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Section A-Research paper

THE INFLUENCE OF ASPHODELACEAEFLOWER EXTRACT ON THE PERFORMANCE OF A DYE SENSITIZED SOLAR CELL

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Abstract

The aloe vera flower is high in trigonelline, phenolic acid and carotenoids, which are all promising sensitizers for use in dye-sensitized solar cells. The extract was made in a Soxhlet extractor using the essential procedure, and the resulting material was used as the photoanode in the proposed cell. Most other functional groups have a lower affinity for binding to TiO2 nanoparticles than the dye's OH, CO, and COOH functional groups. The dye was characterised using FTIR and UV-Visible spectroscopy to confirm the presence of functional groups and the wavelength range over which it absorbs light. The uniform coating of TiO2/dye paste is accounted for in the SEM image of the photoanode on the FTO substrate. The photoanode, I- or I3- electrolyte, and graphene-coated FTO were combined to form a solar cell, which was then jointly characterized. The following are the calculated parameters for the proposed solar cell: The open circuit voltage is 0.6625V, the short circuit current density is 1.25 mA/cm2, and the fill factor is 0.55.

Keywords: DSSC, Flower extract, fill factor, Tio_2/dye, graphene

Introduction

Dye-sensitized solar cells are captivating because they are the third generation of solar cells, are inexpensive, and are environmentally friendly. Both artificial and natural dyes are used as sensitizers in dye-sensitized solar cells to absorb a significant amount of solar radiation. Plant extracts have been used as sensitizers by scientists, who drew conclusions about the plants' efficacy based on their use of these extracts in the plants' flowers, fruits, seeds, and bark. The flower extract is the least biodegradable of the bunch, according to the results of testing extracts derived from the whole plant and its various parts, including the flowers. In 2007, KhwanchitWongcharee and his colleagues used rosella, blue pea, or a combination of the two as sensitizers in the DSSC photoanode. The study discovered that extracting the dye at 50 degrees Celsius and adjusting its pH from 3.2 to 10 significantly improved its efficiency. Hemalatha et al. (2012) extracted the dye from the flowers of Kerria Japonica and Rosa Chinensis, then used both flowers separately in DSSC with the addition of

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sugar as a sensitizer. Because of the presence of cartenoid in the extract, the yield efficiency increased to 0.29 percent when the Japonica extract was mixed with sugar. Sayed Ahmad Mozaffari et al. (2015) successfully extracted and implemented the dye from red siahkouti fruit in DSSC. The cell's efficiency was 0.32%, and the fill factor was 0.73%, according to the results. WuletawAndergieAyale and DeleleWorkuAyale isolated DSSC dyes from the flowers of AcanthuSenniichiovenda and the leaves of Euphorbia cotinifolia (2016). These dyes were used as sensitizers in the process. The exposed DSSC showed a 0.15 percent increase in efficiency, a 0.60 fill factor, and a short circuit density of 0.491 milliamperes per square centimetre. Julio Leyrar and colleagues used dye extracted from maqui berries, which are high in anthocyanins, as the sensitizer in their 2016 research on a dye-sensitized solar cell. A fill factor of 0.55 and an efficiency of 0.19% can be obtained by using an anthocyanin concentration of 1500 mg/L. Bagavathi and Clara Dhanemozhi then used a TiO2-based photoanode with silver nanoparticles and dye extracted from Basellaalba in 2019. Finally, they put their synergy to the test. It has been discovered that adding dye and TiO2 to silver nanoparticles improves their conductivity, resulting in an increase in the efficiency with which they convert energy. Murugalakshmi et al. (2019) investigated the efficiency of a photoanode composed of Mirabilis jalapa flower dye and TiO2 on an FTO substrate. It has been discovered that the colourant has a significant effect on performance due to its increased capacity to absorb solar radiation. NandarapuPurusothamreddy et al. (2020) isolated the betacyanin pigment from prickly pear fruits and used it in dye-sensitized solar cells as a sensitizer. The presence of a hydroxyl (OH) group demonstrated that the dye was firmly embedded in the TiO2. As a result of this discovery, an efficiency of 0.56% was determined at a fill factor of 85%. Ferreira et al. (2020) extracted dyes from the three different coloured petals of the Leucanthemumvulgave flower, which were then used as sensitizers in the DSSC photoanode. Platinum and graphite electrodes are also used and evaluated. It was discovered that a platinum cathode and daisy petals could produce an open circuit voltage of 0.8V. Mahmoud A.M. Al-Alwani and colleagues (2020) discovered the best solvents, temperatures, and pH values for extracting dye from Areca catechu for use as a sensitizer in DSSC. The cell's optimal operating conditions were discovered to be 80 degrees Celsius, a pH of 10, and ethanol as the solvent. VarshaYadhav et al. (2021) conducted their experiment using a dye-sensitized solar cell with the dye extracted from harda fruit incorporated in the photoanode. The output of the solar cell was found to have an efficiency of 3.52%. In the study by Selva Esakki and colleagues, ZnO nanoparticles and dyes extracted from Ixora flowers were combined with TiO2 and used as the photoanode in DSSC (2021). The manufactured solar

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cell has a fill factor of 0.089 and an efficiency of 0.08%. Amarachukwu N. Ossai et al. (2021) conducted an experiment with a solar cell containing sensitizers derived from carica papaya leaf and cosensitizers derived from black cherry fruit. When compared to the use of a single dye, the effectiveness of a mixture containing leaf and fruit extract in a 3:1 ratio produced a value of 0.56%. MufutauAbiodunSalawu and colleagues dyed the DSSC's photoanode with eosin red and hibiscus sabdariffa extract (2021). Under certain conditions, natural dyes have been shown to be an effective substitute for synthetic dyes. Shalini Singh et al. (2021) used dyes derived from nasturtium flowers to test solar cells. The scientists used density functional theory (DFT) to calculate the HOMO and LUMO energies. The cell's efficiency was determined to be 0.28%, with a fill factor of 0.70. Solar cells containing dyes extracted from Baphianitida in alkali medium were tested by researchers OnyekachiOnyinyechiNnozom, Nnozom, and Rosella (2022). When applied to living cells, Baphianitidia dyes have been shown to have a 0.58% efficiency. Subash Chand Yadav and colleagues (2022) also successfully extracted dyes from Hibiscus sabdariffa and compared their performance on counter electrodes made of carbon, graphite, and gold. It was discovered that using gold as the counter electrode increases cell efficiency by 0.23% when compared to any other counter electrode. Abhishek Srivastava and colleagues (2022) examined performance using dye-sensitized solar cells extracted from Variegatum and Delonixregia leaves and flowers. An efficiency of 0.24% was achieved using a dye cocktail in a 1:1 ratio. Researchers Babangida Alkali and colleagues used dye extracts from the flowers of Momordicacharantia, bougngainrillea, and strigahermontheca as the photoanode in a dye-sensitized solar cell (2022). Cellular recombination has been found to be less efficient, resulting in higher overall efficiency. Prakash et al. (2022), Pooja et al. (2022), Inbarajan et al. (2022), and Kathiravan et al. (2022) investigated the efficiency of dye-sensitized solar cells. Sensitizers for solar cells were coloured dyes derived from plant extracts such as leaves, fruits, flowers, and peels. The pigments found in dyes were found to have an effect on their functionality.

The flower extract from the aloe vera plant was prepared using the solvent ethanol and used as a sensitizer in the photoanode of the dye-sensitised solar cell in this study. To determine the anchoring effect with TiO_2, the flower extract was analysed for pytochemical constituents. SEM analysis was performed on the TiO_2/dye morphology and homogeneous layer on the FTO substrate. To investigate the performance of the proposed solar cell, a JV characterization was performed.

Extraction of dye from Flower of Aloe Vera

Following their harvest, the flowers of aloe vera have been washed in distilled water to remove any traces of dust or dirt that may have been present. After being dried in a dark location, it was then ground into a powder. After the dried flower was ground into a powder and subjected to hot air at a temperature of 40 degrees Celsius, the extract was further processed with ethanol. After going through the filtering process, we can now obtain the flower extract.The photograph in Fig. 1 depicts the extraction process for the dye from the Aloe vera flower

Fig. 1 Extraction of dye from the Aloe vera flower

FTIR Spectroscopy of the Dye

FTIR spectroscopy was performed on the dye to determine the presence of functional groups in order to effectively confirm the anchoring effect of dye with TiO2. The results of an FTIR spectroscopic study using IRAffinity with MIRacle 10 in the ATR mode have been recorded. Figure 2 depicts the FTIR spectroscopy, which revealed prominent peaks at 3894 cm-1, 3442 cm-1, 2923 cm $^{-1}$,2853 cm^{-1}2380 cm-1,2037 cm-1 , 1634 cm-1, 1559 cm-1, 1541 cm-1, 1121 cm-1 and 558 cm-1. These peaks clearly show the presence of hydroxyl and carbonyl groups. The functional groups present have a good anchoring effect on the TiO2 nanoparticles and the semiconductor oxide material. It has been established that the dye's components have a higher proclivity for solar radiation absorption. As a result, the dye molecules are excited, and an electron is transferred to the TiO2 nanoparticles' conduction band.

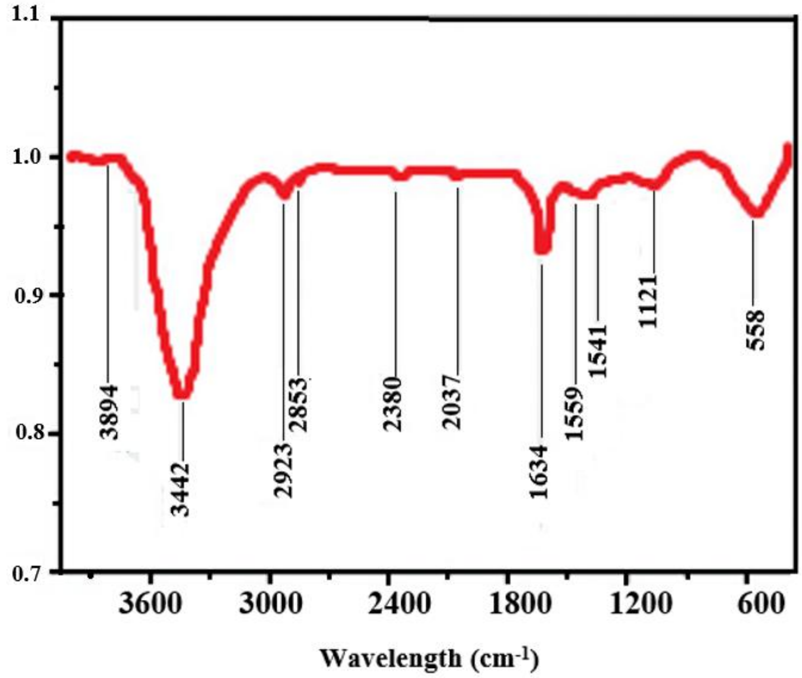

Fig. 2 FTIR spectroscopy of the dye

UV-Visible Spectroscopy of the dye

The dyes were examined using UV-Visible spectroscopy with the help of a Shimadzu spectrometer from the UV-1700 series. Figure 3 depicts the UV-Visible spectroscopy of the dye, which is used to determine the peak absorption wavelength. The dyes were extracted using ethanol and acetone as solvents. The researchers wanted to know which dyes absorb the most ultraviolet radiation from the sun. Both "aloe vera solvent ethanol" (AVE) and "aloe vera solvent acetone" (AVA) refer to the aloe vera flower extract; however, "AVE" refers to the ethanol solvent, whereas "AVA" refers to the acetone solvent. The absorption peaks of ethanol and acetone were measured at the following wavelengths: 534.23 nm, 605.42 nm, 664.85 nm, 537.8 nm, 606.92 nm, and 664.38 nm. When it comes to absorbing solar radiation in the visible spectrum, it was discovered that when compared to one another, the two solvents absorb light with roughly the same level of efficiency.

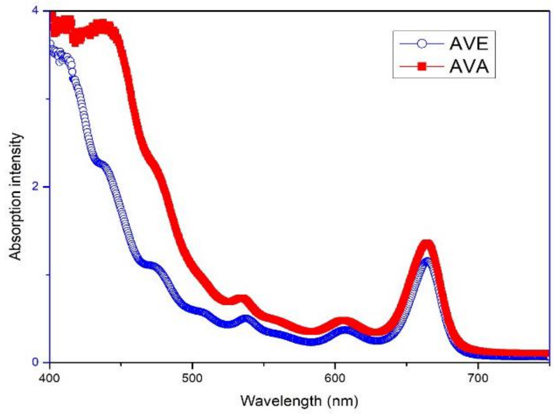

Fig. 3 UV-Visible spectroscopy of the dye with ethanol and acetone

Preparation of Photo anode, Electrolyte and Counter Electrode

Sigma Aldrich provided the TiO2 paste, which was applied to the surface of the FTO glass substrate. Because it has a maximum transmittance of 80% and a sheet resistivity of 4.01 x 10-5 cm, this substrate is ideal for a wide range of applications. After mixing the TiO2 nanoparticle with ethanol to create a paste, the Doctor Blade method was used to coat the FTO substrate with TiO2. This was done following the preparation of the TiO2 nanoparticle. FTO coated with TiO2 was initially immersed in a dye solution. This step was taken to ensure that the dye penetrated the substrate completely. Figure 4 shows a photograph of the TiO2/dye coating that was applied to the FTO substrate. This image was captured using a scanning electron microscope. The dye molecules appear to be evenly distributed across the entire structure because they have successfully anchored themselves to the TiO2, as shown in this figure. In this step of the process, 0.67 grammes of lithium iodide, 0.13 grammes of iodine, and 10 millilitres of acetonitrile were combined to make the cell's electrolyte. For fifteen minutes, a stirrer was used to ensure that the chemicals in a beaker were thoroughly mixed. To mix the chemicals in the beaker, a stirrer was used. Graphene is uniformly coated on the surface of the FTO substrate so that it can be used in the process of creating the counter electrode. When creating a dye-sensitized solar cell, the photoanode, electrolyte, and counter electrode are all layered and sandwiched together. Figure 5 depicts the solar cell that was constructed and tested to determine its JV properties.

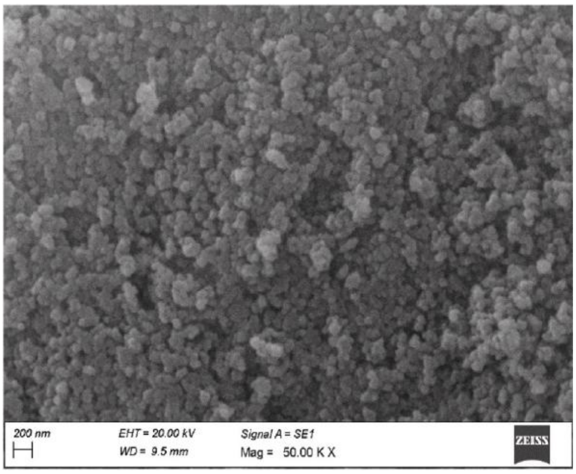

Fig. 4 SEM photograph of the photo anode

Fig. 5 Photograph of the fabricated solar cell

The constructed solar cell is evaluated using JV methods. A Keithley 2400 Graphical Series SMU with a 100 mW/cm2 Xenon lamp was used as a solar simulator for the dye-sensitized solar cell's JV characteristics study. Using the findings from the JV study, the cell parameters were analyzed. The manufactured solar cell had a short-circuit current density of 1.25 mA/cm2 and an open-circuit voltage of 0.6625 V. In addition, the maximum voltage and current density of the solar cell are 0.39275 V and 1.177844 mA/cm2, respectively. By applying these parameters to the solar cell dyed with aloe vera flower extract, we obtain a 0.4625 percent efficiency. The phenolic components of the aloe vera flower have enhanced the performance of solar cells by maximising their capacity to absorb solar radiation. Inhibiting charge carrier recombination, the dye's constituents have been observed to facilitate the transfer of electrons from excited dye molecules to the conduction band of TiO2 particles. In order to reach this conclusion, the dye's constituents were investigated. A graphic image of the proposed solar cell JV characteristics is depicted in Figure 6.

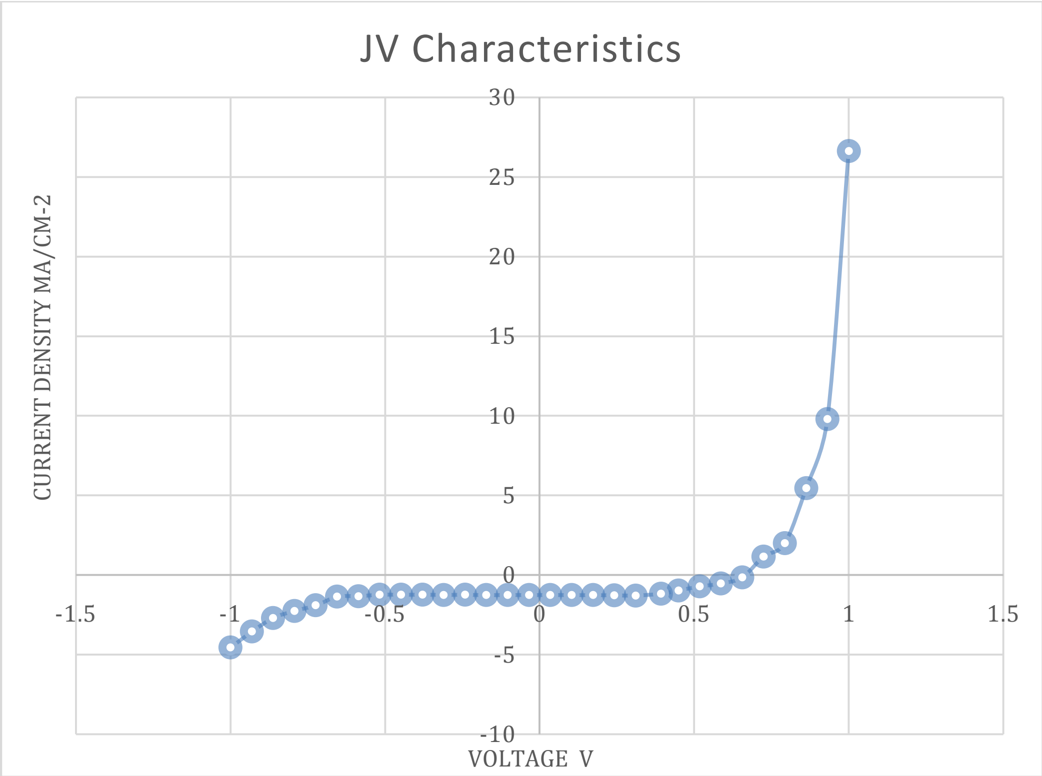

Fig. 6 JV characteristics of fabricated solar cell

Conclusions

The findings of the study have led to the following conclusions, which are as follows:

1. When the aloe vera flower's sensitizer was used to make a solar cell, it was better at moving charges from the dye to the semiconductor oxide material.
2. The dye extract's anthrones, C-glycosides, and anthraquinones, which include aloe-emodin, aloesin, aldehydes, and ketones, have a strong anchoring effect.These compounds contain OH, CO, and COOH groups.
3. The 0.4625 percent efficiency of the solar cell can be explained in part by the fact that photons cause electrons to move into semiconductor oxide material.
4. TiO_2's charge transfer resistance is lowered because its conduction band has the same energy as the dye molecule's excitation level.
5. Due to the slower rate at which the dye taken from the flower of Aloe vera breaks down, the manufactured solar cell is stable for a number of days.

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