KAKATIYA GOVERNMENT COLLEGE

HANUMAKONDA

Name : Dr. BOORGU SREENIVAS

Designation : Asst. Professor of Physics

Year of Award of PhD. : 2024

Name of the University : Osmania University

Year of entering into Govt. Service : 2008

S. No.	Details of copies of Certificates	
1	Copy of Ph.D Certificate	Applied
2	Press note	Enclosed
3	Research work dates of seminars and Pre-Ph.D Date of joining in this college: 30-06-2018	Research Design: 08-09-2021 Pre-sub: 10-08-2023 Pre-PhD: 31-08-2019
4	Details of Ph.D Admission-part time or full time	Part Time 28-03-2017
5	Copies of RDC Approval letters of Ph.D	Enclosed
6	Name of guide/supervisors with mobile number, email id	Dr. P. Hima Bindu Mobile: 9603120715 hb.pitta@osmania.ac.in
7	Copies of guide allotment letter	Enclosed
8	No. of increments sanctioned for Ph.D.	03
9	Published Research article-copies.	Enclosed
10	Original Ph.D Thesis.- Book.	Available in the office

PRINCIPAL
KAKATIYA GOVT.COLLEGE
Hanamkonda.

(B. Sreenivas
Asst. Prof. of Physics)

CONFIDENTIAL SECTION
EXAMINATION BRANCH
NO. 828/Ph.D/Exams/2024

OSMANIA UNIVERSITY
HYDERABAD-500 007,T.S.
Dated: 27 Feb, 2024

PRESS NOTE

The following candidates who had presented the Thesis on the subject mentioned against each for the degree of Ph.D are declared qualified for the award of Degree of Doctor of Philosophy (Ph.D.) of Osmania University, Hyderabad.

Ph.D.

S.No	Reference No.	Name of the Candidate/ Father Name	Subject	Thesis Title	Supervisor/ Regn. Date
1	PHD44786	**Mr. Sayeed Bazaher** S/o. Hussain Bazaher	Urdu	Ahmed Faraz Aur Unki Ghazal Goee	Prof. S A Majeed Bedar Dept. of Urdu, O.U., Hyd. **(04/09/2018)**
2	PHD44787	**Ms. Fahmeeda Tabbasum** D/o. Khaja Qamaruddin	Urdu	Urdu Ki Tarraqui Mein Mustashraqeen Ka Hissa	Dr. Askari Safdar(Retd.) GD&PGC(W), Hussaini Alam, Hyd. **(27/03/2017)**
3	PHD44788	**Mr. Lingampally Nageshwar** S/o. Lingampally Basalingappa	Microbiology	Production of Xylolipid Biosurfactant by Lactococcus Lactis LNH70 and its Application as Fruit Juice Preservative	Dr. Hameeda Bee Assoc. Professor, Dept. of Microbiology, O.U., Hyd. **(18/03/2017)**
4	PHD44789	**Mr. S Suresh** S/o. Sawaranna	Botany	ALGAL Diversity and Water Quality in Sarala Sagar Reservoir Wanaparthy District Telangana State	Prof. P Kamalakar Dept. of Botany, O.U., Hyd. **(24/03/2017)**
5	PHD44790	**Mr. Venumadhav Vurugonda** S/o. Ilaiah	Pharmaceutical Sciences	Pharmacological Evalution of Potential Agents of their Biological Interests	Prof. Veeresh B Dept. of Pharmacology, G Pulla Reddy Coll. of Pharmacy, Hyd. **(26/02/2013)**
6	PHD44791	**Mr. Sreenivas Bourgu** S/o. Muthaiah	Physics	Effect of $Bi_2O_3/PbO/Al_2O_3$ on the Physical, Optical, Structural and Snielding Properties of Zinc Cadmium Borate Glasses	Dr. P Hima Bindu Asst. Professor, Dept. of Physics, O.U., Hyd. **(28/03/2017)**
7	PHD44792	**Ms. Pandli Amala** D/o. Pitchaiah	Mathematics	Computational Techniques for A Class of Multiparameter Singular Perturbation Problems	Dr. K Phaneendra Assoc. Professor, Dept. of Mathematics, O.U., Hyd. **(24/03/2017)**
8	PHD44793	**Mr. Bukya Bheem Rao** S/o. Bukya Seryanaik	EnvironmentalScience	Efficiency of Plants in Tolerating Air Pollution in Kattedan and Balanagar Industrial Areas, Hyderabad	Dr. Syeda Azeem Unnisa Asst. Professor, Dept. of Envi. Science, O.U., Hyd. **(20/03/2017)**

Addl.Controller of Examinations
(Confidential)

Department of Physics
University College of Science
Osmania University, Hyderabad – 7

Mr. B. Sreenivas, research scholar, working under the supervision of Dr. P. Hima Bindu, Nizam College, Osmania University, has presented the **Research Design Seminar** on 08-09-2021 in the Department of Physics, University College of Science, Osmania University, as a part of Pre-condition before submitting the thesis. He has explained the objectives of his research work entitled "**Optical and Photoluminescence Studies on Nanocrystal-Doped Glassy Photonic Materials**" carried out so far and future plan of work satisfactorily.

(Prof. D. Karuna Sagar)
HEAD
DEPARTMENT OF PHYSICS
OSMANIA UNIVERSITY

(Prof. M. Srinivas)
CHAIRMAN
BOARD OF STUDIES IN PHYSICS
DEPARTMENT OF PHYSICS
OSMANIA UNIVERSITY

[Dr. P. Hima Bindu]
SUPERVISOR
NIZAM COLLEGE
DEPARTMENT OF PHYSICS
OSMANIA UNIVERSITY

Department of Physics
University College of Science
Osmania University, Hyderabad – 7

Mr. Boorugu Sreenivas, Research scholar, working under the supervision of **Dr. P. Hima Bindu,** has presented the **Pre-Submission Seminar** on **10-08-2023** in the Department of Physics, University College of Science, Osmania University as a part of pre-condition before submitting the thesis. The topic of his research work is **"Effect of Bi_2O_3/PbO/Al_2O_3 on the Physical, Optical, Structural and Shielding Properties of Zinc Cadmium Borate Glasses"** He has explained the details of the research work carried out and the organization of the thesis. He has answered the questions raised by the faculty and research scholars.

The quantum of work carried out and the explanation offered to interpret the results obtained are quite satisfactory and therefore, the committee recommends the submission of the thesis to the Osmania University for necessary further action.

(Prof. M. Srinivas)
HEAD
DEPARTMENT OF PHYSICS
OSMANIA UNIVERSITY

(Sr. Prof. D. Karuna Sagar)
CHAIRMAN
BOARD OF STUDIES IN PHYSICS
DEPARTMENT OF PHYSICS
OSMANIA UNIVERSITY

(Dr. P. Hima Bindu)
SUPERVISOR
DEPARTMENT OF PHYSICS
OSMANIA UNIVERSITY

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JOINING REPORT OF Ph.D. COURSE, FACULTY OF SCIENCE, OSMANIA UNIVERSITY

1	Name & Phone No / Male / Female	Boorgu Sreenivas Mobile:- 9492309885
2	Father's Name	Muthaiah
3	Details of Scholarship if any	Nil
4	College/Institute at which the Candidate proposes to work	Nizam college, OU.
5	Full-Time/Part-Time	Part Time
6	Name of the Supervisor	Dr. P. Himabindu
7	Department	Physics
8	State wheither you being to OC/BC (A/B/C/D/E)SC/ST	SC.
9	Topic of Research	Barium strontium Titanate ceramic Material with Dopants Ce, Mg, Li and K.

To
The Dean,
Faculty of Science

//Through Proper Channel//

Sir, Ref: Order No: 3498 /DFSc/OU/2017 Dt 16-03-2017

I am herewith submitting my joining report today i.e. on 28-03-2017

I have read the rules and regulations of the Ph.D. Course/ Course and I undertake to abide by them.

I understand that my admission may be cancelled, if the statements I made in my application are found to be false.

I have satisfied all conditions stipulated in my admission order and I am enclosing herewith the necessary certificates (if applicable).

LIST OF ENCLOSURES

1. D.D. No: 530177 Date 24-03-2017 Amount 2000/- SBH Kothagudem

SIGNATURE OF SUPERVISOR

SIGNATURE OF CANDIDATE

SIGNATURE OF THE HEAD OF INSTITUTION IN WHICH CANDIDATE PROPOSES TO WORK
PRINCIPAL
NIZAM COLLEGE
HYDERABAD

SIGNATURE OF HEAD OF THE UNIV. DEPARTMENT 28/3/17
Osmania University, Hyd.

SIGNATUTRE OF THE DEAN 27/4/17
DEAN
Faculty of Science
OSMANIA UNIVERSITY
HYDERABAD-500 007

OFFICE OF THE DEAN FACULTY OF SCIENCE
OSMANIA UNIVERSITY HYDERABAD

No. 3498/A / DFSc/2017 Date: 16.03.2017

ORDERS

Sub : FACULTY OF SCIENCE, OU – Admission to Ph.D. Course Category II 2013-2014 - Orders - Physics - Issued.

Ref: No : No 345 /F/Acad-III/2017 Dated 2.03.2017

• • •

The candidates in the enclosed list are provisionally admitted to the Ph.D. course of Osmania University for the academic year 2013-2014 on the recommendation of the Admission Committee in the Faculty of Science in the subject mentioned against his/her name.

The selected candidates are required to fulfill the conditions, if mentioned against their names, and to submit their Joining Reports (Proforma provided), by **10. 04 . 2017** failing which their admission orders would be deemed to have been withdrawn. No further notice will be given. The Joining Reports along with the original D.D. and all necessary documents should be submitted in the concerned Departments. **No joining report will be accepted without the T.C. (Transfer Certificate) in original or a letter from the respective University where from the Post Graduate Degree has been obtained to the effect that no separate Transfer Certificate will be issued by that University.** The Dean's office shall then issue a list of names of the admitted candidates to the Heads of the Departments concerned, which shall be final.

The registration is valid for a period of four years for Full Time Research Scholars and five years for Part Time Research Scholars from the date of joining after which period it will be cancelled unless otherwise extended.

All the selected candidates both Full-Time and Part-Time have to pay the fee as under:

1.	Both Full Time and Part Time Scholars working in the Osmania University	..	Rs.2000 per year
2.	Scholars working in recognised Research Centres outside the University	..	Rs.5000 per year

(P.T.O.)

LIST OF CANDIDATES SELECTED FOR ADMISSION IN TO Ph.D OU 2013-2014, (CATEGORY II)

No: 3498/A/DFSc/OU/2017
Ref:- 345/F/Acad-III/2017. Date: 02.03.2017

Date:- 16.03.2017

PHYSICS

Sl. No.	Name of the Candidates	Gender	Category	Name of the Supervisor	FT/PT	Place of Work
1	Naresh. M	M	BC-B	Prof.C.Vishnuvardhan Reddy	FT	OU
2	P. Ajay Kumar	M	BC-D	Prof.J.Siva Kumar	PT	OU
3	Dacha Omprakash	M	BC-B	Dr.N.Narsimulu	FT	OU
4	Kasarapu Venkataramana	M	BC-B	Prof.C.Vishnuvardhan Reddy	FT	OU
5	Koneti Srikanth	M	ST	Dr.M.Srinivas	FT	OU
6	Eppa Radha	F	SC	Prof.J.Siva Kumar	FT	OU
7	P. Sowjanya	F	BC-D	Prof.M.V.Ramana Reddy	PT	OU
8	Gundeboyina Suman	M	BC-D	Prof.Ch.Gopal Reddy	FT	OU
9	Chittimadula Madhuri	F	BC-B	Prof.C.Vishnuvardhan Reddy	FT	OU
10	B. Srinivasa Goud	M	BC-B	Dr.A.K.Singh	PT	OU
11	Kalakuntla Spandana	F	BC-B	Prof.Ch.GopalReddy	FT	OU
12	Boorgu Sreenivas	M	SC	Dr.Himabindu	PT	OU
13	Gangula Padma Sree	F	OC	Prof.Ch.Gopal Reddy	PT	OU
14	Rajesh . K	M	BC-D	Prof.M.V.Ramana Reddy	PT	OU
15	J. Pallavi	F	OC	Prof.G.Prasad	FT	OU
16	Kiran Kumar Kusunuru	M	BC-A	Dr.N.Narsimulu	PT	OU

Cont.....

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Effect of Al_2O_3 on the Optical and Physical Characteristics Of Cdo-Zno-B_2O_3 Glasses

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Abstract
A Glass composition of quaternary oxide constituents of different Al_2O_3 content with a composition (80-x)B_2O_3-xAl_2O_3-10CdO-10ZnO; *(x=0 to 20 mol % with a step of 5 mol %) was fabricated by conventional melt quenching method. The primary structural disorderness confirmed by X-ray diffraction analysis. The non-crystalline nature of the produced glasses were verified as the absence of crystalline peaks in X-ray diffraction spectra. The density of the glass system decreased from* 4.410 g.cm^{-3} to 3.138 g.cm^{-3}*with the increase of Al_2O_3content. Optical absorption spectroscopic studies were carried out on the glass system. The Cut-off wave length (λ_c) varied between 378 nm-500 nm whereas, the optical band gaps (E_{opt}) decreased with the addition of Al_2O_3 in the glass network. The role of NBOs on the physical and optical properties was also discussed.*

Keywords: *Density, X-ray diffraction study, optical properties*

Date of Submission: 06-09-2023 Date of Acceptance: 16-09-2023

I. Introduction

B_2O_3 based glasses are of scientific and technical interest due to their low melting point, chemical durability, low cation size, thermal stability and high transparency. B_2O_3 is an excellent glass former among various inorganic oxides and it convert its units from BO_3 to BO_4 very easily when network modifiers like Al_2O_3 etc. were added to the borate host matrix. B_2O_3 based glass matrix undergoes the structural changes when alkali oxides like Al_2O_3 and Ag_2O are added which leads to the creation of non-bridging oxygens (NBOs)[**1-3**]. The crystals and glassy materials containing borates, the boron atom is generally co-ordinated with either three or four oxygen atoms, that forms [BO_3] pyramidal or [BO_4] tetrahedral structural units which are fundamental.

These [BO_3] and [BO_4] units can randomly form either the supposed superstructure or B_xO_y structural groups like diborate, tetraborate, pentaborate, boroxal-ring. Glasses incorporated with ZnO and CdO are of particular attention various areas of optical and electronics based materials [**4-6**]. Addition of Al_2O_3 to a glass matrix causes excess negative charge and also influences the symmetry of glass network. Al_2O_3 containing borate glasses widely used for battery applications due to their higher order ionic conductivity [**7-8**]. Borate glasses have gained significant attention in recent years due to their unique optical and magneto-optical(MO) properties[**9-10**]. In general, these glasses show high transparency of (UV) to the mid-infrared (MIR)spectral region, making them promising for optical applications such as fiber optics, amplifiers, and lasers[**11–12**].The other advantage of borate glasses is their good glass-forming ability[**13**] and relatively easy preparation at mild temperatures[**14**].

The density (ρ) can play a significant role on the structural variations due to the addition of alkali, alkaline earth oxides into the borate glass network. It also explores the tightness of the glass structure. It closely associated with the co-ordination number of the atoms and dimensions of the glass network. Density related physical properties such as molar volume (V_m), molecular weight (M), Oxygen packing density (OPD) etc. have been calculated and studied here. Optical absorption spectroscopy used to study the excited states of molecules or atoms. The present paper deals with the influence of Al_2O_3on the physical and optical properties of CdO-ZnO containing borate glass system. The role of non-bridging oxygens on the density related parameters and optical parameters have been discussed in the paper.

II. Material And Methods

Preparation of glasses

Al_2O_3 added glasses with a chemical composition (80-x)B_2O_3-xAl_2O_3-10CdO-10ZnO (BACZ), where x values lies from 0 to 20 mol% with 5 variation were synthesized by rapid melt-quench route. AR grade B_2O_3, CdO(Sigma), ZnO (AR grade) and Al_2O_3 were taken for preparation of the glass samples. About 15 grams of oxides powder are taken in a crucible made of porcelain, and melted at 1250°C for 1hr. The powder melted and

formed liquid. The liquid in the crucible was agitated/swirled frequently for 1 hr to form a homogeneous liquid melt. The crucible with melt was emptied on a steel plate which is at 250°C and hard-pressed using another steel disc which is also at same temperature which resulted in the formation of glasses. The prepared glassy samples were annealed at around 200°C for 24 hrs for removal of thermal stress and strain and also to avoid cracking of glass samples. The glass samples thus obtained were good transparency. The glass formation was confirmed with the transparency and uniformity.

Characterisation of glasses

Using Archimedes' principle density measurements was carried out on Vibra-HT analytical balance in which xylene used as immersion liquid with random error ±0.002. UV-Vis-NIR spectra were recorded on Spectrophotometer (Shimadzu) in the range 200nm-1000nm with spectral resolution 2nm for all the synthesized glasses and uncertainty is almost ±0.5 nm. X-ray diffraction spectra of the glasses recorded on a PAN analytical X-pert PRO model diffractometer in the Bragg's angle range 10^0-80^0.

III. Results and Discussion

X-Ray Diffraction

The X-ray diffraction (XRD) analysis was performed on a specific set of glasses with varying compositions of $(80\text{-}x)B_2O_3\text{-}xAl_2O_3\text{-}10CdO\text{-}10ZnO$. The x values fixed for the samples were 0, 5, 10, 15 and 20 mol %. The results of the analysis are presented in **Figure 1**, which shows the XRD patterns of all the glasses. The absence of sharp Bragg's peaks in the XRD patterns indicates that the glasses are amorphous in nature. This is because the XRD technique is primarily used to identify crystalline structures, and the absence of any sharp peaks in the pattern suggests that there is no long-range order in the atomic arrangement of the glass. Therefore, the glasses prepared in this study do not exhibit any crystalline behavior and are confirmed to be amorphous.

Density, Molar volume and Oxygen Packing Density(OPD)

The density of the prepared glasses in the present study was measured using Archimedes principle. **Figure.2** illustrates how the density of BACZ glasses varies when B_2O_3 is replaced with modifier concentrations of Al_2O_3. In $(80\text{-}x)B_2O_3\text{-}xAl_2O_3\text{-}10CdO\text{-}10ZnO$ glasses, the density decreased with increasing Al_2O_3 content. The density varies from 4.410 g.cm^{-3} to 3.138 g.cm^{-3}. This decrease in density with the addition of Al_2O_3 can be attributed to several factors: Firstly, Al_2O_3 has a lower atomic weight compared to B_2O_3, CdO, and ZnO. Therefore, the substitution of B_2O_3 with Al_2O_3 leads to a decrease in the average atomic weight of the glass, resulting in a lower density. Secondly, Al_2O_3 has a larger atomic radius compared to B_2O_3, CdO, and ZnO [**24,25**]. This substitution leads to an increase in the average bond length between atoms, which reduces the packing density of the glass and contributes to the overall decrease in density. Finally, the incorporation of Al_2O_3 into the glass network may also lead to the formation of voids or structural defects in the glass, which can further contribute to the decrease in density [**26,27**]. Overall, the decrease in density with increasing Al_2O_3 content in $(80\text{-}x)B_2O_3\text{-}xAl_2O_3\text{-}10CdO\text{-}10ZnO$ glasses can be attributed to a combination of these factors. Nassar et al. [**28**] explored the impact of Aluminium ions on $B_2O_3\text{-}Al_2O_3$ glasses. They observed that substituting B_2O_3 with Al_2O_3 resulted in a reduction in glass density, as the concentration of BO_4 groups decreased and boroxol groups have formed. The introduction of aluminium ions into the B_2O_3glasses caused a shift in the structural units from BO_4 to BO_3, ultimately leading to a decrease in density. In the case of Al_2O_3 series glasses, the experimental density decreases with the addition of modifiers while the molar volume increases. These glasses follow the general trend of molar volume with density. However, in the case of BACZ glasses, density decreased and molar volume increased with an increase in Al_2O_3 content.

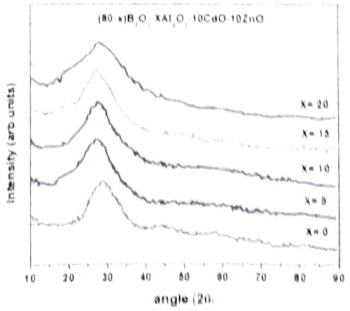

Figure 1: XRD patterns of BACZ glass samples.

Table 1: Density , Molar volume and oxygen Packing density (OPD) of present glasses

Glass Compostion	X	Molar weight	Density ($g.cm^{-1}$)	Molar volume (m^3/mol)	OPD (g-atom/1)
80 B_2O_3-10CdO-10ZnO	0	76.67	4.410	17.39	149.55
75 B_2O_3- 5 Al_2O_3- 10 CdO-10 ZnO	5	78.291	3.395	23.06	112.76
70 B_2O_3- 10 Al_2O_3-10 CdO-10 ZnO	10	79.908	3.349	23.86	108.96
65 B_2O_3- 15 Al_2O_3-10 CdO-10 ZnO	15	81.525	3.231	25.23	103.04
60 B_2O_3- 20 Al_2O_3-10 CdO-10 ZnO	20	83.142	3.138	26.49	98.13

It is also possible to find Al_2O_3-B_2O_3-CdO glass compositions where both the density and molar volume decrease with increasing Al_2O_3 content. The change in glass structure with increasing Al_2O_3 content can again cause this behavior. Jiao Han et al [**29**] investigated physical properties of the calcium boro silica glasses a function of Al_2O_3 content and observed that both glass density and molar volume decreases due to structural changes in the glasses. Ahmed et al., [**30**] reported physical properties of Al_2O_3-B_2O_3-CdO glasses. In that, as the Al_2O_3 content increases, the glass structure shifts from a network of B-O and Cd-O polyhedra to a network of Al-O polyhedra, resulting in a decrease in both density and molar volume. Singla et al., [**31**] investigated the effect of Al_2O_3 content on the properties of Aluminium borate glasses. They found that as the Al_2O_3 content increased from 0 to 50 mol%, the density of the glass decreased from 4.30 g/cm^3 to 4.02 g/cm^3.In the present glasses, if the concentration of network modifiers increases, the oxygen packing density of oxygen atoms in the glass network may decrease due to changes in the local atomic arrangement and the bonding between atoms. This may lead to an increase in the molar volume of the glass, as more free volume becomes available. All the physical parameters were shown in **Table.1**.

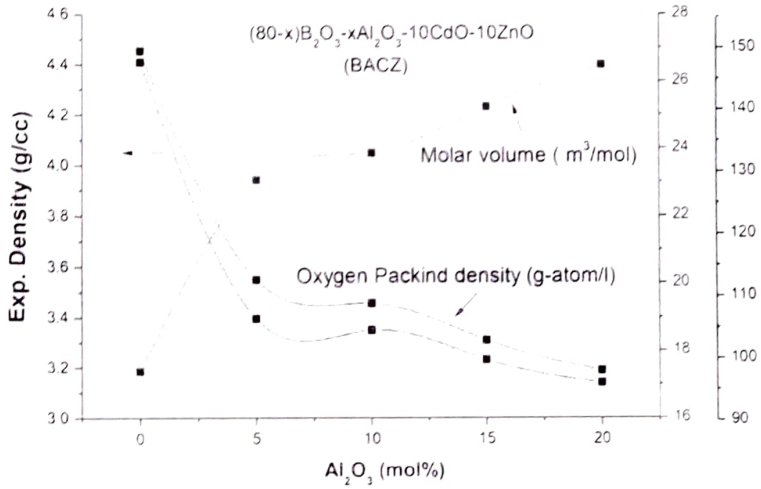

Figure 2: Density and molar volume of BACZ glasses

Optical Studies

Cut off wavelength

The cutoff wavelength is an important parameter in the optical properties of glasses as it provides information about the transparency range of the material. The cutoff wavelength is crucial in the design and selection of optical components. By understanding the cutoff wavelength, one can choose glasses that are suitable for specific applications. For instance, in ultraviolet (UV) applications, glasses with a low cutoff wavelength are preferred, while in infrared (IR) applications, glasses with a high cutoff wavelength are desired. The cutoff wavelength can be determined by identifying the point at which the absorption decreases significantly by drawing tangents in the absorption spectra.

The following equation was used to get the optical absorption co-efficient (ν) at the fundamental absorption edge.

$$\alpha(\nu) = \left(\frac{1}{d}\right) log\ log\ \left(\frac{I_0}{I_t}\right) \qquad (1)$$

Here, incident and transmitted beam strengths are denoted by I_0 and I_t, respectively. d represents the glass sample's thickness in this case. Log (I_0/I_t) is an element that matches absorbance.

In the glass composition (80-x) B_2O_3-xAl_2O_3-10CdO-10ZnO, the increase in cutoff wavelength from 408.66 nm to 500.02 nm when the Al_2O_3 content increases can be attributed to several factors, including changes in the electronic structure, optical properties, and the refractive index of the glass [**33**].The addition of Al_2O_3 to the glass composition introduces different elements and their electronic structures. The energy levels and electronic transitions of Al_2O_3 may contribute to the absorption properties of the glass at different wavelengths. As the Al_2O_3 content increases, there could be a shift in the energy levels or electronic transitions, resulting in a change in the cut-off wavelength [**34**].

Figure.3 depicts the optical spectra. By plotting $(\alpha h\nu)^n$ as a function of hν, where B is a constant related to the extent of the band tailing and hν is the incident photon energy, one can determine the optical energy band gap E_g for all electronic transitions. The value of n, determines the type of transition [**35**]. Generally in glasses the type of transition is indirect allowed (n=1/2). The optical band gap energy E_g is obtained by extrapolating the absorption coefficient to zero in the $(\alpha h\nu)^n$ versus hν plots for n 1/2. **Figure.4** depicts Tauc plots showcasing the band gap energies of glasses comprising (80-x)B_2O_3-xAl_2O_3-10CdO-10ZnO.

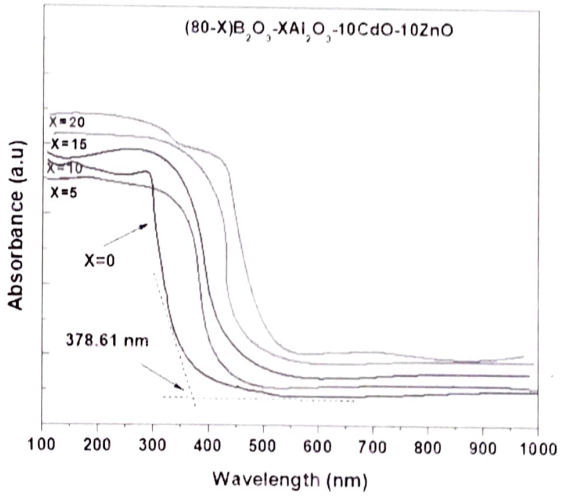

Figure 3: Optical Absorption spectra of BACZ glasses

Optical Energy band gap

The optical band gap of present glasses are calculated from the Urbach plots using following relation,

$$(\alpha h\nu)^n = B(h\nu - E_g) \qquad (2)$$

The extracted values are obtained from **Table.2**, indicating that the band gap energies exhibit decreasing trend as the Al_2O_3 content in the glasses is raised. The addition of Al_2O_3 may introduce new NBOs or modify the existing ones in the glass structure. These changes can affect the electronic structure, leading to a decrease in the band gap energy[**32**]. If the Al_2O_3 NBOs have energy levels closer to the valence or conduction bands, they can facilitate electron transitions, resulting in a smaller band gap. The interaction between Al_2O_3 and other constituents in the glass can result in NBO hybridization. This can modify the energy levels and bonding characteristics, influencing the band gap energy. Hybridization between Al_2O_3 NBOs and those of other elements in the glass can lead to a decrease in the band gap. Sing et al.[**33**] conducted a study on the optical properties of Al_2O_3-PbO-B_2O_3 glasses. Their findings revealed a decrease in energy band gaps as the Al_2O_3 content increased, ranging from 3.28 eV to 2.78 eV. Furthermore, the introduction of zinc content resulted in an increased availability of oxygen ions within the glass network, leading to a transformation from trigonal $[BO_3]$ to tetrahedral $[BO_4]$ configurations. Consequently, this alteration caused a contraction in the glass network, ultimately shifting the absorption edge to lower energy levels [**36**]. In a separate investigation, Lin et al.[**37**] examined the optical properties of Aluminium borate glasses. They observed a similar trend of decreasing optical energy band gaps with increasing Al_2O_3 content. This phenomenon was attributed to structural changes occurring within the glass network, specifically the conversion of $[BO_3]$ units to $BO_4]$ units.

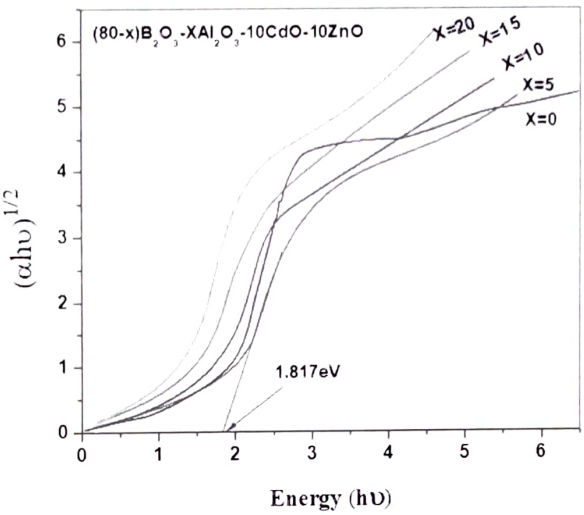

Figure 4: Tauc plots of $(80\text{-}x)B_2O_3\text{-}xAl_2O_3\text{-}10CdO\text{-}10ZnO$ (BACZ) glasses

Urbach energy

The Urbach energy ΔE was used to calculate the creation of defect concentration in the glass structure. The well-known Urbach law [**38**] describes the relationship between α(ν) and ΔE

$$\alpha(\nu) = B \exp\left(\frac{h\upsilon}{\Delta E}\right)$$

B is a constant, while E expressed as Urbach energy.

All glass samples demonstrated Urbach plots depicting ln(α) versus hυ. The inverse slope of the linear segments within the Urbach plots was calculated to determine the Urbach energy (E). The Urbach energy serves as a measure of disorder in non-crystalline materials, where lower values indicate a less glassy nature. To obtain the Urbach energy values, Urbach ΔE plots were constructed by plotting ln(A) versus hv. **Figure 5** illustrates the Urbach energy of BACZ glasses. The graph shows that as the Al_2O_3 content increased, the Urbach energy increased. The energy range recorded in this study ranges from 0.368 eV to 0.411 eV. The addition of Al_2O_3 promotes the creation of strong covalent bonds within the glass matrix, increasing the overall structural integrity. This enhanced structural order reduces the presence of localized states or defects resulting in a increase in Urbach energy. Moreover, Al_2O_3 has a smaller ionic radius compared to B_2O_3, CdO, and ZnO. This difference in ionic radii can induce stress or strain in the glass structure when Al_2O_3 is incorporated. The presence of stress or strain can further limit the formation of defects or localized states, leading to a increase in Urbach energy. The calculated energy values are presented in **Table.2.**

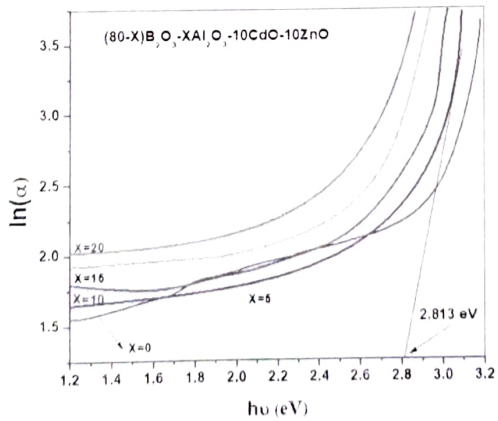

Figure 5: Urbach energy of $(80\text{-}x)B_2O_3\text{-}xAl_2O_3\text{-}10CdO\text{-}10ZnO$ glasses.

Table 2: Optical Parameters of BACZ glasses

X	Cut off Wavelength (nm)	Energy band gap (eV)	Urbach Energy (eV)
0	378.61	2.145	0.368324
5	408.66	1.817	0.355492
10	419.45	1.611	0.36049
15	441.04	1.338	0.389105
20	500.02	1.157	0.410678

IV. Conclusion

The glass composition was successfully prepared by melt quench route. XRD results confirmed the amorphous nature of the glasses. The density was decreased with additive Al_2O_3.The UV-Vis.spectra confirmed the creation of NBOs as its shift towards higher wavelength. The indirect band gap values decreased with increasing Al_2O_3 content. The NBOs are responsible for changes occurred in the optical properties. The Refractive index increased with additive Al_2O_3. The increment of Urbach values confirms more randomness in the glass by adding Al_2O_3 due to NBOs.

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