PHOTOCATALYTIC DEGRADATION OF ACETAMINOPHEN BY USING NANOPARTICLES – A REVIEW

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Abstract - *Over recent years, the appearance of pharmaceutical waste in the environment has become a major worldwide issue. Pharmaceutical compounds are chemical compounds that are used to diagnose, cure, and prevent the occurrence of diseases. But the disposal of pharmaceutical waste in our country is not proper and because of this the environment is very badly affected. In this study, the most commonly used drug acetaminophen pain relief drug, was taken for degradation by using visible light along with nanocatalyst.The most suitable method of degradation of Acetaminophen is "PHOTOCATALYTIC DEGRADATION".The Titanium Dioxide is an important semiconductor material for wide range of solar Energy Conversion Applications.The synthesis of TiO2 from the plant or flower Extract is the feasible and Eco-friendly.The Carbon doped TiO2 gives high Degradation Efficiency of 94%.*

Key Words: **Acetaminophen, Flower Extract, Photocatalytic Degradation, Nanoparticles**

1. INTRODUCTION

Nanomaterials are being highly attracted by researchers to exploit their excellent properties for various Application. Pharmaceuticals and personal care products such as therapeutic drugs, hormones, skincare products have attracted global environment. Among the various pharmaceutical Acetaminophen is one of the widely used pain relief drugs. The method included in this study of degradation of Acetaminophen is "Photocatalytic Degradation". Photocatalytic Degradation is mainly adopted in degradation of Acetaminophen by using Nanoparticles. Pharmaceutical wastes are potentially generated through a wide variety of activities in the health care system, including syringes, and are not limited to intravenous (IV) preparation. Global awareness of ACT as an emergent hazardous material and the requirements of technologies forits efficient control have been increasing rapidly[1]. Titanium dioxide is the most popular photocatalyst in various depredating techniques for emerging contaminants, owing to its highly stable chemical structure, relatively low cost, non-toxicity, and highly oxidizing photo-generated holes[2]. Number of works have been carried out to extend the absorption wavelengths of TiO2 from UV to the visible region by doping with various element[3,4]. Compared the photocatalytic degradation of methylene blue by visible light using carbon (C-TiO2), nitrogen (N-TiO2), and co-doped (C-N-TiO2) nanoparticles that had been prepared by sol-gel methods. C-TiO2 was more active than N-TiO2[5]. Additionally, doping with carbon may form carbonaceous species at the surface of TiO2, which facilitate further degradation under visible light [6]. Synthesized C-TiO2 using solegel method, as a photocatalyst under visible light, and they found that carbon doping was maximal when the calcination temperature was 200 to 250 ºC[7]. The addition of dopants such as C, N, and S favors the transformation of anatase to rutile in TiO2, while a synergistic effect between the anatase and rutile forms reportedly increases the photocatalytic activity of such mixture[7]. Several -modified TiO2 materials were prepared following a hydrothermal method and a further thermal treatment in different atmospheres (air or nitrogen)[7]. Among the different photocatalysts, TiO2 is still the most widely used due to its well-known advantages: low cost, non-toxicity and chemical stability[7].The use of environmental friendly materials like extracts of plant (leave, flower, bark, seed, and peels), bacteria, fungi and enzymes for synthesis of titanium dioxide nano particles offers ecofriendliness and non toxic nature of material[8]. Green synthesis provides advantages over chemical and physical methods because it is not only cost effective but also environment-friendly and easily scalable for large scale production. Also this method does not require costly equipments, high pressures, temperatures and not even small doses of toxic chemicals[9]. Hibiscus rosa sinensis possesses anticomplementary, antidiarrhetic and antiphologistic activity, the flower possesses antispermatogenic, androgenic, antitumour and anticonvulsant activities. The leaves and flowers have been observed to promote hair growth [10].

2. Green Synthesis of TiO2 Nanoparticle

2.1 TiO2 Nanoparticle using Hibiscus Flower Extract: [11]

To synthesis the TiO2 nanoparticles, dissolve 1.0 N of titanium isopropoxide (TTIP) in 100 ml of Millipore water. Added flower extract drop wise under constant stirring up to achieve pH of solution became 7. The mixture was subjected to stirring for 3 hours continuously. In this process nano particles were formed, afterwards separate this nanoparticles using whatman filter paper and washed the materials with water repeatedly to remove the by-products. The nanoparticles were dried at 100^0C for overnight and calcined at 500^0C for 4 hours. The TiO2 nanoparticles were successfully synthesised using green synthesis method. From XRD analysis average crystallite size of the sample was obtained 24.89 nm. It observed thatTetragonal structure was formed. The average particle size was estimated 43.3 nm from particle size analyzer. The optical properties were studied by UV-Visible Spectroscopy it infers that the wavelength was 354 nm and Energy band gap was 3.503 eV. The weight loss was measured by

FIG 2.1

TG-DTA curve as 3.9%. The above results showed that the prepared TiO2 particle in the Nano-range.

2.2 TiO2 Nanoparticle aloe vera Extract: [12]

The leaves of Aloe Vera were separated from plant, which were thoroughly washed and cut into small pieces. Take 25g of the leaves into 100ml distilled water boiled for 2hrs at 90°C. The extract was filtered using what man filter paper. The filtrate was stored for the synthesis of nanoparticles. To synthesis the TiO2 nanoparticles, dissolve 1.0 N of Titanium Chloride (TiCl4) in 100 ml of Millipore water. Added leaves extract drop wise under constant stirring up to achieve pH of solution became 7. The mixture was subjected to stirring for 4 hours continuously. In this process nano particles were formed, afterwards separate this nanoparticles using what man filter paper and washed the materials with water repeatedly to remove the by-products. The nanoparticles were dried at 100°Cfor overnight and calcined at 500°Cfor 4 hours.

FIG 2.2

2.3 TiO2 NANOPARTICLE USING ORANGE FRUIT WASTE: [13]

Orange peel was collected from left over material of eaten orange fruit in the lab, make it into small pieces. Orange peel was collected from left over material of eaten orange fruit in the lab, make it into small pieces. A 50 g of orange peel was directly taken into the beaker and extracted with 150 ml of water for 2 hrs at 90^{0}C. The extract was filtered using what man filter paper. The filtrate was stored for the further synthesis of nanoparticles. The filtrate was stored for the further synthesis of nanoparticles. Dissolve 1.5 N of titanium tetra iso propoxide in 100 ml of distilled water for synthesis of TiO2 Nanoparticles. Add extract dropwise under constant stirring upto achieve pH of solution comes to 7. The mixture was subjected to constant stirring for 3 hours continuously at room temperature. In this process formation of nanoparticles were occurred, separate this nanoparticles using what man filter paper and washed the materials with distilled water repeatedly to remove the by-products. The obtained wet nanoparticles were dried at 80^{0}C for overnight. Finally particles were calcined at 600^{0}C for 3 hours for obtaining Rutile phase.

FIG 2.3

3. PHOTOCATALYTIC DGRADATION OF ACETAMINOPHEN BY USING NANOPARTICLES

3.1 PHOTOCATALYIC DEGRADATION:

The rate of photocatalytic degradation of certain pollutant depends on its nature, concentration and other existing compounds in water matrix. A number of studies have reported the dependency of the TiO_2 reaction rate on the concentration of contaminants in water.

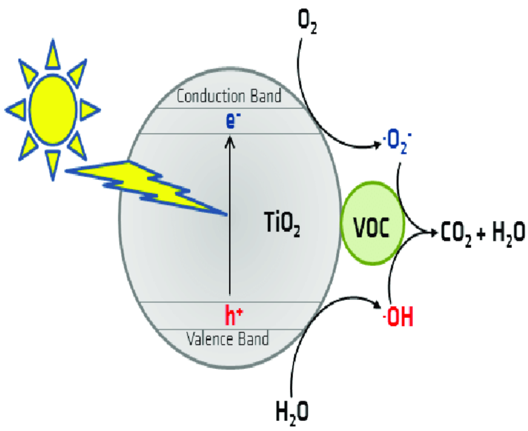

FIG 3.1

3.2 Photocatalytic oxidation of Acetaminophen using carbon self-doped titanium dioxide[14]

A new carbon self-doped (C-doped) TiO2 photocatalyst was synthesized by solegel method, in which titanium butoxide was utilized because of its dual functions as a titanium precursor and a carbon source. The effects of calcination temperature from 200 to 600 ºC on the photocatalytic activity towards acetaminophen (ACT, which was used as a model persistent organic pollutant) under visible light were examined. Photocatalytic activity increased as the calcinations temperature initially increased from 200 to 300 ºC but it decreased as the calcinations temperature further increased from 400 to 600 ºC. C-doped TiO_2 was synthesized using titanium butoxide, ethanol and deionized water in a simple solegel method and was found effective to degrade ACT under visible light. This work also verifies that the calcination temperature of the C-doped TiO2 affects its photocatalytic activity. The results revealed that the photocatalytic activity increased with calcinations temperature from 200 to 300 ºC and then decreased as the calcination temperature was further increased from 300 to 600 ºC. Calcination temperature also affected the crystalline phase and size of the synthesized TiO_2. Amorphous TiO_2 was formed at 200 ºC; the anatase phase was formed at 300 ºC and above, and the rutile phase was formed at 600 ºC. Lower calcination temperatures produced smaller crystals. The Cdoped TiO2 that was calcined at 300 ºC exhibited the highest photocatalytic activity for the degradation of ACT, efficiency of 94%.

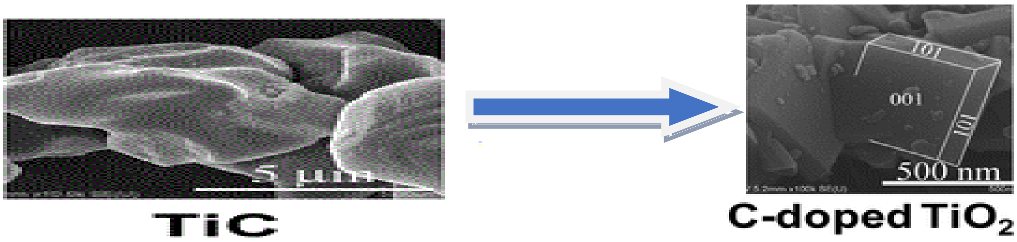

FIG 3.2

3.3 Photocatalytic degradation of acetaminophen using C-modified TiO2[15]

The current study deals with the hydrothermal synthesis of C-modified TiO2 photocatalysts using lignin as carbonaceous precursor. The C-modified TiO2 photocatalysts have been tested for the degradation of a model pharmaceutical (acetaminophen) in water under solar irradiation. Novel C-modified TiO2 photocatalysts were prepared by hydrothermal process. Lignin was used as carbonaceous precursor. The photocatalysts were tested for the degradation of acetaminophen. C-modified TiO2 showed a higher degradation rate than non-modified TiO2. The photocatalysts showed good stability upon four successive cycles.

3.4 Phocatalytic Degradation of Acetaminophen using silver doped TiO_2 Nanoparticle[16]

Nanoparticles of silver deposited on TiO2 have been tested as catalysts for the removal three organic molecules with photocatalysis treatments. The photocatalysis is an efficient treatment for the removal of numerous organic compounds; however, when the catalyst is modified by the addition of metal particles as silver, its efficiency can be increased and even be activated in visible light. It was shown that titanium–silver catalysts doped with the photodeposition method show changes in physical and chemical properties which make them attractive for their use as supported catalysts. According to the results, it was observed that the solids have absorption in the region of the plasmon of 400 to 600 nm that corresponds to the region of the visible reason why the solids have potential to be used with natural light. The fundamental aspects that define the photocatalytic efficiency of the catalysts are in function of their method of synthesis and in the organic molecule that is treated; in this study, the behavior of a common drug acetaminophen was shown which showed conversion rates higher than 80%

FIG 3.3

3.5 Photocatalytic Degradation of Acetaminophen using Fe/TiO_2 Nanoparticle[17]

This work was aimed to prepare Fe doped TiO2 on an ionic liquid template so that nanoparticles (IL-Fe/TiO2(Ar)) could be formed to degrade acetaminophen (ACE) using the photocatalytic process. A novel Fe doped TiO2 was successfully prepared on

1-octadecyl-3-methylimidazolium bromide template. Characteristic analyses like XRD studies showed a pure anatase crystal structure with the presence of Fe impurities. In addition, FT-IR confirmed existence of F–O, C=C, C=N and hydroxyl groups, which are critical for better visible light responses and photocatalytic activity performance.

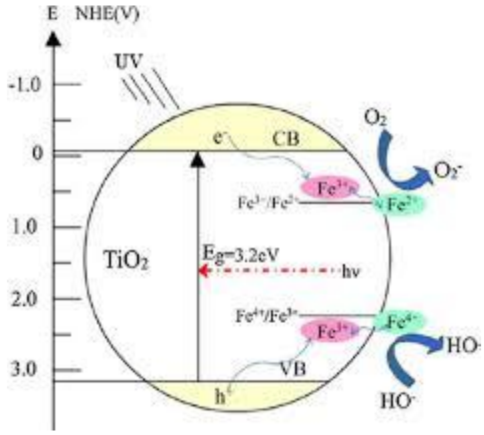

FIG 3.4

3.6 Photocatalytic Degradation of Acetaminophen using Au, Ag, Pt loaded TiO2 Nanoparticle [18]

The sustainability and feasibility of using solar irradiation instead of UV light in photocatalysis is a promising approach for water remediation. In this study, photocatalytic degradation (PCD) of a widely used analgesic and antipyretic drug, acetaminophen (AP), with noble metal loaded TiO2 photocatalysts (Ag/TiO2, Au/TiO2 and Pt/ TiO2) was investigated in aqueous suspension using solar light. Three nanosized noble metal loaded TiO2 photocatalysts (Ag/TiO2, Au/TiO2 and Pt/TiO2) were fabricated, characterized and employed for photocatalytic degradation of AP under solar light and compared with UV light. The metal loaded TiO2 photocatalysts showed enhanced solar photocatalytic degradation of AP in a wide pH range of 4.2–8.0 as well as in the presence of other interferences such as surfactants, and drug excipients and binding materials.The highest photocatalytic activity observed with Pt/TiO2, which was ascribed to the fact that Pt is a better trapping site for photoelectron than Ag and Au. The results demonstrated that the degradation products are dependent upon light energy, irradiation time as well as the type of photocatalyst. Photocatalysis with solar light could be implemented as a feasible and environmentally benign method for effective degradation of AP using noble metal loaded TiO2 photocatalyst.

4. CONCLUSION

From the above study it is concluded that the Green Synthesis of TiO_2 by using the Hibiscus Flower, Aloe vera and Orange fruit waste Extract are Eco-friendly, feasible and Cost effective compared to the chemically synthesized Nanoparticles of TiO_2. And the Characteristics of the Extract are Similar to that of Nanoparticles. The photocatalytic Degradation of Acetaminophen by using Carbon doped Nanoparticles gives high Efficiency of degradation in 94% at Ph range of 7. The photocatalytic Activity is dependent on Calcination Temperature. As if the Calcination temperature increases the catalytic activity of Nanoparticle gets decreased based on study. The Calcination temperature of $CTiO_2$ is at 200 - 300ºC.The Photocatalytic Degradation performed under solar light is Efficient.

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