Effect of Natural Dye on the Spectral Response

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Abstract
Zinc oxide and dye are utilized to absorb and convert incident photons to electric energy using a sandwich construction with an active area of 1.5 x 1.5 cm2, which improves the photodetector's performance as a light sensor. A variable of solution concentration according to the ratio of mass and volume was used to extract natural dye from Barago officinalis .The Barago officinalis absorbance was investigated by spectrophotometer at a wavelength of 200-1000 nm .this indicates that UV absorption has occurred ,and notice when an increasing in the spectral response at concentration of 0.1ml, appear an improvement in the infrared region with a wave length of 950 nm the enhanced sensitivity in the long wavelength region due to formation of dyes aggregates within the devices. which led to the highest value of qualitative detection up to 6.2x 1012W-1 cm. Hz 1/2 thus increasing quantum efficiency to (56.7%) at the wavelength (950nm).
Keywords: UV-visible spectroscopy, AFM, ZnO

1. Introduction

A photodetector sensor is a type of light sensor that is frequently used in applications such as image processing and energy conservation [1]. The optical and light sensors that are Commercial available, however, are inappropriate for use in general. It is distinguished by the components utilized to create a sensor made of a semiconductor substance like CdS. These materials are capable of effective light absorption, however obtaining them comes with significant danger. Since it can be made at a very cheap cost, the photodetector from organic dye sensitization of large band-gap oxide semiconductor has been studied for many years [2-4]. Natural dyes are regarded as eco-friendly since they are regenerative and biodegradable, kind on the skin, and may even improve the wearer's health. Almost all varieties of natural fibers may be dyed using natural dyes. They can also be used to color some synthetic textiles, according to recent study. In addition to their usage in textiles, natural dyes are also employed in the coloring of food, medications, handicrafts, toys, and the processing of leather. Many of the plants that produce dye are also utilized as medicines in a number of different traditional medical systems. The use of natural dyes comes with a number of difficulties and restrictions. The industry now needs around 3 million tonnes of dyestuff. Given this, using natural colors in conventional textile processes is quite difficult. The pH of natural dyes is delicate. Given that natural dyes are typically a blend of many chemical components, altering that pH of the extraction medium by adding acid or alkali can lead to the extraction of various dye components, which result in a range of color outcomes and colorfastness characteristics. To the discover ideal dye extraction circumstances, many researchers have investigated the extraction of natural dyes under various pH settings and compared the color and fastness features of colored cloth. New additions to this knowledge are produced every year in the scientific literature. The photodetector-based dye and TiO2 concept corresponds to Dye-sensitized solar cell (DSSC) [5]. The energy of photons will be absorbed by the dye (D), which binds to the TiO2 particles, when they enter the DSSC from the light source. The dye's electron will then receive energy, and while the dyeing molecules' electrons are stimulated (D*), they will be in an exited condition. The development of photodetectors utilized for a number of applications, such as vivo optical communications, imaging ,biomedicine[6-10] and remote monitoring[11], depends on the detection of near infrared (NIR) photons in the range of 700 nm to 1500 nm.

2. Experimental Part

Zinc oxide nanoparticles were prepared by dissolving (1.89 g/mol) of zinc nitrate per 100 ml of water. The mixture is put on the device (Hot Plate and Magnetic Stirrer) at 60oC for one hour aiming. Then add 5 ml of plant extract (Barago officinalis) 1 prepared by heating with hot water and formed using filter paper, as demonstrated in Figure 1.

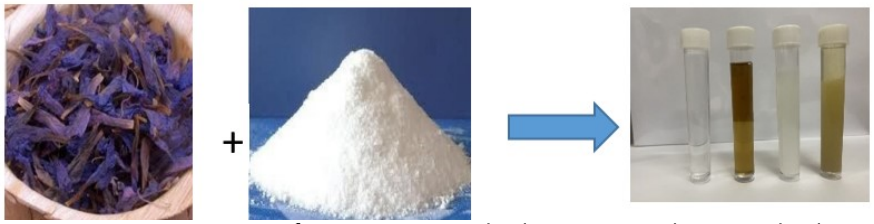

Fig .1 : Preparation of ZnO Nanoparticles by green synthesis method

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Thin films of zinc oxide nanoparticles were prepared on bases of glass (to study the properties of the membrane) as shown in fig.2a and on bases of porous silicon of the p- type for the purpose of manufacturing the hybrid ,see fig.2b by the drop-casting method by adding five drops with a total volume of not more than 50 microliters of secondary zinc oxide and at a heating temperature not exceeding about 60 degrees Celsius.

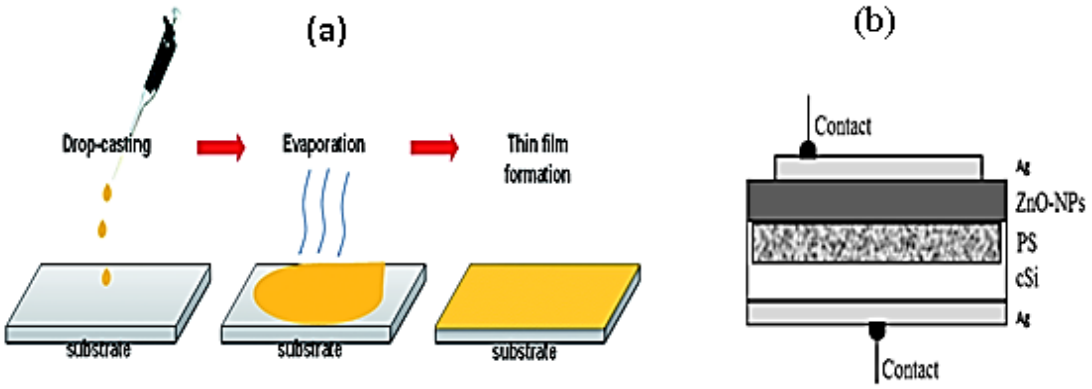

Fig.2: preparation of a) ZnO/glass and b) ZnO /PS by drop casting method

3. Results analysis

The XRD spectrum of the green synthesis of zinc oxid nanostructures utilizing zinc nitrate solution and the polycrystalline Barago officinalis plant extract is shown in Figure (3). Numerous zinc oxide phases and certain salts are also visible in the photograph. The creation of plant extract is also shown by the XRD analysis, and Table1 shows that there are five primary peaks The X-ray examination of the film is critical for determining the type of the nanoparticles generated. It demonstrated different diffraction angles, as shown in Table (1). The diffraction peaks are hexagonal in structure and fit well with the typical peaks. JCPDS card number 79-0207. Table (1) shows the d-value of nanocrysyline ZnO. The Scherrer formula is used to calculate the crystallite size (D) in nm given a known X-ray wavelength at a diffraction angle of ZnO nanoparticles, A strong diffraction plane's peak widths were determined, and the high and narrow summits can be attributed to the preferred development of ZnO crystallites. The dislocation density(δ) and strain (η) were determined from equation :

$D=K\times\lambda/\beta\cos\theta$ (1)

$\eta=\beta\cos\theta/4$.(2)

$\sigma=1/D2$.(3)

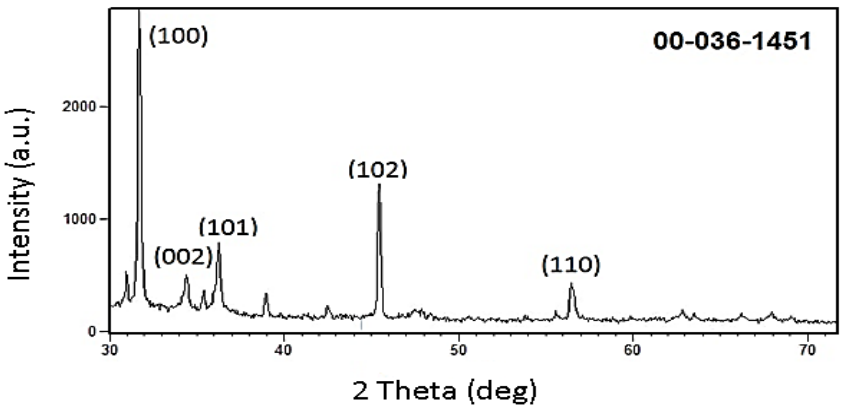

Fig.3:XRD pattern of Zinc oxide nanoparticles

Table (1) XRD properties of ZnO nanoparticle					
2 Theta(deg)	Hkl plans	FWHM (deg)	D (nm)	Strain x10-4	dislocation line.m-2 10+14
31.7	100	0.0034	41.91	8.26	5.69
34.4	002	0.0034	42.21	8.20	5.61
36.2	100	0.0034	42.42	8.16	5.55
47.5	102	0.0034	43.72	7.92	5.22
56.4	110	0.0051	30.42	11.38	10.80

SEM pictures of ZnO 0.1ml nanoparticles made via green synthesis are shown in Fig. 4 The distinct shape of these NPS is confirmed by SEM pictures.

These NPs have an uneven shape and contain many1 tiny, 95 nm-sized nanoparticles.it indicates that the green synthesis preparation method for particle preparation and the droplet decanting method is suitable for the preparation of the dro

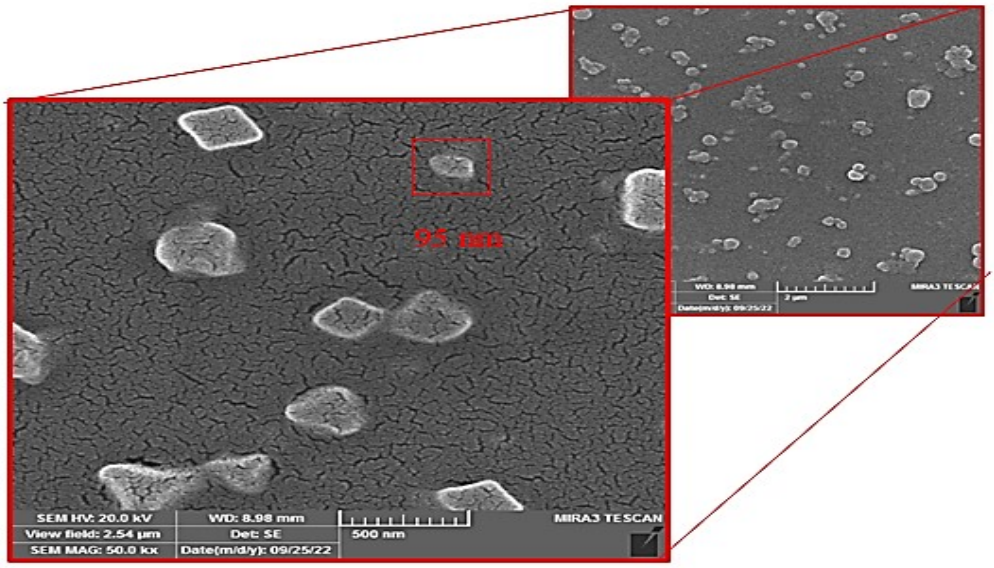

Fig. 4: shows SEM images of ZnO nanoparticles

The surface's topography was examined with an atomic force microscope (AFM) by green synthesis. The fig 5 displayed a three-dimensional image of ZnO nanoparticles arranged in spherical clusters and 1detailed a population of uniform particles with a regular surface figure, in addition to the size distribution of the nanoparticles. ZnO nanoparticles with an average size of 120 nm are shown in Table (2). According to the produced procedures, the researcher discovered that the average size of generated ZnO nanoparticles varies due to quantum to synthesis effect.

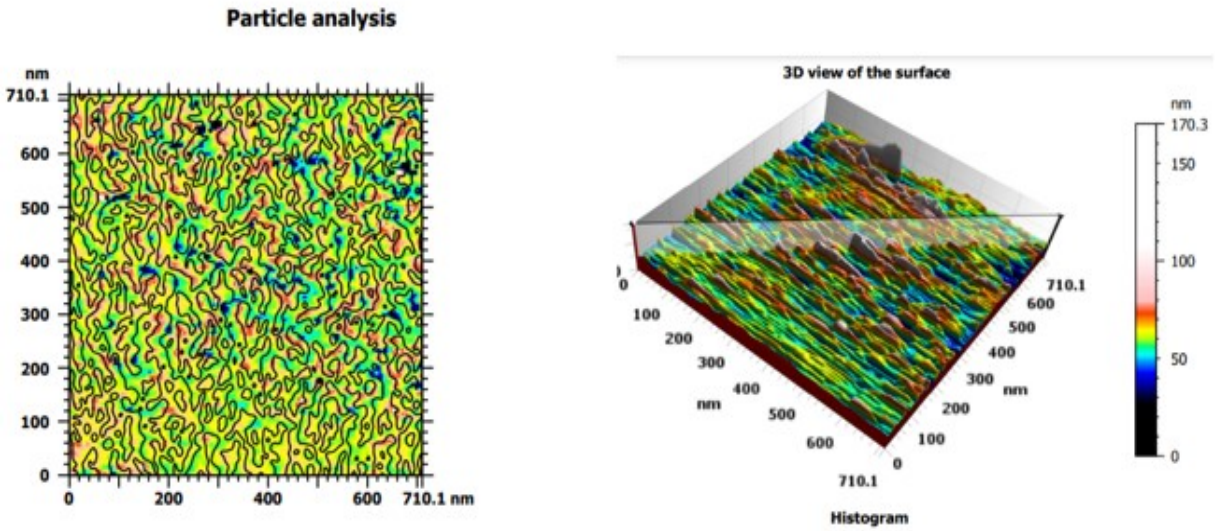

Fig .5 :3D AFM of ZnO nanoparticles of the natural dye

Table (2)AFM and Granularity accumulation distribution chart of ZnO			
Sample	Average diameter (nm)	Root mean squarw (nm)	roughness average (nm)
ZnO	120	4.177	3.269

Finding the functional groups of a material may be done effectively using the FTIR technique.
According to Figure 6, the FTIR spectra of ZnO NPs exhibit peaks at (1627,3329) (1/cm), which were used to analyze the modes of vibration of chemical bonds present in ZnO NPs at various concentrations. The vibration modes of the aldehyde or ketones groups Zn-O, C-C, O-H, C-H are to blame . The existence of alcohols, phenols with symmetric stretching along the O–H bond. This finding is in good agreement with the previous ones [12], [13]. The C=C sources of vibration in alkynes are responsible for the peak at (1635) (1/cm). This conclusion is consistent with those found in references [14,15].

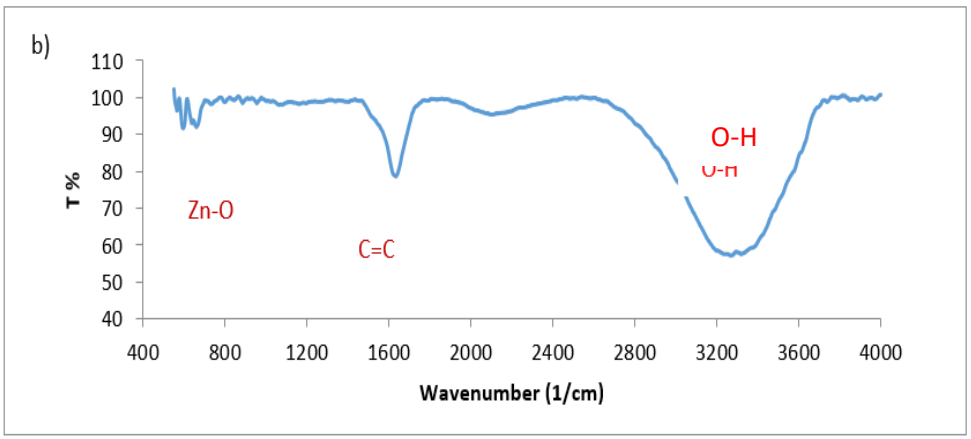

Fig .6 : FTIR spectra of ZnO NPS samples with concentrations of the natural dye

The transmittance spectra with band gap are shown in Fig. 7. The transmittance spectra in the ultraviolet region of the spectrum was increased with longer wavelengths as their particle sizes decreased, which was ascribed to a rise in the optical energy gap (Eg). due to quantum synthesis effect. and the precipitation method at a temperature not exceeding 60 °C leads to the disappearance of the organic matter.

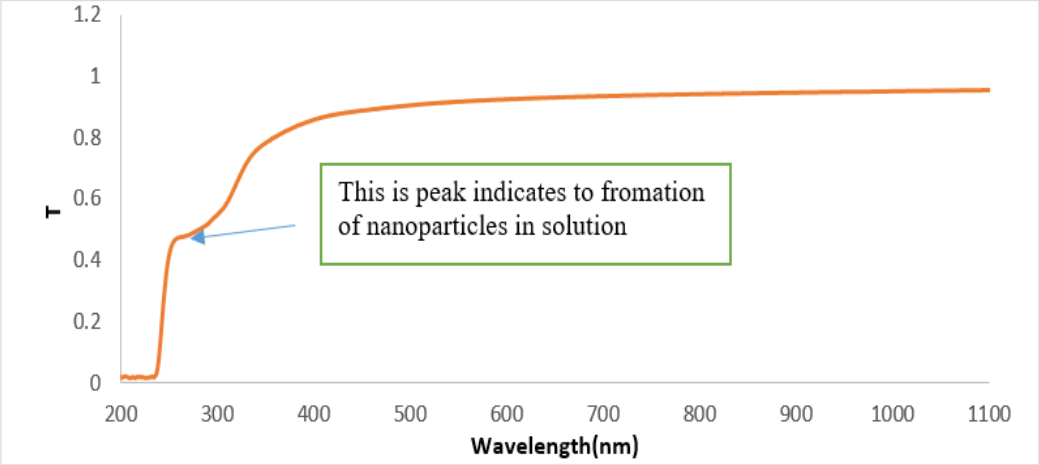

Fig. 7: spectra of ZnO Transmission for nanoparticles of the natural dye

depicts the absorption spectrum. In fig 8 All compositions indicate high absorbance in the UV region and full perfect permeability in the visible region.

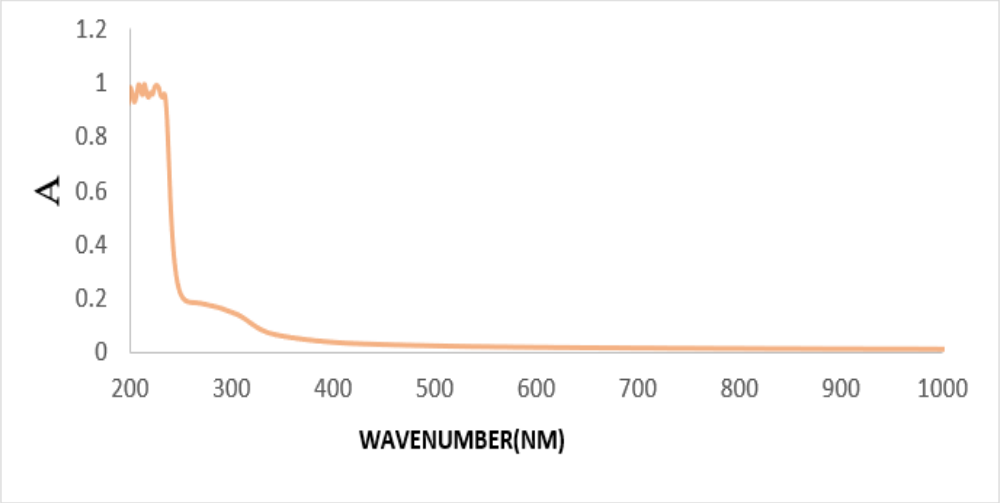

Fig. 8 Absorbance of the ZnO nanoparticles of the natural dye

ZnO film's transmittance (T) and absorbance (A), respectively, are given as The following equation has been used to determine the film's ref:

T+A+R=1 … (4)

ZnO thin film reflection increases with wavelength increases as shown in Fig. 8 due to increased transmittance.

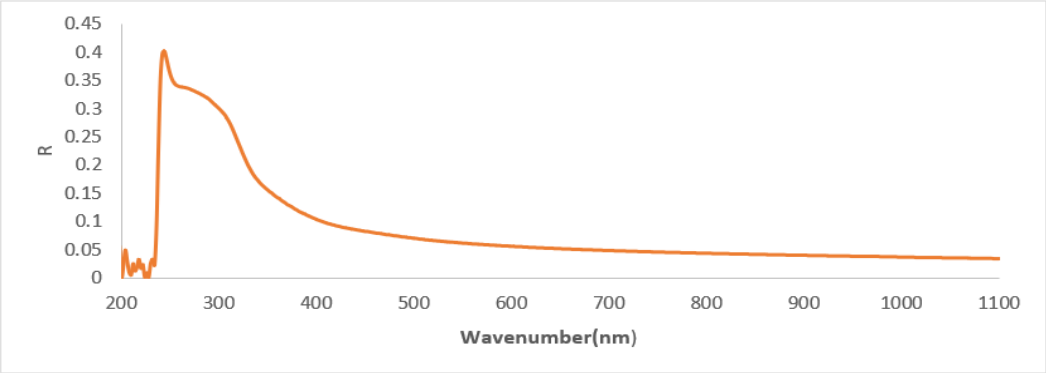

Fig .9: Reflectance spectrum of ZnO NPs of the natural dye

The energy gap can be found through the absorption coefficient by using to it by the following equation :
(ahu)2=A (hv –Eg)n .(5)
Where Eg is the energy gap that the incident photon caused as a result of the quantum effect., A is a constant, and n is the exponent that defines the optical absorption is the process by which the energy of a photon is taken up by matter, typically the electrons of an atom, AFM reinforce the finding that the production of nano-sized ZnO particles is what causes the band gap to widen. The quantum size effect is responsible for the huge band gap (4.9 eV) of ZnO with concentrations (0.1) ml as seen in Fig .10 [16]

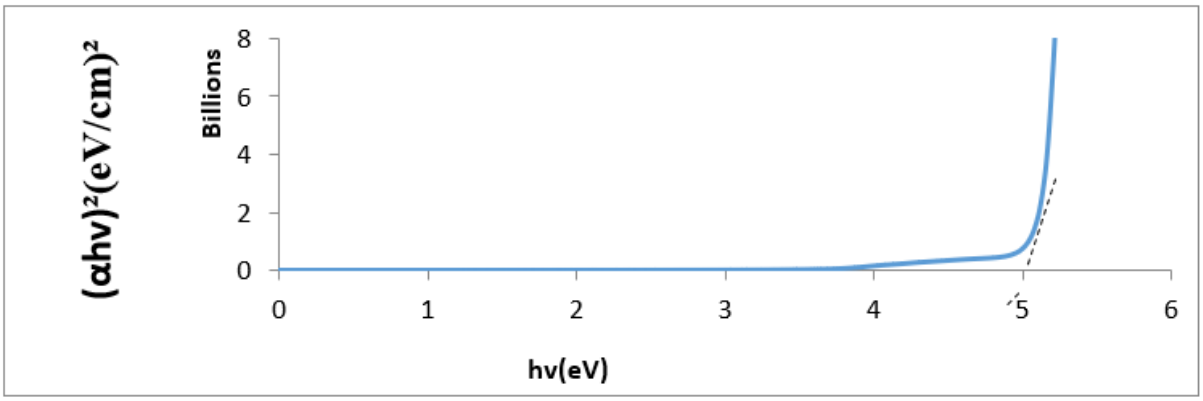

Fig 10 :(αhυ) 2 against photon energy graph of ZnO NPs of the natural dye

ZnO/PSi/p-Si structures generated at various concentrations and etching durations (15 min) with 10mA/cm2 current density are shown in Figures (11) along with spectral responsivity graphs as a function of wavelength. The first peak occurs at 600 nm due to the absorption edge of ZnO nanoparticles, as seen in Figure (11) of the spectral responsivity curve of ZnO/PSi/P-Si., while the second region is located at 950 nm with ZnO due to absorption edge of silicon . This is due to the increased concentration of the dye,which leads to an increased spectral responsivity. The responsivity is given by [17]:
Rλ=IPh /Pin (A/W) .(6)
where Iph: is the photocurrent and : is the input power.

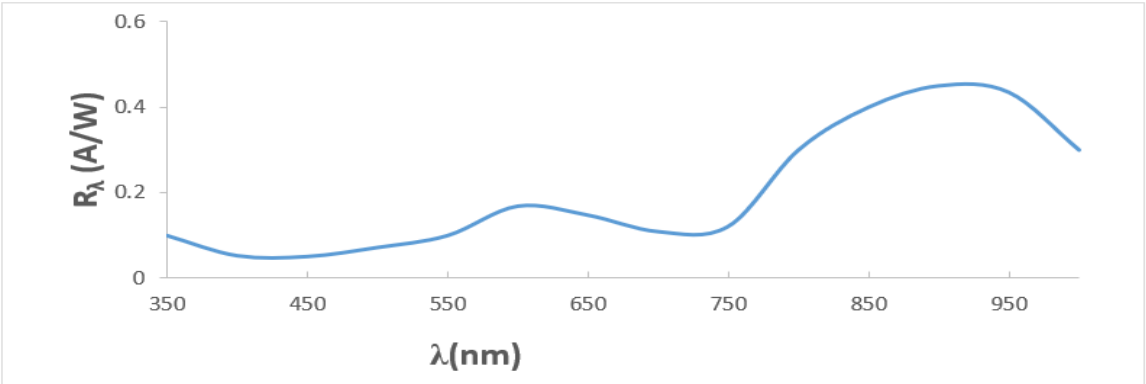

Fig (11): Responsivity as a function of wavelength of ZnO NPs of the natural dye

The aqueous extracts of borage (Borago officinalis) leaves from Annaba region (Algeria) were preliminary analyzed for their phenolic profile (total phenolics, total flavonoids, total flavanols, total tannins and total anthocyanins), as show fig (12)[18].This species contains anthocyanins, a class of flavonoid pigments that are responsible for the intense colors. These anthocyanins have been studied for their potential

use in various applications, including dye-sensitized solar cells and photodetectors [19].The use of Borago officinalis dyes in photodetector applications has been studied in order to determine the influence of these dyes on the spectral responsivity of ZnO nanoparticles, which are typically used as the photosensitive material in photodetectors. It has been determined that the Borago officinalis dyes can increase the spectral responsivity of the ZnO nanoparticle, resulting in improved sensitivity of the photodetector to specific wavelengths of light

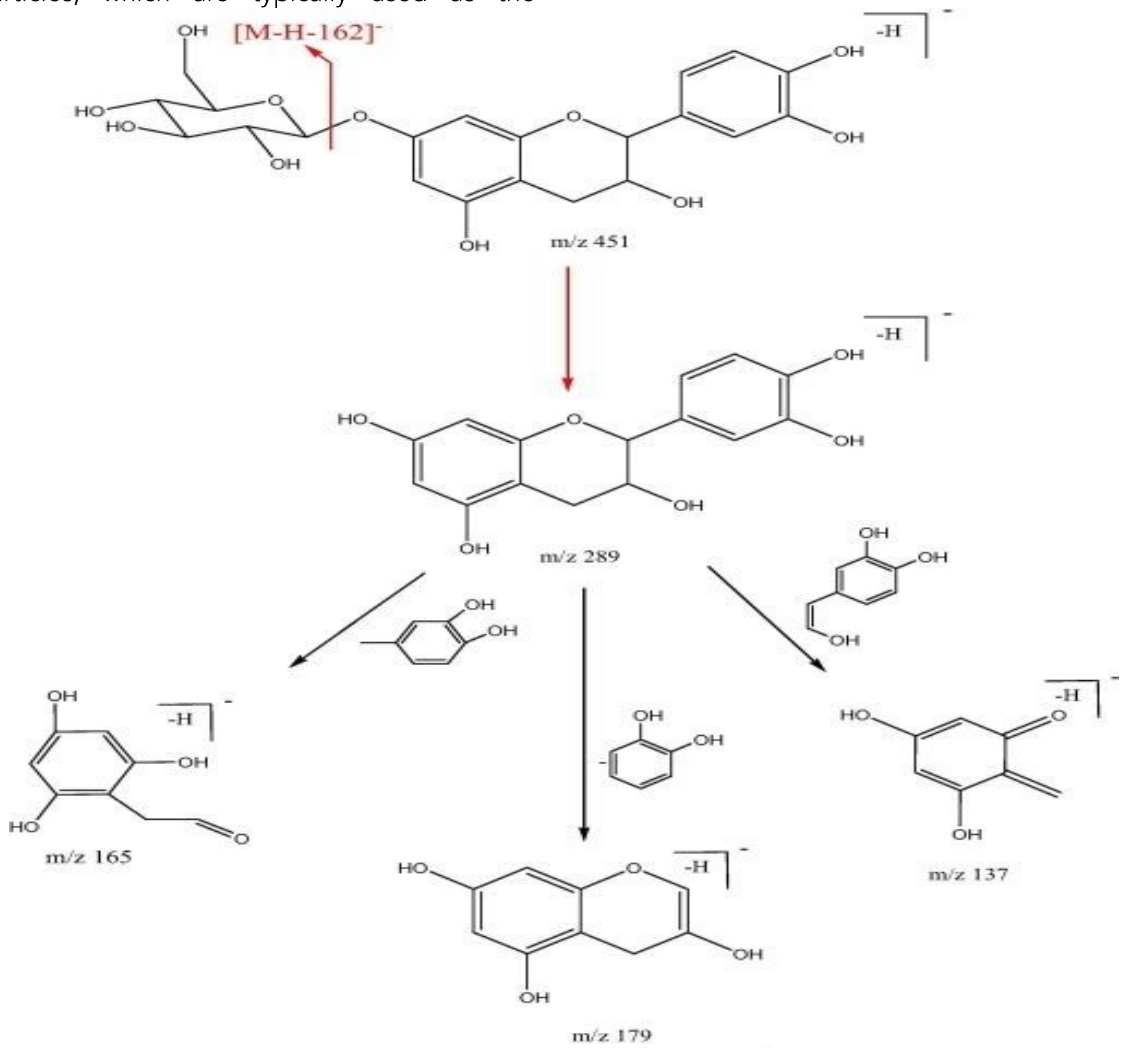

Fig.12: The chemical composition of Borago officinalis [18]

Figures (13) show the specific detectivity for photodetectors at various etching times and current densities as a function of wavelength. These data demonstrate the clear relationship between detectivity and responsiveness. The maximal D* for the ZnO/PSi Photodetector was measured to be 6.2x 1012 W-1.cm Hz1/2 at wavelength 950 nm. specific detectivity measurement by equation [20]:

$D^*=R\lambda (A1/2\ \Delta f/In)$.(7)

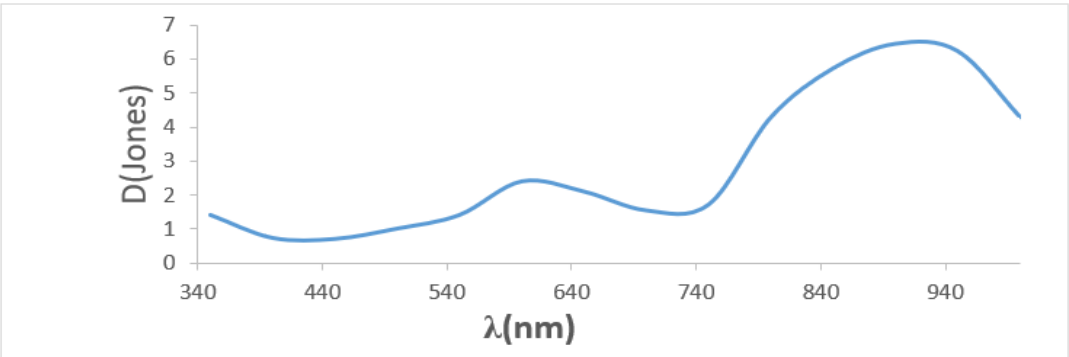

Fig (13): Spectral detectivity plots as a function of wavelength of ZnO NPs of the natural dye

The quantum efficiency is depicted in Figure 14 as a function of wavelength (400–1000 nm). Figure shows that for ZnO, PSI, and p-Si, the peak quantum efficiency was (56.7%)% at 950 nm, respectively. This is because the transmittance in this region has increased, which has increased the generation of charge carriers in the depletion region, which has increased spectral responsiveness, which has

increased the quantum efficiency. the quantum efficiency Q (in percent) may be related to the responsively by the equation:

$$Q = R\lambda\ (1.24/\lambda\ (\mu m)) \times 100\% \quad (8)$$

R (λ): is the responsively (in amperes per watt) of the detector at wavelength λ (μm) [21].

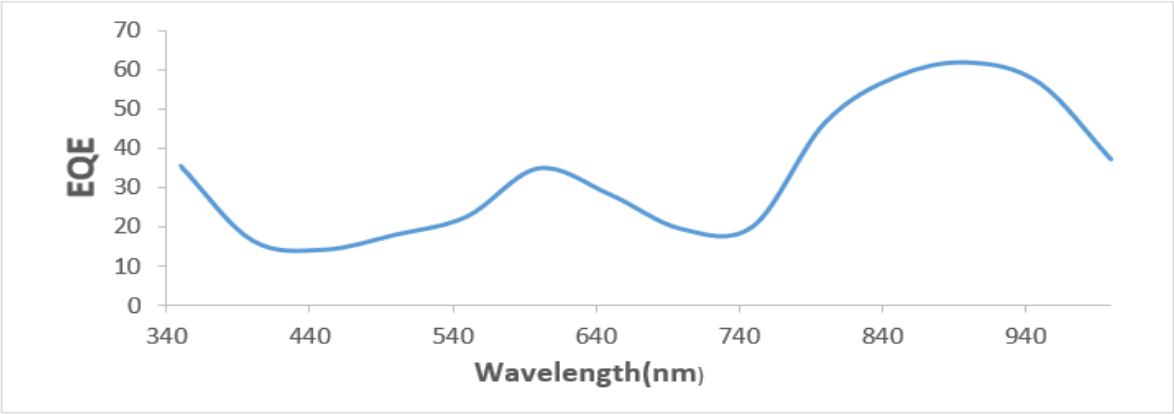

Fig. (14) Quantum efficiency as a function of wavelength of ZnO NPs of the natural dye

4. Conclusions

This paper has demonstrated how ZnO can be produced using a green synthesis process (simple, low cost, and quick method for the synthesis of ZnO Nanoparticals). The sample's behavior, as shown1 in the figure, indicates1 that ZnO has good qualities and can be used in many applications such as solar cells, detectors, antibacterial/antifungal, and anticancer applications. From the results of XRD and SEM, Where size and shape have an important role in process. The spherically or semi spherical shaped NP.

The research indicates the possibility of generating zinc oxide nanoparticles in a green synthesis method with very high purity and economical quality without leaving any toxic gases or solid residues that are difficult to remove. It is also possible to take advantage of the available natural dyes to improve the properties of porous silicon and increase the spectral response.

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