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SOLAR BASED TiO2 NANO STRUCTURE PHOTOCATALYST REMEDIATION SYSTEM FOR WATER POLLUTION

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Abstract
The principle of photo-catalysis based on the self-cleaning that used nano-structured semiconductor TiO_2 surface coating to clean the pollution in the water. Nanostructured semiconductor TiO_2 have a band gap energy that can absorb the light and then can be used in recombination process and caused the reduction reaction. This paper will focus on the study on the carrier generation mechanism in photo-catalyst TiO_2 during the absorption of photon wavelength in the range of 200-800 nm This photon will generated the carrier in nanostructured photo-catalyst semiconductor TiO_2 for quantum convenient effect and then produce the conventional redox reaction and oxidizing agent. Based on the study, it can be concluded that the nanostructured semiconductor TiO_2can be used to reduce the water pollution in the system.

Keywords: water polution, semiconductor photocatalysis, titanium oxide.

1. Introduction

Faced with problems of increasing population leading to urban congestion as well as natural and man-made environmental catastrophes, For this reason, the use of TiO2 photo-catalysis for pollution remediation of water. Water and air pollution significantly affect human health. e via contaminated water[i], primarily in rural areas in less developed nations[1]. TiO2 photo-catalyst is a new technologies to improve access to clean water for drinking, sanitation and hygiene quality. In this last decade, there has been considerable scientific and engineering interest in the application of semiconductor photo-catalysis to water remediation especially i.u. The reasons are the high versatility of such a technology, which allows its application in remote areas lacking electricity and energy supply as well as the environmental friendliness of photo-catalytic processes since (most of the time) the only requirements to degrade water pollutants are moisture, sunlight and the photo-catalyst.

Theory

TiO_2 is a white, highly stable metal oxide, present in nature in three different polymorphs: anatase, rutile and brookite. TiO_2 isan *intrinsic*, *indirect band gap* semiconductor that can undergo optical excitations when irradiated with light. When the semiconductor is hit by photons having energy *at least* equal to the energetic separation (band gap) between the *valence* band (band that in the ground state is fully occupied with electrons) and the *conductance* band (band that in the ground state is empty), electron transitions occur from the former to the latter. As a result positive holes (lack of electrons) are for media the valence band and electrons with high mobility *occupy* the conductance band. The energy band gaps for the three polymorphs anatase, rutile and brookite are equal to 3.2 eV, 3.0 eV and 3.1 eV respectively.

These energies correspond to electromagnetic waves having frequencies in the region of the near UV, therefore only near UV photons can effectively promote charge separation in TiO_2 crystals. In principle, a photo-catalytic reaction may proceed on the surface of TiO_2 via several steps, namely: (i) production of photo-generated electron-hole pairs by exciting the semiconductor with light; (ii) separation of electrons and holes by traps available on the TiO_2 surface; (iii) redox process induced by the separated electrons and holes with the adsorbates (electron acceptors and electron donors) present on the surface; and (iv) desorption of the products and reconstruction of the surface. In semiconductor TiO_2 the energy of the incoming photons is used to excite the electrons from band valence to conduction band and created the electron-hole pairs. The following scheme are given below [2]:

$$TiO_2 + h\upsilon \rightarrow e^- + h^+ \quad (1)$$
$$2H_2O + 4H^+ \rightarrow O_2 + 4H^+ \quad (2)$$
$$2H + 2e \rightarrow H_2 \quad (3)$$

The total reaction is

$$2\,H_2O + 4\,h\upsilon \rightarrow O_2 + 2\,H_2 \quad (4)$$

$$\text{Organicmat.} + O_2 \rightarrow CO_2 + H_2O + \text{mineral acid} \quad (5)$$

Diagram of mechanism of splitting are given in Figure 1

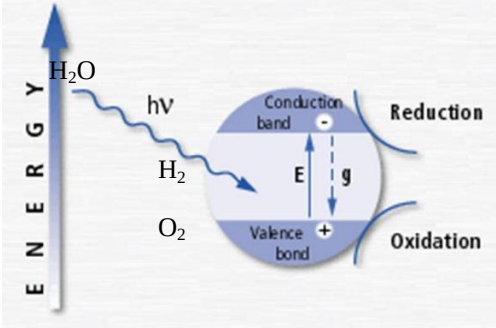

Figure 1 :Diagram of water splitting mechanism

The absorption coefficient of TiO_2 as function of photon energy was measured and plotted in Figure 2.

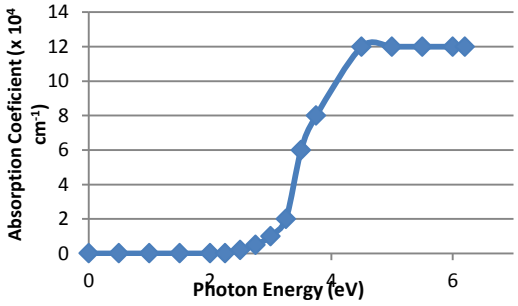

Figure 2. The absorption coefficient a function of photon energy (eV) in TiO_2.

The calculation of the rate carrier generation was given by Zeghboeck, B. [2]in equation :

$$\frac{G_{p,light}}{P_{opt}(x)} = \frac{G_{n,light}}{P_{opt}(x)} = \frac{\alpha}{E_{ph}A}$$

Where α is absorption coefficient (cm^{-1}), E_{ph} is phonon energy (J), A is area (cm^2), and $P_{opt}(x)$ is optical power in the depth x from the surface. In our calculations, the area incoming power A of the sample TiO_2 semiconductor is 1 cm^2. The rate of carrier generation by photon in semiconductor silicon and GaAs [3,4] has been studied and for TisO2 as function of photon energy was calculated from the formula Zeghboeck [5] and the result was given in Figure 3.

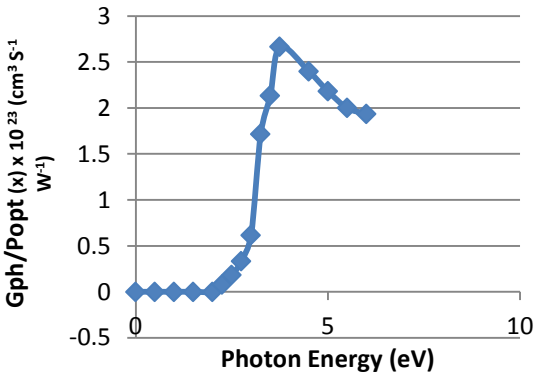

Figure 3. The rate carrier generation per unit power as a function of photon energy (eV) in TiO_2.

The area of A = 1 cm^2 is used where the unit rate generation of carrier (electron or hole) per unit absorption light power in the depth of x is in cm^{-3} $second^{-1}$ $Watt^{-1}$. The rate carrier generation will similar to the graph of the absorption coefficient as a function of photon energy. The rate generation of carrier increase exponentially above the photon energy gap which is equivalent to the band energy gap (3.00 eV). This increasing start from near zero to optimum magnitude value of about 2.5 x 10^{23}. The carrier generation rate in the range of photon energy above 4.00 eV will slightly decrease. The water splitting acccording to the photocatalysis process is shown in the equation of hydrogen and oxygen. Every 4 quanta of photon energy will produce 2 hydrogen and 1 oxygen molecule. The result of rate generation of oxygen molecule and hidrogen production as a function of photon energy is shown in Figure 4.

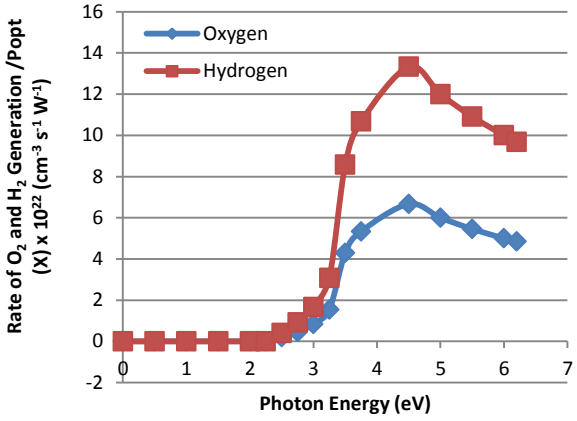

Figure 4. The rate ofH_2 and O_2generation per unit power production as a funccution of photon energy (eV) in TiO_2.

IV. Discussion and Conclusion

On the other hand for hydrogen the value is reduce a half. This phenomenault can be explained as a consequence of magnitude photon energy which equal to the gap energy of TiO_2, the absorption coefficient will start to occur.

The optical absorption will increase exponentially to the magnitude of the order of 10^4 cm^{-1} and stable after 4,00 eV. The rate carrier generation per unit power will increase from zero to 10^{23} cm^{-3} sec^{-1} $watt^{-1}$. Based on the results on Figures 2 and 3, it can be concluded that the rate generation per unit power of H_2 production is half of the carrier generation rate. On the other-hand the rate generation per unit power of O_2 production is quarter of the carriers.

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