A STUDY OF VARIATION IN THERMOELECTRIC CHARACTERISTIC OF BI_2TE_3-PANI UNDER THE INFLUENCE OF VARIOUS AMOUNT OF SELENIUM DOPING

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Abstract. *The electrical conductivity of Polyaniline (PANI) increased immediately with the increase in temperature (the electrical conductivity value of 28 ° C is 0.21 w / cm) cm. Seebeck coefficient decreases with decreasing temperature. Together these two properties indicate that PANI can be used as a P-type semiconductor polymer material and a thermoelectric (TE) material. There is great interest in thermoelectric materials for energy production and storage, and in many cases, including thermal formulations, tellurium is very attractive. To get a clear understanding of this we choose bismuth telluride. Combined with the PANI, the telluride induced (Bi_2Te_3-PANI) exhibits internal thermoelectric properties at room temperature that can be used as any thermoelectric component. Although the electrical parameters and conductors of Seebeck are may be considered unsatisfactory for Bi_2Te_3-PANI. To solve these problems, we modified the entire formulation with different amounts of selenium and attempted to understand the changes in the thermoelectric properties (TE) of Bi_2Te_3-PANI.*

Keyworks: *Bi_2Te_3-PANI, Thermoelectric property, Doping.*

1.INTRODUCTION

The state of energy production and use is an undeniable problem today; Fossil fuel-based energy production needs to be replaced by green, non-polluting methods [1]. Even when these energy sources cannot be replaced, increased efficiency is of paramount importance in both production and use. Thermal electricity (TE) provides a method for exploring both energy production and energy efficiency. By reducing the efficiency due to lower heat loss, the thermoelectricity can be used either as direct power generators or as the thermoelectric or used to increase the efficiency of other established methods [2]. Whether small or large in size, thermoelectricity provides a solid and solid state method for converting heat energy into electrical energy, and it is easy to use and transport [3].

Due to their amazing internal thermoelectric properties at ambient room temperatures, Bismuth telluride (Bi_2Te_3) thin films have been studied in depth by several research teams [4]. To increase the TE property of bismuth telluride, the scientists modified a variety of factors, including chemical composition, crystal phase, crystallization, charge carrier concentration, and steroids [5].

The efficiency of a substance after the thermoelectric conversion can be measured using thermoelectric figure of merit ZT, defined as (σS^2) T⁄κ (where T = absolute temperature and σ = total thermal conductivity) . During maintenance of optimum σ value, the increased S increases the power factor (σS^2), is a key approach for achieving high efficiency thermoelectric materials [6].

One strategy to achieve this is to manufacture inorganic biological formulas. So far, researchers have discovered inorganic organic compounds such as poly (3,4-ethylenedioxythiophene): poly(4-styrenesulfonate) (PEDOT:PSS)/graphene PEDOT: PSS/Te nanorods, PEDOT: PSS/Sb_2Te_3, PEDOT: PSS/PbTe, PEDOT: PSS/Bi_2Te_3, PEDOT: PSS/Ge, P_3HT/Bi_2Te_3, and Polyaniline (PANI)/carbon nanotubes (CNTs) to achieve high-energy components [7]. Among the conductive organic polymers, PEDOT: PSS has relatively high stability and environment. Although PEDOT: PSS value is slightly lower than that of inorganic materials, it is relatively non-toxic, abundant and low which will provide higher ZT phase and liquid organic polymers [8].

The mixture is then poured at a formal level before the electrothermal properties are measured. In this case, the thermoelectric properties of the compounds (S and σ) are described according to the filtration effect by the inorganic bio-method.

Here in this research work, we have used pure PANI and Bismuth telluride to produce a composite of Bi_2Te_3-PANI. The thermoelectric behavior of the above mentioned composite and observation shows an increased rate of electrical conductivity in compare to pure PANI. Then we have doped the composite using different amount of Selenium to further increase the rate of conductivity. Hence we can have a good TE material.

2.EXPERIMENTAL METHODOLOGY

2.1. Pure polyaniline polymer (PANI) synthesis

Chemical oxidative method was used for the production of PANI. In acidic aqueous medium Aniline was oxidized with ammonium persulphate [9] after which it was dissolved in double distilled water and HCl separately. The solvents are then mixed thoroughly at room temperature. The mixture was then stirred for one hour and kept for polymerization. Filter paper was used to collect the PANI precipitate following which the precipitate was using HCl, distilled water, and methanol respectively. The PANI powder was then dried in vacuum. The Bi_2Te_3 are purchased in the powder form from Sigma company with 99.99% purity.

2.2 Bi_2Te3-PANI synthesis

The nanocomposites were prepared in order from the liquefied. The aniline solution was mixed Bismuth telluride which was followed by constant stirring for 30 min. This resulted in the change of color of the solution to blackish. After that APS was added as an oxidant followed by stirring of the mixture at temperature range of 0^0C and 5^0C for 6 h for the polymerization to take place. The mixture was then vacuum dried at 5^0C for 24 hours in an oven. The resultant precipitate that was obtained was blackish green color PANI-Bi_2Te_3 nanocomposite [11].

2.3 Se Doping

Se displays photovoltaic properties, where light is transformed straightly into electricity and we get photoconductive action in which electrical resistance reduces with increased illumination. Selenium a doped polymers show extensive properties as superconductors [4].

In this research and paper, we have doped Bi_2Te3-PANI with different concentrations of the synthetic selenium (5%, 10%, 15% and 20%). Selenium dissolved in chloroform is added to the swollen vessel (swollen with the effect of the solvent) and stirred for 24 hours at room temperature in different proportions. Dry the anesthetic mixture and then finally grind to form the sample.

3. CHARACTERIZATION

The electrical conductivity of these samples is measured at temperature of 300-450 K. The samples were placed between two steel electrodes, located inside the metal sample container to measure the conductivity. To avoid the effect of moisture absorption, samples were annealed prior to the conductivity measurement at a vacuum of 10^{-3} Torr. Temperature measurements are performed by means of a cribble chromal alumel thermocol fixed near the samples. A voltage of 1.5V was applied (via a controlled DC source) to the samples and the resulting current was measured using a 6157A boiler electrometer. Thermal analysis was performed by a differential scanning calorimeter (Model - DSC Plus, Rheometric Scientific Co. UK).

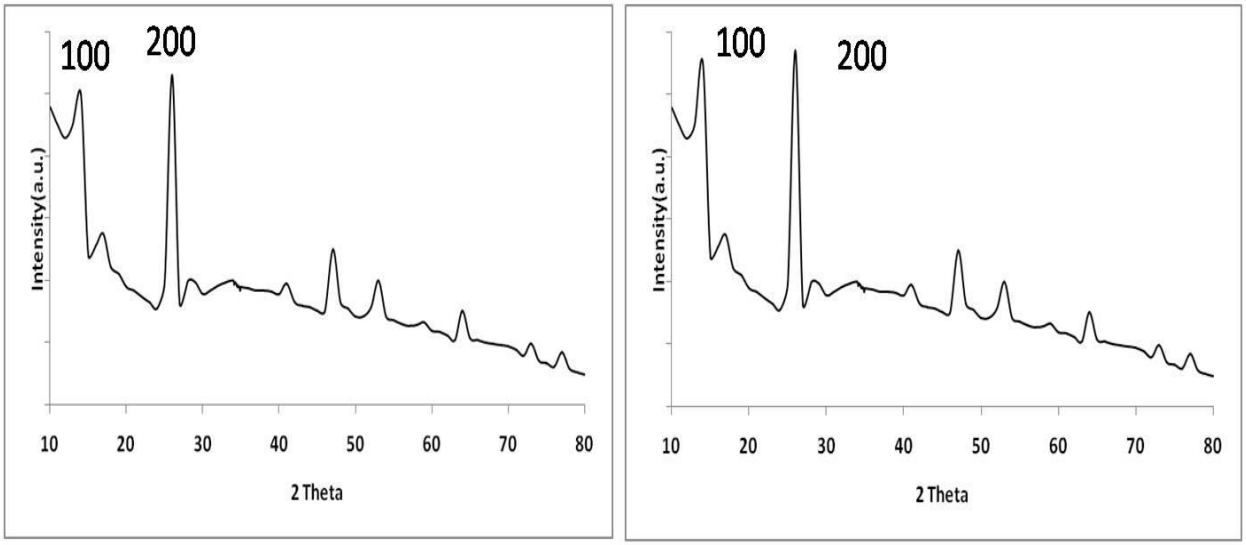
The accuracy of temperature for this device is ±1ºC. For undoped and Se doped Bi_2Te3-PANI samples DSC scans were taken at 10ºC/min heating rates. The temperature in the DSC ranged from 36°C to 180°C. In order to endure UV visible absorption profiles the polymer was dissolved in chloroform. The Compaq M-550 dual-beam scan was used for the visible UV spectrum. Sample morphology was studied using a Scanning electron microscopy (SEM) using a JOL JSM 6380 SEM at 10 KV. FTIR spectra from doped and unplanned PANI-KBR granules with Parkinelma were obtained from in quantities ranging from 400 to 4000 cm^{-1} with a resolution of 4 cm^{-1}.

4. RESULTS AND DISCUSSIONS

For Fig.1, XRD patterns are shown for Bi_2Te_3-PANI and 5% Se doped Bi_2Te_3-PANI. The units associated to Bi_2Te_3-PANI pattern are evidently observable. Compared with the original manufacturer, the related single peak occurs in the same location which can be

clearly observed from the XRD pattern of Bi_2Te_3-PANI group. There has been correlation observed among single peak observations with the repeating unit of Bi_2Te_3 among the Doped Bi_2Te_3-PANI and Penny matrix. This specifies that Se doped Bi_2Te_3-PANI and Bi_2Te_3-PANI give rise to an well-ordered Bi_2Te_3molecular arrangement in a triple combination [12].

FTIR spectra of the unopened and doped Bi_2Te_3-PANI were found with different Se concentrations. Here we only show the 5% IR spectrum of the doped Polyaniline telluride in Fig.2.



A **B**

Source: Realized by author

Fig 1. (**A**) = XDR pattern of Bi_2Te_3-PANI and **(B)** = XDR pattern of 5% Se doped Bi_2Te_3-PANI

Counting doping did not observe Bi_2Te_3-PANI band split. Since it does not show specific absorption bands between 400 and 4000 cm^{-1} in the spectrum, it shows absorption only in the infrared range (400-200 cm^{-1}) [13], so the observed bands are compatible with Bi_2Te_3- PANI only. However, the inclusion of selenium in the polymer induces smaller shifts of some FTIR peaks in the pan. The intensity of the peaks follows the same pattern as shown by measuring the band gap as well as DC conductance.

There are five vibration bands for the Bi_2Te_3- PANI spectrum which are 1470-1510 (stretching vibration of benzene ring), approx 1300 (stretching vibration of CeN), 1560-1610 (stretching vibration of quinoid ring), approx 1140 (characteristic vibrational mode of quinoid ring) and 1–30 rotation (out-of-plane bending vibration of CeH on para-disubstituted rings)[14]. The same pattern of peaks was observed by Se doped Bi_2Te_3-PANI emeraldine base films [11].

Conductivity is a significant feature that exposes the significant and tenacious evidence regarding the transport occurrence and considerable properties of the substance.

The DC conductivity is expressed through the relation [15].

$$\sigma_{dc} = \sigma_o \exp(-\Delta E/k_b T) \quad (1)$$

where: ΔE is the activation energy,
σ_o is pre-exponential factor,
and k_b is the Boltzmann constant.

The straight line plot of σ_{dc} describes that conduction in Bi_2Te3-PANI is taking via an activated process with unique activation energy in the range of 300-450 K (Fig. 3). The slope of the graph can be used to determine the activation energy.

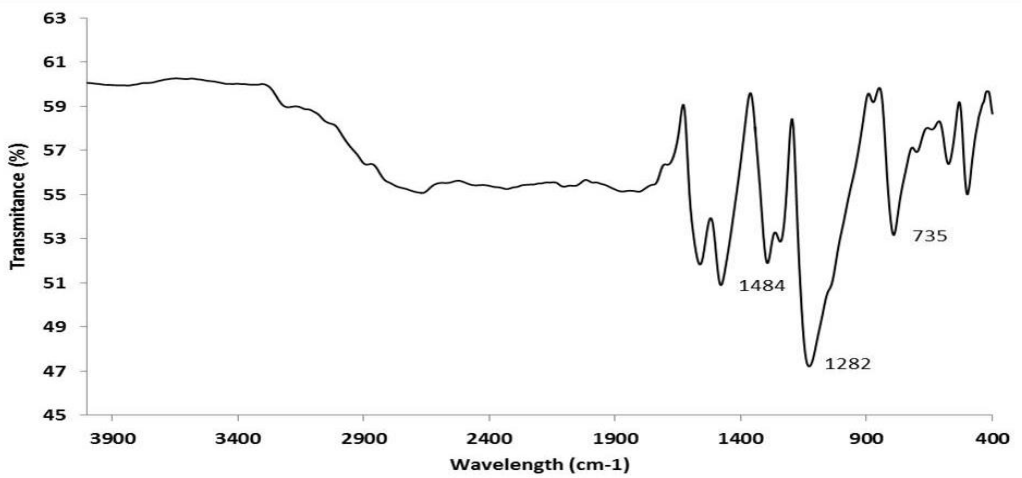


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Fig 2. FTIR spectra of 5% doped Bi_2Te_3-PANI nanocomposite

Figure 4 shows the DC conductivity density and activation capacity against the Dopant graph. It is evident from Fig. 3 that the conductivity increases with increasing the selenium concentration by up to 10% and decrease immediately by 15-20%. Conductivity increases in a sequence of three levels up to 5% of the anesthetized sample and decreases again with increasing density as the activation energy decreases. The increase in DC conductivity with a decrease in the activation strength appears to be related to the change in the Fermi level in the anesthetized samples. It is quite clear from activation energy that at the Fermi level the movement is along the carrier density.

The information from the ΔE isn't sufficient to understand this transmission in localized states. Other factors such as σ_o are also need to be studied in order to fully understand the phenomenon. Mott and Davis described that [16] the value of σ_o (10^3-10^4 Scm^{-1}) can be indicative of the phenomenon in extended states. A smaller value of σ_o signifies a hopping transmission. In this paper, it has been observed that the values of σ_o are small; indicating that the transmission followed the hopping procedure as a result of the presence of a large spectrum of local states in the sample.

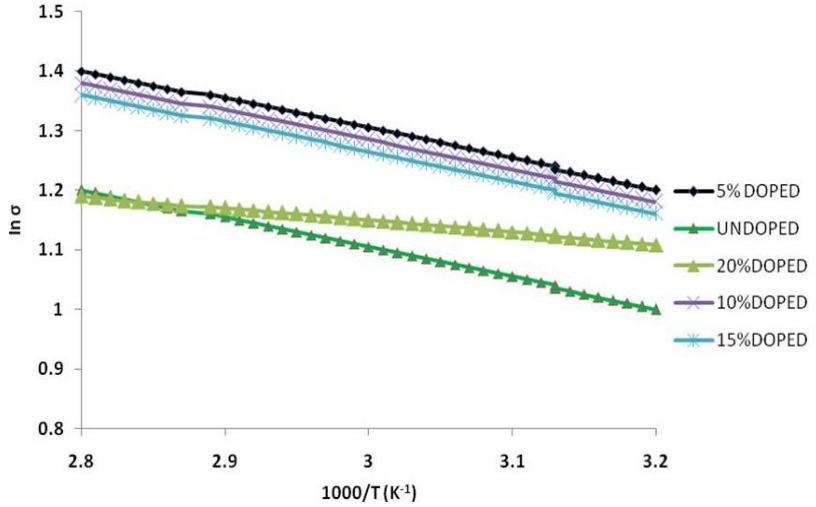

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Fig 3. Temperature dependence of DC conductivity with respect to temperature for undoped Bi_2Te3-PANI and Bi_2Te3-PANI doped with different concentrations of Se.

With the findings in the study it can be concluded that the transmission in the material is facilitated by hopping method as a result of which there is an increased conductivity of the Bi_2Te3-PANI [17]. A smaller σ_o value signifies that the thickness of defect states increases in the material which also agrees to the findings that transmission the Se doped Bi_2Te_3-PANI usually occurs by the hopping method.

The bipolarons and polarons configuration can be used to elucidate the mechanism of transmission [17]. Bipolarons and Polarons have an important role in defining the charge injection, transfer properties as well as optical properties of carrying out polymers. When Bi_2Te_3-PANI was doped with selenium, bipolaron, the production happens but with the highest dopant concentration, the conductivity does not amplify because of saturation of charges.

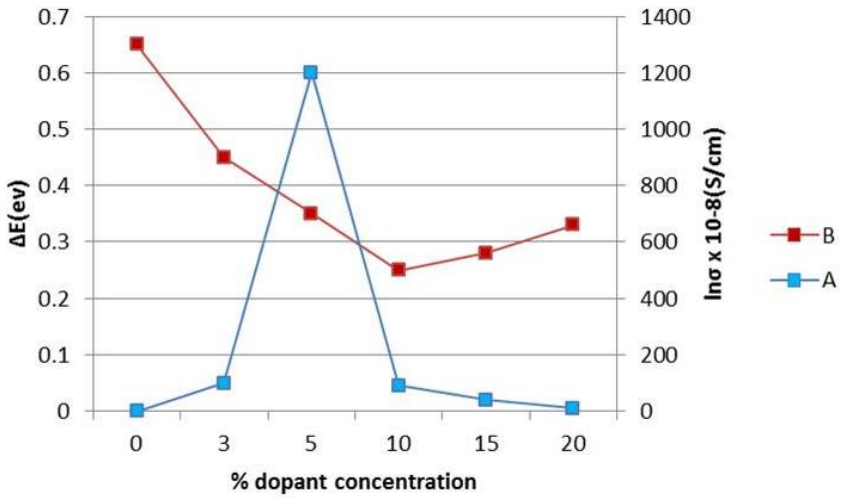

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Fig 4. Variation of DC conductivity (A) and Activation Energy (ΔE), (B) versus undoped Bi_2Te3-PANI and Bi_2Te3-PANI doped with different concentration of Se.

5. CONCLUSIONS

The semiconducting Bi_2Te_3-PANI has been successfully manufactured and doped with different density of Selenium. Three orders of raise in conductivity value of was observed following doping. The procedures of conduction have been clarified both on the basis of pre-exponential factor and bipolaron production. From temperature changes it is evident that there is an increase in ΔE initially with an increase in the density of Selenium which is followed by reduction in density. An association has been observed among the enthalpy released and the metastability of polymer [18].

FTIR spectra show the structural variation of Bi_2Te_3-PANI after doping of Se and also verify the merger of Se in polymer chain. The DC transitivity measurements show the Selenium doping amplifies the conductivity up to a specific density of Selenium and then it began to decrease. The substrate conductivity varies with Se. This is because the change of sample conductivity mainly depends on the carrier concentration, degree and carrier mobility. However, the carrier concentration is increased due to the Se doping leading to increased conductivity; but on the other hand, along with increase Se doping amount, the bulk sample grains gradually become smaller, which will introduce more grain boundaries inside the material, and increase carriers scattering, weaken the carrier mobility and as a result, the conductivity of the sample reduces.

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