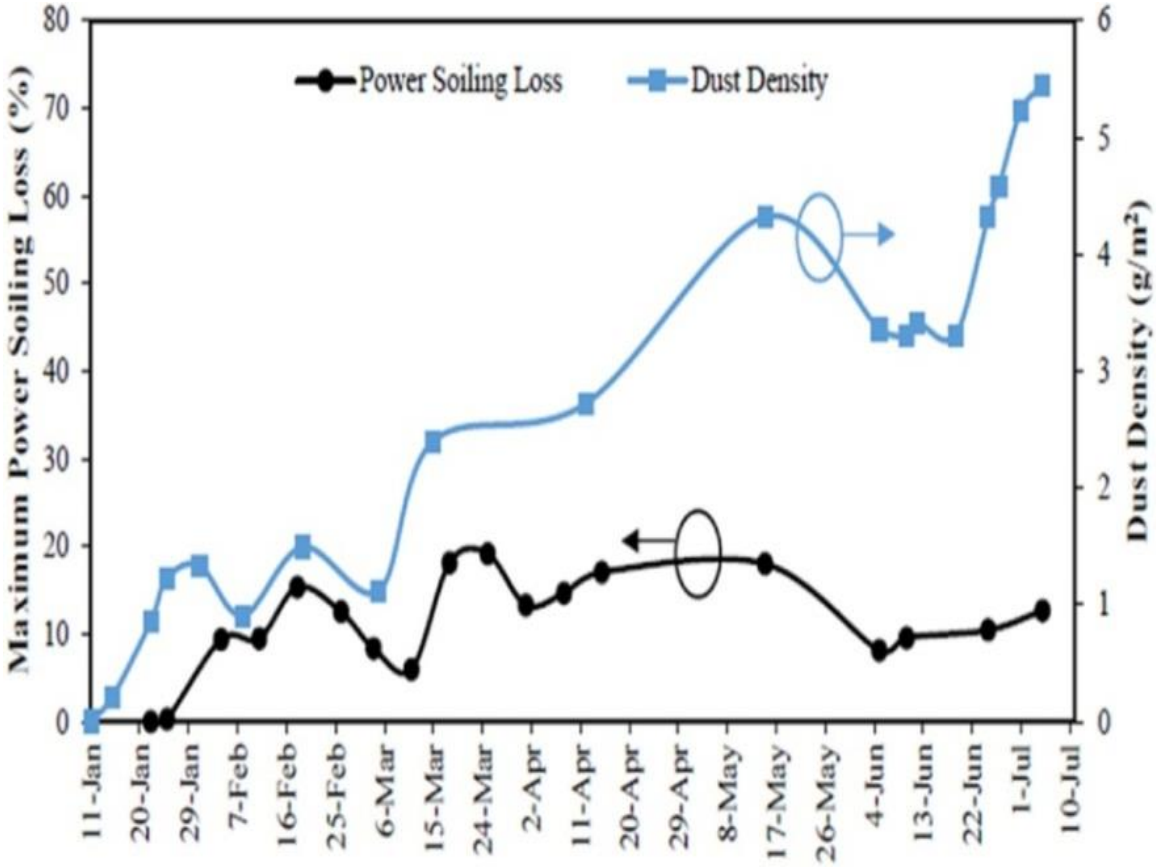

Figure 3: Show power soiling loss and dust density around the year

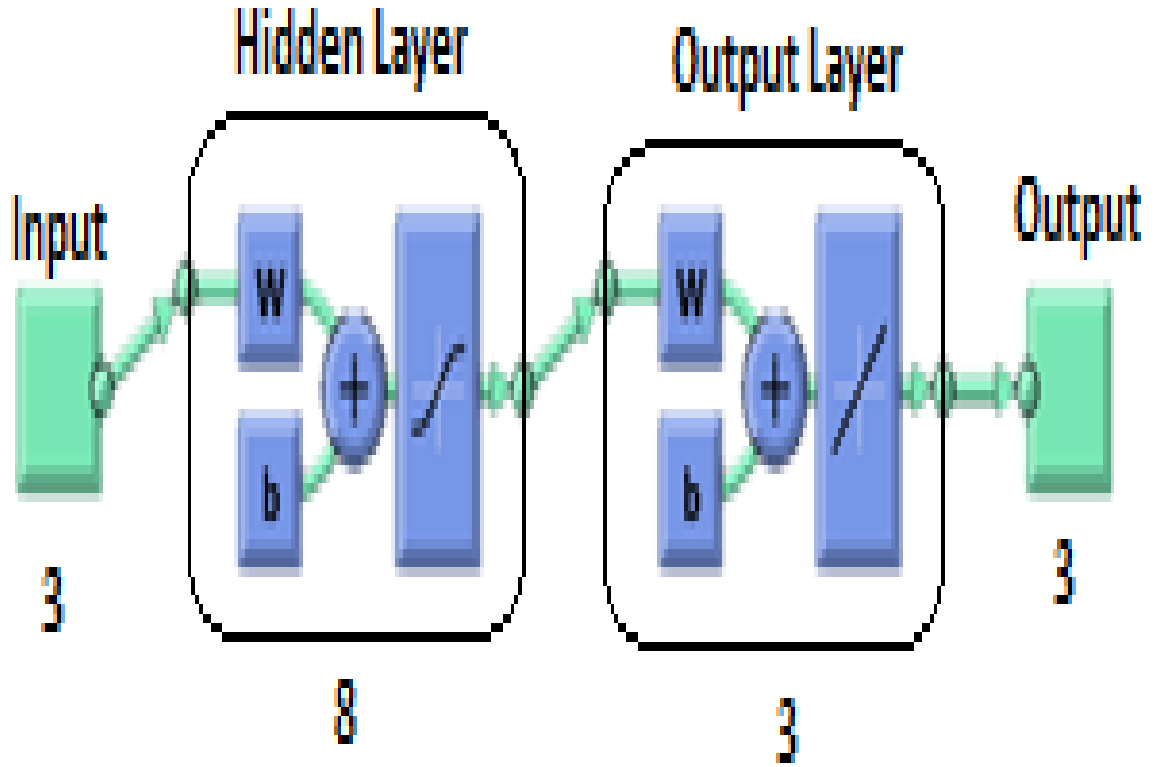

Figure 4: ANN structure with 3 inputs, 3 output and 8 neurons interlayer

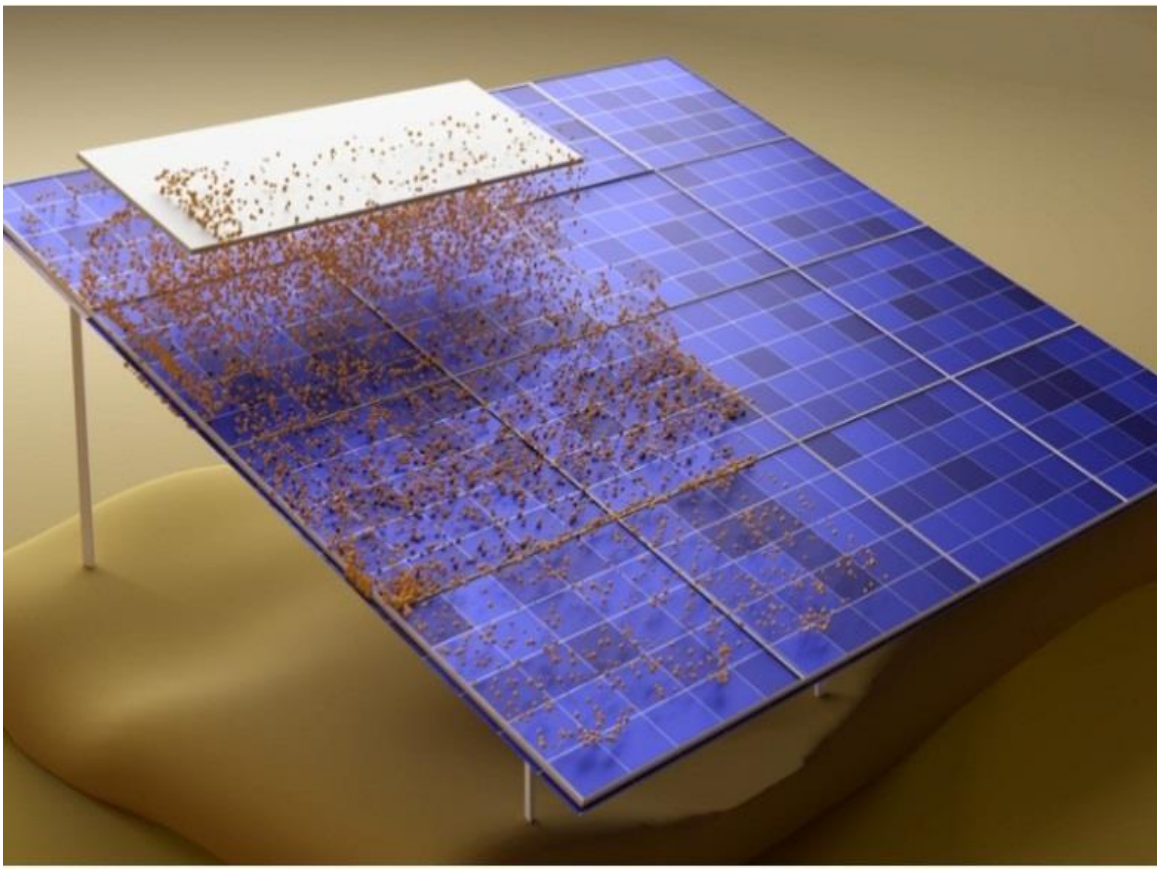

Figure 5: This picture show Dust that accumulates on solar panels data graphs from experiments

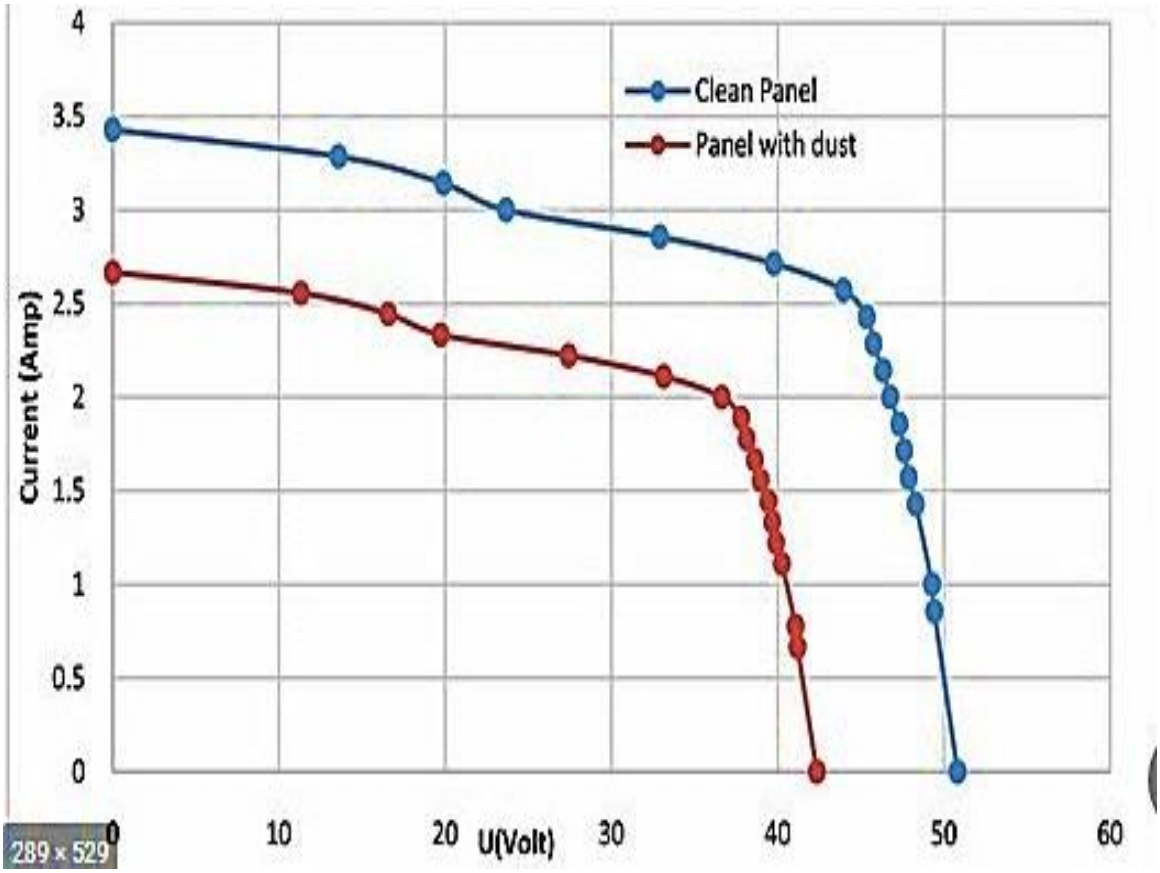

Figure 6: Design and performance of pv dust cleaning system in medina region .Source: scientific research publishing

Figure 7: This picture show self- cleaning lotus effect

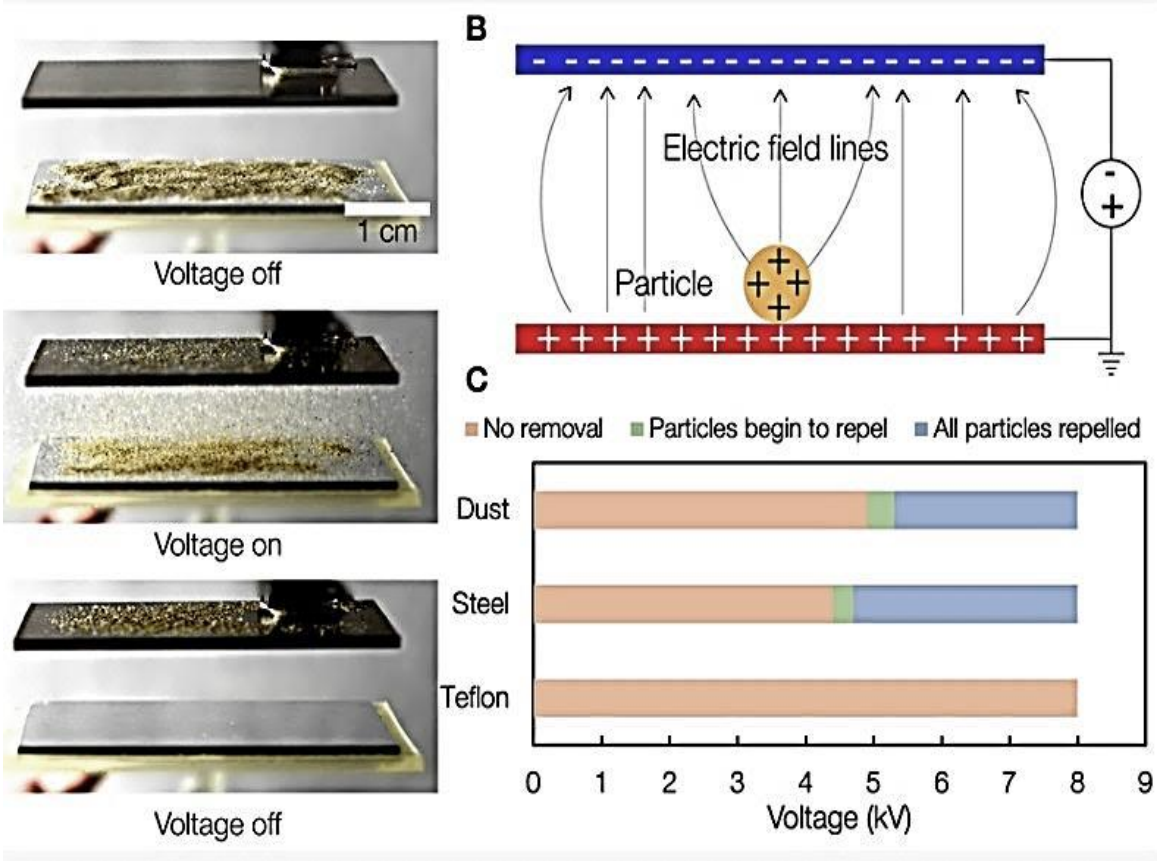

Figure 8: This picture show the new system uses electrostatic repulision to Cause dust particles to detach and virtually leap off panels' surface, without the need for water or brushes, Source: scientific research publishing.

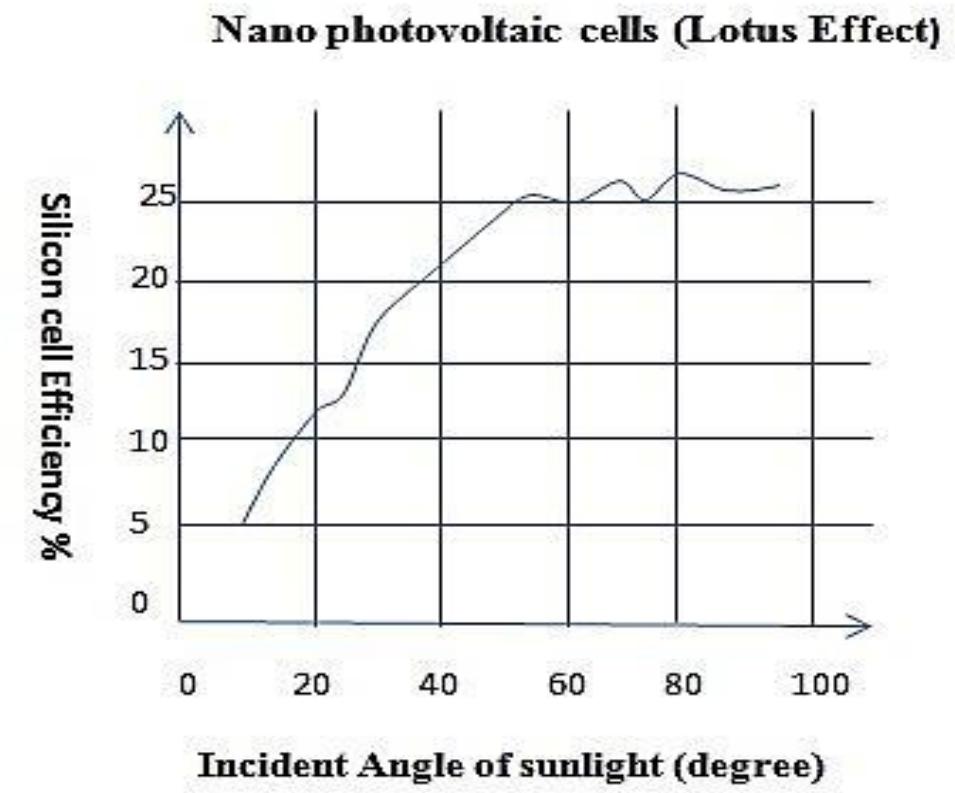

Figure 9: Nano photovoltaic cells (Lotus Effect)

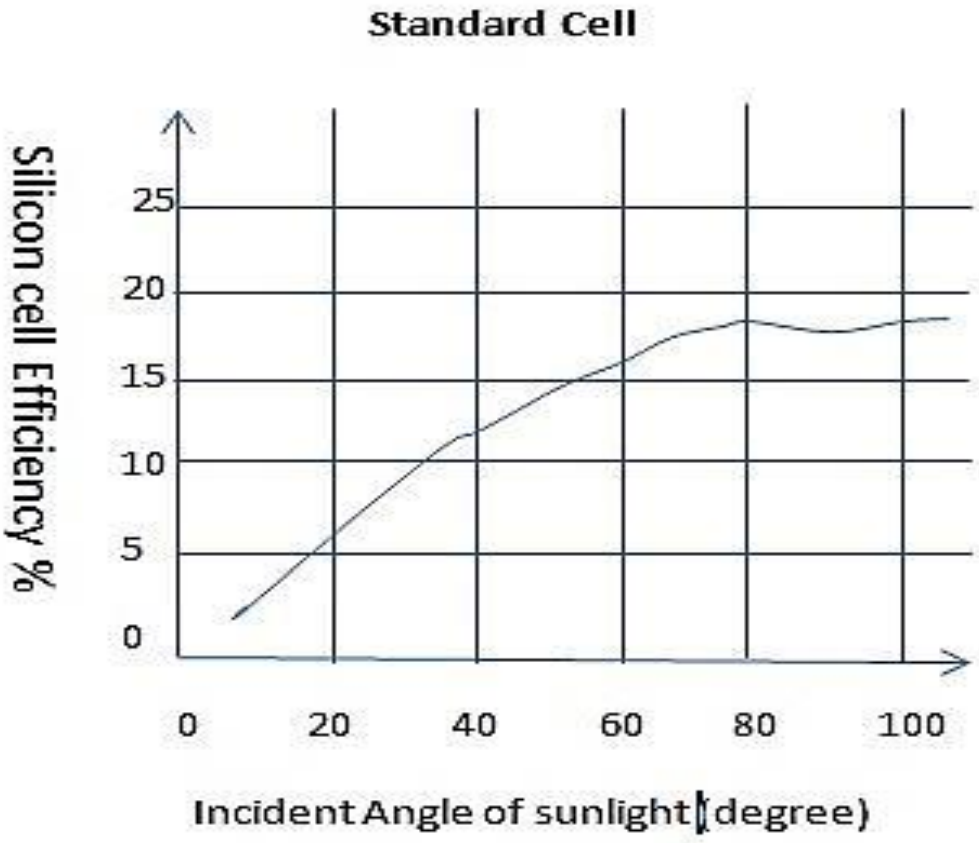

Figure 10: Standard cell (Lotus Effect)

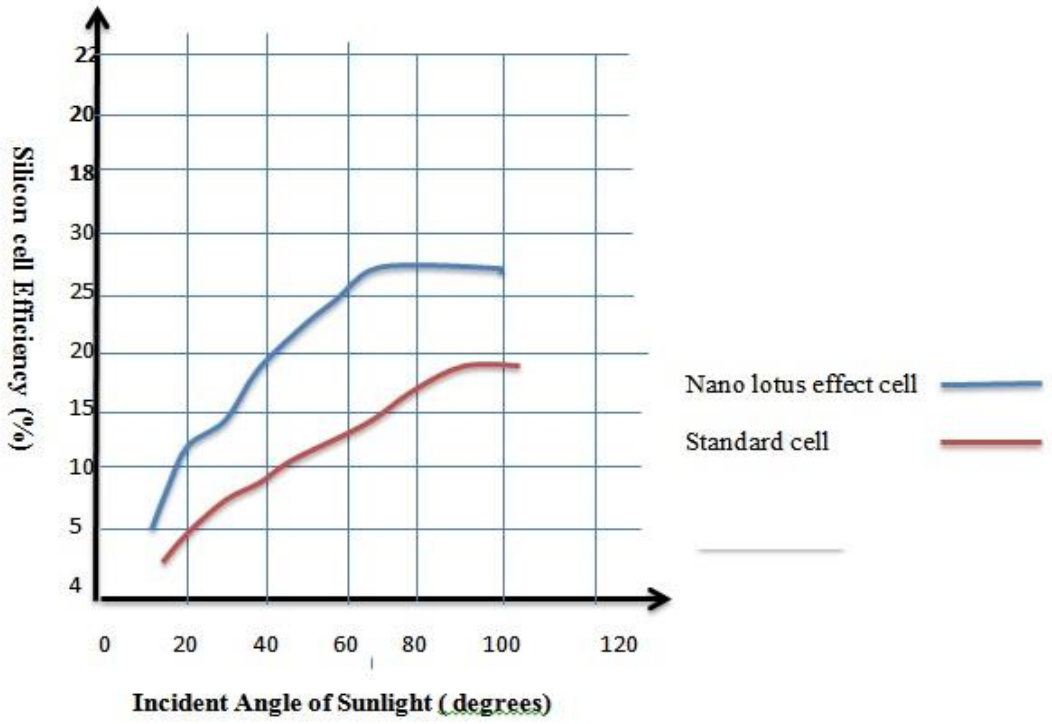

Figure 11: Biotechnology applied to this effect is the Rain Stop

Because, it prevents stains and lightens awkward incidents such as wine spillage; wooden doors and furniture, among many other things. Lotus effect has a great impact, due to its multiple benefits , that now multiple benefits, that now the commercialization of products has spread globally , making nanotechnology one of most powerful markets. In this preponderant rise of nanotechnology, Nanografi offers a wide range of products related to Nanotechnology. Let's have a deeper look at lotus effect in nanotechnology. Lotus effect with epicuticular wax covered surface nanostructures responsible for super hydrophobicity of leaf surface.

3.3. Understanding of the lotus effect

Figure 7 show new system uses electrostatic repulsion to Cause dust particles to detach and virtually leap off panels' surface, without need for water or brushes.

3.4. Important of lotus effect

The importance of the lotus effect to create self – cleaning materials is clear, so much so that biologists Neinhuis and Barthlott patented the idea under the name "lotus- effect". Since then, the lotus effect has been studied by many botanists and physicists to better understand the phenomenon and find possible technological applications. Unlike hydrophobicity (water repulsion), which is a chemical property, super hydrophobicity is fundamentally physical property. The difference between 90 and 150 degrees, we get hydrophobic properties. On the other hand, with an angle of contact greater than 150 degree, this effect is amplified and becomes an impossible to wet surface thus obtaining super hydrophobic characteristics.

3.5. Application of Lotus Effect

The Lotus, an ancestral symbol of spirituality, is now a source of inspiration for innovative technological applications, potentially applicable in innumerable sectors, including the building sector, with the creation of roofs and paints capable of self- cleaning. Some interesting applications of the Lotus effect could be the development of paints that prevent corrosion of metallic materials. Such paints have excellent physical and structural properties and the incomparable Lotus- Effect technology. This technology has the ability to clean itself: the dirt slips away with the rain and the façade remains clean and dry a long time. In addition to being used perfect insulators to prevent damage to electrical or electronic equipment by accidental contact with water. The effect is useful in paints for protecting the walls and protection of public spaces against vandalism, as well as the development of antibacterial surfaces.

3.6. Biotechnology applied to this effect is the Rain Stop

A Nano technological hydrophobic solution for glass and windshields. One applied , the product guarantees optimal visibility in all weather conditions, contributing to road safety.an evocative idea, born from the mind of the Architect and Artist Luc Schuiten , observing the Lotus , was to think of a model by him, the vegetable cities, inspired not only by lotus leaf, which could replace our roofs due to its particular shape that already in nature is able to channel the water creating a system of pipes and rainwater collection tanks inside the ideal building; but also to same flower, from which organic waste from the city and to transform each petal into a huge solar panel. For this reason, architect collaborated with artesella where over time, more than 300artists have come and gone in this path, delivering their work to care Of the Sella Association. Other applications could be aimed at preventing water condensation and ice formation in extreme climates on surface of cars, and airplanes. Rain, less polluting clothes for health sector, garments impossible to stain and, therefore, no need to wash them. This could mark end of

washing machine. Without a doubt, nature and its four billion years of experience continue to inspire technology.

3.7. Lotus effect and & Nanotechnology (Nano biology)

Let`s take a short trip together that will introduce us to world of nanotechnology. Today the term "Technology" indicates the search for solutions to practical problems through the creation of tools or procedures to improve or simplify an aspect of everyday life. In physics, what we mean Nanotechnology is theory that hypothesizes possibility of controlling the structure of matter by acting on nature of talk about Nanotechnology when looking for solutions through study of matter structure entering infinitesimal dimension field. We use nanometer scale for measurement of molecules and atoms. Nanometer corresponds to a billionth of a meter. The field of application of nanotechnology is much range from field of robotics to medicine, from electronics to construction, from textiles to optics. It is from observation of nature and its marvelous "microscopic" creations that idea of creating mirrors based on periodic modulation of refractive index for application of optical telecommunications.

4. Conclusion

Through the study of all pigments is born, or the idea of creating self- cleaning materials that copy the microscopic morphology of the surface of the lotus plant, or the idea of replicating the creation of materials that allow perfect adherence to surfaces. Nano technological products are able to bring nanotechnology into our homes. For example, Nanotechnology silicon-based Products use silicon Nano particles that create molecular – level bonds in silicon- based substrates (e.g. glass, ceramics, stone) which modify the surface structure of the substrates to form a uniform and breathable " active " barrier makes it Hydro-oil Repellent .since each product has its own molecular structure , there are specific nanotechnology products for each surface that bind to the structure of the support at the molecular level, creating an invisible Barrier effect that protects it from the action of water, oil, atmospheric agents, preserves it from the wear and ease of cleaning . And through the laboratory test for the use of photovoltaic cells treated with lotus technology, results showed an increase in the efficiency of cells due to self-cleaning by 85% compared to untreated photovoltaic cells.

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