A comparative study of the photoelectric properties for lithium oxide prepared by Green synthesis method

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Abstract: Lithium oxide Li$_2$O was synthesized by two green synthesis methods using two plants saffron and turmeric. Then the Li$_2$O colloidal is deposited on p-type porous Si substrate p-PSi and n-type porous silicon substrate n-PSi to fabricate Al/Li$_2$O/p-PSi/pSi/Al heterojunction and Al/Li$_2$O/n-PSi/nSi/Al heterojunction. The morphological studies were measured by X-Ray Diffraction XRD getting an average crystallite size 34.7 nm for green synthesized saffron and 31.36 nm average crystallite size in case of green synthesized turmeric. Scanning Electron Microscopy SEM was about 80 nm size in case of saffron and about 55 nm. Fourier Transformation Infra-Red FT-IR was nearly the same in both cases. Optical measurement UV-visible occurred by calculating the transmittance and absorbance spectra and finally IV- in dark and IV under illumination were measured for the application of a heterojunction as a solar cell.

Keywords: Green synthesis, Biosynthesis, artificial methods Nanoparticles, porous silicon.

1. Introduction:
To synthesis high-quality nanomaterials, it can be achieved through a simple process which is called (biosynthesis) synthesis of metal nanomaterials compared with the (artificial methods). The biological approach is close to principles of (Nature) and involves natural phenomenon that takes place in biological systems. Much interest has been created by the term “green nanotechnology”. Among several biological methods for NPs synthesis, microbial mediated synthesis of is, yet not commercially viable as they involve maintenance of highly hygienic conditions and very complex processes of maintaining cultures [1]. Many plants are reported to facilitate the formation of NPs and their potential applications [2-4]. In 1954, researchers changed the technology to ensure improved efficiencies, lower cost and better reliability from the commercialization of the first solar cell[5]. The Silicon solar cell of the first generation (monocrystalline, polyethylene, hybrid and amorphous), because of its easy production and good conversion efficiencies, has and still continues to dominate the market. Second generation or the Thin Film technology mainly comprising Amorphous Silicon (a-Si), CdTe, CIGS and other non-Si technologies have been able to meet the need to implement bulky modules to provide flexibility and reliability [6]. The high-efficiency material of solar cells absorbs light over a wide range of spectra, produces high-efficiency transmission modes and recharges these loads to lower-loss electrodes[7]. The ability to produce straight pores makes the porous silicone a good material for different metal deposition [8]. Different pore morphologies from p-type nanometric pores to micrometric pores obtained from the illuminated n-type substrates can be derived, depending on the doping of a silicene anodized substratum. In the latter case, holes can be photogenerated in bulk by hitting the wafer's behind surface with sufficient energetic photons. These holes move towards the silicon-electrolyte front interface and dissolution of silicene under anodic distortion. The electric
champ at first focuses on the flat wafer surface with sharp defects. Therefore, surface defects are seed points for formation of macrophores [9-11].

2. Synthesizing Li$_2$O by using saffron

In this method, in a beaker 0.5 gm of saffron was added to 100 ml of distilled water then added the mixture to a solution composed of 7 gm of lithium nitrate LiNO$_3$ which was dissolved in 100 ml of distilled water. Thereafter the solution was put in the beaker on a hotplate at 40± 10 °C with maintaining the stirring for 45 min. The produced Li$_2$O colloidal has the orange color.

Fig.1: shows the Li$_2$O colloidal created by green synthesis for the plant saffron

The XRD pattern of the lithium nitrate LiNO$_3$ mixed with Saffron NPs prepared by green synthesis shows the presence of three sharp peaks. The average crystallite grain size which is calculated by using Scherrer formula found to be about 34.7 nm. Strong diffraction peaks were locating at 29.35, 32.5, 63.8 then smaller peaks at 16.5, 39.1, 54.35, 61.9, 63.8, 78.05 corresponding to (111), (200), (222) for the main peaks and (100), (200), (104), (222), (224), (112) respectively. Corresponding d-values were compared with the standard [JCPDS file, plane (Alpha Order): 01-089-4407, 01-073-7127, 01-076-9237, 01-076-9262, 01-073-1640, 01-074-0115, 00-012-0254, 01-074-6256.

Fig.2: XRD graph of Li$_2$O thin film prepared by green synthesis (saffron+LiNO$_3$)

| No. | Peak position (degree) | β° FWHM (degr) | hkl (planes) | D (nm) | δ (lines.m$^{-2}$) *10$^{14}$ | η*10$^{-4}$ (lines$^{-2}$.m$^{-4}$) |
|-----|------------------------|----------------|--------------|-------|---------------------------|-----------------------------|
| 1   | 16.4                   | 0.6888         | (100)        | 11.65 | 7.36                      | 120.14                      |
| 2   | 29.61                  | 0.1968         | ---          | 41.75 | 5.73                      | 34.27                       |
SEM is a significant study that has been performed to confirm the surface morphology of Li$_2$O NPs prepared by green synthesis. The right SEM image shows the nearly ellipsoidal accumulation shape of aggregated nanoparticles with 30kx magnification. The left SEM image magnified 70kx and it confirms the irregular morphology of these nanoparticles of nearly 80 nm size, there are also tiny nanoparticles. Figure 3 shows SEM images of Li$_2$O prepared by green synthesis for the saffron.

![Fig. 3: SEM images of Li$_2$O NPs prepared by green synthesis](image)

The Li$_2$O FT-IR spectrum produced by green synthesis is shown in Figure 4. The inter-atomic vibrations of the ribbons (5741/cm) equivalent to Li-O-Li. Noticed the (1651 and 3317.5), perhaps due to the expansion and deformation of the (O-H). The strips are (O4) with water absorbent on the metal surface, at (624,81/cm). In Li$_2$O, which is a high-profile film[12], similar FT-IR spectrum was reported by Kurnar and Rani.

![Fig. 4: FT-IR spectrum of Li$_2$O NPs prepared by green synthesis](image)
visible (Vis) spectrums are shown to be between (200 – 900) nm. It has been observed that there is a progressive increase from 335 nm to 480 nm; afterwards an almost stable growth occurred at 900 nm up to the end of the spectrum. Figure 5 illustrates transmittance versus wavelength.

![Transmittance spectrum of Li$_2$O](image1.png)

**Fig. 5:** Transmittance spectrum of Li$_2$O prepared by green synthesis using saffron

Figure 6 shows the absorbance spectrum of Li$_2$O colloidal prepared by green synthesis as a function of wavelength. The graph begins rising from 191nm till reaching the maximum peak at 236nm then, we can easily recognize the sudden dropping of absorption after 274nm till 268 nm, after reaching the second small peak 296 nm there is a dramatic fall and getting 394 nm, and after the previous the spectrum is stable.

![Absorbance spectrum of Li$_2$O](image2.png)

**Fig. 6:** Absorbance spectrum of Li$_2$O colloidal prepared by green synthesis

Then we can estimate the optical bandgap of Li$_2$O NPs by plotting the square of ($\alpha h\nu$) versus ($h\nu$). The extrapolating of the straight line to the X- axis ($\alpha h\nu)^2 =0$ gives the value of energy gap as illustrated in figure 7. The bandgap value of Li$_2$O is found to be about 3.5 volt.

![Tauc plot of band gap](image3.png)

**Fig. 7** Tauc plot of band gap of Li$_2$O prepared by green synthesis
3. Synthesizing Li$_2$O by using turmeric

In this method we dissolved 1gm of turmeric in 100ml of distilled water and added the mixture to a solution composed of 4gm LiCl and 100 ml of distilled water. We filtered the produced solution using nomination paper. Then we put the filtered solution in a beaker and applied it on a hotplate at 40±10 ºC with keeping the continuous stirring for 45 min. The resultant is a bold orange colloidal. Figure 8 shows the Li$_2$O prepared by green synthesis with compared to water.

The XRD pattern of Li$_2$O colloidal which is prepared of mixing lithium chloride and Turmeric prepared by green synthesis, shows 4 peaks reveals the existence of two main peaks. The average crystallite grain size calculated by Scherrer formula is found to be equal to 31.36 nm. Strong diffraction peaks locate at 28.5 for the second higher peak while the value of the highest peak did not show up. The smaller peaks lie at 16.2, 56.6, 58.75, 66.3 corresponding to (102), (110) for the second higher peak and (100), (102) (110), (220), (110) (204), (214) for the small peaks respectively. Corresponding d-values were compared with the standard [JCPDS file, plane (Alpha Order): 01-089-4407, 01-073-7127, 01-076-9237, 01-076-9262, 01-073-1640, 01-074-0115, 00-012-0254, 01-074-6256].

![Figure 8: Li$_2$O prepared by green synthesis orange color with compared to water.](image)

![Figure 9: shows the XRD pattern of Li$_2$O NPs prepared by green synthesis](image)

| No. | 2 theta | βº | hkl | D (nm) | δ | η*10^{-4} |
|-----|---------|----|-----|-------|---|----------|
|     |         |    |     |       |   |          |
The below images of SEM of the Li$_2$O NPs which is produced by green synthesis. The left image magnified at 30kx shows the uniform morphology of ball shaped that the nano particles and other smaller balls. The right image is magnified at 50kx shows the nano particles ball shaped with some cracks with granular size nearly about 55 nm.

The Li$_2$O prepared nanoparticles by green synthesis by using the plant turmeric has a bold orange color. The transmittance characteristics are highly significant tool to analyze nanomaterials. Where, due to the interference phenomena between the generated wavefronts at the two interfaces (air and prepared colloidal) which can be defined by sinusoidal curves, transmittance versus wavelength of light. It is observed that the transmittance spectra in the near infra-red (NIR) and visible (Vis) range from (200 - 900) nm. From the figure 12 we can observe a steady growing starts 205 nm we can also observe a gradual increment starts from 275 nm till getting the maximum at 895 nm. Figure 12 illustrates transmittance versus wavelength.

|   | (degree) | (degree) | (planes) | lines.m$^{-2}$) *10 | (lines$^{2}$m$^{-4}$) |
|---|---------|---------|----------|---------------------|----------------------|
| 1 | 16.0473 | 0.6888  | (100)    | 11.64               | 1.20                 |
| 2 | 28.5146 | 0.1476  | (102), (110) | 55.53               | 2.57                 |
| 3 | 31.8868 | 0.1476  | ---      | 55.97               | 2.56                 |
| 4 | 56.5694 | 0.3444  | (220)    | 26.19               | 5.96                 |
| 5 | 58.6148 | 0.2952  | (110), (204) | 30.86               | 5.11                 |
| 6 | 66.3422 | 0.2952  | (214)    | 32.15               | 5.09                 |

Fig. 10: Shows SEM images of Li$_2$O NPs prepared by green synthesis using turmeric

Figure 11 shows the Li$_2$O FT-IR spectrum which was prepared by green synthesis. The bands that appear at (563) cm$^{-1}$ are caused by inter-atomic vibrations correspond to Li-O-Li. Noticed the (1651.2 and 3305.9) cm$^{-1}$, possibly due to the expansion and deformation of (O-H). The bands correspond for (O$_4$) showed up at (586) cm$^{-1}$ to absorb water on the metal surface. Kurnar and Rani reported that similar FT-IR spectra were observed in Li$_2$O, which would be a high-profile film [12].

Fig. 11 FTIR spectrum of Li$_2$O NPs prepared by green synthesis by using turmeric

The Li$_2$O prepared nanoparticles by green synthesis by using the plant turmeric has a bold orange color. The transmittance characteristics are highly significant tool to analyze nanomaterials. Where, due to the interference phenomena between the generated wavefronts at the two interfaces (air and prepared colloidal) which can be defined by sinusoidal curves, transmittance versus wavelength of light. It is observed that the transmittance spectra in the near infra-red (NIR) and visible (Vis) range from (200 - 900) nm. From the figure 12 we can observe a steady growing starts 205 nm we can also observe a gradual increment starts from 275 nm till getting the maximum at 895 nm. Figure 12 illustrates transmittance versus wavelength.
Fig. 12: Transmittance spectrum of Li₂O NPs prepared by green synthesis by using turmeric. Figure 13 shows the absorbance spectrum of Li₂O colloidal prepared by green synthesis as a function of wavelength. The graph begins rising from 205 nm to the maximum of peak at 240 nm, thereafter a fast drop down occurs at 575 nm then, we can see a very slow decrement till reach the end at 900 nm.

Fig. 13 shows Li₂O absorbance prepared by green synthesis. Then we are able to estimate the optical bandgap of Li₂O NPs by plotting the square of \((\alpha h\nu)\) versus \((h\nu)\). The extrapolating of the straight line to the X-axis \((\alpha h\nu)^2 = 0\) gives the value of energy gap as presented in figure 14. The bandgap value is found to be 3.8 ev.

Fig. 14 Tauc's plot of Li₂O bandgap prepared by green synthesis.
4. Fabrication of Al/Li2O/PSi/nSi/Al and Al/Li2O/PSi/nSi/Al heterojunction by green synthesis (saffron)

After letting the solution cool down to the room temperature 5 drops of the solution were deposited on n and p-PSi layers and were put in oven at 300 ºC for 2h and let it cool down gradually for the next day to fabricate a heterojunction and study its characteristics. The electrical properties of the Al/Li2O/nSi/PSi/Al heterojunction, in general they are represented by the current – voltage characteristics in reverse and forward bias voltage, under the dark condition. In figure 15 shows the IV characteristics in dark at 300 ºC.

**Fig. 15** I-V Characteristics In forward and reverse bias of Al/Li2O/PSi/n,pSi/Al for the Li2O prepared by green synthesis method using saffron deposited on the n-PSi layer and p-PSi layer.

The photocurrent characteristics are extremely valuable for the sake of their application in optoelectronics and electronic devices, since we will study the procedure of converting the incident light rays to the photocurrent. Solar cell is an electronic device which used the sunlight and transforms it into a current, this process due to electrons in the surface of substrate absorbs light energy and rises to higher energy state this electrons transition generate the current to the external circuit. In figure 16 shows the I-V characteristics in reverse bias under illumination. In the case of illumination with intensity about 100 mw/cm² lamp and about 30cm away from the heterojunction sample.

**Fig. 16**: I-V characteristics in Reverse bias under dark and illumination of (Al/Li2O/PSi/n,p-Si/Al ) for the green synthesis method with using saffron+LiNO₃ deposited on n-PSi and p-P-Si
Fig. 17: I-V characteristics in Reverse bias under dark and illumination of \((\text{Al}/\text{Li}_2\text{O}/\text{PSi}/\text{n,p-Si}/\text{Al})\) for the green synthesis method with using turmeric+LiCl deposited on n-PSi and p-P-Si.

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**Conclusion**

The green synthesis method is considered one of the simplest and easiest methods in preparing metal oxides due to their economic quality and high efficiency and the preparation of lithium oxide in this way is more appropriate. In addition, we note that the lithium oxide particles have a high diffusivity in the porous silicon layer, which leads to an increase in the lig

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