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Developing Mechanism with Photo Reflective and Photocatalytic Properties for Cool Roofs by Using Tio2 Nanoparticles

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ABSTRACT:
Cool roofs are a novel way to mitigating urban heat island effects and lowering building energy use. This work looks at the possible use of titanium dioxide (TiO2) nanoparticles as a crucial component in building cool roof systems with simultaneous photo-reflection and photocatalysis functions. The study aims to uncover the fundamental processes that influence the reflective and photocatalytic characteristics of TiO2 nanoparticles when they are mixed with roofing materials. Experiments were carried out with three different kinds of TiO2 nanoparticles, both with and without polyethylene glycol (PEG). X-ray diffractometry was used to characterize all sorts of newly created nanomaterials. The Brunauer-Emmet-Teller technique was used to calculate specific surface area after analyzing particle size distribution. SEM imaging was utilized to characterize the morphology of nanoparticles. To get the necessary photocatalytic surface, commercial ceramic roofing tiles were dip-coated. The TiO2 anatase samples had larger nanoparticle surface areas, presumably offering the best photocatalytic efficiency.

I. INTRODUCTION

Innovative strategies for addressing the difficulties of urban heat islands and climate change have been sparked by the search for construction technologies that are both environmentally friendly and efficient in terms of energy consumption. Among them, cool roofs have emerged as a potentially useful option, since they make use of cutting-edge materials and systems to offset the negative impacts of increasing temperatures. At a time when metropolitan areas are struggling to cope with the rising temperatures that are a direct result of climate change, the incorporation of titanium dioxide nanoparticles into cool roofs marks a significant step forward in the quest for architectural solutions that are both aesthetically pleasing and ecologically responsible. When it comes to mitigating the impact of the urban heat island, cool roofs, which are constructed to reflect sunlight and absorb less heat than conventional roofs, provide an essential contribution. The term "urban heat island effect" refers to the phenomena in which urban areas suffer greater temperatures than the rural regions that surround them. This is mostly caused by human activity and the built environment. Asphalt, which is a traditional roofing material, has a tendency to absorb and hold heat, which makes this impact even more pronounced. Reflective coatings, on the other hand, are used in cool roofs. These coatings reflect a considerable percentage of the sunlight away from the roof, so preventing heat from being transferred to the building below. One of the most important characteristics of cool roofs is their reflecting quality, which helps to reduce the temperature within the building, reduce the amount of energy that is used for cooling, and create a more pleasant urban atmosphere. The incorporation of titanium dioxide nanoparticles into cool roof coatings results in the introduction of a dual mechanism that improves the performance of the coatings. In the first place, the photo-reflective characteristics of the coating are enhanced by the presence of TiO2 nanoparticles. Because of its one-of-a-kind optical properties, titanium dioxide (TiO2) is able to reflect a wide range of wavelengths from the sun, including the infrared wavelengths that are responsible for generation of heat. This high reflectivity results in the

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roof absorbing less heat, which in turn brings to a reduction in the temperature of the surface in question. Because of the photo-reflective properties of TiO2 nanoparticles, the cool roof is able to reflect sunlight more effectively, which makes it a powerful weapon in the fight against heat-related problems in metropolitan settings.

TiO2 nanoparticles, in addition to their photo-reflective qualities, also possess photocatalytic activities, which distinguish them as a revolutionary contribution to the field of cool roof technology. When exposed to ultraviolet (UV) light, titanium dioxide (TiO2) is recognized for its photocatalytic activity. Photocatalysis is a term that describes a chemical process that is promoted by light exposure. TiO2 is able to degrade organic pollutants and reduce the production of dangerous compounds on the surface of the roof as a result of this characteristic. In the context of cool roofs, the photocatalytic activity of titanium dioxide not only enables the roof to clean itself, but it also contributes to the purification of the air in the surrounding area. In the photocatalytic process that is triggered by TiO2 nanoparticles, the formation of reactive oxygen species (ROS) occurs when the nanoparticles are exposed to ultraviolet light. By actively interacting with organic contaminants, these reactive oxygen species (ROS) break them down into molecules that are simpler and less hazardous. By preventing the buildup of dirt, grime, and pollutants on the surface of the roof, this self-cleaning system ensures that the reflecting characteristics of the roof are preserved throughout time. In addition to this, the photocatalytic activity helps to purify the air by lowering the amount of dangerous pollutants that are present in the environment around the area. As pollutants accumulate on urban surfaces, especially roofs, the interaction of these pollutants with TiO2 nanoparticles has the potential to result in a cleaner and much healthier urban environment. When it comes to solving the issues that are brought about by increasing temperatures in urban areas, the incorporation of TiO2 nanoparticles into cool roof coatings provides a comprehensive solution. Cool roofs have the potential to reach new levels of energy efficiency, sustainability, and environmental responsibility. This is made possible by using both the photo-reflective and photocatalytic capabilities of titanium dioxide (TiO2). Not only do the synergistic effects of these features contribute to a cooler urban environment, but they also play a role in improving air quality and prolonging the lifetime of cool roof installations. Furthermore, they contribute to a cooler urban environment.

Titanium dioxide nanoparticles, in addition to the functional advantages they provide, provide a solution that is both adaptable and scalable for applications involving cool roofs. Nanoparticles are readily included into a wide variety of coating formulas, which enables designers to be more flexible in their designs and adapt to a wider range of roofing materials. This versatility makes TiO2-enhanced cool roofs a feasible alternative for both new constructions and retrofitting existing structures. They provide a practical and cost-effective way of applying sustainable building practices on a large scale, which is a significant benefit. Within the realm of cool roof technology, the investigation of cutting-edge materials such as titanium dioxide nanoparticles is becoming an increasingly important topic as the need for environmentally friendly construction solutions continues to increase. TiO2 is a major participant in the continuing attempts to develop urban settings that are energy-efficient, ecologically friendly, and resilient. This is because of the combination of photo-reflective and photocatalytic qualities that TiO2 has.

II. REVIEW OF LITERATURE

Bai, Xiao et al., (2023) Materials for construction that are based on titanium dioxide (TiO2) have the ability to purify the air, clean themselves automatically, and sterilize themselves. These novel green building materials have a significant potential for applications in the future that include reducing emissions and conserving energy. On the other hand, there are still a lot of obstacles to overcome in order to improve the efficiency and stability of photocatalytic processes from the laboratory to practical applications. In recent years, researchers have put in a significant amount of effort to enhance the effectiveness and durability of construction materials that are based on titanium dioxide (TiO2). This article provided a concise overview of the air purification concept that is based on photocatalytic construction, as well as the procedures for producing building materials that are based on titanium dioxide (TiO2) and the strategies that are used to increase the effectiveness of TiO2. As an additional point of interest, this article has

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provided an overview of the primary elements that influence the performance of photocatalytic buildings in practical applications, as well as an analysis of the limits and potential future developments. In conclusion, we put up a few recommendations for more study on photocatalytic buildings and their practical applications. Our objective was to provide a useful reference for the development of photocatalytic building materials that are both highly efficient and stable. In the area of green buildings, the purpose of this study is to give effective advice for the use of photo-catalysts based on titanium dioxide (TiO2), with the goal of assisting in the construction of low-carbon buildings that are more efficient and stable, therefore contributing to the development of sustainable cities.

Phi Hung et al., (2021) The degrading process and the capacity of acrylic/A-TiO2 nanocomposite coating to clean itself from the inside out are the primary objectives of this research. In the investigation of photocatalytic degradation, the results obtained from infrared spectroscopy (I.R.) demonstrated that the losses of alkane C.H. group, as well as the weight and transparency of the nanocomposite coating, rose as the nanoparticle concentration increased. In order to provide an explanation for this discovery, we hypothesized a novel degrading process for this nanocomposite coating made of water-based acrylic and A-TiO2. A high level of self-cleaning capacity was shown by the coating in its as-prepared state, as demonstrated by the fact that it was able to eliminate methyl blue as well as artificially created dirt mixes for the self-cleaning test. After twelve hours of exposure to ultraviolet light, the amount of methyl blue may be seen to have decreased. Furthermore, when this nanocomposite coating was utilized as a topcoat in the Solar heat reflectance (SHR) coating system, the heat reflectance of the SHR coating system was greatly recovered from 59% to 76% after 48 hours of exposure to ultraviolet light. This was owing to the self-cleaning activity of the nano-topcoat. However, when topcoats were not present, the heat reflectance of the SHR coating was only marginally recovered, ranging from 57% to 61%.

Niaraki, Somayeh et al., (2020) Within the scope of this work, an investigation was conducted to examine the impact of the crystalline structure of Fe2O3(amorphous) @TiO2, α-Fe2O3@TiO2, and α-Fe2O3 @SiO2 @TiO2 nanocomposites on the near-infrared (NIR) reflectance and photocatalytic characteristics. The preparation of nano-sized α-Fe2O3, SiO2, and TiO2 was accomplished by four distinct methods: co-precipitation, Stober, and sol-gel, respectively. Following a process that lasted for 120 minutes, the photocatalytic performance of the nanoparticles was evaluated by observing the photodegradation of Acid Red18 under the influence of ultraviolet light. Both colorimetric parameters and NIR-diffuse reflectance were carried out for measurement. Both the photocatalytic activity and the NIR-reflectance were found to have been significantly improved as a consequence of the treatment with the TiO2 coating. The nanocomposite composed of Fe2O3 (amorphous)@TiO2 exhibits the greatest NIR-reflection, whereas the nanocomposite composed of α-Fe2O3 @TiO2 highlights the highest photocatalytic degradation. It has been shown that the NIR-reflectance and photocatalytic degradation of the α-Fe2O3@SiO2@TiO2 nanocomposite have been enhanced to their highest possible levels, thanks to the presence of silica covering. As a consequence of this, this multifunctional composite is suited for simultaneous development for applications, including those involving photocatalytic and cool pigment properties.

Niaraki, Somayeh et al., (2019) within the scope of this investigation, a dual functional nanostructured Fe2O3@TiO2 pigment, often referred to as a cool pigment, is reported. This pigment has both photocatalytic capabilities and NIR reflectivity. The nano pigments composed of Fe2O3 and TiO2 were made by combining varying amounts of Fe2O3 and TiO2 at concentrations of 0.06, 0.62, and 1.24. The co-precipitation approach was used to produce Fe2O3 nanoparticles, and the sol-gel method was utilized to coat the nanoparticles with TiO2. Iron oxide precursors were utilized. Techniques such as X-ray diffraction, scanning electron microscopy, transmission electron microscopy, Fourier transform infrared spectroscopy, band edge energy transfer, liquid chromatography-mass spectroscopy, near infrared reflectance, and photoluminescence spectroscopy were used to characterize the pigments that were produced. In order to evaluate the photocatalytic capabilities of the nanocomposites that were manufactured, the degradation of acid red 18 and reactive black 5 was examined while the nanocomposites were exposed to ultraviolet light. NIR reflectance was found to be significantly improved

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by the crystallization of Fe_2O_3 and TiO_2, as shown by the findings. Furthermore, the presence of Fe_2O_3/TiO_2 demonstrated a significant impact on the band gap of the nanocomposite, as well as on its catalytic capability and NIR reflection. An increased photoactivity as well as the maximum NIR reflectance (73%) was observed for Fe_2O_3@TiO_2 with Fe_2O_3/TiO_2 = 0.06 in comparison to other Fe_2O_3 that was supported. However, the fact that these pigments have a brownish hue gives rise to the possibility that they may be an excellent option for a cool color coating.

Nasikhudin et al., (2018) there has been a significant amount of research conducted on titanium dioxide because of its photocatalytic properties and applications that have great performance for photovoltaic applications. The purpose of this study was to explore the effects of TiO_2 nanoparticles on the degradation of methylene blue when exposed to UV radiation and under a range of pH conditions. Both SEM and XRD were used in order to characterize the TiO_2 nanoparticle. The findings demonstrated that the structure of the TiO_2 nanoparticles is similar to that of anatase, and their particle size is 27 nanometers. The photocatalytic activity of TiO_2 nanoparticles demonstrates that the degradation of methylene blue under UV light results in the removal of 97% of the dye in three hours. On the other hand, the degradation of methylene blue without UV light results in the removal of 15% of the dye in three hours. Specifically, it was found that the photocatalytic activity of TiO_2 nanoparticles might take place in the presence of ultraviolet light. The destruction of 15% methylene blue is not a photocatalytic activity; rather, it is the adsorption of methylene blue by TiO_2 nanoparticles. If UV light is not present, the photocatalytic activity cannot take place. There is a pH-dependent relationship between the photocatalytic activity of TiO_2 nanoparticles. In an acidic environment (pH 4.1), the photocatalytic activity of TiO_2 nanoparticles is forty percent, whereas in a neutral environment (pH 7.0) it is ninety percent, and in a base environment (pH 9.7) it is ninety-seven percent. The basic state is the one in which the maximum photocatalytic activity takes place. This is because the base condition leads OH^- to have a direct reaction with a hole, which results in the production of hydroxyl radical (OH*).

Qi, Yanli et al., (2017) In order to address concerns about overheating caused by absorbed solar radiation (Ultraviolet-Visible-Near infrared) and infrared thermal energy from the surrounding environment, the cool roofing materials were manufactured. Due to their high solar reflectance and excellent actual heat-insulation properties, four different types of titanium dioxide (TiO_2) were selected for use in the fabrication of cool roofing materials in this study. These types of TiO_2 include hydrophobic rutile nano-TiO_2, hydrophilic anatase nano-TiO_2, unmodified rutile TiO_2, and unmodified anatase TiO_2. ASA resin, which stands for poly (acrylonitrile-styrene-acrylate), is used in matrix because of its exceptional resistance to the elements. An Ultraviolet-Visible-Near Infrared (UV–vis–NIR) spectrophotometer was used to assess the reflectance, and a device that was created by the individual themselves was used to test the real heat-insulation qualities. For the purpose of conducting contact angle analysis, a contact angle meter was used. After the incorporation of hydrophobic rutile nano-TiO_2 particles at a weight percentage of five percent, the ASA/TiO_2 hybrid material exhibits a reflectance of 45.2% throughout the near-infrared spectrum and 59.4% across the whole solar spectrum. In the range of 8–13 μm, the thermal emissivity is measured to be 0.87, whereas in the range of 2.5–15 μm, it is measured to be 0.86. There is a correlation between the high solar reflectance and the high thermal emissivity, which results in materials that have great cooling properties. When compared to unloaded ASA resin, the presence of a considerable reduction in temperature demonstrates that the material possesses outstanding cooling properties. In particular, according to the results of the indoor temperature test conducted using a solar simulator, a maximum drop of 34 degrees Celsius may be detected, and a decrease of 10 degrees Celsius can be reached when the test is conducted outside under natural sun radiation. Specifically, the contact angle of the sample that was created by the addition of hydrophobic rutile nano-TiO_2 particles is 103 degrees, which results in the formation of a hydrophobic surface. Furthermore, the cool roofing materials that were manufactured in this research exhibit exceptional resilience to the elements, hence satisfying the stringent criteria for deployment in outdoor settings.

van Driel et al., (2015) Over the course of the 20th century, titanium dioxide was the white pigment that was used the most often. Not only is the pigment still used in the creation of current art, but it is also utilized as a retouching pigment for the preservation of earlier sculptures and paintings. It is unfortunate that the pigment, in addition to its great qualities, has one significant potential downside, which is its photocatalytic activity, which has the potential to cause the deterioration of artworks in which it is involved. We report on a novel approach that we developed in order to assess the photocatalytic activity of various quality classes of titanium dioxide white pigments in this study. This may be accomplished statistically in a laboratory that specializes in chemical analysis, or qualitatively in a method that is fast and simple, in a museum or an artist's workshop, with insufficient use of laboratory equipment. The use of UV-Vis spectrophotometry allows for the monitoring of the photocatalytic degradation of an organic dye known as acid blue 9 in an aqueous solution that contains titanium dioxide over a period of time. Within a few hours of being exposed to UVA, dye solutions that include pigments that have a high photocatalytic activity will lose their color. However, dye solutions that include titanium dioxide that is stable to ultraviolet light do not deteriorate after twenty-four hours of being exposed to ultraviolet A. An understanding of the photocatalytic activity of titanium white pigments, which may be achieved via the use of this innovative test, is of utmost significance for the preservation of contemporary art through preventative measures.

Hadnadjev Kostic et al., (2010) Through the process of degrading a wide variety of organic pollutants that are present on solid surfaces, the phenomenon known as heterogeneous photo catalysis takes place. The process of photo catalysis involves the excitation of a semiconductor via the use of supraband gap photons. This excitation is followed by the migration of electron-hole pairs to the surface of the photo catalysts. This migration ultimately results in the formation of hydroxyl radicals through the interaction of the holes with adsorbed hydrogen peroxide and hydroxyl radicals. As a result of the stability and photosensitivity of TiO2 semiconductors, this system has been thoroughly researched and is of considerable interest from both an ecological and industrial perspective for the purpose of being used in the area of building materials applications. Because of their prolonged use, clay roofing tiles are susceptible to deterioration on several levels, including physical, chemical, and biological degradation, which ultimately results in their disintegration. Due to the fact that ceramic systems have a high percentage of total porosity and that they do not tolerate organic coatings, the use of surface active materials (SAM) that induce porosity in TiO2 coatings is of fundamental importance. The amount of titanium dioxide (mass/cm2) on the surface of the tile was varied in order to construct photocatalytic coatings that could be applied to clay roofing tiles under industrial settings. These coatings ranged from thin to thick layers of titanium dioxide. The use of PEG 600 as a surface active material resulted in the favorable modifications that were seen in the specific surface area and the mesopore structure of the coatings that were created. When applied to ceramic tiles under industrial conditions, it was demonstrated that a thin photocatalytic layer (0.399 mg suspension/cm2 tile surface) exhibited superior photocatalytic activity in the decomposition of methylene blue, hydrophilicity, and antimicrobial activity compared to a thick photocatalytic coating (0.885 mg suspension/cm2).

III. RESEARCH METHODOLOGY

Materials

PEG with a molecular weight of 500 was acquired from Sigma-Aldrich. The three varieties of TiO2 that were purchased were titanium (IV) oxide anatase Nano powder, titanium (IV) oxide combination of rutile and anatase nanoparticles in colloidal dispersion, and titanium (IV) oxide rutile Nano powder with a particle size of less than 100 nanometers.

The "KPG roofing" Company was responsible for the production and distribution of two distinct varieties of clay roofing tiles, one of which included silicon and the other didn't.

Preparation and Characterization of the TiO2 Nanoparticles

Using strong magnetic stirring, TiO2 aqueous suspensions were created by combining deionized water with 2.5 mass percent of each of the three varieties of TiO2 and 0.208 mass percent of polyethylene glycol (PEG 600). A process that was quite similar to this one

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was used in order to create TiO_2 nanoparticles that did not include PEG. After that, a dip-coating process was used to two different kinds of ceramic roofing tiles (type B and type C; with and without a silicon layer, respectively) in order to get the necessary photocatalytic surface. At the end of the process, the tiles were dried in an industrial furnace at temperatures of 100 ◦C and 290 ◦C. An industrial furnace was used to dry TiO_2 aqueous suspensions with and without PEG. The samples were dried at temperatures of 100 ◦C and 290 ◦C. This was done for the purpose of characterizing the samples. The total number of samples that were prepared was twelve. Techniques for characterization were carried out, and X-ray diffraction analysis was used to investigate the results of the determination of sample phase compositions. A Brucker D8 Advance diffractometer, operating in the reflection mode with Cu Ka radiation, was used to conduct X-ray diffraction (XRD) measurements on materials that had been dried and subjected to heat treatment. The measurements were carried out within the 2θ interval of 10–80◦. It was determined whether or not the powders' diffraction patterns were comparable to the reference found in the ICDD database. Using an experimental conformation instrument, the specific surface area of the samples was determined in accordance with the Brunauer– Emmett–Teller theory. This was accomplished by the use of low-temperature nitrogen adsorption at a temperature of -196 ◦C. Before the isotherm measurements were taken, each and every sample was degassed. Using a laser diffraction method and a Nano ZS (Malvern Instruments, zeta-nano series), the particle size distribution of the suspensions, which consisted of a 2.5% TiO_2 water suspension and the newly generated photocatalytic active suspension, was examined. For the purpose of dispersing both suspensions inside the sample cell, water was used. In a volume of thirty milliliters of water, about 0.1 milliliter of these suspensions was mixed with the dispersant. In order to do statistical calculations with the help of the particle sizing tool known as Dispersion Technology Software (DTS), the refractive index of each solvent was used as a preference index. This was done for TiO_2 with a thickness of 2.5. Prior to the measurements, the samples were subjected to ultrasonic water action for ten minutes in order to investigate the change in particle size distribution that was caused by ultrasonic action.

IV. RESULT AND DISSCUSSION

Both a and b of Figure 1 are scanning electron micrographs that show the surface of the coated ceramic roof tiles. Within the scope of these investigations, two distinct varieties of furnaced tiles, namely type B and type C, were examined. On the type B tile, a covering of silicon was plainly visible; on the other hand, the type C tile had a more favourable arrangement of nanomaterials on its surface. In Figure 1a and 1b, you can see SEM pictures of tiles that belong to the latter category. A variety of regions on the surface of the samples, in which elemental analysis was carried out, are shown in Figure 2b. The oxidized regions that appeared as a result of the heat breakdown of polyethylene glycol are referred to as Spectrum 1 and Spectrum 2. The nanoparticle of titanium dioxide is represented by spectrum 3, while the interface between a nanoparticle and a degraded molecule of polyethylene glycol (PEG) is shown by spectrum 4. The findings regarding the precise surface areas of all of the samples that were investigated are shown in Table 1. As shown, the sample of TiO_2 (anatase Nano powder) with polyethylene glycol, which was dried at a temperature of 100 ◦C, showed the maximum specific surface area (91.5 m2/g). Conversely, the same kind of sample, which was dried at a temperature of 290 ◦C, displayed a specific area that was lower (74 m2/g). At a temperature of 290 degrees Celsius, the degradation of PEG owing to thermal degradation took place. In addition, samples that included the same kind of TiO_2 but did not contain any PEG revealed a specific area that was lower (77.1 and 77.7 m2/g from the respective values). Differentiations between the specific surface areas of TiO_2 samples that were composed of a combination of anatase and rutile, both with and without the addition of PEG, were also observed. While the samples created without PEG showed the lowest specific surface area (49.9 and 49 m2/g), the sample that included PEG and was dried at a temperature of 100 degrees Celsius had the greatest specific surface area (58.9 m2/g) among the samples that contained this kind of TiO_2. Finally, as can be seen in Table 1, the third form of TiO_2 nanoparticles, which was rutile nano powder, had the specific surface areas that were the lowest. The incorporation of PEG into these particular samples resulted in an increase in surface area going from 31 m2/g to 36.3 m2/g.

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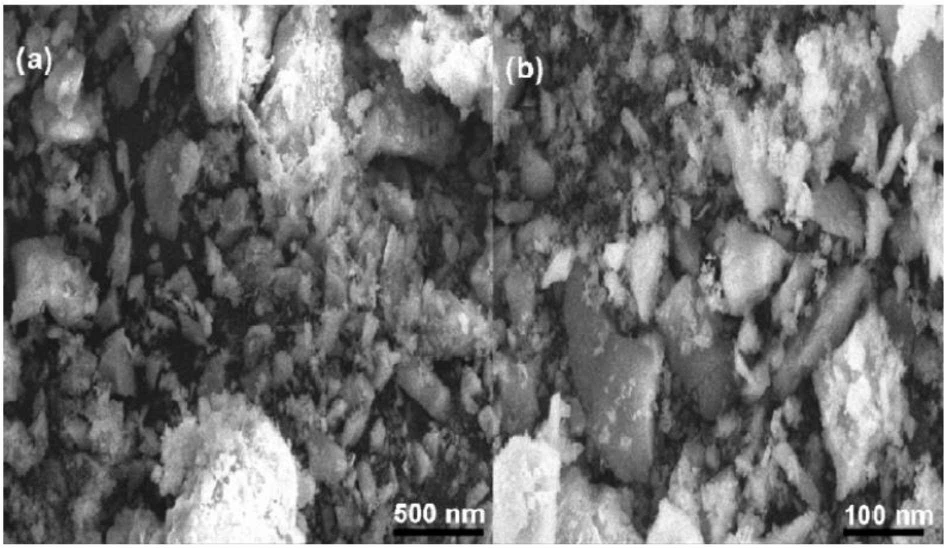

Figure 1. TiO2 Nanoparticles on Coated Roof Tiles (a) SEM Imaging (b) Elemental Analysis in Spectrum Zones.

Table 1: Samples and results of their specific surface area

Type of TiO_2	**Sample**	**Specific Surface Area (m^2/g)**
Anatase nanopowder +PEG	1_200/ 2_300	91.3/76.4
Mixture of anatase and rutile +PEG	2_200/ 2_300	77.6/77.2
Anatase nanopowder	3_200/ 3_300	58.8/49
Rutile nanopowder +PEG	4_200/ 4_300	49.8/48
Rutile nanopowder	5_200/ 5_300	36.2/33.5
Mixture of anatase and rutile	6_200/ 6_300	30/31.4

In the following table, specific surface area measurements (in meters squared per gram) for several kinds of TiO2 samples are shown. An enzyme Nano powder that contains PEG has a specific surface area that is very high, measuring 91.3/76.4 (m2/g). Following closely after with values of 77.6/77.2 (m2/g) is a combination of anatase and rutile which is also including PEG. Anatase Nano powder has a specific surface area of 58.8/49 (m2/g), while rutile Nano powder with PEG and rutile Nano powder both have specific surface areas of 49.8/48 (m2/g) and 36.2/33.5 (m2/g) respectively. On the other hand, the specific surface area of the combination of anatase and rutile is lower, coming in at 30/31.4 (m2/g). These findings suggest that the surface attributes of TiO2 samples are not uniform, since the particular surface areas of these samples are influenced by a variety of factors, including the composition of the samples and the processing techniques used.

V. CONCLUSION

One of the most innovative approaches to addressing the difficulties that are presented by urban heat islands and

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climate change is the integration of nanoparticles of titanium dioxide (TiO_2) into cool roof coverings. TiO_2's photo-reflective and photocatalytic qualities work together to improve the effectiveness of roof cooling while also contributing to air purification and self-cleaning capabilities. This synergistic combination of features is what makes TiO_2 so effective. Not only does this dual process increase energy efficiency and sustainability, but it also has the potential to produce urban settings that are healthier for people to live in. Given that TiO_2 nanoparticles are able to be included into a wide variety of coating formulations, the adoption of TiO_2-enhanced cool roofs has emerged as a flexible and scalable technique that can be used for both the construction of new buildings and the retrofitting of existing structures. At a time when cities all over the globe are looking for more environmentally friendly construction methods, TiO_2-enhanced cool roofs are a shining example of innovation. They provide a method that is both practical and efficient for addressing the urgent issues of urban heat and environmental impact.

REFERENCES

1. Bai, Xiao & Meng, Hong & Wu, Que & Wei, Yuan & Zhang, Yong. (2023). TiO_2-Based Photocatalytic Building Material for Air Purification in Sustainable and Low-Carbon Cities: A Review. 10.20944/preprints202308.1381.v1.
2. Dorosheva, I. & Valeeva, A. & Rempel, A. & Trestsova, M. & Utepova, I. & Chupakhin, Oleg. (2021). Synthesis and Physicochemical Properties of Nanostructured TiO_2 with Enhanced Photocatalytic Activity. Inorganic Materials. 57. 503-510. 10.1134/S0020168521050022.
3. Giampiccolo, Andrea & Tobaldi, David & Leonardi, Salvatore & Murdoch, Billy & Seabra, Maria & Ansell, Martin & Neri, Giovanni & Ball, Richard. (2018). Sol gel graphene/TiO_2 nanoparticles for the photocatalytic-assisted sensing and abatement of NO_2. Applied Catalysis B: Environmental. 243. 10.1016/j.apcatb.2018.10.032.
4. Hadnadjev Kostic, Milica & Ranogajec, Jonjaua & Petrovic, Snezana & Sinisa, Markov & Ducman, Vilma & Marinkovic-Neducin, Radmila. (2010). Design of self-cleaning TiO_2 coating on clay roofing tiles. Philosophical Magazine. 90. 2989-3002. 10.1080/14786431003767017.
5. Honda, H. & Ishizaki, A. & Soma, R. & Hashimoto, Kazuhito & Fujishima, A.. (2013). Application of Photocatalytic Reactions Caused by TiO_2 Film to Improve the Maintenance Factor of Lighting Systems. Journal of the Illuminating Engineering Society. 27. 42-49. 10.1080/00994480.1998.10748209.
6. Kennedy, John & Elayaperumal, Manikandan & Futter, John & Markwitz, Andreas. (2012). Morphology and characterization of TiO_2 nanoparticles synthesized by arc discharge. Chemical Physics Letters. 521. 86–90. 10.1016/j.cplett.2011.11.046.
7. Loh, Kai & Gaylarde, Christine & Shirakawa, Márcia. (2018). Photocatalytic activity of ZnO and TiO_2 'nanoparticles' for use in cement mixes. Construction and Building Materials. 167. 853-859. 10.1016/j.conbuildmat.2018.02.103.
8. Nasikhudin, Nasikhudin & Diantoro, Markus & Kusumaatmaja, Ahmad & Triyana, Kuwat. (2018). Study on Photocatalytic Properties of TiO_2 Nanoparticle in various pH condition. Journal of Physics: Conference Series. 1011. 012069. 10.1088/1742-6596/1011/1/012069.
9. Nguyen, Thien & Phi Hung, Dao & Nguyen, Tuan Anh & Mac van, Phuc & Do, Vy & Dang, Thi & Ha, Minh & Trinh, Hoang & Lu, Le & Tran, Dai & Nguyen, Thanh & Nguyen-Tri, Phuong. (2023). Effects of nano-TiO_2 and nano-SiO_2 particles on the reflectance and weathering durability of solar heat reflectance coating. Journal of Photochemistry and Photobiology A: Chemistry. 442. 114752. 10.1016/j.jphotochem.2023.114752.
10. Niaraki, Somayeh & Ghasemi, Behrooz & Habibolahzadeh, Ali & Ghasemi, Ebrahim & Ghahari, Mehdi. (2020). Cool and photocatalytic reddish-brown nanostructured Fe_2O_3@SiO_2@TiO_2 pigments. Materials Science and Engineering: B. 262. 114752. 10.1016/j.mseb.2020.114752.

11. Niaraki, Somayeh & Ghasemi, Behrooz & Habibolahzadeh, Ali & Ghasemi, Ebrahim & Ghahari, Mehdi. (2019). Nanostructured Fe2O3@TiO2 pigments with improved NIR reflectance and photocatalytic ability. Materials Chemistry and Physics. 235. 121769. 10.1016/j.matchemphys.2019.121769.
12. Phi Hung, Dao & Nguyen, Thien & Nguyen, Tuan Anh & Oanh, Doan & Hoang, Thu & Le The, Tam & Nguyen-Tri, Phuong. (2021). Acrylic polymer/TiO2 nanocomposite coatings: Mechanism for photo-degradation and solar heat reflective recovery. Materials Chemistry and Physics. 272. 124984. 10.1016/j.matchemphys.2021.124984.
13. Qi, Yanli & Xiang, Bo & Zhang, Jun. (2017). Effect of titanium dioxide (TiO2) with different crystal forms and surface modifications on cooling property and surface wettability of cool roofing materials. Solar Energy Materials and Solar Cells. 172. 34-43. 10.1016/j.solmat.2017.07.017.
14. van Driel, Birgit & Kooyman, Patricia & Van den Berg, Klaas Jan & Schmidt-Ott, Andreas & Dik, Joris. (2015). A quick assessment of the photocatalytic activity of TiO2 pigments – From lab to conservation studio!. Microchemical Journal. 126. 10.1016/j.microc.2015.11.048.
15. Wu, Yunpeng & Krishnan, Padmaja & Zhang, Min-Hong & Yu, Liya. (2018). Using photocatalytic coating to maintain solar reflectance and lower cooling energy consumption of buildings. Energy and Buildings. 164. 176-186. 10.1016/j.enbuild.2018.01.011.