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Synthesis and Characterization of CuO Nanoparticles For Increase The Efficiency of the photovoltaic cell

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Abstract
The green manufacture of CuO nanoparticles using Peppermint plant extract and calcination at 400 C for 60 minutes is described in this paper. The phase and structure of the CuO nanoparticles were investigated using XRD and SEM, respectively. The SEM scan indicated that the CuO nanoparticles were spherical, with a particle size average of 14-55 nm. The optical characteristics were studied using Spectroscopy in the UV-Visible range, plus the bandgap was calculated to be 2.7 eV. The DSSC characteristics such as voltage in the open circuit (Voc), The J-V curve was used to calculate the short circuit current density (Jsc), fill factor (FF), and efficiency (h)., and their values were Jsc =0.020 A\cm2, Voc= 0.47 V, Jmax =0.009 A\cm2 , Vmax =0.367 V, and FF = 0.351 . the conversion energy Efficiency is 3.3 %. It can be concluded that copper oxide Nanoparticles are good in synthesizing solar cells through energy production.

Keywords: CuO nanoparticles, Peppermint plant extract, Dye-sensitized solar cell

1. Introduction

People's lives and development require a substantial amount of energy. Solar cell energy is becoming an increasingly important energy-generating construction of the future [1]. Solar cells will readily convert solar energy into electrical energy, making it the most practical power in modern life. Solar cell applications are price-effective, allowing higher energy conversion efficiency at a lower cost [2,3]. Because of their better photovoltaic converting efficiency and lower cost, DSSCs are the most viable replacement to conventional solar cells. In recent years, in addition to energy conversion efficiency and stability issues, a critical issue has been lowering the by incorporating novel materials and methods based on the development of nanomaterials and nanotechnology. The expense of solar cells can be reduced [4,5]. Due to their desirable features and applications in several industries, semiconductor materials nanoparticles have gotten much attention in recent years [6-13]. These nanomaterials' new electrical, structural, and thermal properties are tremendous scientific significance in fundamental and applied disciplines [14-18]. CuO nanoparticles have a huge surface area, making them ideal for use [19-21]. Copper oxide semiconductors have a substantially higher optical absorption, low raw material costs, and are non-toxic. Copper oxide is one of the crucial oxides of manufacturing solar-cells since it exhibits variable characteristics, both physical/chemical, depending on nanostructures' morphology [22,23]. This research describes a green production of CuO nano-particles utilizing Peppermint plant extract and their prospective application in DSSC.

2. Experimental

2.1. Preparation of plant extract

Peppermint plant extract was obtained. The dry leaves are gently mixed in a mixer to make consistent

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powders. After that, 8 grams of the leaves were pulverized and mixed with 150 ml de-ionized water then heated for 10 minutes at 75 °C till a bright pale-yellow dyed solution remained. The solution was then cooled to ambient filtered and kept a clear pale-yellow tinted plant extract solution at a certain temperature. This extract functions as a capping and lowering agent. CuO nanoparticles are made with a tiny amount of fresh leaf extract.

2.2. Preparation of CuO nanoparticles

CuO nanoparticles were made by dissolving 3 grams of salt in 100 ml of double-distilled water in a flask. The mixture was shaken for 10 minutes at room temperature on a magnetic stirrer to get a homogeneous solution. Then, 25 ml of Peppermint plant extract was added using a magnetic stirrer while stirring continuously at 75 °C for 30 minutes. After adding the plant extract, the solution turns yellow. Drop by drop, 1 M NaOH was added until the pale-yellow color solution was achieved. They have turned into a pale yellow color precipitate after 30 minutes of stirring. The solution was then cooled to ambient temperature before centrifuged for 15 minutes at 6800 rpm. The supernatant solution was extracted and centrifuged again after being rinsed with water. The CuO nano-particle was gathered and dried on a watch glass at 75 °C overnight in the oven after centrifuged three times. The dried CuO nano-particles have been calcined for 60 minutes at 400 degrees Celsius in a furnace to remove any evaporable contaminants. After cooling to ambient temperature, the calcined samples were kept for future examination.

2.3. Fabrication of CuO based DSSC

Indium-doped tin oxide with a glass coating (ITO, 8 ohm resistant, 83 percent transmitted) was Until being dried with a dryer; it was cleaned with ethanol and distilled water several times in an ultrasonic bath eliminate impurities. The after procedures were performed utilizing a dye-sensitized solar cell (15 * 20 * 1 mm): For generate a colloidal solution of CuO nanoparticles, nano oxide (0.2 g) coupled with 10 ml of ethanol. The photoanode was created by covering solution of colloid on the conducting side of glass using a dropper for half an hour in cold, then half an hour at 150 degrees Celsius annealing. Next cooling, CuO electrode was engulfed for 60 minutes in a 0.5 M dye (Anthocyanin). A counter electrode with a conductive glass side covers the platinum nano-sheets [5]. By capillary action between the photoanode and the counter electrode.

3. Results and discussions

3.1 The X-ray diffraction

The XRD of copper oxide reveals that all of the refraction peaks are perfectly aligned with basic copper oxide diffraction data; no distinguishing peaks for other oxides were discovered. Figure (1) illustrates the 2θ (deg) of CuO. The diffraction peaks are 32.38, 35.58, 38.81, 48.79, 58.85, 61.23, 66.13, and 67.21, with corresponding reflected planes (110), (002), (200), (20-2), (202) (11-3), (31-1) and (113). The Debye-Scherer equation [24] was used to calculate sizes of crystallites in the sample:

$$D = \frac{k\lambda}{\beta \cos \theta}$$

Where K = 0.9, λ is the wavelength of Cu-K radiations, β is the complete width at half maximum, and the angle is calculated from two values matching the XRD pattern's greatest intensity peak. From the Debye-Scherer equation, the crystallite size was 15.54 nm.

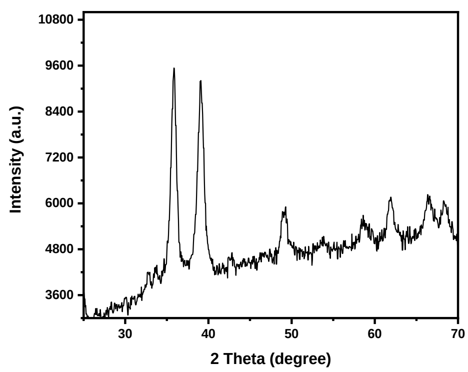

Figure 1. XRD of Copper oxides NPs

3.2. UV-Vis spectrophotometer

The Uv- vis spectroscopy investigated the band gab of copper oxide (CuO) Nanoparticles. CuO absorption has also been red-shifted to a longer wavelength with having max = of 458.6 nm, Figure (2). From the equation, 1240\λ (nm), (Eg) was found to be (2.7) eV for CuO in nanoscale [1].

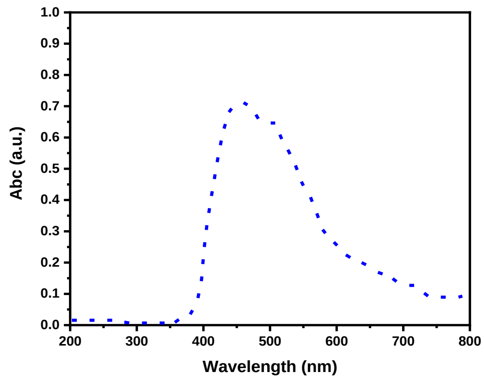

Figure 2. Uv-Vis spectroscopy of Copper oxide NPs

3.3. Field emission scanning electron microscope

The CuO NPs image from a scanning electron microscope as shown in Figure (3) is a useful tool for determining the size of CuO nanoparticles. The size and dispersion of the mean particle were determined at random on the SEM picture. With particles sizes ranging from 14 to 55nm, the SEM image shows improved crystallinity and a sphere-shaped morphology.

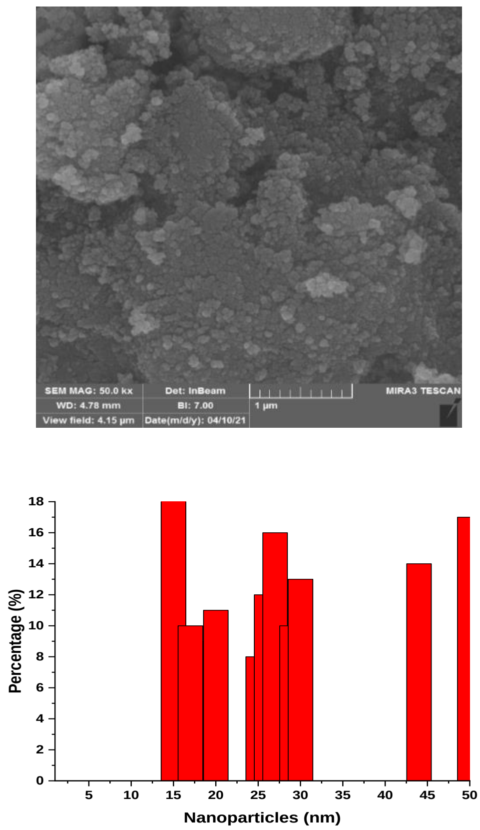

Figure 3. SEM image of Copper oxide NPs

3.4 Parameters of dye sensitized solar cells

Figure 4 shows the working electrode parameter (Isc, Voc, Imax, and Vmax) of a photo-sensitized solar cell made of a Copper oxide nanoparticle. A 100mW / cm2 halogen lamp is used to light the solar cell in a solar simulator. The efficiency of solar cell energy conversion was also measured [7].

$$\eta = \frac{pm}{pin} \times 100\%$$

$$F.F = \frac{Jm\,Vm}{Jsc\,V_0c}$$

The Parameters of dye-sensitized solar cells are Jsc =0.020 A\cm^2, Voc= 0.47 V, Jmax =0.009 A\cm^2 , Vmax =0.367 V, and fill factor (FF) = 0.351 . the conversion energy Efficiency is 3.3 %. It was reported to be crucial for CuO nanoparticles-based systems because the concentration sensitized dye and small particles of generated CuO nanoparticles. The enhanced absorption could describe the dye molecules' greater efficacy on the CuO nano-particle surface. As a result of the ease with which the method may be carried out and the materials formed, CuO nano-particles appear promising for future photovoltaics. The photocurrent is the more critical in exhibiting the overall device effectiveness limits. Due to their enormous surface energy and surface area, basic materials act differently while particle sizes near the nanoscale .This led to obtaining good information for the dye solar cell regarding efficiency, voltage, and current. This result obtained agrees and exceeds many previous studies [1-6, 24].

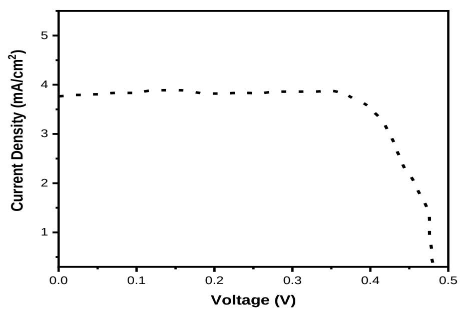

Figure. (4) the I-V Curve parameter of the DSSC

4. Conclusion

CuO nanoparticles were effectively generated utilizing Peppermint plant extract in a simple and environmentally acceptable plant-mediated biological approach (Peppermint plant extract). The spherical form of the nanoparticles was revealed via SEM analysis. Due to their toxicity, we did not utilize any additional capping agents in this experiment to reduce aggregation; nonetheless, The plant acts as a reducing and capping agent. As a result, the current process is more cost-effective and environmentally benign than alternative methods for producing CuO nanoparticles. The CuO nano-particle possessed a particle size of 14-55 nm. The increased dye molecule absorbance on the surface of CuO nanoparticles is responsible for the improved efficiency of the created DSSC. As a result, using green-produced CuO nanoparticles in the fabrication of DSSC is a promising and straightforward strategy for the future health of our planet.

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