Analysis and Efficiency of Dye Cabbage On Tio2 Semiconductors With a Method of Spin Coating as a Material Solar Cell

Abdul Rais

{abdulrais@unimed.ac.id}

Physics Department, Medan State University

Abstract. Fabrication, which is based on TiO2, electrolyte FTO layers, and a solution of distilled aquades water, aquabides, methanol, isopropanol, and antymonyl chloride, has been carried out to analyze the efficiency of dye-cabbage on TiO2 semiconductor. The TiO2 manufacturing process uses the method of sun gel by grinding using a hot plate and magnetic stirrer, then spinning the coating at 3000 rpm for 30 seconds. Using scanning electron microscopy (SEM), XRD, and UV-vis to study the TiO coating shows that the hydrolysis temperatures change between 3500, 4500, and 5500 C. SEM analysis results on TiO layer 2 have a wide spectrum [117.54], [125.64], and (104.75). In XRD analysis, the results obtained for each hydrolysis temperature of 350°C, 450°C, and 550°C have crystal sizes of 105.21 nm, 85.21 nm, and 64.34 nm. It has the maximum effiency value at the temperature of 550˚C: 2.0.10 -3 % - 0.545.10 -3 % and 2.5.10 -3 % - 0.85.10 -3 %. The result of UV-Vis spectrophotometer analysis showed that pencil TiO2 managed to absorb the solution dye cabbage in the visible light absorption area. The result can provide a current of 2.5–3.5 mA and a maximum voltage of 2.7–7.5 eV.

Keywords: Dehydrolysis, Dye Cabagge, Synthesis, Thin Films FTO, TiO2 Semiconductor

1 Introduction

The energy requirements required by humans and other living creatures are fundamental and very important for the continuity of human life and stability in this world. This is widely felt by various companies and investors who want to develop energy, both in the world of economics, science and technology as well as defense and security. Indonesia is a country that is provided with an enormous amount of natural resources, such as: water, coal, bio diesel, geothermal, wind and solar thermal energy which is renewable energy (*renewable*). The World Bank projects that by 2050, when the global population reaches 9 billion, energy demands will double and reach 30 trillion. Fossil fuels presently satisfy a mere 60% to 80% of global energy demands [1].
The demand for electricity is escalating in correlation with the rise of global population and economic expansion. Consequently, the government prevails in its attempts to develop power plants and advance technology in alignment with projected electricity demands and growing economies [1].
Energy can be obtained from plant and similar sources sources such as food, fruit, electricity, oil fuel and solar energy [3]. All prospective and existing values that could be crucial for a

ICoSTA 2023, November 02, Medan, Indonesia

DOI 10.4108/eai.2-11-2023.2343850

power plant operating on a renewable energy resource were evaluated, and one of these power plants was selected.
Renewable energy comprises of energy generated from natural sources, like the sun, wind, and water, and is available at all times [4]. Renewable energy, which is also referred to as environmentally friendly is generated from processes or resources that replenish themselves naturally. Wind and sunlight, for instance, continue to move and shine despite the fact that their availability is conditioned on time and weather. Although renewable energy might appear as an emerging technology, it has been utilized for centuries to provide heating, transportation, illumination, and other purposes. Wind has been used to propel ships across oceans and power grain-grinding turbines. The sun supplies solar cells, provides warmth throughout the day, and continues into the evening.

Third-generation solar cells known as Dye-Sensitized Solar Cells (DSSCs) utilize pigments to absorb photons [5]. Dye-sensitized solar cells (DSSCs) are a subset of thin-film solar cells that have been the subject of extensive research for over twenty years. This is primarily because of their economical nature, straightforward synthesis process, negligible toxicity, and straightforward manufacturing process. However, substantial potential remains for the replacement of existing DSSC materials owing to their exorbitant cost, limited availability, and robustness. To expedite the reaction between sunlight and the solar cell, an electrolyte solution is deposited on top of the dye-coated TiO2 material [6].

The primary material utilized in this investigation is TiO2. TiO2 solar cells comprise photoelectrochemical solar cells and are classified as solar cells of the third generation [7]. In recent times, dye-sensitized solar cells (DSSCs) utilizing titanium dioxide (TiO2) nanoparticles (NPs) have garnered significant attention from scientists. This is primarily owing to the remarkable photoconversion efficiency and exceptional physicochemical properties of these nanoparticles.

From the background of the problem above, the researcher moved to develop the potential that exists in Indonesia's natural wealth and to deepen and develop this research by using TiO2 semiconductors as a synthesis material and dye cabagges as extracts and mixtures thereof. The method used is spin coating, and various precursor processes at various degrees of calcination. Also, data analysis, influence analysis, and efficiency of tests: UV-Vis, XRD, and SEM, as well as measurements of current, voltage, power, fill factor, and efficiency. The following are the aims of the research:

1. To increase the peak point, wavelength, crystal size, and so on, the band gap in the synthesis of TiO semiconductors at a calcination temperature of 350^{O}C, 450^{O}C and 550^{O}C from the TiO semiconductor material.
2. To observe the amount of current, voltage, power, fill factor, and efficiency against immersion of TiO2 semiconductors on dye cabbage.
3. To examine the synthetic analysis of the XRD, UV-vis, and SEM-EDX tests on dye cabbage at a calcination temperature of 350^{O}C, 450^{O}C and 550^{O}C from the TiO semiconductor material.

2 Methodology

The methods used in this investigation were sol gel [1-2], and mixing techniques [3] synthesis, spin coating and furnace at temperatures of 350o C, 450o C and 550o C. Then the TiO2 samples were characterized and analyzed using UV-vis, XRD, SEM-EDX, FTIR and I-V equipment. The research materials used were coal and TiO2. Coal was cleaned and then mixed with aquabides and extracted using blenders, then filtered using fine filters. While TiO2 is synthesized by mixing methanol, diethanolamine, anthymon chloride, isopropanol, and then on a hot plate with a magnetic stirrer at a temperature of 100o C, at a speed of 300 rpm at a time of 3 hours. The sample has been extracted, and synthesised, then tested with the aim of looking at the absorption spectrum, the size of the crystal / peak point, the morphology of the shape of the material, the wavelengths and the current-stress. Three phases was performed in the current study in order to synthesize TiO2. The first procedure required the weighing of 0.5 grams of TiO2, followed by its mixture with 5 milliliters of methanol. The resulting mixture was subsequently ground using a mortar and stirrer. Finally, synthesizing the TiO2 semiconductor material at a speed of 300 revolutions per minute and a temperature of 100 degrees Celsius required two hours.

Following the final phase of the synthesis process, which involved the application of sol gel treatment, each sun gel was affixed to a thin film of fluorine-doped tin oxide (FTO) measuring 2 cm x 2 cm. Subsequently, spin coating was performed at a speed of 1000 rpm for a duration of 30 seconds. In the next step, every sample that underwent the spin coating process was purified for one hour utilizing a Nabertherm tool, which was manufactured in Germany and displayed in the subsequent image with a timer. Following calcination at 350°C, 450°C, and 550°C, the samples were allowed to rest for thirty minutes at room temperature.

The third step is to characterize each sample with SEM -EDX, FTIR and UV-vis as shown in the following semiconductor materials:

1. TiO_2, calcined at 350^OC
2. $TiO_{2,}$ calcined at 450^OC and
3. TiO_2 , calcined at 550^OC

3 Result and Discussion

3.1 Characteristic FTIR of TiO_2 / Al 350^OC, 450^OC and 550^OC

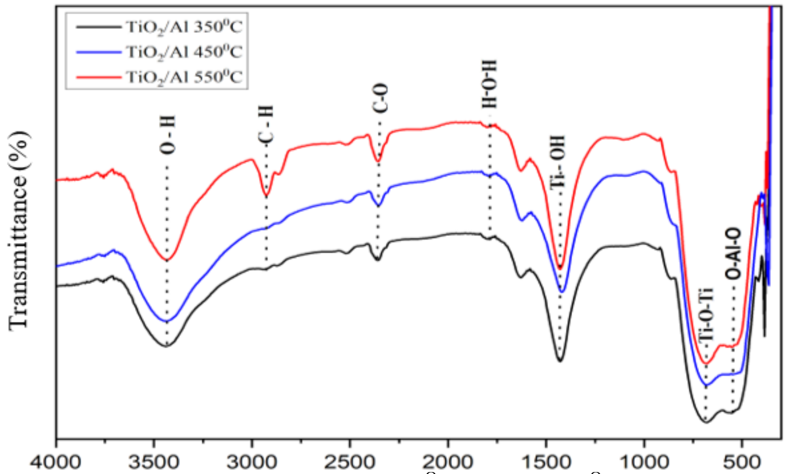


Fig 1. FTIR spectrum of TiO_2/Al 350 ^{O}C, TiO_2/Al 450 ^{O}C, and TiO_2/Al 550 ^{O}C

Table 1. FTIR spectrum analysis results

Molecular bonds	Number of Waves (cm^{-1})		
	TiO_2/Al 350 ^{O}C	**TiO_2/Al 450 ^{O}C**	**TiO_2/Al 550 ^{O}C**
O-Al-O	555	523	523
That-O-That	681	674	674
Ti-OH	1425	1411	1411
H-O-H	1622	1622	1622
C-O	236	2347	2347
C-H	2929	2929	2919
O-H	3440	3433	332

Table 1 describes the results of the FTIR spectrum test analysis. The highest wavelength is found in the TiO semiconductor$_2$/Al 350^{O}C, namely: 3440 (cm^{-1}), and the lowest is found in the semiconductor TiO_2/Al 550^{O}C, namely: 332 (cm^{-1}) with O – H molecular bonds.

3.2 Characteristic UV-vis TiO_2 / Al 350°C, 450°C and 550°C

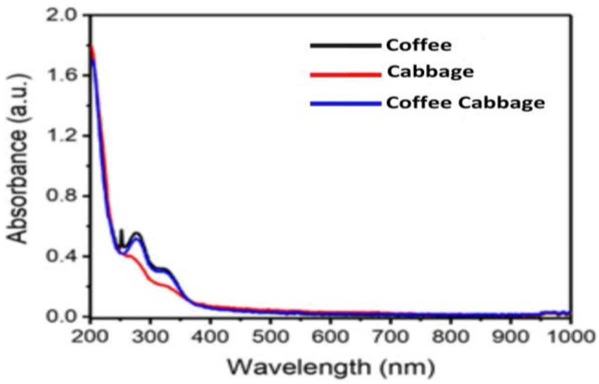


Fig 2. Characteristic UV-vis TIO2 doping Al with temperatures of 350 C, 450 C and 550 C.

As it is shown in Figure 2, the results of UV-vis test analysis on TiO_2 with a wavelength is at (200 – 1000) cm^{-1}, then the highest wavelength is found in coffee extract, namely: with a wavelength of 280 cm^{-1} with an absorbance of 1.8 (0.6) and the lowest wavelength col is with an absorbance of 1.8 (0.4).

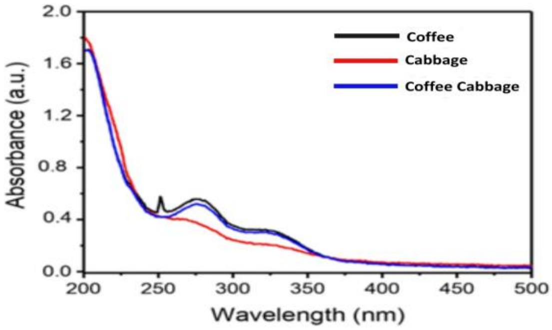


Fig 3. Characteristic of SEM-EDX TiO2 +cabbage with a temperature of 350 C

Figure 3 illustrates the results of UV-vis test analysis on TiO_2 with a wavelength of (200 – 500) cm^{-1}, then the highest wavelength is found in coffee extract, namely: with a wavelength of 250 cm^{-1} with an absorbance of 1.8 (0.5) and the lowest wavelength col is with an absorbance of 1.8 (0.3).

3.3 XRD Characterization Using FTO Glass (*fluorine-doped tin oxide*) + Cabbage

XRD Testing, TiO_2 + Cabbage with a calcination temperature of 350°C, TiO_2 + Cabbage 450°C and TiO_2 + Cabbage 550°C

Figure 4 below shows the XRD test results; TiO_2 + Cabbage with a calcination temperature of 350°C, TiO_2 + Cabbage 450°C and TiO_2 + Cabbage 550°C, from the graph results obtained, using FTO glass the graph generated are:

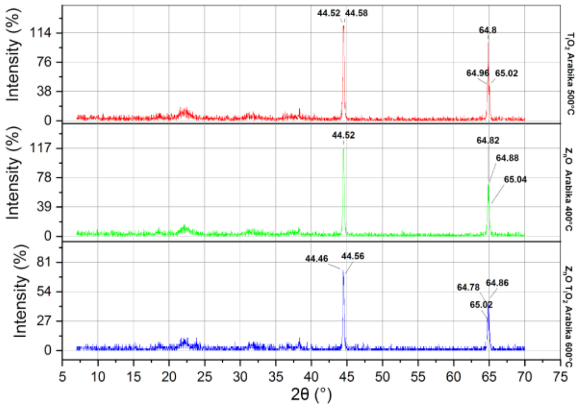


Fig. 4. Graph of XRD Test Results, TiO_2 + Cabbage with a calcination temperature of 350°C, TiO_2 + Cabbage 450°C and TiO_2 + Cabbage 550°C

1. The XRD test graph reveals that TiO2 + Cabbage, calcined at 350°C, exhibits its highest peaks at positions 31, 42, and 32, consistent with the initial data presented in the previous graph.
2. Peak no. 15, 20, and 21 of the XRD test graph for TiO2 + Cabbage with a calcination temperature of 450°C are the highest, which corresponds to the initial data from the graph above.
3. The highest peaks on the XRD test graph for TiO2 + Cabbage with a calcination temperature of 550°C are at no. 27, 33, and 24, which correspond to the initial data from the graph above.

Of the three temperature variations calcined in the peak graph above using Cabbage, the highest peak point calcination is:

1. $TiO_{2\,+}$ cabbage calcined at 450°C, namely: *Integrated Int* (*counts*) is 1035 and *The intensity* (*counts*) is 100.
2. TiO_2 + cabbage calcined at a temperature of 350°C, namely: *Integrated Int* (*counts*) is 924 and *Intensity* (*counts*) is 83.

3.4 Energy Calculation of Semiconductor Photons in FTO Glass with Cabbage

Energy Calculation of Semiconductor Photons With **Calcination Temperature Variations of 350°C, 450°C and 550°C With Cabbage**

The amount of energy of semiconductor photons can be known by the equation:

$$\mathbf{AND_f = hc / x}$$

Where: h = Planck's constant = $6.63 \cdot 10^{-34}$ (Js) or $4.14 \cdot 10^{-15}$ (eV)

c = Speed of light = $3.\ 10^{8}$ (m/s)

χ = Wavelength (m)

1. That$_2$ 350°C With Cabbage

   = 381.00 A^O

   Then:

   $AND_f = h \cdot c / x$

   $= 4.14 \cdot 10^{-15} \cdot 3 \cdot 10^{8} / 576.64$

   $= 0.0225385683 \cdot 10^{-7}$

   $= 2.25 \cdot 10^{-9}$ eV

The next calculation results for photon energy at TiO_2 450°C with Cabbage, and TiO_2 550°C with Cabbage, they are desribed in table 2 below:

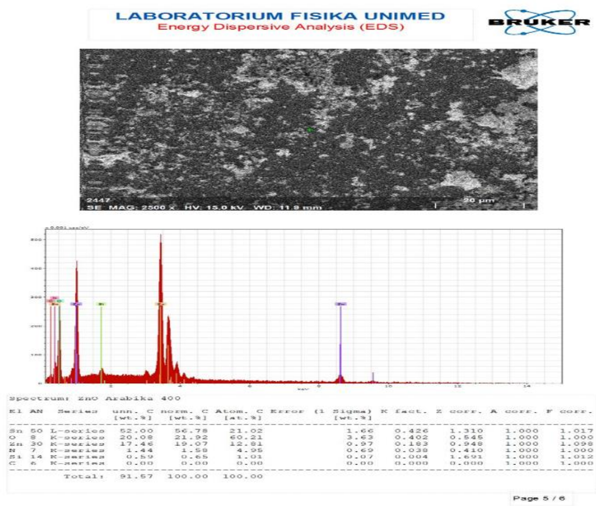
Table 2. Table of Photon Energy Calculation Results.

No	Material	Calcination Temperature	(Armstrong)	Photon Energy
1	TiO_2	350°C	381.00	$2.25. 10^{-9}$eV
2	TiO_2	450°C	391.84	$3.27. 10^{-9}$eV
3	TiO_2	550°C	432.87	$2.89. 10^{-9}$eV

From the calculation of the energy of semiconductor photons using FTO glass on arabica coffee with a calcination temperature of TiO_2 350°C, TiO_2 450°C and TiO_2 550°C the highest value of photon energy is found in TiO_2 + Cabbage at a temperature of calcination 450°C with a photon energy of $3.27. 10^{-9}$ eV.

3.5 SEM – EDX Characterization Using FTO With Cabbage

SEM – EDX, TiO_2 + Cabbage With Calcination Temperature 350^O C



El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]	K fact.	Z corr.	A corr.	F corr.
Sn	50	L-series	52.00	56.78	21.02	1.66	0.426	1.310	1.000	1.017
O	8	K-series	20.08	21.92	60.21	3.63	0.402	0.545	1.000	1.000
Zn	30	K-series	17.46	19.07	12.81	0.97	0.183	0.948	1.000	1.098
N	7	K-series	1.44	1.58	4.95	0.69	0.038	0.410	1.000	1.000
Si	14	K-series	0.59	0.65	1.01	0.07	0.004	1.691	1.000	1.012
C	6	K-series	0.00	0.00	0.00	0.00	0.000	0.000	1.000	1.000
		Total:	91.57	100.00	100.00					

Fig 5. The Characteristics Result of SEM-EDX TiO2 + Cabbage With Calcination Temperature 350^O C

The total spectrum produced by calcining TiO2 + Cabbage using FTO glass at 350°C was determined to be 100.00 C Atom [at%], 91.87 unn [wt%], and 100.00 C norm [wt%], according to the results of the SEM-EDX test. The quantity of semiconductor is illustrated in the preceding figure.

4 Conclusion

TiO2 + Cabbage calcined at 450°C has the highest peak calcination point of the three temperature variations calcined at 350°C, 450°C, and 550°C using XRD testing with Cabbage: Integrated Int (counts) is 1035 and Intensity (counts) is 100. Regarding the SEM-EDX test, the spectrum with the highest value is: TiO_2 + Cabbage at 350^O C calcination temperature = 91.57. At a calcination temperature of 450 °C, TiO2 + Cabbage have the highest photon energy, measuring 3.27 10-9 eV. Based on the outcomes of various tests (XRD, SEM-EDX, and Photon Energy), the effect of mixture, synthesis, Spin-coating, and calcination temperature is extremely influential in terms of testing or characteristic.
The fabrication of composite semiconductor materials using TiO2, or a combination of them, began with the calculation of the required quantities of each mixture and some parameters such as synthesis, spin-coating, furnace or heating time, testing or XRD characteristics, crystal size, SEM-EDX, energy photons, and UV-vis. Further investigation into the utilization and analysis of supplementary dye materials ought to be undertaken in future studies.

ZnO + TiO2 with a calcination temperature of 500°C has the highest Integrated Intensity (counts) of 2043 and the highest Counts of Intensity (209), as determined by micro slide XRD analysis. At a calcination temperature of 400°C, ZnO crystals with the longest and largest dimensions are 79.21 nm and ? = 792.0585 Ao, respectively. At a calcination temperature of 500 °C, the spectrum of TiO2 is at its maximum at 114.84.

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