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Growth and Optical Properties of Un-Doped and Bamboo Doped Tin (II) Oxide

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***Abstract*— In this research work, we studied the optical properties of Tin (II) oxide doped with Bamboo Stem extract. Tin (II) oxide was grown by reacting some quantities of aqueous Tin chloride and aqueous sodium Hydroxide and allowed to deposit on a glass slide using chemical bath technique. Bamboo stem wasgrinded and dissolved in distilled water, stirred, and sieved to remove theundissolved parts of the dopant.Samples B1 was un-doped, B2 was doped with 0.2 ml of bamboo extract, B3doped with 0.3 ml of bamboo extract, B4 doped with 0.4 ml and B5doped with 0.5 ml.Optical properties of the samples were determined. Results showed that the peaks of bamboo doped Tin (II) oxideoccurred at angles of 22o, 27o, 31o, 35o, 45 o, 55 o, at 2 • with light intensities of 220, 400, 630, 490, 200, 110 counts respectively. The introduction of impurities of Bamboo stem extract to Tin (II) Oxide increased the band gap. The band gap ranged from 3.8 to 3.9. The samples can be used in making of antireflective coating, mirrors, transparent glasses and in high temperature/high power devices.**

***Index Terms*— Thin II Oxide, Bamboo doped, Optical Property and Band gap.**

I. Introduction

A. Thin Film

Thin film technology does exciting things in the development of solid state electronics. Crystal growth is an interdisciplinary subject covering physics, chemistry, materials science and chemical engineering, etc. In the past few decades, there has been a growing interest on crystal growth processes and doping technology so as toincrease the demand for materials for technological applications (Ufere et-al., 2016). A material is said to be a thin film when it is built up as a thin layer on a substrate by controlled condensation of the individual atomic, molecular or ionic species either directly by a physical process or through a chemical or electrochemical reaction otherwise, it is a thick film (Ezema, 2004).In solar energy conversion, thin films less than 100 nm in thickness are now serving as antireflection coatings on solar energy collectors. Semitransparent metal films are used in schottky barrier solar cells, combinations of thin films are used for photo thermal devices that generate low or high grade heat and thin semiconductor films on metal or glass substrate form a promising type of low cost solar cells (Uhuegbu, 2010).

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B. Tin (II) Oxide (SnO)

Tin (II) oxide or stannous oxide is a compound with the formula SnO. It is composed of tin and oxygen where tin has the oxidation state of +2. There are of two forms; stable blue-black form and metastable red form (Zumdahl, 2009; World Health Organization, 2005).It has a tetragonal structure. It is predominantly used as a precursor in the manufacturing of other tin compounds or salts and as a reducing agent and in the creation of ruby glass. Cerium (III) oxide in ceramic form, together with Tin (II) oxide (SnO) is used for illumination with UV light, (Peplinski D.R. et-al., 1980).

C. Bamboo

Bamboos are evergreen perennial flowering plants in the subfamilyBambusoideae of the grass family Poaceae. (Kelchner, 2013; Soreng et al., 2015).It is hollow in the internodal regions of the stemand the vascular bundles in the cross-section are scattered throughout the stem instead of in a cylindrical arrangement. It has nodicotyledonouswoodyxylem. It is the absence of secondary growth wood that causes the stems of monocots, including the palms and large bamboos, to be columnar rather than tapering (Farrelly, 1984). It is one of the fastest-growing plants in the world (Farrelly, 1984), because of its unique rhizome-dependent system. Certain species of bamboo can grow 910 mm (36 in) within a 24-hour period, at a rate of almost 40 mm (1.6 in) an hour. This implies a growth around 1 mm every 90 seconds, or 1 inch every 40 minutes. Giant bamboos are the largest members of the grass family (Guinness World Records, 2014). Chemical analysis proved that bamboo has about 1.3% ash, 4.6% ethanol-toluene, 26.1% lignin, 49.7% cellulose, (Okpala, 2013). It has a higher specificcompressive strength than wood, brick or concrete, and a specific tensile strength that rivals steel (Roach, 1996; Rottke, 2002). It can be applied in many areas like; the construction of yam bang. (Lakkad, 1981; Landler, 2002; Nancy and Bibi, 1987; Michelle, 2009), bridges, as fuel, musical instruments and weapons, etc. It was the only plant that survived the radiation of atomic bomb in Hiroshima in 1945, (Okpala, 2013).

D. Experimental details

Preparation of Bamboo Stem Extract

Fresh bamboo stem was obtained from a nearby bush dried, cut into small pieces then gradually crushed with manual grinding machine. The grinded particles were dissolved into 100 cm^3 beaker of distilled water and stirred vigorously. The mixture was sieved to remove the undissolved particles.

Growth of un-doped and bamboo doped Tin (II) Oxide (SnO) films

40 ml of tin (II) oxide chloride was mixed with 20 ml of sodium hydroxide to produce tin oxide as a byproduct.

$$SnCl_2(aq) + 2NaOH(aq) \rightarrow SnO(aq) + 2NaCl\ (aq) + H_2O\ (l) \quad (3.2)$$

The mixture was placed in a magnetic stirrer at temperature of 60°C for 20 minutes. After which glass slides were immersed into the beaker containing the sample for 24 hours to allow deposition of tin (II) oxide to take place. Analytical grade glass slides were boiled in concentrated chromic acid for 30 minutes and rinsed in deionized water. Samples B1 was un-doped,B_2 was doped 0.2 ml of bamboo extract, B_3 was doped with 0.3 ml of bamboo extract, B_4 was doped with 0.4 ml and B_5 was doped with 0.5 ml.

Table 1.1: The Summary of Experiment Conducted with Tin (II) Oxide and Bamboo Stem Extract

Sampl e	$SnCl_2$ (aq)	NaOH (aq)	Bamboo stem extract
B_1	40ml	20ml	Nil
B_2	40ml	20 ml	0.2 ml
B_3	40 ml	20 ml	0.3 ml
B_4	40 ml	20 ml	0.4 ml
B_5	40 ml	20 ml	0.5 ml

II. RESULTS AND DISCUSSIONS

Optical studies of the un-doped and bamboo doped tin II oxide films grown through chemical bath deposition were done using StellarNet UV-VIS-NIR spectrophotometer operating at a wavelength range of 300 nm-900 nm. The samples were B_1 for un-doped Tin (II) Oxide, B_2 for 0.2 ml, B_3 for 0.3 ml, B_4 for 0.4 ml and B_5 for 0.5 ml of Bamboo Stem Extract.

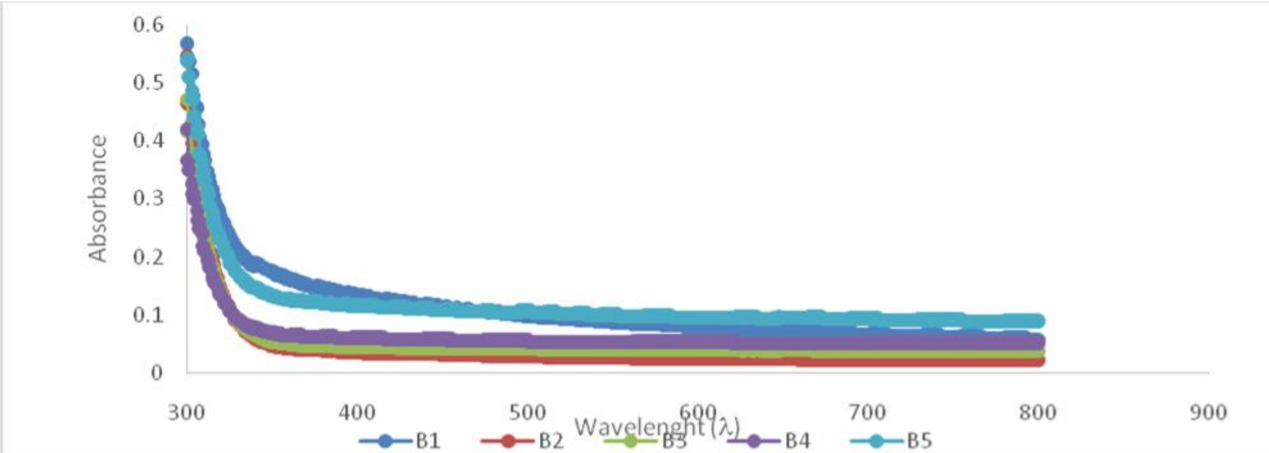

Figure 2.1: Absorbance against Wavelength

In Figure 2.1, absorbance decreased with increased wavelength. Sample B_1wasun-doped tin (II) oxide;the peak absorbance value was 0.55 at wavelength of 300.00 nm and decreased towards the infrared region. Sample B_2 is Tin (II) oxide doped with0.3mL of bamboo; the peak absorbance value was 0.5 at 300 nm and decreased towards the infrared. For sample B_3,the peak value of absorbance was 0.40 at wavelength of 300 nm and decreased towards the infrared. Sample B_4, had absorbance of 0.45 at wavelength of 300 nm and decreased towards the infra-red. Sample B_5 had the highestabsorbance but decreased towards the infra-red.

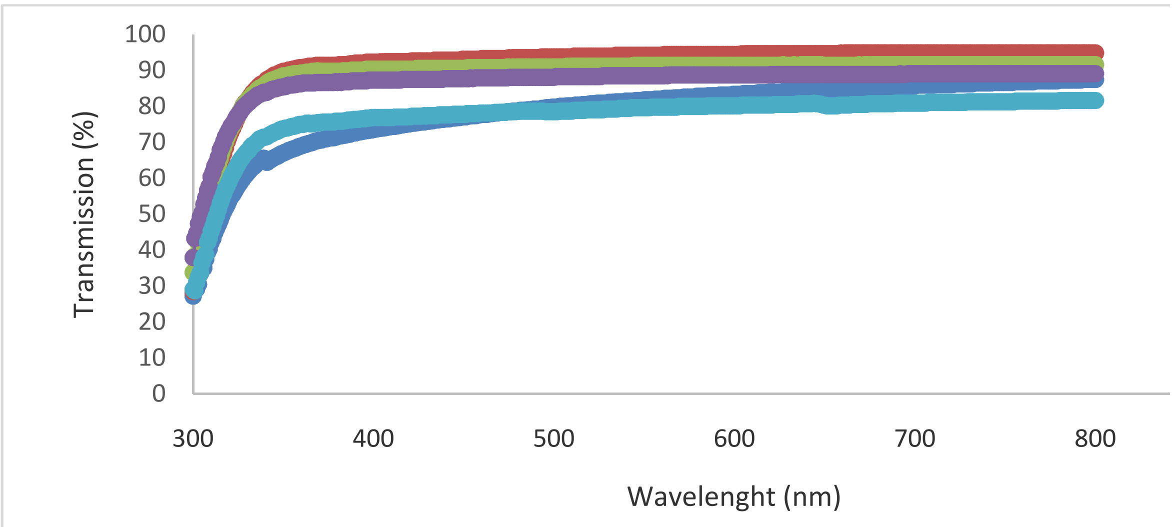

Figure 2.2:Transmittance (%) against wavelength

The transmittance of the samples; B_1, B_2, B_3, B_4, and B_5 increased with increased wavelength. The transmittance for

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sample $B_1$was low between 300-350 nm and increased towards the infrared region. The transmittance for sample B_2 was low between 300-350 nmand increased towards the infrared. It has the highest transmittance between of 60% to 90% from 350 to 900 nm. Sample B_3 had low transmittance from 300-350 nm and maintained a steady transmittance of 90% from 350-900 nm. Sample B_4 had low from 300-350 nm and had a steady transmittance of 89% up to 900nm. Sample B_5had low transmittance from 300-350 nm and became steady up to 450 nm before it had a small increment to 900 nm.It had the least transmittance. All the samples have very high transmittance from visible to the infrared regions and as such are good materials for poultry and solar energy applications, (Okpala V. Uche., et-al., 2012).

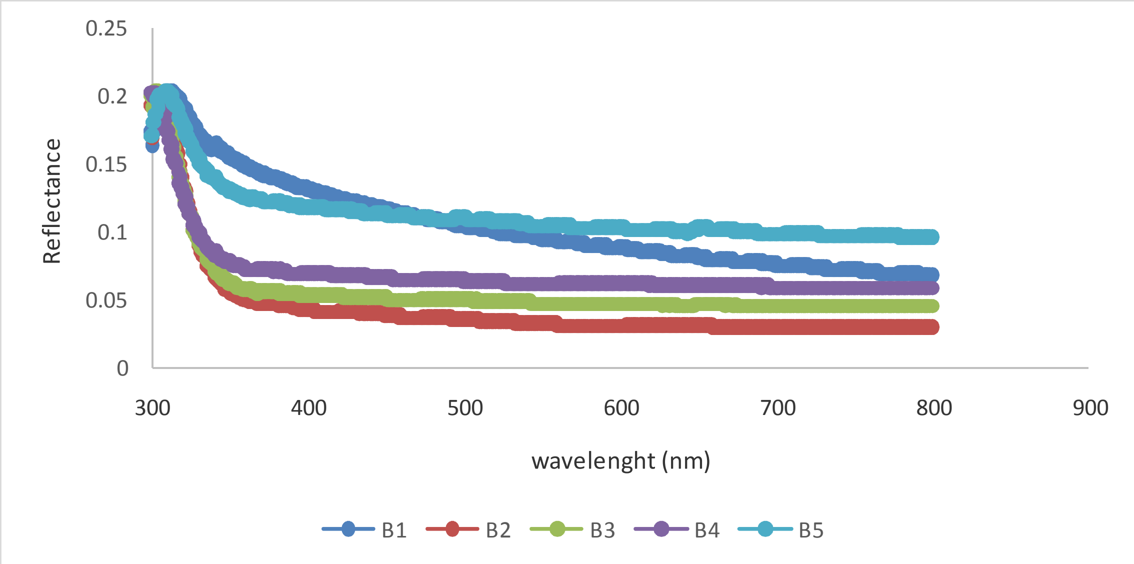

Figure 2.3: Reflectance for Samples B1 to B5

The samples had their peak reflectance little above 0.2 at wavelength of 300nm. Least reflectance for sample B1 was little above 0.05 at wavelength of 800 nm. There was least reflectance for B2 below 0.05 at 800 nm. Sample B3 was 0.05 at 800 nm. B4 was little above 0.05 at 800nm. Least reflectance for sample B5 was 0.1 at wavelength of 800 nm. The reflectance of the sample was not high, high reflectance was I00 percent so it can be used in antireflective coating, (Edmund, 2007).

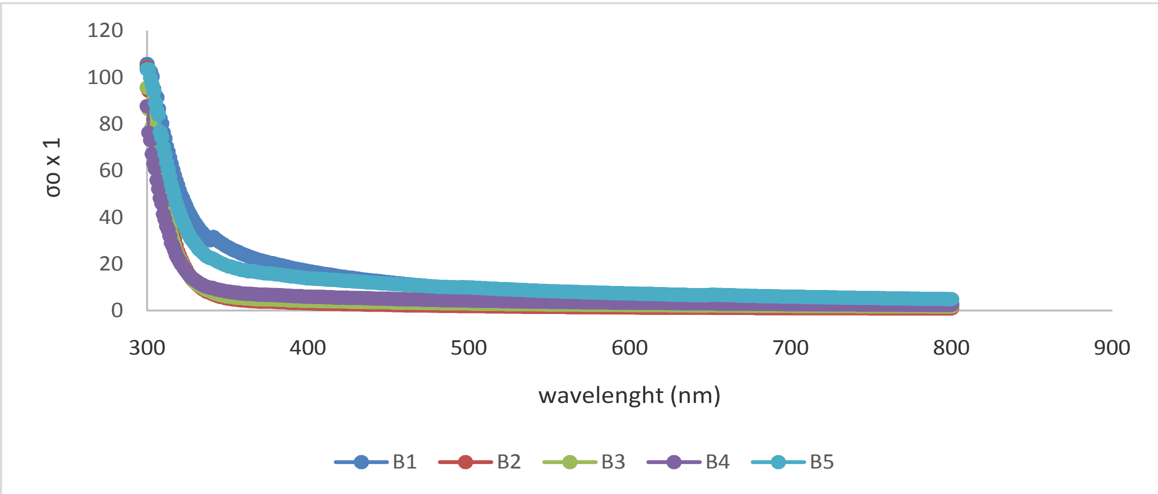

Figure 2.4: Optical conductivity against wavelength

Optical conductivity decreased with increased wavelength. All the samples had peaks above I00 at 300 nm. Sample B5 had the highest reflectance. The blue line was for sample B1 (un-doped Tin (II) Oxide), red line was for sample B2, the green line for sample B3, purple line was for sample B4, while the light blue was for sample B5.

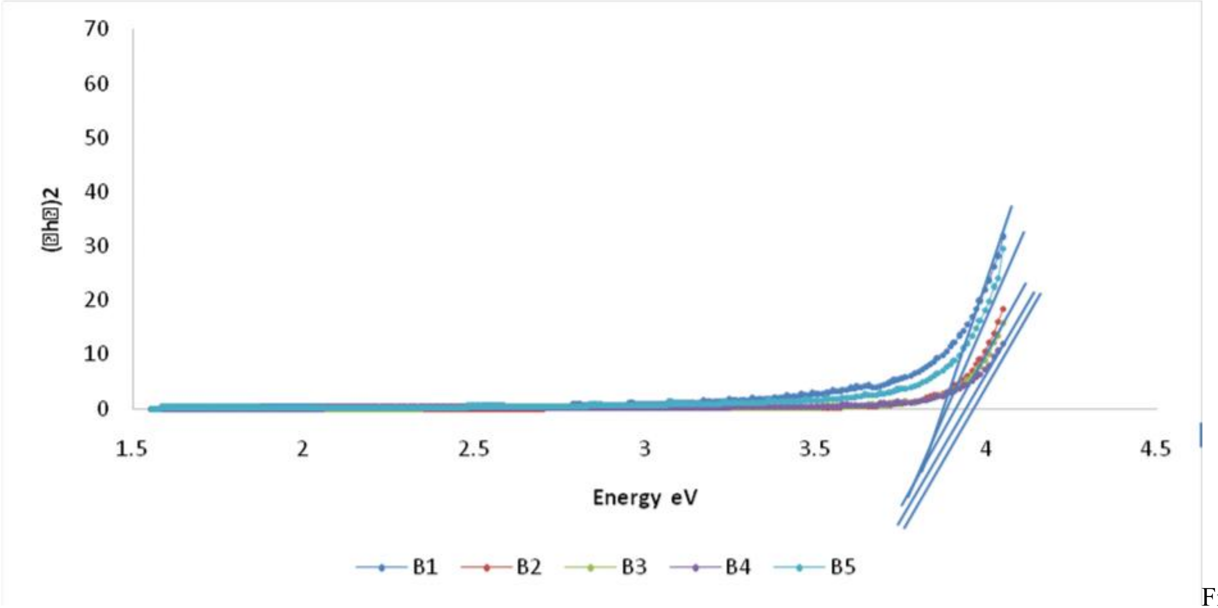

Figure 2.5: Energy Band Gap for Samples B1 to B5

Figure 2.5 shows that energy of absorption coefficient $(\alpha h\upsilon)^2$ was moving linearly with photon energy until at 3.5eV where it started to increase with increasing photon energy. The energy band gap which indicated the electrical conductivity of materials were between 3.8 – 3.9 eV which showed that the samples were semiconductors. Increase in band gaps were observed due to the presence of bamboo impurities. The materials were of wide band gap as such can be used in high temperature materials (Okpala et-al., 2012; E.N. Ufere et-al., 2016). It also made it possible to use the materials in making electronic components such as diodes, transistors and also in the fabrication of electronic devices and building of logic gate (Yoshikawa, 2007).

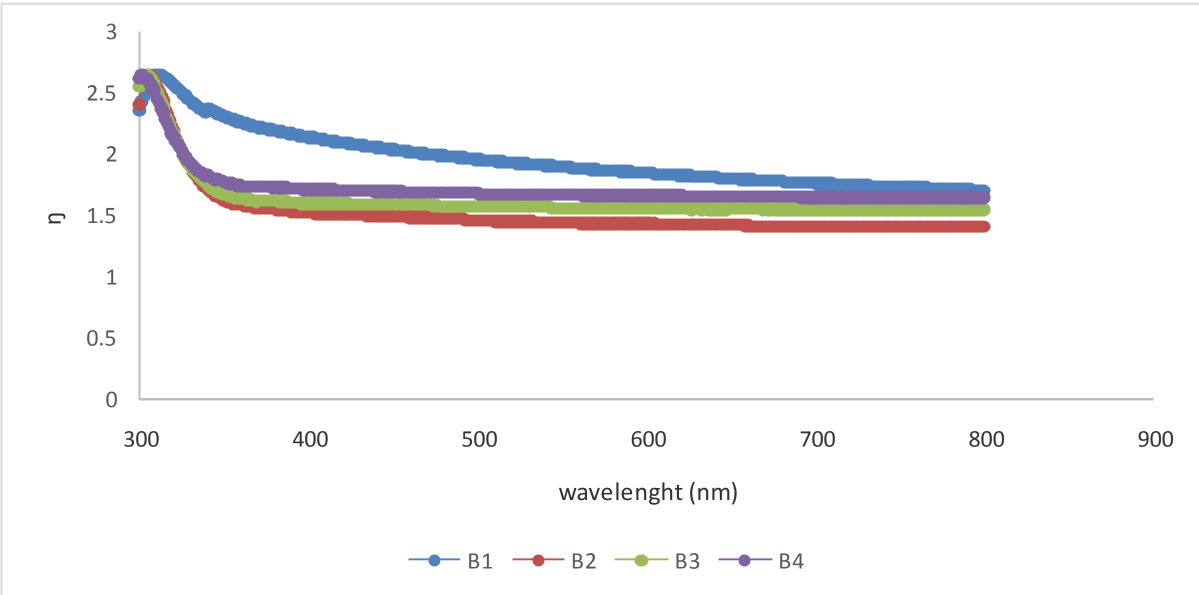

Figure 2.6: Refractive Index for Samples B1 to B5

In Figure 2.6, the refractive index was decreasing with increasing wavelength with peak little above 2.5 of refractive index at wavelength of 300nm. Sample B5 started increasing above 2.0 until above 2.5 of refractive index where it started decreasing. It could be applied in making lens, optical circuits and fibre, antireflective films and coating, waveguide etc (Hun-Ju Yen and Guey-Sheng Liou, 2010).

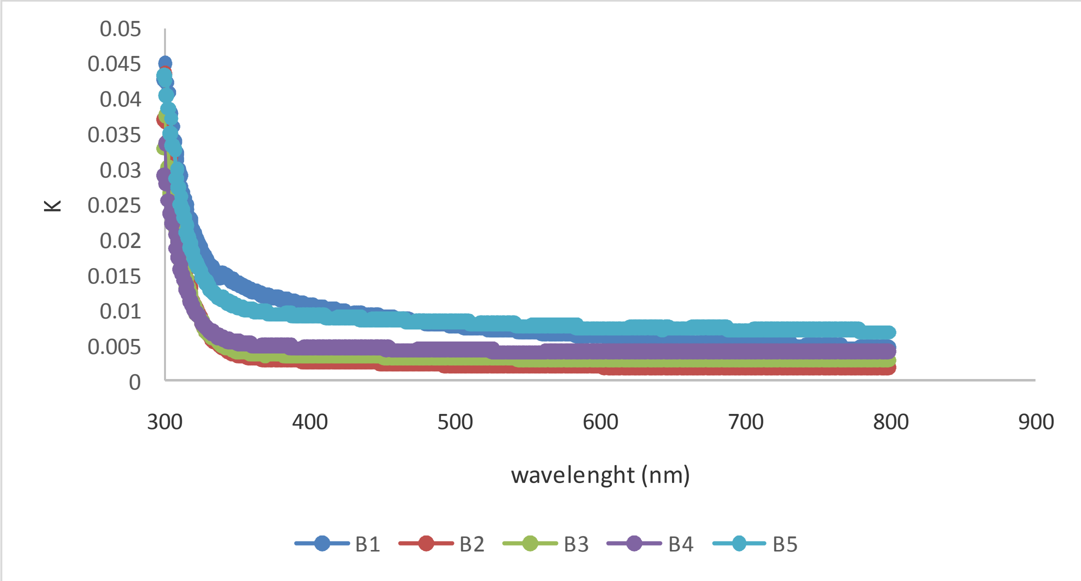

Figure 2.7: Extinction Coefficient for Samples B_1 to B_5

In Figure 2.7, the extinction coefficient k was decreasing with increasing wavelength. The peak of the graph is at 0.0045 of extinction coefficient at wavelength of 300 nm. Sample B1 has least extinction coefficient of 0.01 at wavelength of 350 nm. Sample B2 had least extinction coefficient below 0.05 at wavelength of 350 nm. Sample B3 has least extinction coefficient below 0.005 at wavelength of 350 nm. Sample B4 has extinction coefficient of 0.05 at wavelength of 350 nm. Sample B5 has least extinction coefficient of 0.01 at wavelength of 350 nm. We observed that the samples had very low extinction coefficient which implies that they cannot absorb much rays of light. They were suspected to be transparent materials and can be applied in making of transparent glasses, ceramics, plano optics line windows, mirrors, lenses and as a polarizer. (Hunju-Yen and GueySheng Lion, 2010).

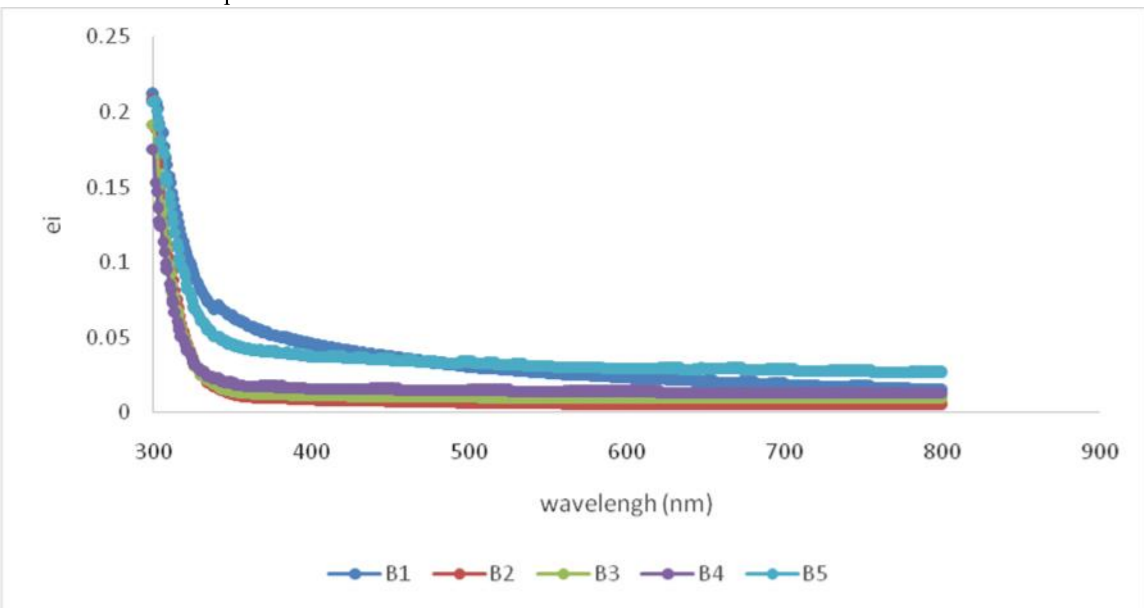

Figure 2.8: Imaginary Dielectric Constant for Samples B_1 to B_5

In figure 2.8, the imaginary dielectric constant decreased with increasing wavelength. The peak of the graphs were above 0.2 percent at wavelength of 300nm. High dielectric constant are used making capacitors while low dielectric constants were used to provide insulations between conductors to reduce loss. The higher the dielectric constant, the larger the energy of the capacitor (Alfredo, 2005).

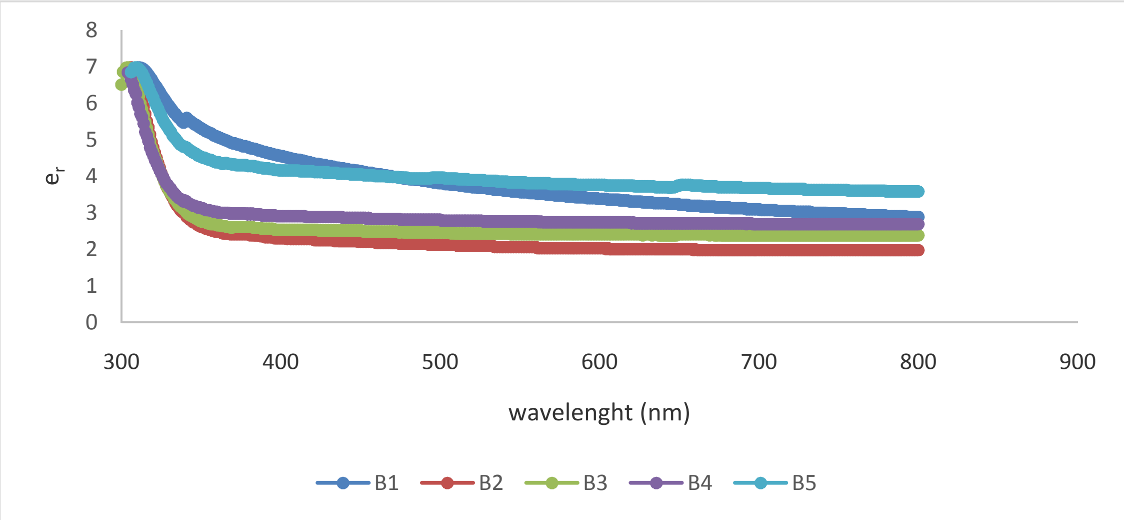

Figure 2.9: Real Dielectric Constant for Samples B_1 to B_5

In Figure 2.9, the graphs were at 7 percent of real dielectric constant at wavelength of 300 nm. The graph showed that real dielectric constant decreased with increasing wavelength. High dielectric constant materials were used in making capacitors while low dielectric constants are used to provide insulations between conductors. The higher the dielectric constant, the larger the energy of the capacitor (Alfredo, 2005).

III. Conclusion

UV spectrometer result for optical characterization showed thatthe samples were highly transmittancefrom the visible to near infra-red regions and as such are good for poultry and solar energy applications, (Okpala V. Uche., et-al., 2012). The presence of bamboo in Tin (II) oxide decreased the rate of absorption and increased the percentage transmittance of light spectrum of tin oxide. From this analysis, the sample can absorb light spectrum of low wavelength. This sample can be used as an antireflective coating and in dulling of light spectrum (Edmund, 2001).Introduction of impurities of bamboo stem extracts to Tin (II) oxide increased the band gap. This implies that the materials are of wide band gaps and can be used in making electronic components such as LEDs and lasers, military radars, transistors, diode etc., (Yoshikawa, 2007). SamplesB5 showed high refractive index and as such can be used in making lenses, optical fibre, antireflective films and coatings, wave guide (Hung-Ju Yen and Guey-Shenglion, 2010).

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