Synthesis and Characterization of Conducting polymers based on plant waste

Nawras Hofzi Shliouh*[1], Nihad Abdulameer Salih[2]
[1]Department of Physics, College of Science, University of Babylon, Hilla, Iraq.
[2]Department of Physics, College of Science, University of Babylon, Hilla, Iraq.
Email: nawras.m2020@gmail.com

Abstract

Synthesis of a composite based on plant waste using thin film method by spin coating. The Samples of (PANI/plants waste) blend were prepared with polyaniline (PANI) and okra plant waste and (PANI/plants waste /Ag) nanocomposites were prepared with silver (Ag) nanoparticles added to the (PANI/okra plant waste) blend at different weights (0.5% and 1%). The DC conductivities, of (PANI/plants waste) blend and (PANI/plants waste/Ag) nanocomposites have been measured in the temperature range from (20 – 110) oC using Keithley electrometer type 2400. It was found that the electrical conductivity for (PANI/plants waste) blend is higher than nanocomposites. So, this is a simple way by which electrical properties of other conductive polymers may be enhanced by using plant waste. AFM microscopy revealed significant the samples in terms of shapes and morphologies have a fine and grainy structure fused together and exhibit varying microstructures.The results confirm that these okra plant fibres show potential as reinforcement in polymer matrix blend.

1. Introduction

Polymeric materials have gained a lot of attention in recent years due to their wide range of applications in various fields of life, including medical, engineering, and industrial, due to the fact that the polymer possesses unique properties like optical, mechanical and electrical properties that ensure ease of handling industrial [1]. A polymer is large molecule that contains hundreds, or thousands of atoms formed by combining one or two or sometimes more small (monomers) types of the molecule into a chain or network structure [2]. One of the most important means of developing new materials is polymer blending. Blending multiple polymers with a combination of properties improves on the individual polymer components. Generally, polymer materials may by excellent insulators that can by mixed with conductive fillers to improve their conductivity [3] . polymers containing natural fibers have obtained considerable attention. The interest in the natural fiber reinforced polymer arises rapidly due to the high-performance physical properties and low cost low density. Natural fibers are renewable, cheaper, pose no health hazards and finally provide a solution to environmental pollution by finding new uses for waste materials. Furthermore, natural fiber reinforced polymer composite form a new class of materials which seem to have good potential in the future. When these fibers are incorporated polymer matrix, they would yield materials with better properties suitable for various applications [4]. Application In industrial and biomedical for their superior characteristics [5]. PANI is an excellent conducting polymer due to its high degree of stability, simplicity in preparation and superior physical properties [6]. The electrical conductivity of these polymers can be improved by using natural fibers, when these fibers are combined in a polymer matrix they will produce materials with better properties suitable for different applications [7]. Plant-based natural fiber, a high potential field of the reinforced polymer composite material, is considered as lightweight and economical products as they possess lower density, significant material characteristics, and extraordinary molding flexibility [8]. Okra is one of the plant fibers that contain various natural materials, the most important of which are cellulose and lignin, which act as a support material for plant fibers [9]. Where was Use this fiber in composite materials has amplified over the last few decades for their relatively low-costs and environment-friendliness compared to the traditional artificial materials (aramid, glass, and carbon fibers), their recyclability, biodegradability, low density, lighter weight and minimal health hazard issues [10,11].

2. Materials and Methods

The materials that used polyaniline (PANI), okra plant, silver (Ag) nanoparticles and chloroform, to prepared composite from plant waste.
To prepare the solution of 1 g of PANI in 50 ml chloroform, then the solution is placed on the magnetic mixer and stir well to dissolve the material
To prepare okra plant waste wash it thoroughly with water, cut into pieces, and soak it overnight in distilled water. After that, the mucilage was extracted by filtering it through cloth and the extracted mucilage was dried in a 40° C oven to get a powder then 1g of okra powder is dissolved in 50 ml of chloroform and stirred with a magnetic stirrer for 60 minutes to get okra solution.
(PANI/okra plant waste) blend prepared by mix the two solutions PANI and okra plant waste for 60 minutes with a magnetic stirrer.
The (PANI/okra plant waste/Ag) nanocomposites are prepared by added Ag nanoparticles for the purpose

doi.org/10.31838/hiv23.02.38 Received: 20.10.22, Revised: 10.11.22, Accepted: 22.12.22

of doping different proportions (0.5% and 1%) to (PANI/okra plant waste) blend and mixed with a magnetic stirrer for 30 minutes to make the mixture more homogenous after that the films were prepared by spin coating method.

3. Results and Discussion

Atomic Force Microscope (AFM)

Figures (1) and (2) shows a 2D and 3D micrograph respectively of the (PANI/ plants waste) blends and (PANI/ plants waste /Ag) nanocomposites films with different ratio of Ag which showed a uniform granular surface morphology. The roughness values (root mean square RMS), mean height and maximum height of the samples are listed in table (1). It may be noted that this value of the roughness is increasing with okra plant which indicates increased available surface of the (PANI/ plants waste) blends. The high value of roughness observed indicates porous morphology of the film [12].

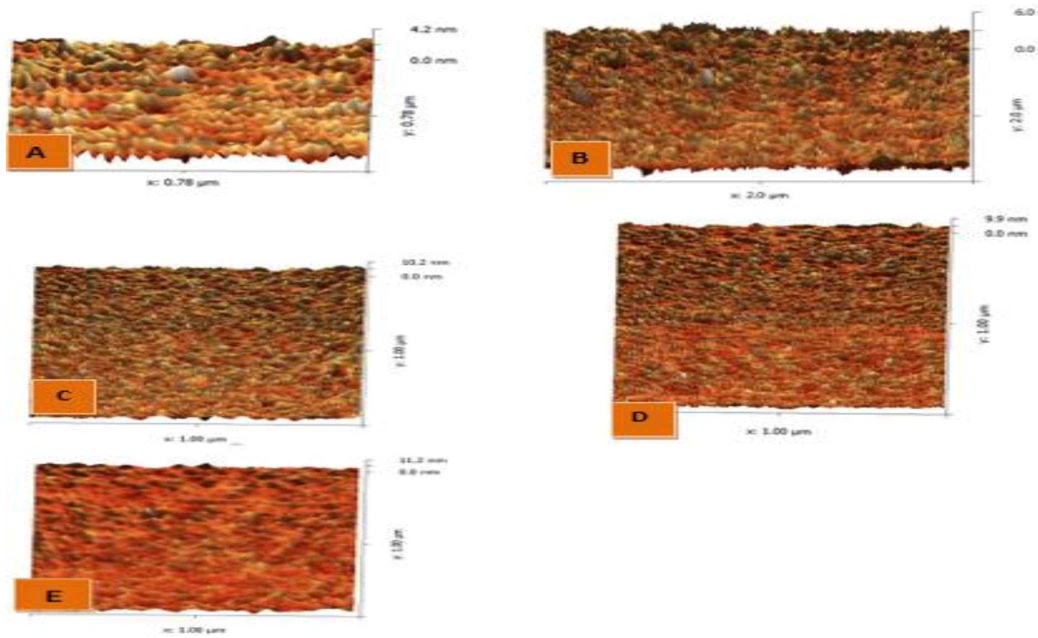

Figure (1): 2-D images for of (A) Okra plant (B) PANI (C) (PANI/ okra plant waste) blend (D) (PANI/okra plant waste/0.5%Ag) nanocomposite (E) (PANI/ okra plant waste /1%Ag) nanocomposite (F).

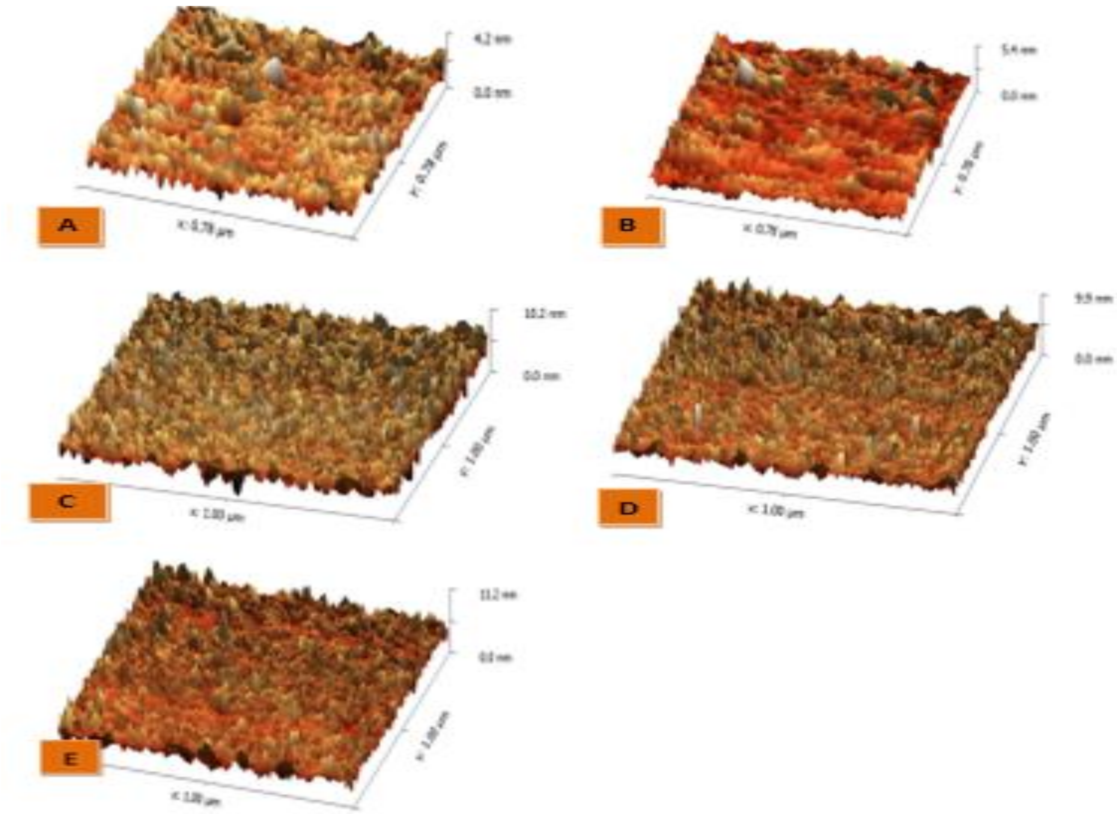

Figure (2): 3-D images of (A) Okra plant (B) PANI (C) (PANI/ okra plant waste) blend (D) (PANI/okra plant waste/0.5%Ag) nanocomposite (E) (PANI/okra plant waste /1%Ag) nanocomposite.

Table (1): AFM data for (PANI/okra plant waste) blend and (PANI/okra plant waste /Ag) nanocomposites thin films.			
Sample	Mean Height (Sa) (nm)	Root Mean Square (RMS)	Maximum Height (Sz)
Okra plant	8.51	14.24	109.6
PANI	1.67	2.01	12.02
(PANI/okra plant waste) blend	5.55	6.75	24.77
(PANI/okra plant waste /0.5%Ag) nanocomposites	1.34	1.71	14.05
(PANI/okra plant waste /1%Ag) nanocomposites	3.35	4.38	28.92

4. I-V Characterization

Figure (3) shows I-V characteristics taken by using thin films method on the prepared film of the (PANI/okra plant waste) blend and (PANI/okra plant waste/Ag) nanocomposites. Figure (3AandC) shows the I-V characteristics of okra plant waste and (PANI/okra plant waste) blends which clearly indicates that ohmic contact has been established the PANI and okra plant waste. Electron transfer, which readily occurs on the surface of okra plants fibers, increases electrical conductivity. Okra plant fibers are better candidates as lightweight conductive materials because of their lower densities and the moisture content in fibers increases conductivity [4,13,14]. The results observed in this study give new feasibility for use of natural fiber and polymer composites as conductive filler in polymer. The results obtained help in the development of conducting polymer composites for medical applications such as electrodes will be suitable candidates for flexible, environmentally safe, lightweight and all-organic of energy storage devices [15,131].

Figure (3B, DandE) is evident that there exist a transition between two linear regions of the curve at (4.7) V. Figure (3B) reveals that, the I-V characteristics between (0.7-4.7)V, figure (3D) between (1.2-4.7)V and Figure (3E) between (1.4-4.2) V has been linear. Thus, PANI and (PANI/ okra plant waste/0.5 and1% Ag) nanocomposites behaves as ohmic material within the region of 0.7 to 4.7 V. The second region of I-V characteristics lowest 0.7, 1.2 and 1.4 V thus, PANI and (PANI/okra plant waste/ 0.5 and 1% Ag) nanocomposites respectively has non-ohmic in nature. This property is greatly useful in the fabrication of rectifiers and photodiodes[17].

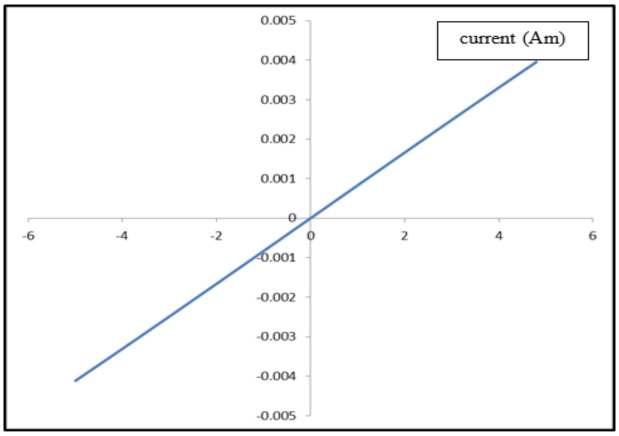

Figure (3A): Current-Voltage of okra plant.

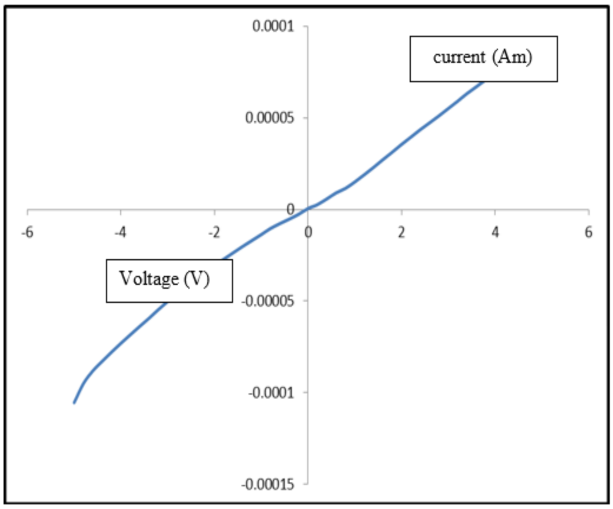

Figure (3B): Current-Voltage of PANI.

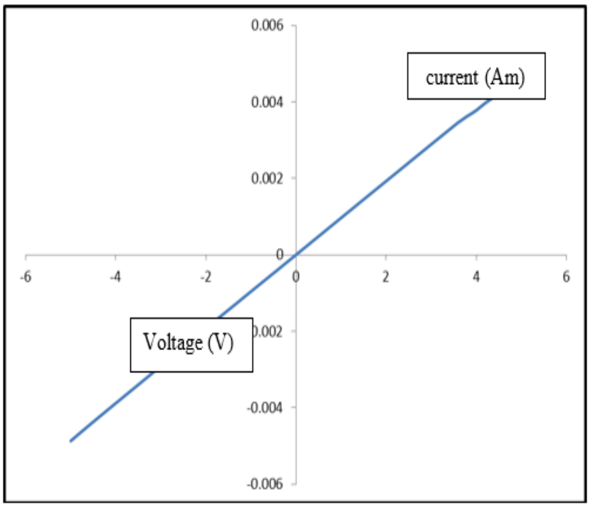

Figure (3C): Current-Voltage of (PANI/ okra plant waste) blend.

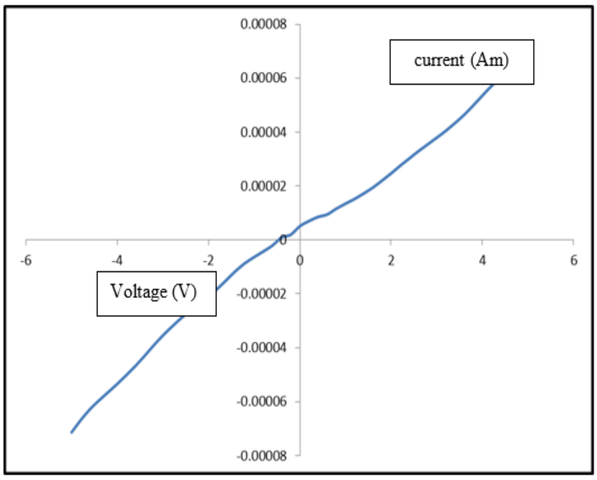

Figure (3D): Current-Voltage of (PANI/ okra plants waste/0.5% Ag) nanocomposites.

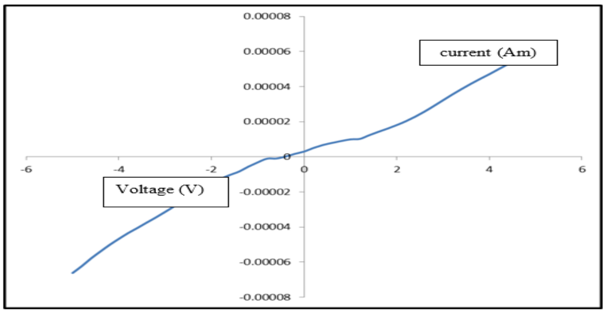

Figure (3E): Current-Voltage of (PANI/okra plants waste / 1% Ag) nanocomposite.

DC-Electrical Conductivity

Figure (4) show the DC electrical conductivity for each of (PANI/okra plant waste) blend and (PANI/okra plant waste/Ag) nanocomposites measured by Keithley electrometer type 2400. Where this Figure shows the effect of the okra plant on the electrical conductivity values in the temperature range (20 – 110) ^{o}C for a of samples prepared. The results indicate that the electrical conductivity of the (PANI/okra plant waste) blend is higher than that of the (PANI/okra plant waste/Ag) nanocomposite. The electrical conductivity depends mainly on the temperature, which increases with increasing temperature to increase the number of charge carriers, from the above results we can conclude that the mobility mechanism is responsible for increasing the electrical conductivity [18].
Thus, the electrical conductivity of the prepared samples can be found through the following relationship [19]:

$\sigma_{Dc} = 1/\rho$

ρ is the specific resistance of the material

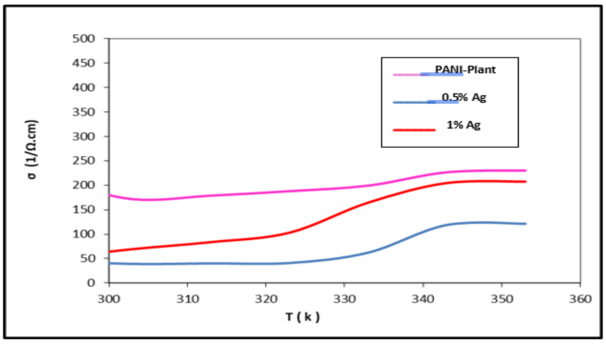

Figure (4): Variation of (DC) conductivity with temperature of (PANI/ okra plant waste) and nanocomposites.

5. Conclusion

we have synthesized (PANI/okra plant waste) blend and (PANI/okra plant waste/Ag) nanocomposites by thin film method using spin coting. nanocomposites were prepared with Ag nanoparticles added to the (PANI/okra plant waste) blend at different weights (0.5% and1%). From AFM image it was observed that a well-dispersed plant and homogeneous in (PANI/okra plant waste) blend and nanocomposites, The results confirm that these okra plant fibres show potential as reinforcement in polymer matrix blend. All prepared samples showed ohmic behavior. D.C electrical conductivities of (PANI/okra plant waste) blend and (PANI/okra plant waste/Ag) nanocomposites were studied as a function of okra plant content of films, and the conductivity increased with okra plant content, furthermore the okra plant was found to be a more effective than Ag nanoparticals and effective reducing agent. The (PANI/okra plant waste) blend exhibit remarkable improvement of electrical conductivity when compared with nanocomposites. So, this is a simple way by which electrical properties of other conductive polymers may be enhanced by using okra plant. It can be concluded that with systematic and persistent research there will be good scope and better future for the electric properties of natural fiber reinforced conductive polymer composites for suitable electrical applications.

References

Salih.R.A,(2008), "Preparation of Poly aniline-poly vinyl alcohol (PAni/PVA (by chemical method and Study of its some Electrical Conductivity", Basrah journal of science, Vol. 26, No. 1, PP.1-14
Shawai.A. S and Essa. A. F, (2021), "Preparation and study of the structural and optical properties for polyaniline/Cu nanocomposite", Materials Today: Proceedings, Vol. 45, PP. 5804-5808.
Alkhayatt. A. H, A. H. Al-Azzawi and Z. Alakayashi, (2016), "Rheological and optical characterization of polyvinyl pyrrolidone (PVP)-polyethylene glycol (PEG) polymer blends", IOSR Journal of Applied Physics, Vol. 8, No.1, PP. 11-18.
Pathania.D and Singh. D, (2009), "A review on electrical properties of fiber reinforced polymer composites", International journal of theoretical & applied sciences, Vol. 1, No. 2, PP. 34-37.
Mahmud. S, Hasan, K. M, Jahid. M, Mohiuddin. K, Zhang. R, and Zhu. J, (2021),"Comprehensive review on plant fiber-reinforced polymeric biocomposites", Journal of materials science, Vol. 56, No. 12, PP. 7231-7264.
Afzal. B, Akhtar.M. J, Nadeem. M, Ahmad.M, Hassan. M. M, Yasin.T and Mehmood.M, (2009),"Structural and electrical properties of polyaniline/silver nanocomposites", Journal of Physics D: Applied Physics, Vol. 42, No.1, pp. 015411.
Pathania. D and Singh.D, (2009)," A review on electrical properties of fiber reinforced polymer composites", International journal of theoretical & applied sciences, Vol. 1, No. 2, pp. 34-37.
Mahmud.S, Hasan.K. F, Jahid. M. A, Mohiuddin. K, Zhang.R and Zhu. J, (2021), "Comprehensive review on plant fiber-reinforced polymeric biocomposites", Journal of Materials Science, Vol. 56, pp. 7231–7264.
Fortunati.E, Puglia.D, Monti.M, Santulli.C, Maniruzzaman. M and Kenny. J. M, (2013)," Cellulose nanocrystals extracted from okra fibers in PVA nanocomposites", Journal of Applied Polymer Science, Vol. 128, No. 5, pp. 3220-3230.
Gholampour.A and Ozbakkaloglu.T, (2020), "A review of natural fiber composites: Properties,

modification and processing techniques, characterization, applications", Journal of Materials Science, Vol. 55, No. 3, pp.829-892.

Cisneros-López.E.O, González-López.M.E,Pérez-Fonseca.A.A, González-Núñez.R, Rodrigue.D, Robledo-Ortíz.J.R, (2017), "Effect of fiber content and surface treatment on the mechanical properties of natural fiber composites produced by rotomolding", Composite Interfaces, Vol. 24, No. 1, pp. 35-53.

Abdullah. E. T, R. S. Ahmed, Hassan.S. M and Naje.A. N, " Synthesis and characterization of PANI and polyaniline/multi walled carbon nanotube composite," Int. J. Application or Innovation Eng. Mgt, Vol. 4, No. 9, pp. 130-134, 2015.

Gawri.I, Khatta. S, Singh.K. P and Tripathi.S. K,(2016), "Synthesis and characterization of polyaniline as emeraldine salt", In AIP Conference Proceedings ,Vol. 1728, No. 1, p. 020287.

Pengxia. L, Yong.Z, Fangfang.L, Guomin.L, Xuemin.D, Xiangling.J, Zhixin.D and Xuepeng.Q, (2016), "Fabrication of polyaniline/polyimide composite fibers with electrically conductive properties", Applied Surface Science, Vol. 367, pp.335-341.

Karthikeyan. R, Sridhar.R and Suresh. R, (2018), "Synthesis and analysis of polyaniline coated Natural/Synthetic Fiber composites for gas sensor application”, International Journal of Applied Engineering Research, Vol. 13, No.1, pp.149-156.

Aneeqa. M, Zahid.S,Zunaira.Y,Maham.S, M. F.I, Rehman.A. R, Sultana .I and Aamir.R, (2019), "High capacity natural fiber coated conductive and electroactive composite papers electrode for energy storage applications", Journal of Applied Polymer Science, Vol. 136, No. 13, p.47282.

Srinivas.C. H, Srinivasu. D, Kavitha.B, Narsimlu. N and Kumar. K. S, (2012), "Synthesis and characterization of nano size conducting polyaniline" ,IOSR J Appl Phys, Vol. 1, No.5, pp. 12-15.

Safenaz. M. R and Sheikha. M, (2012), "Synthesis and electrical properties of polyaniline composite with silver nanoparticles”, Advances in materials Physics and Chemistry, Vol. 2, pp. 75-81.

A. Cullis, L. Canham, and P. Calcott, "The structural and luminescence properties of porous silicon," Journal of applied physics, vol. 82, pp. 909-965, 1997.