A PHOTOCATALYST THAT REACTS WITH EM WAVES FOR ENHANCED EFFICIENCY

Inventor: Wing Hong Peter CHEUNG

Field of the Invention:

[0001] The present invention relates to titanium oxide-based photocatalysts. In particular, the present invention provides apparatuses for VOC decomposition based on Cu(II)- / Zn(II)-doped TiO_2 photocatalysts, and their application in ventilation systems for air purification thereof.

Background of the Invention:

[0002] Volatile organic compounds (VOCs) are one of the major contributors to air pollution, adversely affecting both indoor and outdoor air quality and human health. Indoor VOC concentration can be 10 times higher than outdoor, as a result of emissions from building materials, consumer goods, and food. Harmful total volatile organic compounds (TVOCs), including but not limited to cooking emissions, grease trap odor, sewage odour, toilet odor and garbage room odor, not only cause foul odor, but also pose potential health risks.

[0003] One way to deal with these organic pollutants is by photocatalytic oxidation (PCO). This process can degrade and oxidize organic compounds like VOCs into mineral products like carbon dioxide and water. Titanium dioxide (TiO_2) is widely used as a photocatalyst due to its high photocatalytic efficiency. In the presence of water or oxygen, it can effectively produce strong oxidizing agents, reactive oxygen species (ROS) like hydroxyl radicals, which are capable of destructing various organic contaminants, consequently improving the air quality and reducing the odor, etc. Furthermore, the photocatalytic properties of TiO_2 make it effective in the disinfection and deactivation of microbial contaminants including fungi, algae, and bacteria.

[0004] Despite the common use of pure TiO_2, features like wide band gap and high electron hole recombination rate limit the potential of pure TiO_2. To further modify pure TiO_2 and improve its efficiency of pollutant removal, one promising approach is doping with metals. Through doping of metal ions like Cu, Ni, Ag, Mn, Zn, Al, etc., photocatalytic activity of TiO_2 can be enhanced with change in the band

gap, surface area, recombination rate, etc., ie., the removal rate of pollutants can be further improved through the significant increase in ROS generation rate, leading to easier and more effective purification of air.

[0005] However, existing Fe(III)-doped TiO_2 technologies still face shortcomings. For example, while Fe(III)-doped TiO_2 photocatalysts absorb a wider spectrum of electromagnetic wavelengths, the Fe^{3+} ions also act as recombination center for photo-generated e^-/H^+ pairs, which in turn shortens carrier lifetimes and reduces ROS generation efficiency.

[0006] Therefore, there exists a need in the art to provide substitutes to Fe(III)-doped TiO_2 which retains the photocatalytic performances while having a higher stability in ROS generation and shelf life of the apparatus. This invention addresses this need.

Summary of the Invention:

[0007] In response to the above technical challenges, provided in the first aspect of the present invention is an apparatus for accelerating decomposition of organic compounds with a smaller amount of energy and a shorter time compared with pure TiO_2, while applicable under a wider range of irradiation wavelength compared to other conventional photocatalysts, the apparatus comprising a photocatalyst.

[0008] In particular, the photocatalyst is configured to absorb certain wavelengths of the irradiated electromagnetic radiation of a wavelength that is within a first range of wavelengths and produce one or more agents for organic compounds decomposition. The photocatalyst is fabricated as a metal doped TiO_2.

[0009] In addition, the metal of the metal doped TiO_2 is selected from a group of metals comprising copper and zinc and constitutes 0.05 - 5 weight percent of the metal doped TiO_2.

[0010] In an embodiment of the first aspect of the present invention, the photocatalyst is fabricated by a fabrication process comprising: (i) adding a titanium precursor to an organic solvent with continuous stirring for approximately 30 minutes to dissolve and form an organic solution, wherein the titanium precursor is titanium isopropoxide and the organic solution is ethanol, (ii) adding an amount of water dropwise to the organic solution for approximately 1 hour with continuous stirring, (iii) adding a dopant precursor to the organic solution with continuous stirring, wherein the dopant precursor is selected from a group comprising copper

(II) nitrate, zinc nitrate or aluminium nitrate, (iv) coating a metallic substrate with the organic solution by dip coating to obtain a coated substrate, (v) drying the coated substrate at room temperature of 25 degrees Celsius for approximately 24 hours to obtain a dried substrate, (vi) heating the dried substrate in an oven under a temperature increasing from 25 degrees Celsius to 500 degrees Celsius with a rate of increase of 5 degrees Celsius per minute until the complete drying is achieved, and (vi) calcining the dried substrate in the oven under a temperature of 500 degrees Celsius for a time period of approximately 2 hours to obtain the photocatalyst.

[0011] In a further embodiment, the metallic substrate is 6061 aluminum alloy plate.

[0012] In another embodiment, the first range of wavelengths is 100-700 nm.

[0013] In other embodiment, the one or more agents for organic compounds decomposition are reactive oxygen species selected from a group consisting of superoxide radical anion, hydroxyl radical, hydrogen peroxide, singlet oxygen, or a combination thereof.

[0014] In a second aspect of the present invention, an air purification and ventilation system is provided. The system comprises ductwork having a first end for receiving air to be purified, and a second end for releasing purified air, and a section or opening in the ductwork, wherein the section or opening is installed with the aforementioned apparatus. Particularly, the ductwork is configured to direct the kitchen exhaust fume received from the first end to flow through the apparatus of claim 1 for purification and be released at the second end in a unidirectional flow.

[0015] In an embodiment of the second aspect of the present invention, the photocatalyst is fabricated by a fabrication process comprising: (i) adding a titanium precursor to an organic solvent with continuous stirring for approximately 30 minutes to dissolve and form an organic solution, wherein the titanium precursor is titanium isopropoxide and the organic solution is ethanol, (ii) adding an amount of water dropwise to the organic solution for approximately 1 hour with continuous stirring, (iii) adding a dopant precursor to the organic solution with continuous stirring, wherein the dopant precursor is selected from a group comprising copper (II) nitrate, zinc nitrate or aluminium nitrate, (iv) coating a metallic substrate with the organic solution by dip coating to obtain a coated substrate, (v) drying the coated substrate at room temperature of 25 degrees Celsius for approximately 24 hours to obtain a dried substrate, (vi) heating the dried substrate in an oven under a

temperature increasing from 25 degrees Celsius to 500 degrees Celsius with a rate of increase of 5 degrees Celsius per minute until the complete drying is achieved, and (vi) calcining the dried substrate in the oven under a temperature of 500 degrees Celsius for a time period of approximately 2 hours to obtain the photocatalyst.

[0016] In another embodiment, the first range of wavelengths is 100-700 nm.

[0017] In other embodiment, the one or more agents for organic compounds decomposition are reactive oxygen species selected from a group consisting of superoxide radical anion, hydroxyl radical, hydrogen peroxide, singlet oxygen, or a combination thereof.

[0018] In yet another embodiment, the metallic substrate is 6061 aluminum alloy plate.

Brief Description of the Drawings:

[0019] Embodiments of the invention are described in more details hereinafter with reference to the drawings, in which:

[0020] FIG. 1 depicts a schematic diagram of an apparatus illustrating the photocatalyst together with an aluminum alloy base in accordance with one embodiment of the present invention; in this illustration, apparatus 1 comprises a photocatalyst 2 and an aluminum alloy 6061 base 3; and

[0021] FIG. 2 depicts a schematic diagram of a device illustrating the working principle of the photocatalyst in accordance with one embodiment of the present invention; in this illustration, the device is configured to emit EM waves, i.e., UV 4, having UVC wavelengths of 200-280nm and UV wavelengths of 100-400nm; and

[0022] FIG. 3 illustrates a fabrication method of the photocatalyst in accordance with one embodiment of the present invention.

[0023] FIG. 4 provides a schematic illustration of an exemplary embodiment of the invention, configured to be installed into a commercialventilation system.

Detailed Description:

[0024] The invention is a newly fabricated metal doped titanium dioxide. By introducing a specific amount of certain metal into TiO_2, the ability of the photocatalyst has been enhanced, which improves degradation efficiency of organic pollutants and microbes under photocatalytic oxidation.

[0025] The new photocatalyst enhances the efficiency of the decomposition of organic air pollutants, i.e. pigments, oil mist, odor, and industrial emissions, in photocatalysis reaction.

[0026] The new photocatalyst benefits different industries, i.e., manufacturing industry with air pollutant emissions, restaurants, and facilities with odor emissions, including but not limited to grease trap odor, sewage odor, toilet odor and garbage room odor.

[0027] The advancement in performance can be attributed to various factors, two of the key modifications are the reduction of band gap and recombination rate. The efficiency of photocatalytic reactions is governed by how effectively electrons and holes are channeled into oxidation and reduction reactions before recombination of electrons and holes takes place. The reduction of band gap allows formation of electrons and holes with less energy, and lower recombination rate, in other words, leads to higher rate of oxidation and reduction, thus, higher rate of production of ROS.

[0028] Emitted by UV light or even solar light, which includes visible light, the doped TiO_2 can, by reaction with water and oxygen in the air, effectively produce ROS, which oxidize and degrade pollutants, like TVOCs, readily, producing less harmful, if not harmless products like water and carbon dioxide.

[0029] The effectiveness of the TiO_2 photocatalysts (metal-doped TiO_2 photocatalysts in particular) in air purification is rooted in its ability to target and treat a wide range of airborne pollutants commonly found in kitchen exhaust and industrial emissions, utilizing distinct photocatalytic mechanisms for different pollutant types. Upon irradiation, the metal-doped TiO_2 photocatalyst generates highly reactive hydroxyl radicals (OH) and other reactive oxygen species (ROS) on its surface. These species aggressively attack and mineralize odorous compounds, such as volatile sulfides (e.g., hydrogen sulfide, methyl mercaptan) and amines (e.g. trimethylamine), as well as harmful volatile organic compounds (VOCs) including aldehydes (e.g. formaldehyde, acrolein), ketones, and aromatic compounds (e.g., benzene, toluene, xylene, and polycyclic aromatic hydrocarbons (PAHs)). Through advanced oxidation processes, these pollutants are rapidly converted into non-odorous and harmless products such as carbon dioxide (CO_2) and water (H_2O), effectively eliminating unpleasant odors and reducing the toxicity of the exhaust.

[0030] One of the implementations for this doped TiO_2 is the ventilation system of building, for instance, kitchen ventilation system. The light source and doped photocatalysis system can be installed into the ventilation system and enhance the degradation and removal of pollutants like oil mists, TVOCs, bacteria etc., leading to improved air quality in the kitchen. One exemplary installation is a metal plate deposited of the doped TiO_2, which is irradiated by a UV light source, with both placed inside the ventilation duct perpendicular to the direction of the airflow, purifying the air flowing from the room.

[0031] The new photocatalyst is fabricated to have better photocatalytic activity than pure TiO_2. By doping a certain amount of metal, for example, 0.05 to 5 weight percent of Cu or Zn into TiO_2, modifications like a narrower band gap and a smaller recombination rate can be achieved. The efficiency of photocatalytic reactions is governed by how effectively electrons and holes are channeled into oxidation and reduction reactions before recombination of electrons and holes takes place. The reduction of the band gap allows the formation of electrons and holes with less energy, and a lower recombination rate, in other words, leads to a higher rate of oxidation and reduction, thus, a higher rate of production of ROS like hydroxyl radicals can be achieved in photocatalytic reaction.

[0032] Since the formation of electrons and holes requires less energy due to the reduction of the band gap, certain EM waves that do not excite pure TiO_2 much in photocatalytic reaction can now excite the new photocatalyst readily, example could be UVA and visible light. Moreover, the higher rate of oxidation and reduction caused by lowered recombination rate further enhances photocatalytic activity with water and oxygen in the air and increases the formation of ROS. Consequently, more reactive agents that readily degrade organic pollutants can be produced with the use of the new photocatalyst, leading to a more efficient treatment of organic pollutants like TVOCs.

[0033] As such, there have been multiple Fe(III)-doped TiO_2 photocatalysts developed to achieve the above advantages that are otherwise lacking in pure TiO_2. However, there are certain technical limitations of Fe(III)-doped TiO_2 photocatalysts that need to be addressed.

[0034] Fe^{3+} introduces 3d states within the TiO_2 band gap as mentioned above, which widens the spectrum of irradiation wavelength that excites and triggers photocatalytic reaction. However, Fe^{3+} also acts as recombination centers for photo-

generated electron-proton pairs, which shorten carrier lifetimes and hampers ROS generation at practical doping levels.

[0035] In addition, in application contexts, industrial or kitchen exhaust fumes that are received to be purified may be at a high temperature. Fe^{3+} doping, which may potentially destabilize the TiO_2 lattice and accelerate the anatase-to-rutile transformation at elevated temperatures, may in turn lower photocatalytic efficiency and hence and reduced efficacy of the apparatus.

[0036] Fe^{3+}/Fe^{2+} cycling may promote Fenton-like reactions in ROS generation. However, this is only accelerated at acidic pH levels, which is impractical in in-situ application as installations.

[0037] Moreover, the photocatalytic reaction of Fe(III)-doped TiO_2 is only improved within an irradiation wavelength of 100 – 400 nm.

[0038] In response, the present invention provides TiO_2 doped with Cu(II), Zn(II) and Al(III) as substitutes. This is achieved as the d^9 electronic configuration of Cu^{2+} and d^{10} electronic configuration of Zn^{2+} which both promote ROS formation without introducing electron-proton recombination as severe as Fe^{3+}. In addition, both Cu^{2+}, Zn^{2+} and Al^{3+} pose less structural instability as compared to Fe^{3+}, therefore the photocatalytic activities are retained at higher levels even under exposure to high temperature waste fumes.

[0039] The photocatalytic apparatus of the present invention is also applicable under irradiation of a wider range of wavelength up to 700 nm, which is closer to visible light spectrum and has improved efficiency.

[0040] The Example section below discusses the fabrication process of the organic compound decomposition-accelerating apparatus of the present invention, and an exemplary embodiment of its application as an installation to a kitchen exhaust fume purification and ventilation duct system.

[0041] **Examples:**

[0042] General structure of the photocatalytic apparatus and its installation in ventilation systems

[0043] FIG. 1 provides a schematic illustration of the structure of photocatalytic apparatus 1 of the present invention. The apparatus is built on a metallic substrate 3. Particularly in the exemplary embodiments below, 6061 aluminum plates are selected to be the choice of the metallic substrate.

[0044] The metallic substrate 3 is further dip-coated to form a photocatalytic layer 2 consisting of a Zn^{2+} / Cu^{2+} /Al^{3+}-doped TiO_2. The detailed fabrication process of the photocatalytic apparatus 1, including the preparation process of the TiO_2 photocatalyst layer and the dip coating processes are described in the section below.

[0045] UV irradiation is necessary for the photocatalysis of the decomposition of VOCs by photocatalytic apparatus 1. Accordingly, depending on the context of the application, the photocatalytic apparatus 1 can be applied to a ventilation system as illustrated in FIG. 2 in two methods.

[0046] In the first configuration, photocatalytic apparatus 1 is installed at the outlet of the ventilation duct, where the exhaust fume is to be purified right at the exit. The photocatalysis process can be initiated by the UV from solar radiation. This configuration, applicable in ventilation or air purification systems with outlets directly connected to the exterior of a building, utilizes solar UV, and as such is highly cost-effective. However, this configuration is not applicable in circumstances in which the entirety of the ventilation systems is installed indoors. Also, the performance of the photocatalytic apparatus may be affected by the weather and variance of sunlight throughout the day.

[0047] In a second configuration, photocatalytic apparatus 1 is installed in the interior of the ventilation duct, with additional UV irradiation devices 4 installed adjacent to the photocatalytic apparatus 1, which can be remotely controlled. This configuration allows application in any ventilation systems, and can achieve energy efficiency, as the operation of the system can be controlled, for example, through a switch, such that the UV irradiation is only applied to initiate photocatalyzed VOC decomposition when air purification is needed, and no energy is wasted when the switch is turned off. Also, in comparison with the first configuration, the UV irradiation is significantly less prone to external factors, thereby ensuring more stable performance of the photocatalytic apparatus.

[0048] Fabrication of photocatalytic apparatus

[0049] Referring to FIG. 3 for the following description. The method of fabrication starts with step 30, in which a titanium precursor (i.e., TTIP (titanium isopropoxide)) that is prepared is added to and dissolved in an organic solution (i.e., ethanol). The solution is immediately stirred by a magnetic stirrer for a certain period (i.e., 30 minutes).

[0050] Subsequently, in step 31, a certain amount of water is added dropwise to the solution for a certain period with continuous stirring (i.e., 1 hour). Next, in step 32, a prepared dopant precursor (i.e., $Al(NO_3)_3$ (aluminium nitrate), $Cu(NO_3)_2$ (copper (II) nitrate), $Zn(NO_3)_2$ (zinc nitrate)) is added to the solution slowing with continuous stirring. For example, 0.05 to 5 weight percent of Fe into TiO_2. Stirring is continued for a certain period (i.e., 24 hours) under room temperature until a sol-like solution is obtained. A base (i.e., aluminum 6061 plates) is slowly coated with the solution by dip coating in step 33. As a specific example, an aluminum 6061 plate is slowly dipped into the solution 5 times. The base is then placed still and dried at room temperature for a certain period (i.e., 24 hours) to remove the solvents. Finally, the dried base is heated in an oven for complete drying and calcination, in which the temperature is increased to 500 degrees Celsius with an increased rate of 5 degrees Celsius per minute, and then calcined at 500 degrees Celsius for a certain period (i.e., 2 hours) in step 34.

[0051] Performance of Different Doped Titanium Oxide Photocatalysts

[0052] Table 1 below procides a comparison of the performance of different doped TiO_2 photocatalysts in terms of TVOC removal. Particularly, their performances under typical UV irradiation and visible light irradiation are also tabulated.

[0053] Table 1:

Photocatalyst material	Typical TVOC Removal Rate (%)	
	Visible light (400-700 nm), intensity 800 μW/cm²	UV (100-400 nm), intensity 300 μW/cm²
None	0	70 - 80
Pure TiO_2	5 - 15	85 - 92
Cu-doped TiO_2 (1-7 mol% Cu)	60 - 80	89 - 96
Zn-doped TiO_2 (0.5-2 mol% Zn)	50 - 70	75 - 90
Al-doped TiO_2 (0.5-2 mol% Al)	30 - 60	70 - 85

[0054] As observed above, the three doped TiO_2 photocatalysts of the present invention retains TVOC removal rates comparable to conventional TiO_2 photocatalysts under UV irradiation of wavelength 100-400 nm,

[0055] However, the three doped TiO_2 photocatalysts of the present invention, demonstrates significant improvement in their TVOC removal performances under visible light irradiation of wavelength 400-700 nm, in comparison with conventional photocatalysts which have very limited TVOC removal efficiency under visible light irradiation. This highlights the wider application of the photocatalytic apparatus of the present invention, extending beyond installation onto not only indoor ventilation systems to potential application in outdoor contexts.

[0056] Installation application in ventilation systems

[0057] As illustrated in FIG. 4, which illustrates an exemplary embodiment of the invention in a practical application, the apparatus is designed for seamless integration into ventilation systems, such as a commercial kitchen exhaust duct.

[0058] The installation process typically involves creating a section or opening in the existing ductwork to accommodate the core photocatalytic module (13) implementing the apparatus of the invention. Once the module (13) is installed within the airflow path, its internal light sources are activated. As polluted air, containing contaminants such as VOCs, odor, and oil mist, is drawn through the duct, it passes directly through the activated module. Inside, the pollutants are continuously degraded into non-polluting byproducts like water vapor and carbon dioxide, which are then exhausted from the system.

[0059] This in-situ purification offers several key benefits: it has significantly lower maintenance needs due to the self-cleaning nature of the photocatalytic surface, it does not require consumable replacements like traditional filters, and it effectively mineralizes pollutants rather than simply trapping them. Therefore, the present invention serves as a robust and economically viable solution for direct installation into air ducts to provide effective, continuous air purification.

[0060] The apparatus, in addition to its efficacy in treating gaseous pollutants, displays a mechanism for the remediation of aerosolized oil mist, which is of particular significance in kitchen exhaust purification application. Oil mist consists of larger aerosolized droplets containing fats, fatty acids, and other long-chain organic compounds. The ROS generated by the photocatalyst continuously oxidize the surface layer of oil droplets that deposit on the coating, breaking down complex, long-chain organic molecules into smaller, more volatile, and less harmful compounds. This ongoing surface oxidation not only prevents the accumulation of sticky, performance-inhibiting grease layers but also imparts a significant self-

cleaning effect to the apparatus surface, thereby maintaining long-term operational efficiency and stable performance.

[0061] As used herein, terms "approximately", "basically", "substantially", and "about" are used for describing and explaining a small variation. When being used in combination with an event or circumstance, the term may refer to a case in which the event or circumstance occurs precisely, and a case in which the event or circumstance occurs approximately. As used herein with respect to a given value or range, the term "about" generally means in the range of ±10%, ±5%, ±1%, or ±0.5% of the given value or range. The range may be indicated herein as from one endpoint to another endpoint or between two endpoints. Unless otherwise specified, all the ranges disclosed in the present disclosure include endpoints. When reference is made to "substantially" have the same numerical value or characteristic, the term may refer to a value within ±10%, ±5%, ±1%, or ±0.5% of the average of the values.

[0062] The foregoing description of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations will be apparent to the practitioner skilled in the art

[0063] The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the art to understand the invention for various embodiments and with various modifications that are suited to the particular use contemplated.

Claims:

1. An apparatus for accelerating decomposition of organic compounds with a smaller amount of energy and a shorter time compared with pure TiO_2, the apparatus comprising a photocatalyst;

wherein the photocatalyst is configured to:

absorb certain wavelengths of the irradiated electromagnetic radiation of a wavelength that is within a first range of wavelengths; and

produce one or more agents for organic compounds decomposition;

wherein the photocatalyst is fabricated as a metal doped TiO_2;

wherein the metal of the metal doped TiO_2 is selected from a group of metals comprising copper, zinc and aluminium; and

wherein the metal constitutes 0.05 to 5 weight percent of the metal doped TiO_2.

2. The apparatus of claim 1, wherein the photocatalyst is fabricated by a fabrication process comprising:

adding a titanium precursor to an organic solvent with continuous stirring for approximately 30 minutes to dissolve and form an organic solution, wherein the titanium precursor is titanium isopropoxide and the organic solution is ethanol;

adding an amount of water dropwise to the organic solution for approximately 1 hour with continuous stirring, wherein the weight ratio of the titanium precursor to water is 15:200;

adding a dopant precursor to the organic solution with continuous stirring, wherein the dopant precursor is selected from a group comprising copper (II) nitrate, zinc nitrate or aluminium nitrate;

coating a metallic substrate with the organic solution by dip coating to obtain a coated substrate;

drying the coated substrate at room temperature of 25 degrees Celsius for approximately 24 hours to obtain a dried substrate;

heating the dried substrate in an oven under a temperature increasing from 25 degrees Celsius to 500 degrees Celsius with a rate of increase of 5 degrees Celsius per minute until the complete drying is achieved; and

calcining the dried substrate in the oven under a temperature of 500 degrees Celsius for a time period of approximately 2 hours to obtain the photocatalyst.

3. The apparatus of claim 1, wherein the first range of wavelengths is 100-700 nm.

4. The apparatus of claim 1, wherein the one or more agents for organic compounds decomposition are reactive oxygen species selected from a group consisting of superoxide radical anion, hydroxyl radical, hydrogen peroxide, singlet oxygen, or a combination thereof.

5. The apparatus of claim 2, wherein the metallic substrate is 6061 aluminium alloy plate.

6. An air purification and ventilation system, comprising:

a ductwork having a first end for receiving air to be purified, and a second end for releasing purified air;

a section or opening in the ductwork, wherein the section or opening is installed with the apparatus of claim 1;

wherein the ductwork is configured to direct the air to be purified received from the first end to flow through the apparatus of claim 1 for purification and be released at the second end in a unidirectional flow; and

wherein the apparatus of claim 1 is installed in a configuration perpendicular to the unidirectional flow.

7. The system of claim 6, wherein the photocatalyst is fabricated by a fabrication process comprising:

adding a titanium precursor to an organic solvent with continuous stirring for approximately 30 minutes to dissolve and form an organic solution,

wherein the titanium precursor is titanium isopropoxide and the organic solution is ethanol;

adding an amount of water dropwise to the organic solution for approximately 1 hour with continuous stirring;

adding a dopant precursor to the organic solution with continuous stirring, wherein the dopant precursor is selected from a group comprising copper (II) nitrate, zinc nitrate or aluminium nitrate;

coating a metallic substrate with the organic solution by dip coating to obtain a coated substrate;

drying the coated substrate at room temperature of 25 degrees Celsius for approximately 24 hours to obtain a dried substrate;

heating the dried substrate in an oven under a temperature increasing from 25 degrees Celsius to 500 degrees Celsius with a rate of increase of 5 degrees Celsius per minute until the complete drying is achieved; and

calcining the dried substrate in the oven under a temperature of 500 degrees Celsius for a time period of approximately 2 hours to obtain the photocatalyst.

8. The system of claim 6, wherein the first range of wavelengths is 100-700 nm.

9. The system of claim 6, wherein the one or more agents for organic compounds decomposition are reactive oxygen species selected from a group consisting of superoxide radical anion, hydroxyl radical, hydrogen peroxide, singlet oxygen, or a combination thereof.

10. The system of claim 7, wherein the metallic substrate is 6061 aluminium alloy plate.