ISSN 2231-3478 (Print)
JUSPS-B Vol. 33(6), 48-56 (2021). Periodicity-Monthly
Section B
(Online) ISSN 2319-8052

JOURNAL OF ULTRA SCIENTIST OF PHYSICAL SCIENCES
An International Open Free Access Peer Reviewed Research Journal of Physical Sciences
website:- www.ultraphysicalsciences.org
Estd. 1989

A Review on Physical and Optical Properties of Zinc Tellurite Glasses Co-doped with different rare earth ions

SUKHDEV BAIRAGI[1*] and GHIZAL F. ANSARI[1]

[1]Physics Department, Madhyanchal Professional University, Bhopal-462044 (M.P.) (India)
*Corresponding author's e-mail address:bairagisukhdev07@gmail.com
http://dx.doi.org/10.22147/jusps-B/330601

Acceptance Date 11th December, 2021, Online Publication Date 20th December, 2021

Abstract

In this work we review the effect of physical and optical properties with different ion zinc contents of tellurite base glass. The physical properties of the glasses were evaluated and the change in density, molar volume and ionic packing density in these glasses indicates the effect of ZnO different content show on the glasses structure. The study of optical properties such as the optical band gap and refractive index of zinc tellurite glass were studied. Zinc Tellurite glasses doped with Er^{3+} ions were synthesized by varies researcher. The glasses were characterized by X- ray diffraction, optical absorption and photoluminescence spectra. The glassy nature of zinc Tellurite host glass has been confirmed through XRD measurements. The glasses doped or co-doped with rare-earth ions have generated much interest due to the possibility of several promising applications such as optical data storage, visible laser, fibre amplifier, optical communication and sensor devices.

Key word : Zinc Tellurite glasses, molar volume, optical properties, band gap, refractive index.

1. Introduction

In the past two-decade, tellurium oxide (TeO_2) based glass doped with rare earth (RE) ions are the main subject of research because of their special optical and physical properties such as high thermal stability, high densities, high refractive index, high nonlinear refractive indices, high dielectric constants, a wide band infrared transmittance and large third order non-linear optical susceptibility[1,2] low phonon energy (~800 cm^{-1}), low melting temperatures non-hygroscopic nature, and excellent as host matrix for active dopant[3-5].

These outstanding properties make tellurite glasses are most favoured use in application relating to solid state lasers, optical amplifiers, non-linear optical devices and optical data storage[6-9] Unlike other glass formers, pure TeO_2 does not have ability to form glass under normal condition easily without addition of another oxide which acts as modifier in the system. The present of modifiers like alkali, alkaline earth and transition metal oxide/heavy metal oxide into TeO_2 networks is crucial to initiate the formation of a glass from TeO_2 powder[10] Furthermore, combination of different oxide also improve the linkage between Te-O chains which lead to increase in glass forming ability[11] The ZnO-TeO_2 system was used as a basis for multi-component optical glass synthesis and The TeO_2-ZnO system shows good and stable glass-forming ability with a broad region. However, this glass formation strongly depends on the cooling rate and the size of the melt, especially in the TeO_2-rich region[12]. Properties of TeO_2-ZnO glass system (good durability, thermally stable to crystallisation, and high rare-earth solubility) was first examined and stated by[13] creating the aforementioned compositions, is ultimate for optical fibre devices[13].

Apart from their applications, there is a lack of data on structural investigations of these glasses in the literature. Therefore, the objectives of this research are to study the physical and optical properties of $ZnOTeO_2$ glass system and compare with those past studies which will ultimately help us understand the fundamental origin of their properties. This study reports the investigation of the physical and optical properties of zinc tellurite glass system.

2. Objective of the study :

a. To study the physical and optical properties of zinc tellurite glasses for their promising application.

b. To study the zinc tellurite glasses doped and co-doped with different rare earth ion (Dy^{3+}, Er^{3+}, Eu^{3+}, Tm^{3+}, Tb^{3+}, Nd^{3+}, Gd^{3+}, Ho^{3+}, Yb^{3+}) have successfully synthesized and prepared by varies researcher and obtain their luminescence and photoluminescence properties.

3. Review of Literature :

Rolli, R. *et al.* (2003) have investigated Optical transitions of Er^{3+} ion in two tellurite glasses of molar composition $75TeO_2$:12ZnO: $10Na_2O$:2PbO:$1Er_2O_3$ and $75TeO_2$:12ZnO: $10Na_2O$:$2GeO_2$:$1Er_2O_3$. The measured absorption and emission spectra were analysed by Judd–Ofelt and McCumber theories, in order to obtain radiative transition rates and stimulated emission cross sections. It was found that these glasses have high and broadband absorption and stimulated emission cross sections at 1.5 µm. For the metastable 4I13=2 level, by comparing the measured lifetime with the calculated radiative decay time, quantum efficiency higher than 80% was found[14].

Yousef, E. *et al*. (2007) have studied the Glasses in the system TeO_2–Bi_2O_3–ZnO with respect to their linear refractive indices and optical absorption in the UV– vis range. The experimental Kerr susceptibilities are in the range of 5.49– 6.58 x 1013 esu. They increase with increasing Bi_2O_3 concentration. Kerr susceptibilities calculated with Lines' equation are more than 50% larger than the experimentally determined ones. The studied glasses show optical band gap energies in the range from 2.57 to 2.63 eV and Urbach energies which lie between 0.054 and 0.066 eV. Both optical band gap and Urbach energy are smaller than for other glass systems reported in the literature up to now. This indicates low defect concentrations[15].

Lakshminarayana, G. *et al.* (2008) have concluded and successfully developed transparent, moisture resistant and more stable Er^{3+}/Yb^{3+}, Tm^{3+}/Yb^{3+}, Er^{3+}/Tm^{3+} and Nd^{3+} ionsdoped $50TeO_2$–20ZnO–$10B_2O_3$–$10Li_2O$–$10Na_2O$ glasses for their optical characterization. The X-ray diffraction (XRD) and differential scanning calorimetry (DSC) profiles of the host glass matrix have been carried out. From the DSC Thermogram, glass transition (Tg), crystallization (Tc) and melting (Tm) temperatures have been evaluated .The NIR spectra of Er^{3+}/Yb^{3+}, Tm^{3+}/Yb^{3+}, Er^{3+}/Tm^{3+} and Nd^{3+} ions-doped glasses have shown FWHM around 58, 127, 87 and 35 nm, respectively.

These glasses with better thermal stability and broad near-infrared emissions should have potential applications in broadly tunable laser sources and broadband optical amplification at low-loss telecommunication windows[16].

Jaba, N. *et al.* (2009) have investigated the spectral features and concentration quenching of the $^4I_{13/2} \rightarrow ^4I_{15/2}$ electron transition of Er^{3+}-doped TeO_2-ZnO binary glasses. The investigation includes Raman scattering, optical absorption, luminescence, and lifetime measurements techniques. The study is particularly focussed on two aspects: (i) the effect of the dopant ion concentration on spectral broadening of the 1.53 mm emission line, and (ii) the concentration quenching of the $^4I_{13/2} \rightarrow ^4I_{15/2}$ electron transition. Raman data show structural changes when increasing the concentration of optically active ions. Optical absorption does not see any effect with the increasing Erbium content. The 1.53 mm emission band, however, shows a large broadening with increased Er^{3+} concentration. The relevant values of the effective bandwidth of 1.53 mm emission range from 77 to 108 nm. In the paper, this is also reported that the effect of the Erbium content on the emission intensity of the $^4I_{13/2} \rightarrow I_{15/2}$ transition as well as on the lifetime of the $^4I_{13/2}$ level. Based on the electrical–dipole interaction theory, the luminescence concentration quenching mechanism by hydroxyl groups is analyzed. The data suggest that <10% of hydroxyl groups are coupled to Erbium ions in the zinc Tellurite glass network[17].

Wang, N.Q. *et al.* (2010) have synthesized and characterized the Low phonon energy $Tm^{3+}/Ho^{3+}/Yb^{3+}$ triply doped bismuth Tellurite glasses. The multicolor fluorescence composed of three primary colors green, red and blue up conversion emissions from Ho^{3+} and Tm^{3+} has been investigated. By adjusting the excitation power, the fluorescence colors can be tuned from multicolor to white color, and the dependence of color tunability on pump power has been presented in the CIE 1931 chromaticity diagram. With the increase in pumping power, the color coordinates move along the down-left direction and hit the equal energy point. Upconversion color tunability by changing the pump power intensity holds the promise for novel three-dimensional solid state display, upconversion white lighting and biomedical multicolor imaging[18].

Jakutis, J. *et al.* (2010) have been demonstrated an enhancement of 400 times in the green Er^{3+} upconversions in the presence of 5% Yb^{3+} ions for Tellurite glasses and fibers. The red Er^{3+} emission increased more than the green emission with higher Yb_2O_3 content. Pump power dependent studies revealed that both, green and red emissions resulted from two photon upconversion processes. The best fittings of the 660 nm and 550 nm luminescence are in agreement with the n6 and n7 populations behaviour obtained using the rate equations system for Er^{3+} in Yb/Er doped Telluride glasses pumped by CW laser 960 nm, where the Yb–Er transfers (T1, T2 and T3) are dependent on the ytterbium concentration. Successful experiments with fiber pulling indicate that these glasses should prove to be an excellent option for optical applications such as photonic devices, infrared sensors and also fiber amplifiers[19].

Ming Oo, H. *et al.* (2012) have found that the density and molar volume of the glass sample increases due to the fact that the atomic mass of bismuth ions is higher than that of tellurite ions, and that the atomic radius of bismuth is also greater than that of tellurite ions. Additionally, the refractive index increases due to the increase of polarity of the Bi^{3+} ion content in tellurite based glasses.The Fourier transform infrared spectroscopy (FTIR) results show the bonding of the glass sample and The optical band gap shifts to a low energy while the Urbach energy shifts to high energy when non-bridging oxygen (NBO) increases as bismuth content increases[20].

Reza Dousti, M. *et al.* (2013) have investigated the influence of NPs concentration and annealing time on the structural and optical behaviour. HR-TEM image reveals silver NPs with the face-centered cubic structure. The TEM micrograph confirms the presence of silver NPs with Gaussian size distribution having average size ~12 nm. Strong plasmon absorption bands of silver NPs are observed. The quenching in the Raman spectra by the introduction of silver NPs is observed. The heat treatment enhanced the intensity of vibrational spectrum by eight times and caused red shift. In contrast, the PL shows five times enhancement of the electronic transitions by further addition of silver NPs and increasing the annealing time up to 4h. However, the quenching in visible emissions of Er^{3+} ions took place upon further annealing due to dissolution of aggregated NPs. The mechanism of enhancement and quenching in the presence of silver, NPs and heat treatment is partly understood. Our systematic experimental and theoretical methodology may contribute towards the development of nanophotonic[21].

Faeghinia, A. *et al.* (2015) have been studied the structural properties and spectroscopic behaviour 80mol.%TeO2-20mol. % LiF glasses which were doped with 0.05, 0.2 mole% Gd_2O_3. FT-IR visible results showed the deformed TeO_4 groups in these glasses. Uv-visible absorption proved some relatively broad bands in the optical absorption spectra of the G5 and G2 samples. Absorption edge in 320nm was recorded. Upon excitation at 320 nm, the emissions at 431nm and 627nm were noted. By modifying the excitation wavelength, the PL peaks change correspond to the disorder arrangement of Te^{4+} ions[22].

Dousti, M.R. *et al.* (2015) have studied the structural, thermal, chemical and spectroscopic properties of zinc-tellurite glasses with composition 20ZnO–80TeO_2 doped with up to 2.5 mol% Er_2O_3 in detail. The glasses can be easily prepared at relatively low temperature and they display high refractive index, large density, high rare earth solubility, low maximum phonon energy and excellent luminescence properties in the visible and near infrared spectral regions. . Particularly, Er^{3+}-doped tellurite glass compositions have been actively studied for broadband near infrared applications where the requirement for low dimension needs to be compensated by higher doping ion concentration. In this work, we revisit Er^{3+}-doped zinc tellurite glasses, which are among the most thermally and chemically stable tellurite compositions. The glasses were prepared by the melt-quenching technique and the favourable effects of increasing dopant concentration on chemical durability, water resistivity and thermal stability (up to 140°C) are discussed. The photophysical properties of the glasses were studied by absorption and luminescence spectroscopic techniques. The Stokes and anti-Stokes emissions of Erbium were analyzed and it was verified that the width of the emission band at 1532 nm strongly depends on Er^{3+} concentration varying from 60 to 82 nm for 0.5 and 2.5 mol% of Er_2O_3, respectively. The intensity of green and red upconversion emissions was evaluated and the increased efficiency of red emission with increasing concentration is attributed to energy transfer mechanisms between infrared energy levels[23].

Bilir. G. *et al.* (2016) have synthesized Tellurite glasses doped singly and doubly with Yb^{3+} and Er^{3+} ions using the conventional melt quenching method. The J-O parameters measured from the absorption and luminescence spectra of the samples were used to investigate the effect of the Yb^{3+} on the infrared and visible up-conversion luminescence properties of Er^{3+} ion in the doubly doped zinc tellurite glasses. Presence of Yb^{3+} ions in doubly doped glass improves the stimulated emission cross section (11–15%) and the bandwidth (1–4%) of the 1.5 μm emission of the Er^{3+}. The band gap energies for both direct and indirect possible transitions and the Urbach energies were measured from the absorption spectra. The effect of the ytterbium ions on the emission properties of Erbium ions was investigated and the energy transfer processes between dopant ions were studied by measuring the up-conversion emission properties of the materials. The colour quality parameters of obtained visible up-conversion emission were also determined as well as possibility of using the Er^{3+} glasses as erbium doped fiber amplifiers at 1.55 μm in infrared emission region[24].

Fawzy Ahmed, K. *et al.* (2017) have successfully synthesized with the role of co-doping on optical properties of tellurite glasses with composition (69.5-2.5x) TeO_2–30$ZnCl_2$–xNd_2O_3– xEr_2O_3–(0.5+0.5x) AgCl (x =0.0 to 3.0 mol%) by using conventional method. The amorphous nature of the prepared samples is confirmed by XRD. Density is an effective tool to explore the degree of structural compactness, modification of the geometrical configurations of the glass network, change in coordination and the variation of dimensions of the interstitial holes. The Optical absorption behaviour is measured using UV-VIS-NIR spectroscopy. It was observed that the maximum value of both of the optical band gap (E^{I}opt. =2.830eV) and Urbach energy (ΔE=1.330eV) is at the concentration of Nd^{3+}/Er^{3+} at 1.5% contents for the third sample coded with TZNEA1.5. The results approved that the second glass sample has formed a greater number of TeO_3 units in the glass matrix. Both the optical band gap and the Urbach energy are found to be strong analytical functions of the co-dopant concentration. The results are in good agreement with the work of other researchers. The glass forming mechanism is being understood by this. It is interesting to investigate the photoluminescence behaviour and the structural properties by using Differential thermal analysis (DTA), Fourier transform infrared spectroscopy (FTIR) and Raman spectroscopy in these glass systems as a function of co-dopant concentration[25].

Badamasi, S. and Tanko Y. A. (2018) have been successfully prepared the six series of Dysprosium doped zinc sodium tellurite glass in the form $(65-x)TeO_2$-25ZnO10NaO-xDy_2O_5 (where x = 0.0, 0.4, 0.8, 1.2, 1.6, and 2.5 mol%) via conventional melt quenching technique. The increase in the density of glasses from 5.334-5.366 gcm^{-3} due to a change in crosslink between TeO_2 chains and coordination number of Te^{2+} ions. The thermal properties of tellurite glasses such as the glass transformation temperature, 5ØGÜg, crystallization temperature Tc, glass stability temperature and Hruby's parameter H, were studied with respect to Dy^2O^3 content. the glass transition temperature Tg, was in the range of 287-302°C, crystallization temperature Tc from 408-502°C, these glass samples possess high thermal stability greater than the 100°C required by the thermal stability criteria. Hence, all the studied samples are promising candidates for rare-earth-doped optical fibre. While Hruby's parameter H, is 0.47-1.33. These suggest that the prepared tellurite glass exhibits a good thermal stability and consequently might be a potential candidate for fibre drawing and other nonlinear optical devices[26].

Kostova, I. *et al.* (2018) have found the Zinc-boron-phosphate glasses are comparatively a new material with a wide application potential for some optic devices. This is so because they are an excellent host matrix for different rare earth metals, especially for Samarium ions, which in turn leads to intense luminescence in the visible region. Based on some previous studies of the structure, chemical durability, thermal stability, physical and optical properties it is found that this matrix is not only a good candidate as a host material for different RE ions but it is also applicable in sensing and valuable documents protection. The present communication reports result referring to the synthesis of new rare earth (Eu, Gd, Tb, Nd) doped and co-doped with Gd/Nd, Gd/Sm, Nd/Eu, Nd/Sm, Tb/Sm ZBP glasses and study of their absorption and fluorescent properties. The synthesis is performed by the conventional melt quenching method at 950ºC in a muffle furnace. It is found that all synthesized glasses are homogeneous (with no gases inclusion), while some of them are fully transparent. The luminescent analysis reveals strong fluorescence in the visible and near infra-red region for different doping ions[27].

Akbar, N. *et al.* (2019) have been demonstrated with the present results that luminescence efficiency of rare-earth ion inside the glassy matrix can be controlled and enhanced by the local electric field of silver nanoparticles. These glasses may be commercially exploited in optical memory devices, lasers and optical displays due to their significantly enhanced fluorescence. In our view, this process has the potential to be scaled-up to larger quantities for bulk composites due to its simplicity. In summary, it has been demonstrated with the present results that luminescence efficiency of rare-earth ion inside the glassy matrix can be controlled and enhanced by the local electric field of silver nanoparticles[28].

Yuliantini L. *et al.* (2019) have found the development of laser gain medium has been more attractive to be investigated due to the laser application in human daily life. For example, laser is used for medical treatment, surgery, security system, cutting, spectroscopy characterization and sensor. Laser is produced by the system including pump source, resonator, and an optical gain medium. This paper will be focused in a gain medium based on trivalent rare earth ions (Ln^{3+}) such as Dy^{3+}, Sm^{3+}, and Eu^{3+} doped glass. The gain medium is developed by melt and quenching technique. The raw materials are a powder that is melted at the glass transition temperature. Afterwards, the glass liquid is poured at stainless steel at room temperature and annealed for several hours. After the annealing process, the bulk glass is cut and polished for characterization. Physical, optical, and luminescence properties of the gain medium are analyzed and discussed in this paper. The CIE 1931 chromaticity diagram coordinate is calculated to define the proper coordinate of glass sample emission light. The previous research shows that Dy^{3+}, Sm^{3+}, and Eu^{3+} in glass system can emit white, orange, and reddish-orange excited by 388 nm, 403 nm and 393 nm, respectively. From the results, trivalent rare earth ion doped glass possesses high potential to be developed for laser gain medium material[29].

Shaharin M. S. B. *et al.* (2019) have studied the Tungsten doped niobate tellurite glasses by using melt quenching method. The influence of dopants (WO_3) concentration, to improve the physical properties is examined. For all these three glass samples, the structural and the compositional dependence of different physical parameters such as density, molar volume and ionic packing density have been analyzed. The amorphous nature of the samples has been confirmed by X-ray diffraction analysis. The physical properties of the glasses were evaluated and the change in density, molar volume and ionic packing density in these glasses indicates the effect of WO_3 different content registered on the glasses structure. The maximum refractive index value of 2.171 was obtained for $78TeO_2–10Nb_2O_5– 12WO_3$ glass. It is found that the Density and molar volume increase with increase in WO_3 concentration due to its higher molecular weight. The value of optical energy band gap decreases with increase in WO_3 concentration due to the formation of NBO[30].

Bilir G. *et al.* (2019) have investigated the mechanisms which are contributed to the linear and nonlinear absorption properties of binary tellurite glasses .It has been investigated by using absorption spectrophotometer and open aperture Z-Scan experiments, respectively. The band gaps of the glass samples were determined by using linear absorption spectra and found to be blue shifted at about 32 nm with the increasing amount of ZnO and red shifted at about 70 nm with the change of the type of the modifier. The results of the open aperture Z-scan experiments indicated that the studied tellurite glasses modified with different amounts of WO_3, Nb_2O_5, and ZnO possessed larger nonlinear absorption coefficients (among $2.62x10^{-7}$ cm/W and $6.38x10^{-7}$ cm/W) than the nonlinear absorption coefficients of previously investigated tellurite glasses. As for the nonlinear optical measurements, it was found that the two-photon absorption signals and the response times are relatively fast which is a desired feature for optical switching and photodetector applications Conclusion[31].

Adel G. *et al.* (2019) have been studied the optical and electrical properties of xSb_2O_3 (35-x) B_2O_3 $60Bi_2O_3$ $5TeO_2$ glass system (where, x=10, 20, 30). it was found that both of the values of density and molar volume increase by increasing Sb_2O_3 content. Also, the values of optical energy gap and the values of the activation energy of conduction decrease for all the studied samples. While the values of refractive index and optical dielectric constant increase. The high values of third order nonlinear optical susceptibility for all the studied samples, were found to be in the range (3.827-8.219) x 10^{-12} esu, which is larger than that of pure silica glass. Finally, it was found that, all the studied glasses which have high refractive index, high optical basicity, high oxide ion polarizability and high third order nonlinear susceptibility are promising materials for nonlinear optical devices[32].

Ansari G. F. *et al.* (2021) have been found the Optical and upconversion properties of bismuth tellurite glasses compositionsTeO_2-Bi_2O_3-Na_2O co-doped with rare earth ions Er^{3+}-Yb^{3+} ions by melt-quench and press method. The batch composition is taken (80-x-y)%TeO_2-10% Bi_2O_3-10%Na_2O-x%Er_2O_3-y%Yb_2O_3, (x, y) are (0.1, 0) and (0.5, 0.5). Thermal study of the synthesized sample is done by Differential Scanning Calorimetry (DSC). Amorphous nature of samples is characterized by X-Ray diffractogram. Heaviness of the samples justifies by the calculated densities of the glass sample is 5.26gm/cc and Refractive index (R.I.) of sample is 2.05, Their optical band gap and Urbatch's energies are in the order of 3 eV and 300 meV respectively, justify its candidature for photonic devices. Upconversion luminescence in the synthesized TBNEY glass is the attribution of Er^{3+}-Yb^{3+} ions. Excellent green and red upconversion emissions were observed under excitation of 980 nm[33].

4. Conclusion

It is observed in the study work done by researchers that tellurite glasses co doped with rare earth ions exhibit remarkable up conversion phenomenon**.** The physical and optical properties of zinc tellurite glasses were found generally affected by the changes in the glass composition. The glasses can be easily prepared at relatively low temperature and they display high refractive index, large density, high rare earth solubility, low and maximum phonon energy and excellent luminescence properties in the visible and near infrared spectral regions. The densities of the zinc tellurite glasses increase as the ZnO content was added to substitute the TeO_2 content while molar volume decreases. The increased in density were probably because of the decreased in average inter atomic spacing. Density is an effective tool to explore the degree of structural compactness, modification of the geometrical configurations of the glass network, change in coordination and the variation of dimensions of the interstitial holes. The refractive index of the TeO_2-ZnO glasses increase with substitution of ZnO oxides into TeO_2, bridging Te-O-Te bonds are altered and non-bridging Te-O-Zn^{2+} bonds are formed. The linear and nonlinear absorption properties of tellurite glasses have been investigated using absorption spectrophotometer and open aperture Z-Scan experiments, respectively. The band gap of the glass samples was determined using linear absorption spectra.The linear optical absorption measurements showed the tunability of the band gaps of the glass samples, which has great significance for photonics applications, by changing the type and the amount of the modifiers. Absorption and photoluminescence measurements were performed on Er^{3+}-doped TeO_2– ZnO glasses. The Judd–Ofelt intensity parameters and radiative transition rates have been calculated. The FTIR spectra of TeO_2-ZnO showed that the strong band existence of ZnO content. The modifiers enter the glass lattice network by breaking up the Te-O-Te bonds introduce coordinated defects in these glasses. Based on the results we propose that zinc-tellurite glasses are promising low phonon hosts for rare-earth elements that can also become potential candidates for the development of solid-state lasers, near infrared sensors, modern lighting devices, optical displays and optical fibers, photonic devices, as visible laser sources or near-infrared detectors. In future heavy metal oxide doped tellurite glasses have a wide scope in up conversion and down conversion phenomenon.

Acknowledgements

I acknowledge Department of Physics, Madhyanchal professional university Bhopal for providing literature support.

References :

1. El-Mallawany, R.A., Tellurite Glasses Handbook, Physical Properties and Data. CRC Press, Baca Raton, FL., pp: 540 (2002).
2. Khattak, G.D. and M.A. Salim, X-ray photoelectron spectroscopic studies of zinc-tellurite glasses. J. Elect. Spectroscopy Relat. Phenomena, *123,* pp: 7-55 (2002).
3. Gayathri Pavani, P., Sadhana, K. and Chandra Mouli, V., 'Optical, physical and structural studies of boro-zinc tellurite glasses', Physica B: Condensed Matter. Elsevier, 406(6–7), pp. 1242–1247 (2011).

4. Selvaraju, K. and Marimuthu, K., 'Structural and spectroscopic studies on concentration dependent Er^{3+} doped boro-tellurite glasses', Journal of Alloys and Compounds. Elsevier, *553(5)*, pp. 273–281 (2013).
5. Maheshvaran, K. *et al.*, 'Structural and luminescence behavior of Er3+ ions doped Barium tellurofluoroborate glasses', Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy. Elsevier B.V., 135, pp. 1090–1098 (2014).
6. Lezal, D. *et al*., 'Heavy metal oxide glasses: Preparation and physical properties', Journal of Non-Crystalline Solids, 284(1–3), pp. 288–295 (2001).
7. Ersundu, A. E. *et al.,* 'Glass formation area and characterization studies in the CdO-WO_3-TeO_2 ternary system', Journal of the European Ceramic Society, *31(15),* pp. 2775–2781 (2011).
8. Zamyatin, O. A. *et al.*, 'Glass-forming region and physical properties of the glasses in the TeO_2– MoO_3–Bi_2O_3 system', Journal of Non -Crystalline Solids, 452, pp. 130–135 (2016).
9. Sayyed, M. I. *et al*. 'Evaluation of physical, structural properties and shielding parameters for K_2O–WO_3 –TeO_2 glasses for gamma ray shielding applications', Journal of Alloys and Compounds. Elsevier B.V, 714, pp. 278–286 (2017) .
10. Nayar, P. *et al.*, 'Physical, structural, thermal, and optical spectroscopy studies of TeO_2 –B_2O_3 –MoO_3 – ZnO–R_2O (R=Li, Na, and K)/MO (M=Mg, Ca, and Pb) glasses', Journal of Alloys and Compounds, 690, pp. 799–816 (2016).
11. Manikandan, N., Ryasnyanskiy, A. and Toulouse, J., 'Thermal and optical properties of TeO_2–ZnO–BaO glasses', Journal of Non -Crystalline Solids. North-Holland, *358(5),* pp. 947–951 (2012).
12. Kozhukharov, V., S. Neov, I. Gerasimova and P. Mikula, Neutron diffraction investigation of a tellurite-tungstate glass. J. Mater. Sci., *21,* pp. 1707-1714 (1986).
13. Wang, J., Vogel, E., and Snitzer, E., Tellurite glass: a new candidate for fiber devices. Optical Materials, 3, pp.187-203 (1994).
14. Rolli, R. *et al.*, 'Erbium-doped tellurite glasses with high quantum efficiency and broadband stimulated emission cross section at 1.5 μm', optical materials *21,* pp.743-748 (2003).
15. Yousef, E. *et al*., 'Effect of ZnO and Bi_2O_3 addition on linear and non-linear optical properties of tellurite glasses', Journal of Non-Crystalline Solids *353,* pp. 333–338 (2007).
16. Lakshminarayana, G. *et al*., 'NIR luminescence from Er^{3+}/Yb^{3+}, Tm^{3+}/Yb^{3+}, Er^{3+}/Tm^{3+} and Nd^{3+} ions-doped zincborotellurite glasses for optical amplification',Journal of Luminescence *128,* pp. 690–695 (2008).
17. Jaba, N. *et al.*, 'Spectral broadening and luminescence quenching of 1.53 mm emission in Er3+-doped zinc tellurite glass', Journal of Luminescence *129,* pp. 270-276 (2009).
18. Wang, N.Q. *et al.*, 'Upconversion and color tunability in $Tm^{3+}/Ho^{3+}/Yb^{3+}$ doped low phonon energy bismuth tellurite glasses'. Journal of Luminescence *130,* pp. 1044–1047 (2010).
19. Jakutis, J. *et al*. 'Increased Er3+ upconversion in tellurite fibers and glasses by co-doping with Yb^{3+}', Optical Materials 33 107–111 (2010).
20. Ming Oo, H. *et al*., 'Optical Properties of Bismuth Tellurite Based Glass', Int. J. Mol. Sci., 1*3,* pp. 4623-4631 (2012).
21. Reza Dousti, M. *et al*., 'Surface enhanced Raman scattering and up-conversion emission by silver nanoparticles in erbium–zinc–tellurite glass', Journal of Luminescence *143,* 368–373 (2013).
22. Faeghinia, A. *et al.*, Luminescence Properties of TeO_2-LiF-Gd_2O_3 Glasses ACERP: Vol. *1,* No. 2, pp.1-5 (2015).
23. Dousti, M.R. *et al*., 'Er3+-doped zinc tellurite glasses revisited: Concentration dependent chemical durability,

thermal stability and spectroscopic properties', Journal of Non-Crystalline Solids *429,* pp.70–78 (2015).

24. Bilir. G. *et al*., 'Spectroscopic investigation of zinc tellurite glasses doped with Yb^{3+} and Er^{3+} ions', Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy *165,* pp.183–190 (2016).
25. Fawzy Ahmed, K. *et al*., 'Physical and optical properties of zinc tellurite Glass embedded Silver Nanoparticles co-doped with Nd^{3+}/Er^{3+} ions Journal of Zankoy sulaimani', *19,* pp.19-1 (2017).
26. Badamasi, S. and Tanko Y. A., 'Thermal properties of TeO_2-ZnO-Na_2O glasses: effect of Dy_2O_3 doping', Science World Journal Vol *13,* pp. 4 (2018).
27. Kostova, I. *et al.,* 'Luminescent properties of rare earth doped ZnO-B_2O_3 -P_2O_5 glasses', Journal of Chemical Technology and Metallurgy, 53, 6, pp.1087-1094 (2018).
28. AKBAR, N. *et al*., 'nano-silver enhanced upconversion emission in Nd^{3+}: Ag-zinc-tellurite glass', Journal of Ovonic Research Vol. *15,* No. 3, pp. 161 – 166 (2019).
29. Yuliantini, L. *et al.*, 'Optical and Luminescence Properties of Trivalent Rare Earth Ion (Sm^{3+}, Dy^{3+}, and Eu^{3+}) doped Glass for Laser Gain Medium Development: A Review', Journal of the Physical Society of Indonesia Vol. *1,* no. pp. 5-8 (2019).
30. Shaharin , M. S. B. *et al*., 'Effect of Tungsten on Physical and Optical Properties of Niobate Tellurite Glasses', open journal of science and technology *2(1),* pp. 21-25 (2019).
31. BILIR, G. *et al*., 'Nonlinear Optical Properties of Tellurite-based Glasses', The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), Vol. *6,* pp. 131-134 (2019).
32. Adel G. *et al*., 'Electrical and Optical Properties of Sb_2O_3 B_2O_3 Bi_2O_3 TeO_2 Glass System, Egypt. J. Phy. *47,* pp.1 (2019).
33. Ansari G. F. *et al*., 'Optical and upconversion properties of bismuth tellurite glasses Co-doped with Er^{3+}-Yb^{3+} ions materials today proceeding (2021).