Magnetic assisted efficiency of a hybrid TiO_2/spinel ferrite nanocomposites based DSSC

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Experimental Techniques

This report describes different experimental techniques used to fabricate dye sensitized solar cells studied in this paper and those used for structural and magnetic characterization of the obtained photoanodes.

This section includes a presentation of the materials used in the work and the method for preparing dye solar cells. The doping materials are ferromagnetic $CoFe_2O_4$, to the TiO_2 photoanode which was pasted on glass substrates formula (FTO). Prepartion a solution of N719 dye and preparation of the cathode electrode from acid. Chloroplatinic dissolved in isopropyl alcohol and then deposition on slides.

Cleaning glass substrates (Cleaning Work tools (FTO).

In our work, we use FTO pillars that resist 11-15 mm of shock from Ossila company. It must be cleaned well before the deposition process according to the method shown below:

1- Washing the glass substrates with distilled water and detergent powder to get rid of any stuck-on materials.

2-The glass substrates are immersed in distilled water in the ultrasound device.

For 15 minutes.

3- The glass substrates are immersed in 99% high-purity ethanol in an ultrasound machine for 15 minutes.

4-The glass substrates are immersed in pure isopropyl alcohol in the ultraviolet device for 15 minutes.

5- The glass substrates are immersed in a diluted 50% deionized water in Ultrasound

device.

6. Placing the glass substrates in the oven at a temperature of 100 degrees Celsius for 20 minutes for the purpose of curing them.

Synthesis of Fe_3O_4 MNPs

Cobalt ferrite particles were prepared using the (sol - gel) method. 0.01 M of iron (III) nitrate was dissolved in water and 0.01 M of iron (III) nitrate was dissolved in water separately, then the two solutions were mixed together with the addition of 0.005 M of citric acid and the addition of ammonia solution. Until the solution becomes neutral, the solution is placed at a temperature of 70 degrees Celsius until a fragile foam is obtained. The sediment is separated, washed several times, and heat treated at a temperature of 400 degrees Celsius for an hour

Preparation of the Dye Solution

Dye Solution is prepared by adding (0.0118 gm) of N719 dye powder shaken from (Ossila) company. Figure (2-2) explains the properties of the dye N719 (20 ml of 99% pure ethanol and stirs with a magnetic mixer for 30 minutes***.***

Preparation of pure and doped TiO_2 paste

A pure TiO_2-NPts sample of Titanium oxide [88] was prepared by mixing 0.1 gm of TiO_2 with

) with two drops of Triton X-100 (120µl) and Acetylacetone (0.02ml). Dilute nitric acid with ethanol (PH = 3). The mixture was mixed well for 10 minutes. This same method was used to manufacture Titanium oxide films impregnated with different percentages (1,2,3,4,5%) of

$CoFe_2O_4$ where zinc oxide was ground with each magnetic material with five different ratios before adding liquid materials. Figure (3.2) shows the sample symbols and their description. The sample was plated onto pre-cleaned FTO substrates using the doctor blade technique using a tape which works like a mold.

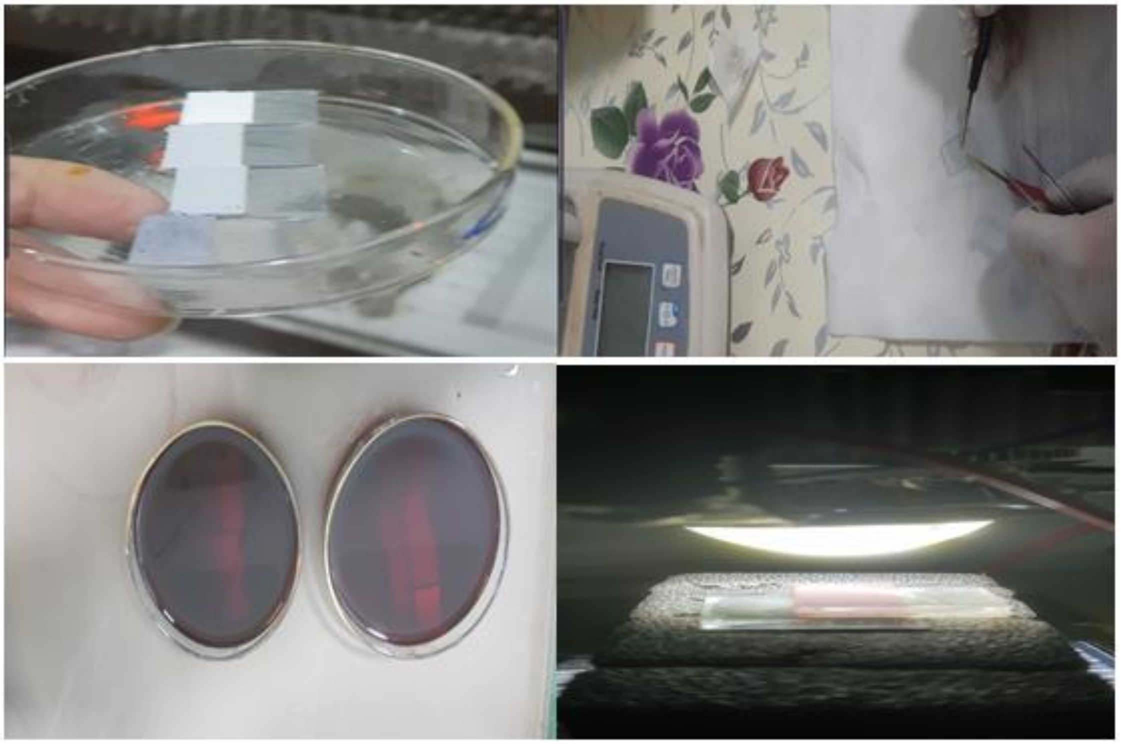

Figure 1: Step by step construction of dye sensitized solar cell – preparation of TiO2 photoanode and immersing dye solution.

Preparation Of the Counter Electrode

Chloroplatinic acid powder (H2Ptcl6.6H2O) was dissolved in a ratio of 1:1 in a mixture of75% isopropanol and . [93] n-butanol %25 The solution was stirred with a magnetic stirrer for 6 minutes Hours at room temperature, then deposited on the FTO substrate by casting coating method. The substrates were thermally treated at 200°C for 10 minutes.

We determine which side of the FTO substrate is mobile by examining the substrate with both connected contacts With a resistance measuring instrument, we use a suitable tape to fix the pillars. The sample was painted to cover the exposed part from the substrate, after it has dried, the tape is carefully removed and then placed in a convection oven at a temperature of 450^{o} it for 30 minutes. After removing the slide from the oven, leave it to cool, then immerse it in the prepared dye solution. Previously for 24 hours. The slide was removed from the staining evaporator with forceps and rinsed with ethanol and Tf to get rid of moisture.

2.2 Characterization devices

For image analysis, samples of nanoparticles were set up into a FE-SEM Supera Zeiss Model and scanned at a magnification of 50 k. The XRD analysis of the prepared sample of pure and doped ZnO nanoparticles, and data was collected for the 2θ range of 10° to 80° with a step of 0.1972°. nanoparticles was done using a XRD-Rigaku diffractometer, Cu-Kα X-rays of wavelength (λ)=1.5406 Å. The results supported the presence of nanoscale ZnO powder. We recorded the absorption spectra of the samples with a visible-NIR spectrometer (Shimadzu UV-1800 PC) Magnetic characterization were conducted by using Vibrated Sample Magnetometer (VSM-MDK Iran). The Solar Cell Measurements. Current-voltage characteristics of the prepared DSSC cells were conducted with a Keithley source meter 2400 (SCIENCE TECH) and solar simulator lamp AM1.5 systems with illumination of 100 mW/cm^2.

2.2 Preparation of CoFe2O4 particles

Briefly, 1,2-Tetradecanediol (10 mmol), iron (III) acetylacetonate (2 mmol), diphenyl ether (20 mL), Oleic acid (6 mmol), Oleyl amine (6 mmol), and (1 mmol) Cobalt (II) acetacetonate were mixed and magnetically stirred under nitrogen atmosphere. The mixture was heated at 200 C for 30 min and subsequently heated to reflux at 265 $C_{\circ}$ for 30 min. The mixture was slowly cooled to room temperature, and the product was dissolved in hexane. Centrifugation was utilized to remove any undispersed residue.

2.3 Preparation of (TiO2/$CoFe_2O_4$) Films

The following procedure was used to prepare the pure and doped (TiO2). A homogenous zinc oxide paste were fabricate by following procedure [14],we blend 0.1 g of (np-ZnO) with 0.02 ml of (acetyl acetone), 20 µl of (Triton X-100), two drops of were mixed with Nitric acid ethanol (PH=3), and finally, the combination were mixed thoroughly for 10 minutes. The same procedure were used to fabricate doped zinc oxide films with different ratios (1,2,3,4,5) % from ($CoFe_2$O4), the previous pasts were coated pre-cleaned (FTO) by doctor blade technique using Scotch tape (thickness about 1 µm). the films were air dried and then sintered at 450 °C for 30 minutes, after removing the films from the oven, its immersed in a (N719) dye solution of concentration (0.5mM) for 24 hours, after that removed, washed several times with ethanol, and dried in air.

2.4 Preparation the dye solution

Prepared by adding 0.0118 gm of N719 concentration (0.5mM) dye powder prepared to 20 ml of pure ethanol (99%) and stirred with a magnetic stirrer on the magnetic stirrer for 30 minutes**.**

2.5 Preparation of counter electrode

$H_2PtCl_6 \cdot 6H_2O$ was dissolved in a 1:1 mixture of isopropanol and n-butanol at concentrations of 0.25 wt%[15], The appropriate $H_2PtCl_6 \cdot 6H_2O$ solution was stirred for 6 h at room temperature and then sprayed onto the FTO substrate to give an electrode with an active area of 1 cm^2. After blow-drying at room temperature, the substrates were heated at 200 C for 10 minutes.

2.7 The solar cell measurements system

After the cell collection process is completed, we fix the cell with a clamp on its edge and use the device (I-V) from the solar cell measurements system to measure the cell's efficiency, short-circuit current, voltage, fill factor, series resistance, and parallel resistance. As illustrated in Figure 2, the photovoltaic cell measurement circuit is composed of a computer-connected, light source (a 100mW/cm^2 xenon lamp) and a current and voltage measuring device (Keithly 2400).

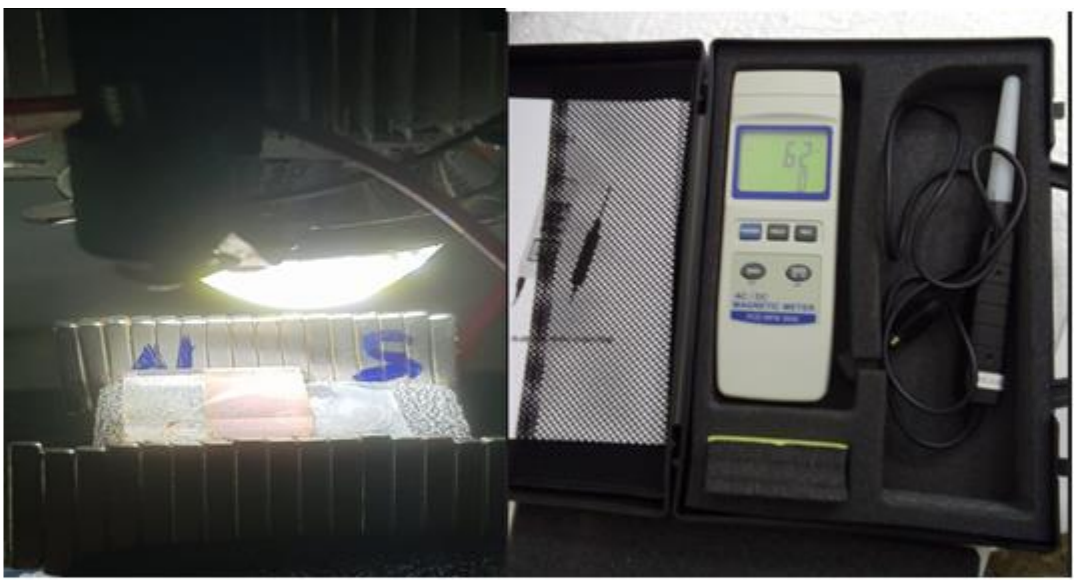

Figure 2:(left panel) Dye sensitized solar cell during subjecting magnetic field during measurement (right panel) Gaussmeter.

The Photo Voltaic Devices and Measurements Branch at the Solar Energy Research Laboratory at the Department of Physics, College of Science, University of Basrah, follows these procedures for calibration and efficiency measurement. The uncertainty in the calibration number has been lowered to less than 1% through the use of spectral irradiance measurements to calibrate reference cells used in these measurements. For a wide range of test cell/reference cell combinations, the spectral mismatch index can reduce measurement errors to approximately 2%. It also eliminates the need for a close match in spectral responses between the source spectrum and the standard spectrum or between the test cell and reference cell. For a range of cell spectral responses, the impact of different spectra used by the PV community on the short-circuit current is presented.

Current density-voltage (J-V) characterizations were carried out in order to investigate the impact of various TiO_2 layers on the performance of TiO_2-based DSSCs (Fig. 4). Prior to analysis, a standard silicon solar cell was used as the reference cell to calibrate the light intensity of the solar simulator (to 100 mW cm^{-2}). The power of the Xenon lamp was adjusted to make the reference cell's short-circuit current density (JSC) under simulated sunlight as high as it was under the calibration condition. The ZnO coating that was produced in multiple steps was responsible for the altered photovoltaic parameters of the manufactured cells.

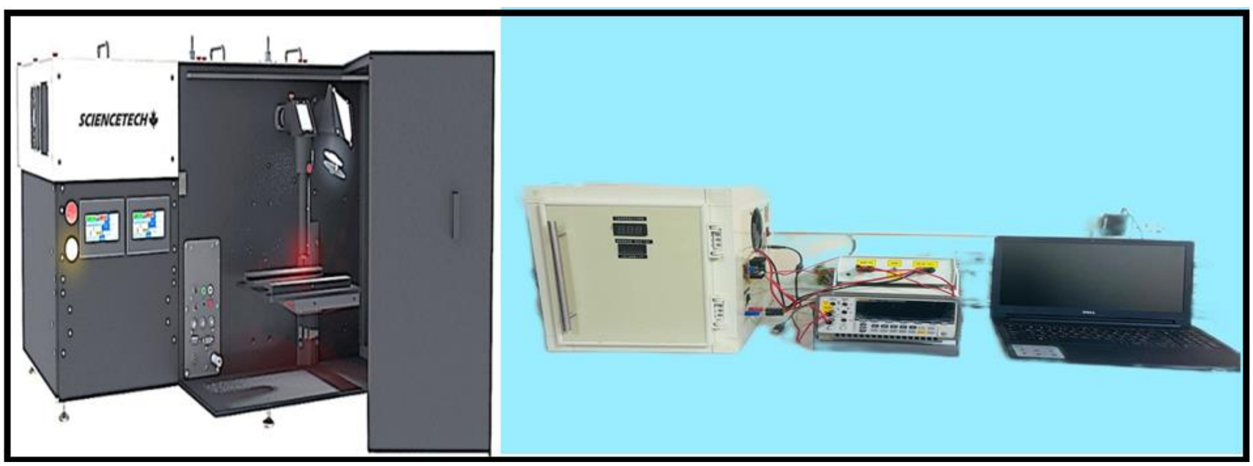

Figure 3: Solar cell measurement system used to obtain I-V characteristic of the DSSC under investigation

vibrating sample magnetometer (VSM)

In this study, we have effectively used a vibrating sample magnetometer (VSM-MDK Kashan-Iran) which is a highly sensitive scientific instrument used to characterize the magnetic properties of materials. This instrument is widely used to study the magnetic behavior of materials ranging from ferromagnetic and ferrimagnetic to antiferromagnetic and paramagnetic substances in fields like materials science, physics, and engineering.

Figure 4: Vibrated Sample Magnetometer (VSM) (MDK-Kashan-Iran) used for magnetometeric measurements of this study.

Due to the high sensitivity of MDK-VSM, even small variations in a material's magnetic properties can be detected. It is therefore perfect for studying materials with weak magnetic properties, like paramagnetic and antiferromagnetic materials. A broad range of magnetic field strengths can be produced in MDK-VSM by utilizing electromagnets with maximum field of (1.4 Tesla). This makes it possible to study materials with different saturation magnetizations and coercivities. By providing automated data collection and analysis, modern VSM systems enable quick material characterization while lowering the possibility of human error.