

FTIR Analysis of $\text{Bi}_2\text{O}_3\text{-B}_2\text{O}_3\text{-Fe}_2\text{O}_3$ Glass System Doped with Nd_2O_3

**A THESIS SUBMITTED IN PARTIAL FULLFILLMENT OF THE
REQUIREMENTS
FOR THE DEGREE OF BACHELOR OF TECHNOLOGY**

By

**SANTAK DASH MOHAPATRA
(ROLL NO : 10508020)**



**DEPARTMENT OF CERAMIC ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA
2009**

FTIR Analysis of $\text{Bi}_2\text{O}_3\text{-B}_2\text{O}_3\text{-Fe}_2\text{O}_3$

Glass System Doped with Nd₂O₃

**A THESIS SUBMITTED IN PARTIAL FULLFILLMENT OF THE
REQUIREMENTS
FOR THE DEGREE OF BACHELOR OF TECHNOLOGY**

By

**SANTAK DASH MOHAPATRA
(ROLL NO : 10508020)**

**Under the Guidance of
Prof. SUMIT KUMAR PAL**



**DEPARTMENT OF CERAMIC ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA
2009**



**NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA
2009**

CERTIFICATE

This is to certify that the thesis entitled, “**FTIR Analysis of $\text{Bi}_2\text{O}_3\text{-B}_2\text{O}_3\text{-Fe}_2\text{O}_3$ Glass System Doped with Nd_2O_3** ” submitted by Mr. Santak Dash Mohapatra, (Roll no:10508020) in partial fulfillment of the requirements of the award of Bachelor of Technology Degree in Ceramic Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other university / institute for the award of any Degree or Diploma.

Date: 12.05.2009

Prof. Sumit Kumar Pal
Dept. of Ceramic Engineering
National Institute of Technology
Rourkela – 769008

ACKNOWLEDGEMENT

I wish to express my deep sense of gratitude and indebtedness to Prof. Sumit Kumar Pal, Department of Ceramic Engineering, NIT Rourkela for introducing the present topic and for his inspiring guidance, constructive criticism and valuable suggestion throughout this project work.

I would also like to thank to all my friends, seniors and other staffs who have patiently extended all sorts of help for accomplishing this work.

Date: 12.05.2009

Santak Dash Mohapatra

Roll no :10508020

Department Of Ceramic Engineering

NIT Rourkela

CONTENTS:

	<u>Page no</u>
A. ABSTRACT	2
B. TABLE OF CONTENTS	3
C. CHAPTERS	
1. INTRODUCTION	3
2. LITERATURE REVIEW	
2.1 EFFECT OF Bi_2O_3 ON DIFFERENT PHYSICAL PARAMETERS OF BORATE GLASS	4
2.2 STRUCTURAL INVESTIGATIONS OF BISMUTH BORATE GLASSES AND CRYSTALLINE PHASES	9
2.3 Fe_2O_3 - Bi_2O_3 - B_2O_3 GLASS SYSTEM	10
2.4 GLASS FORMATION REGION	12
2.5 FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR)	13
2.6 FTIR STUDY OF BORATE GLASSES	13
3. STATEMENT OF THE PROBLEM	15
4. EXPERIMENTAL WORK	
4.1 MATERIALS	16
4.2 SYNTHESIS PROCEDURE	16
4.3 CHARACTERISTIC OF PREPARED SAMPLE	17
5. RESULTS AND DISCUSSION	18
6. CONCLUSIONS	24
D. REFERENCES	

ABSTRACT

In the present work $\text{Bi}_2\text{O}_3\text{-B}_2\text{O}_3\text{-Fe}_2\text{O}_3$ glasses have been prepared via melt quenching method. The composition has been fixed to 60 mol% B_2O_3 , 20 mol% Bi_2O_3 and 20 mol % Fe_2O_3 which is a stable glass forming composition. In these glasses, Nd_2O_3 has been doped in exchange of Fe_2O_3 concentration. FTIR studies have been performed in these glasses to examine the distribution of different borate and bismuth structural groups. The effect of iron and neodymium on these distributions has been examined.

TABLE OF CONTENTS

LIST OF FIGURES

Figure 1	3D structure of boron trioxide
Figure 2	Ring structure of boron trioxide
Figure 3	Change in density with Bi ₂ O ₃ content
Figure 4	Change in glass transition temperature with Bi ₂ O ₃ content
Figure 5	Change in oxygen packing density with Bi ₂ O ₃ content
Figure 6	Glass formation region for B ₂ O ₃ -Bi ₂ O ₃ -Fe ₂ O ₃ glass
Figure 7	FTIR spectra of undoped sample
Figure 8	FTIR spectra of 0.1 mol% Nd ₂ O ₃ doped sample
Figure 9	FTIR spectra of 0.3 mol% Nd ₂ O ₃ doped sample
Figure 10	FTIR spectra of all the samples combined together

LIST OF TABLES

Table 1	Specific vibrations for different absorption bands /wavenumber
---------	--

CHAPTER 1: INTRODUCTION

Bismuth borate glass is of great interest in optoelectronic devices due to its low melting temperature (600-800°C), extensive glass formation range, high refractive index ranging from 1.9 to 2.3, high physical and chemical stability, and nonlinear optical property.

Pure boron trioxide (B_2O_3) is a very good glass former, covalently bonded, with interesting physicochemical properties [1]. It exhibits unique structural features and attracts interest because of its simple composition which consists of planar BO_3 triangle [2, 3]. Melts with compositions rich in B_2O_3 exhibit rather high viscosity and tend to the formation of glasses. In crystalline form, on the other hand, borates with various compositions are of exceptional importance due to their interesting linear and nonlinear optical properties [4].

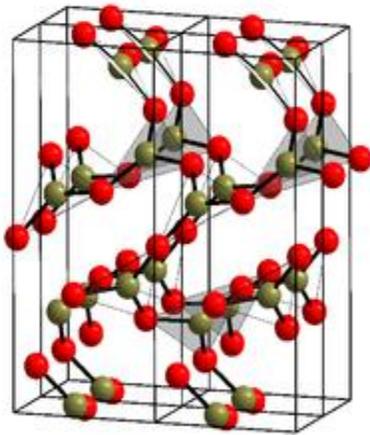


Fig. 1

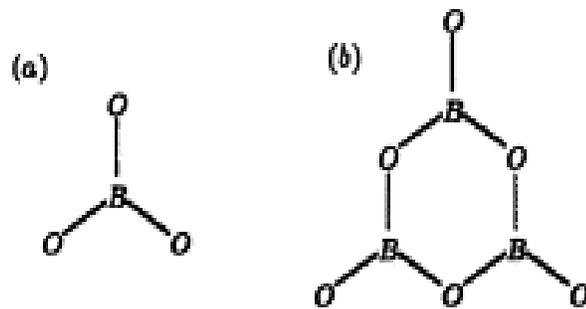


Fig. 2

Bismuth oxide cannot be considered as network former due to small field strength of Bi^{3+} ion. However, in combination with B_2O_3 , glass formation is possible in a relatively large compositional range. Bismuth from Bi_2O_3 generally tends to occupy octahedral

positions in the glass structure. The additional oxygen required for octahedral coordination of Bi are provided by the oxygen atoms in the host matrix through non-bonding coordination, because Bi_2O_3 by itself can only give rise to $[\text{BiO}_{3/2}]_0$ units [5]. Glasses based on heavy metal oxide such as Bi_2O_3 have wide applications in the field of glass ceramics, layers for optical and electronic devices, thermal and mechanical sensors, reflecting windows, etc [6].

Also, Fe_2O_3 is not a glass network former; this makes it relatively difficult to prepare glasses containing highly Fe^{3+} ions, because the maximum range for glass formation is with Fe_2O_3 (10–20 mol%). In our endeavor to obtain Fe ion having high conductivity, we were interested in the $\text{Fe}_2\text{O}_3 - \text{Bi}_2\text{O}_3 - \text{B}_2\text{O}_3$ system because its glass formation region and a maximum range of Fe_2O_3 content were expected to expand further considering that B_2O_3 is a good glass network former by rapid quenching [6]. Fe-ion-containing oxide glasses are likely to exhibit ferromagnetism as well as semiconduction. If any glass having a high electrical conductivity at room temperature and high thermal stability can be obtained, then these glasses may find useful applications as sensors in magneto-resistance effect [6, 7].

A survey of literature shows that there are many reports available on bismuth borate glasses [6]. However the studies with Nd_2O_3 addition are very limited. The present work is taken up with an objective to characterize the $\text{Fe}_2\text{O}_3 - \text{Bi}_2\text{O}_3 - \text{B}_2\text{O}_3$ glass system with higher B_2O_3 content and varying Nd_2O_3 concentration by means of infrared studies and to understand structural details.

CHAPTER 2: LITERATURE REVIEW

Research on borate glasses have been carried out by many researchers during the past several decades, especially pertaining to an optimization of glass preparation, investigation on their structural and physical properties. A systematic bismuth borate glass series in the glass systems have been successfully prepared by melt quenching technique over a wide range of composition ($x = 20-85$ mol%). Also glass from the system: $\text{Fe}_2\text{O}_3\text{-Bi}_2\text{O}_3\text{-B}_2\text{O}_3$ has been prepared and their DC conductivity, optical and structural properties has been measured by different analysis techniques like vibrational spectroscopy, DSC/TG, etc.

2.1 EFFECT OF Bi_2O_3 ON DIFFERENT PHYSICAL PARAMETERS OF BORATE GLASS

Bi_2O_3 addition has important effects on the properties of different borate glasses [5]. The more general ones are:

- The density of glasses increases as the Bi_2O_3 content increases. This is due to the high relative molecular mass of Bi_2O_3 compared to other glass constituents. The density of pure B_2O_3 glass is reported as 1832 kg/m^3 . The density of bismuth borate glass which contains 5 - 45 mol% Bi_2O_3 , as measured by El-Adawy and Moustafa, is also included for comparison. They also found that the density of bismuth borate glass increased up to the investigated level of 45 mol% Bi_2O_3 . As expected, the increase in density is due to the addition of Bi_2O_3 molecules which have a higher molecular weight (465.96g) as compared to B_2O_3 (69.622g). From a microscopic perspective, the increase in density of glasses is probably due to increase in the number of non-bridging oxygen (NBO) atoms and may be attributed to replacement of a low-density oxide (B_2O_3 , 2550 kg/m^3) by a high-density oxide (Bi_2O_3 , 8990 kg/m^3). The increase in density is also consistent with

previous work on the bismuth borate glass system, as reported previously . Recent studies have shown that at lower Bi_2O_3 content, Bi_2O_3 dilutes into B_2O_3 -matrix without interrupting the B-O-B bond, while at moderate concentration, Bi_2O_3 will act as a network modifier by formation of Bi-O-B bonds. At higher Bi_2O_3 content, the B-O-B bond will be substituted by Bi-O-B and Bi-O-Bi bonds. In short, the increase in density of the glasses accompanying the addition of Bi_2O_3 is probably attributable to a change in cross-link density and coordination numbers of Bi^{3+} ions .

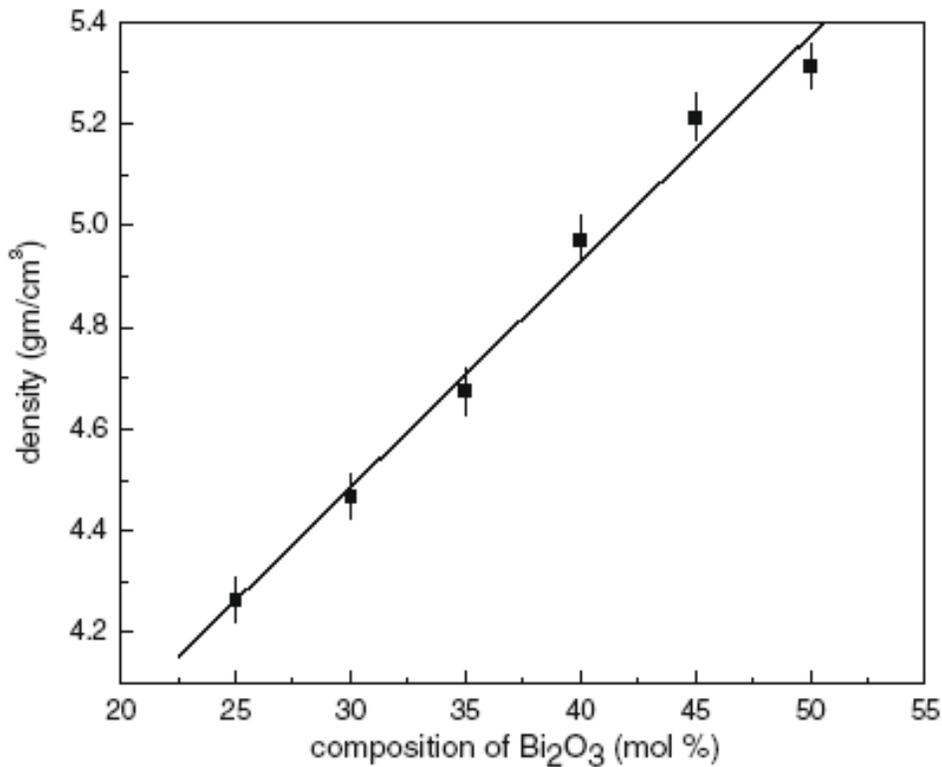


Fig. 3

- The glass transition temperature (T_g) decreases with increase in the Bi_2O_3 content [3]. The decrease in T_g may be due to the increasing number of non-bridging oxygen atoms as Bi_2O_3 content increases. It is obvious that the decrease in T_g is due to increase in the number of Bi-O linkages which are

weaker than B–O linkages. It may be noted that the bond strength of Bi–O is 81.9 kcal/mol and the bond strength of B–O is 192.7 kcal/mol.

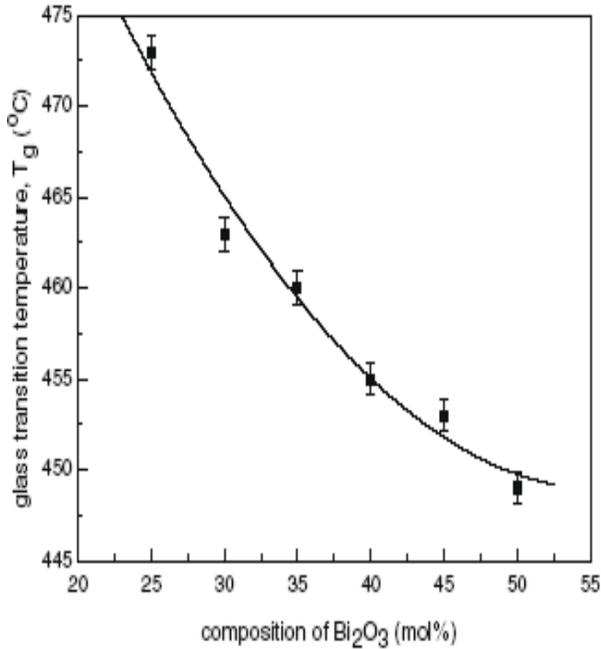


Fig.4

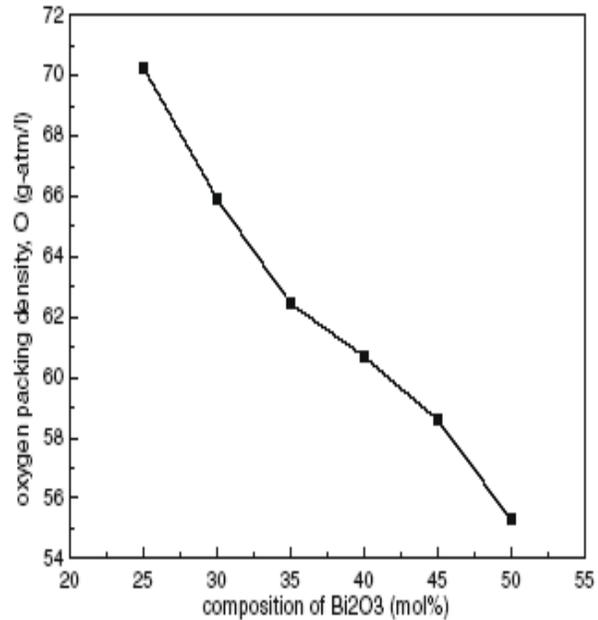


Fig. 5

- Oxygen packing density which is a measure of the tightness of packing of the oxide network can also be used to explain the decrease in T_g with the increase in Bi_2O_3 content [8]. Oxygen packing density decreases as the concentration of Bi_2O_3 increases. This indicates that the structure becomes loosely packed with increase in the concentration of Bi_2O_3 . A looser macromolecular structure requires smaller internal energy for the chain mobility which is needed for the glass transition. Thus, the addition of Bi_2O_3 indicates the formation of a more open macromolecular chain in the present glass system leading to decrease in T_g .
- The theoretical optical basicity (K_{th}) values increase with increase in Bi_2O_3 content. The basicity increases with increase in polarizability. It is well known in the literature that Bi^{3+} ions are highly polarizable. Therefore, increase in Bi_2O_3 content causes an increase in optical basicity in these glasses.

- The variations of longitudinal modulus (L), shear (G) modulus, bulk modulus (B) and Young's modulus (Y) against mol fraction of Bi_2O_3 are also observed [11]. The values of longitudinal modulus and bulk modulus of these glasses initially increased but then decreased subsequently as more Bi_2O_3 was added into the borate network. However, their Young's modulus and shear modulus decrease with incremental increase of Bi_2O_3 . The slight increase of the longitudinal elastic modulus and bulk modulus as a function of Bi_2O_3 content reveals an increase of minimal rigidity of the glassy network.

2.2 STRUCTURAL INVESTIGATIONS OF BISMUTH BORATE GLASSES AND CRYSTALLINE PHASES

Bismuth borates form transparent glasses over a wide Bi_2O_3 concentration range of (20–85) mol%. Therefore there is significant interest in the preparation and characterization of bismuth borate glasses, glass ceramics and single crystals for their application in non-linear optics. The phase diagram of Bi_2O_3 – B_2O_3 system was first determined by Levin and Daniel [13], and a variety of stable phases are known to exist.

A number of earlier studies have reported the density, thermal, optical and structural studies of Bi_2O_3 – B_2O_3 glass and melts. An early comprehensive study of several oxide glasses containing Bi_2O_3 as a network former was reported by Dumbaugh [6]. There are however inconsistencies in the reported properties and structural information about bismuth borate glasses due to use of different crucible materials and variation in preparation conditions. Borate glasses unlike silicates show two coordination numbers of 3 and 4 with oxygen and also depend upon the external parameters like temperature and pressure. It is therefore important to carefully prepare and measure density, thermal and optical properties in these technologically important materials.

The first step of the crystalline phases formation mechanisms from vitreous matrices was less studied. The structural studies refer especially to local order in vitreous state and crystalline structure after devitrification. There are some studies regarding structural transformation from crystalline to amorphous phase for Bi-2212 superconductor compounds during their melting at high temperature. It was proposed a model of

rejecting the whole layer during the phase transition from crystalline to amorphous state since the phase obtained during the melting process has approximately the same interlayer distance with the Bi-2212 initial phase. In the first step of 2212 phase formation, simple perovskite cubes characterize the local order and then a layer-type structure is formed. Finally, the 2212 crystalline phase with (110) preferential orientation is obtained. X-ray diffraction analysis also shows that the transformation during heat treatment from amorphous to crystalline phases of bismuth-borate glass samples takes place in sequences. After a short heat treatment, 5 min at 550 °C, a layered structure with a preferred orientation of crystallites on the surface is observed. After a long heat treatment, 8 h at the same temperature, normal polycrystalline bulk samples are obtained.

2.3 Fe₂O₃ - Bi₂O₃-B₂O₃ GLASS SYSTEM

Using reagent grade Fe₂O₃ (98%), - Bi₂O₃ (99.9%) and B₂O₃ (90%), a glass batch (5 g) was prepared by melting in an electric furnace in air at 1423 K for 1 h. Recently, there are relatively few reports on Fe₂O₃ -containing semiconducting glasses. Several properties of semiconducting Fe₂O₃ - Bi₂O₃ – Li₂B₄O₇ glasses have been investigated [8]. These properties include Mossbauer spectroscopy, differential scanning calorimeter (DSC), density, thermoelectric power and DC conductivity. Mossbauer spectroscopy results revealed that the relative fraction of Fe²⁺ increases with an increasing Fe₂O₃ content. Density was observed to decrease with an increase in Fe₂O₃ content. The glassy state was confirmed by the absence of peaks in X-ray powder diffraction patterns. The XRD patterns exhibit a broad diffuse scattering at low angles instead of crystalline peaks, confirming a long-range structural disorder characteristic of amorphous network.

Glass systems of composition 95% $[x \text{ B}_2\text{O}_3 (1 -x) \text{ Bi}_2\text{O}_3]$ 5% Fe₂O₃ with different Bi/B nominal ratios (0.07<x<0.90) have been investigated by means of Raman and infrared spectroscopy in order to obtain information about the competitive role of B₂O₃ and Bi₂O₃ in the formation of the glass network. The glass samples have been prepared by melting at 1100°C and rapidly cooling at room temperature. The samples

have been further kept at 575 °C for 10 h in order to relax the glasses structure as well as to improve the local order and to develop the new formed crystalline phases. The influence of both Bi₂O₃ and Fe₂O₃ on the vitreous B₂O₃ network as well as the local order changes around bismuth and boron atoms in as prepared and heat-treated samples have been studied. Structural modifications occurring in the heat-treated samples compared to the untreated glasses have been pointed out. Because iron is frequently present in trace amounts as an impurity introduced with the raw materials, various studies have been carried out to establish the environments of Fe³⁺ and Fe²⁺ ions, mostly at the few percent level in different glasses. It was supposed that, at low concentrations, the ions act as modifiers similar to the alkali metals or alkaline earths . In order to find new applications of the doped Bi₂O₃–B₂O₃ glasses a better understanding of their structure becomes necessary. Glass samples belonging to 95%[x B₂O₃ (1- x) Bi₂O₃] 5% Fe₂O₃ with 0.07<x<0.90 were prepared using as starting materials H₃BO₃, Bi(NO₃)₃.5H₂O and Fe₂O₃ of reagent purity grade. The mixtures corresponding to the desired compositions were melted in air, in sintered corundum crucibles, in an electric furnace at 1100°C and maintained for 10 min at this temperature. The melts were quickly cooled at room temperature by pouring and pressing between two stainless steel plates. The glass samples were subjected to partial crystallization by heat treatment applied at 575 °C for 10 h. X-ray diffraction measurements on as prepared glasses and heat-treated samples have been carried out in order to identify the crystalline phases developed after heat treatment. Previously, by analyzing Raman and infrared spectra of 95%[x B₂O₃ (1-x) Bi₂O₃] 5% Fe₂O₃ system it was found that Bi³⁺ cations are incorporated in the untreated glass network as [BiO₆] polyhedra, in the heat-treated samples as [BiO₃]pyramidal and [BiO₆] octahedral units and as distorted [BiO₆] polyhedra for x > 0:20. The spectra of the heat-treated samples evidence that the glass stability is decreasing as the bismuth concentration increases [11]. After 10 h heat treatment at 575 °C, only the sample with highest boron content, x > 0.20, remains non-crystalline while all the others crystallize. In comparison to previous studies on bismuth borate glasses doped with 0.5% Fe₂O₃ the results obtained in the study show that the higher iron content (5% Fe₂O₃) strongly influences the structure of the bismuth-borate

matrices, determining a more ordered bismuth vicinity ($x= 0.20$), and stabilizing the glass network in the compositional region with relatively small bismuth concentration.

2.4 GLASS FORMATION REGION

The glass formation region of the $\text{Fe}_2\text{O}_3 - \text{Bi}_2\text{O}_3 - \text{B}_2\text{O}_3$ system is illustrated in the figure indicating a compositional range for glass formation: $0 < \text{Fe}_2\text{O}_3 < 40 \text{ mol}\%$, $0 < \text{Bi}_2\text{O}_3 < 100 \text{ mol}\%$ and $0 < \text{B}_2\text{O}_3 < 100 \text{ mol}\%$ [9]. This compositional range was found to be larger than those in our previous studies on Fe_2O_3 glasses.

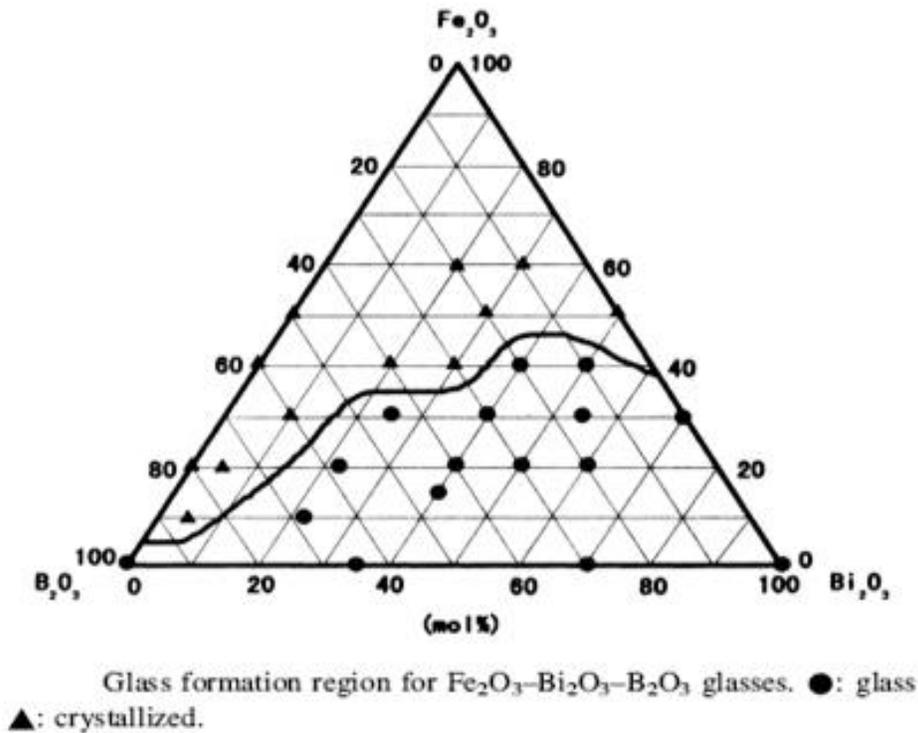


Fig.6

2.5 FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR)

Infrared spectroscopy (IR spectroscopy) is the subset of spectroscopy that deals with the infrared region of the electromagnetic spectrum. It covers a range of techniques, the most common being a form of absorption spectroscopy.

Fourier transform infrared spectroscopy (FTIR) is a measurement technique for collecting infrared spectra [14]. Instead of recording the amount of energy absorbed when the frequency of the infra-red light is varied (monochromator), the IR light is guided through an interferometer. After passing through the sample, the measured signal is the interferogram. Performing a mathematical Fourier transform on this signal results in a spectrum identical to that from conventional (dispersive) infrared spectroscopy.

2.6 FTIR STUDY OF BORATE GLASSES

IR spectroscopy is a very sensitive and one of the most used spectroscopy methods applied in the investigation of the local structure characterizing vitreous materials like oxide glass. The borate glasses are very often investigated because they are relatively easy to obtain and, moreover, in their structure appears a large variety of structural units over a wide range of modifier concentration. Borate glasses are scientifically interesting because of the occurrence of the boron anomaly and for their application as a dielectric material. The presence of some transitional metal ions in the glass structure makes the glass electrically semiconducting and super paramagnetic.

FTIR spectroscopy has been frequently used before for the structural study of glass systems containing B_2O_3 like $3B_2O_3.BaO$ glass matrix, $Fe_2O_3-B_2O_3-BaO$ glass system etc [7]. The results reveal the spectral contribution of each component on the structure of the glass. Various intense bands for different wavenumber are observed and each

has a special role in the structure of the glass. The absorption bands are assigned for different stretching and bending vibrations like specific vibrations of Ba-O bonds, specific vibrations of Mn-O bonds, B-O-B bending vibrations, $O_3B-O-BO_4$ bending vibrations, B-O stretching vibration of BO_4 units in tri-, tetra- and penta- borate groups, B-O stretching vibration of trigonal BO_3 units in boroxol rings, B-O stretching vibrations of BO_3 units in meta-, pyro- and orthoborate groups, specific vibrations of Fe-O and Ba-O bonds, specific vibrations of Fe-O and Ba-O bonds, B-O-B bending vibrations, $O_3B-O-BO_4$ bending vibrations, B-O stretching vibration of BO_4 units in tri-, tetra- and penta-borate groups, B-O stretching vibration of B-O bond of BO_4 units from boroxol rings, B-O stretching vibrations of BO_3 units in metaborate, pyroborate and orthoborate groups. The role of the modifier ions like iron, manganese etc on the BO_4 / BO_3 ratio is found out by FTIR analysis [7, 8]. It is also noted whether the ions have any influence on the structural disorder of the glass matrix.

CHAPTER 3: STATEMENT OF THE PROBLEM

1. Preparation of Fe_2O_3 - Bi_2O_3 - B_2O_3 glass
2. Preparation of Fe_2O_3 - Bi_2O_3 - B_2O_3 glass doped with Nd_2O_3
3. FTIR analysis
4. Effect of Nd_2O_3 doping on the glass structure

CHAPTER 4: EXPERIMENTAL WORK

4.1 MATERIALS

1. Boric Acid GR (H_3BO_3)
2. Bismuth Oxide (Bi_2O_3)
3. Ferric Oxide (Fe_2O_3)
4. Neodymium Oxide (Nd_2O_3)

4.2 SYNTHESIS PROCEDURE

Glass from the system: $20\text{Fe}_2\text{O}_3 \cdot x\text{Bi}_2\text{O}_3 \cdot (80-x)\text{B}_2\text{O}_3$ ($x= 20$ mol%) was prepared by melt quenching technique. Batch calculations were done and appropriate amounts of boric acid, Bi_2O_3 , and Fe_2O_3 were weighed and thoroughly mixed together in agate mortar-pestle. The mixture was grinded repeatedly to obtain a fine powder. The batch mixture was transferred to a platinum crucible and first sintered in raising hearth furnace at 800°C for around 1 hr. The temperature was then slowly raised to a maximum of 1250°C and kept at that temperature for another 1 hr. The temperature was sufficient to produce clear, bubble free melt. The melt was then quenched on a pre-heated brass mold to avoid thermal stresses produced by non-uniform rapid cooling of the glass. Clear, bubble free glass was obtained and characterization was carried out.

Two more glass samples were prepared by same procedure by replacing the Fe_2O_3 content with 0.1 mol% and 0.3 mol% Nd_2O_3 respectively. The glasses were then characterized by FTIR spectroscopy and DSC/TG.

4.3 CHARACTERISTIC OF PREPARED SAMPLE

IR transmittance and absorption spectra were measured on the three crystalline samples prepared by KBr pellet technique in the wavenumber range of 4400–450 cm^{-1} on a Shimadzu FTIR (Model 8400 S) spectrophotometer. The die and the punch were cleaned using tissue paper and ethanol to get better results. The infrared spectra were corrected for the dark current noises, and normalized to eliminate the concentration effect of the powder sample in the KBr disc. The obtained spectra were deconvoluted to enable shedding further light on the structural changes of BO_3 triangles and BO_3 tetrahedra, as they are the basic units in these glasses.

CHAPTER 5: RESULTS AND DISCUSSION

Figs. 7,8, 9 and 10 show the effect of composition on the infrared spectra of the studied glasses.

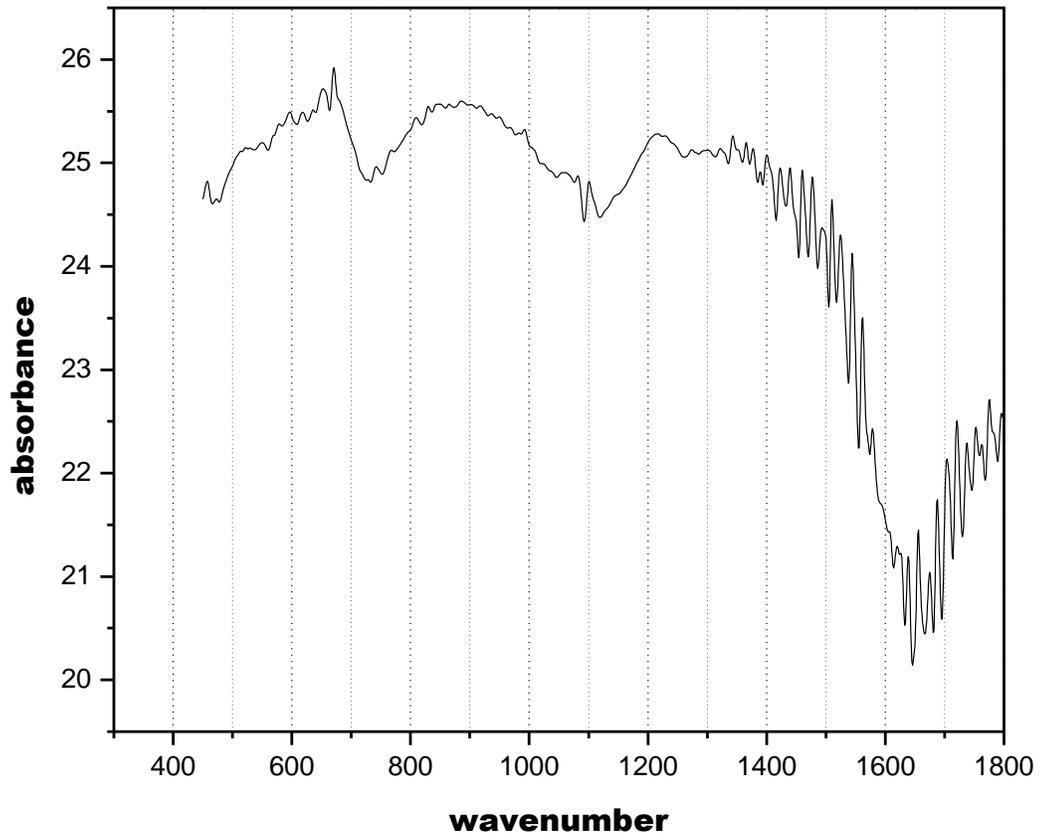


Fig. 7 Absorption spectra of undoped Fe₂O₃-Bi₂O₃-B₂O₃ glass

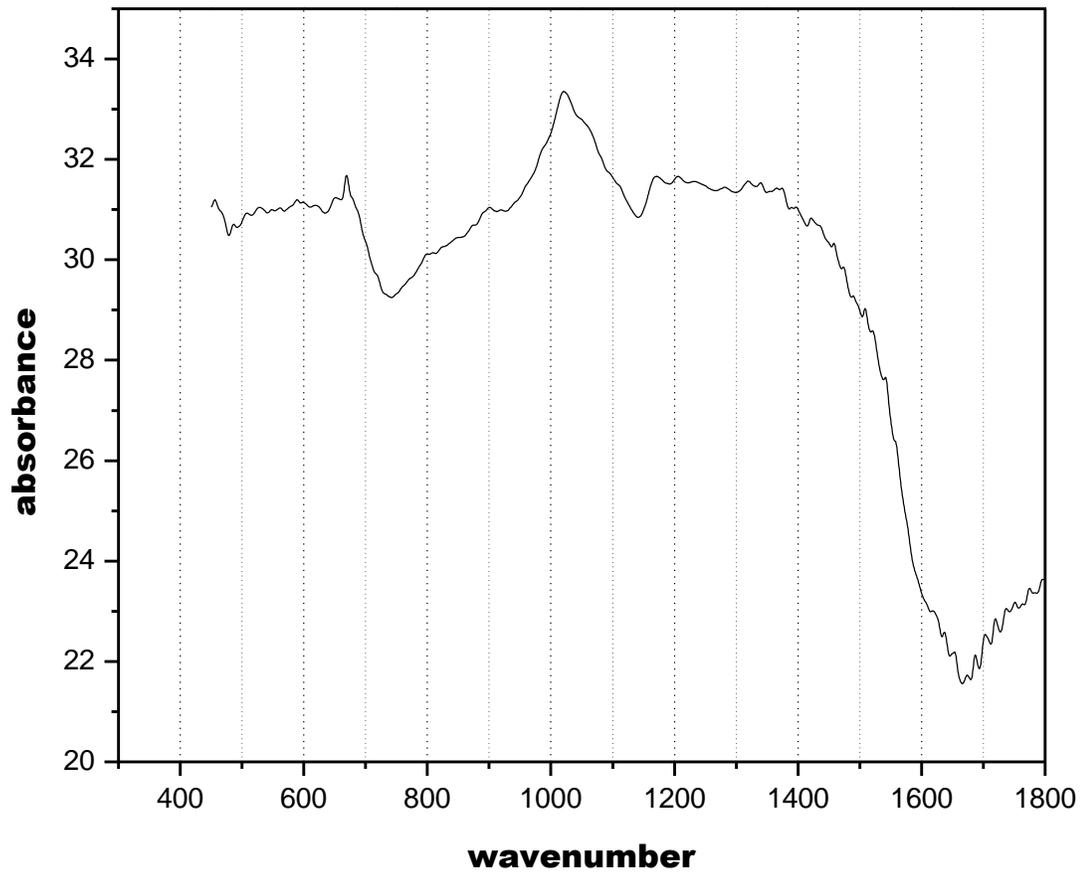


Fig. 8 Absorption spectra of 0.1mol% Nd₂O₃ doped Fe₂O₃-Bi₂O₃-B₂O₃ glass

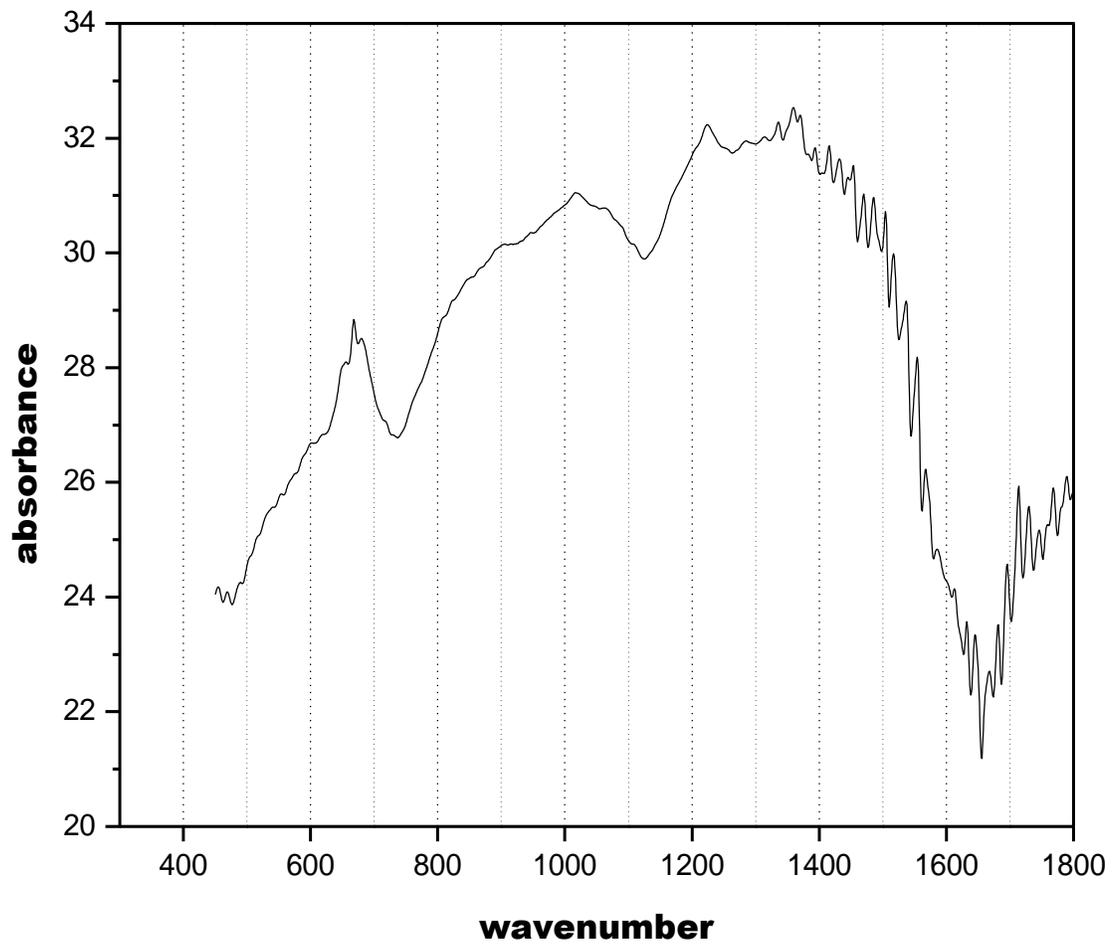


Fig. 9 Absorption spectra of 0.3 mol% Nd₂O₃ doped Fe₂O₃-Bi₂O₃-B₂O₃ glass

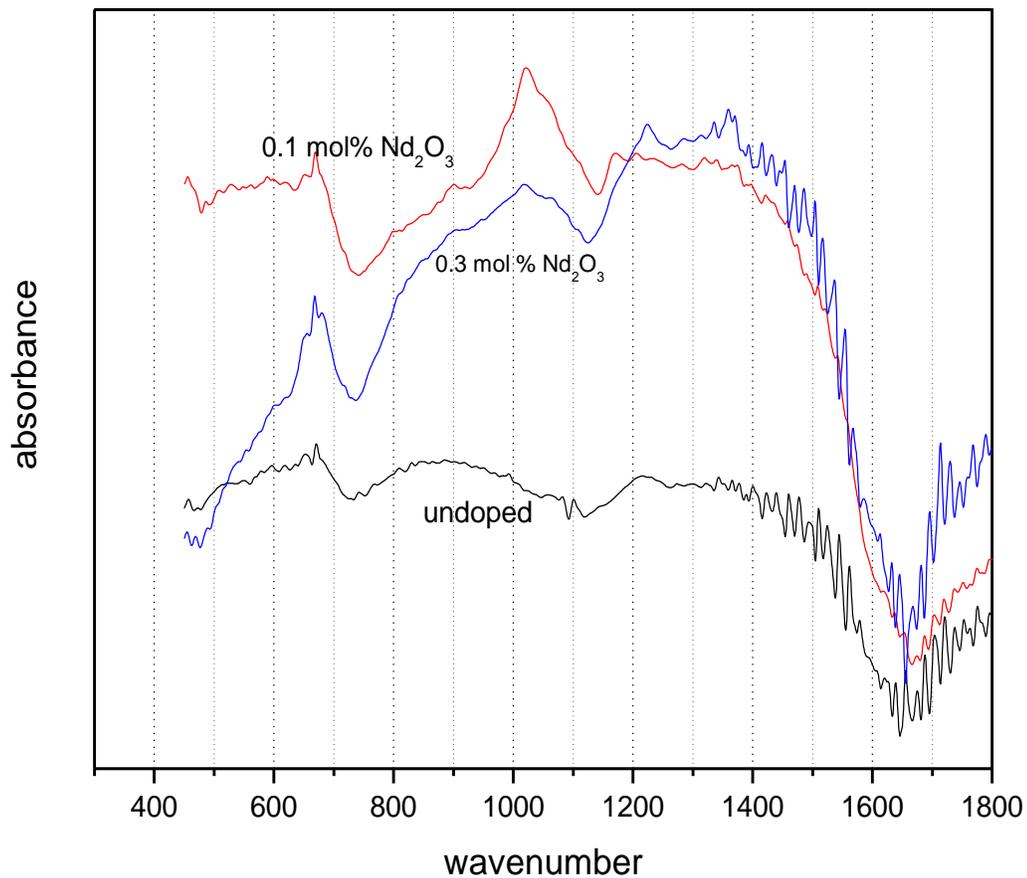


Fig .10

The experimental FTIR spectra of the Fe₂O₃ - Bi₂O₃-B₂O₃ glass was studied and following observations were made:

At 460 cm⁻¹, Fe-O bond bending vibrations have been observed in all three samples with no change in intensity.

Furthermore, at 570 cm⁻¹, Fe-O bond vibration is observed. In this case there is no change in intensity in undoped and 0.1 mol% doped samples but there is a slight change in intensity for 0.3 mol% Nd₂O₃ doped sample. This may be due to presence of higher amount of Nd₂O₃.

Absorption of infrared radiation below 610 cm^{-1} is attributed either to cationic vibrations in the network or to various modes of Bi–O vibration in BiO_6 .

At 840 cm^{-1} , Bi-O stretching vibrations has been observed for all samples but for doped sample there is slight change in intensity of these vibrations, This may also be due to addition of Nd_2O_3 .

In all the IR spectra appears a band at 710 cm^{-1} from the spectrum of vitreous B_2O_3 , which is due to the bending vibration of B-O-B linkage in borate network .The intensity of this band remains almost constant for all the samples as the Fe_2O_3 content does not vary much.

The band at 770 cm^{-1} is assigned to the B-O-B bending vibration of bridges containing one trigonal and one tetrahedral boron and has approximatively the same intensity for all the compositional range.

At 900 cm^{-1} , the bands reveal that there is a linking between B_2O_3 and Bi_2O_3 which is confirmed by the stretching vibrations of BO_4 units that are connected by the bismuth cations.

B–O stretching vibration of BO_4 units in tri-, tetra- and penta- borate groups has been assigned to the bands at 930, 1015 and 1060 cm^{-1} . Interestingly , there is a change in intensity to a great extent at 1060 cm^{-1} for the doped sample. This may be due to the doping of the glass with Nd_2O_3 .

At 1200 cm^{-1} , B–O stretching vibration of trigonal BO_3 units in boroxol rings has been observed. The intensity does not change but the absorption peak is shifted slightly in the doped samples.

B-O stretching vibrations of BO_3 units in metaborate, pyroborate and orthoborate groups have been observed at 1360 cm^{-1} . All the three samples exhibit same intensity.

Table 1 summarizes the result determined for the studied glasses.

Table 1

Wavenumber (in cm^{-1})	Assignment
460	Specific bending vibrations of Fe- O bonds
570	Specific bending vibrations of Fe- O bonds
610	Cationic vibrations in the network or to various modes of Bi–O vibration in BiO_6
709	B-O-B bending vibrations
770	$\text{O}_3\text{B-O-BO}_4$ bending vibrations
840	Stretching vibrations of Bi–O in BiO_3 units
900-950	Stretching vibrations of BO_4 units that are connected by the bismuth cations.
930 1015 1060	B–O stretching vibration of BO_4 units in tri-, tetra- and penta- borate groups.
1200	B–O stretching vibration of trigonal BO_3 units in boroxol rings.
1360	B-O stretching vibrations of BO_3 units in metaborate, pyroborate and orthoborate groups.

CONCLUSIONS:

FTIR analysis of Fe_2O_3 - Bi_2O_3 - B_2O_3 glasses have been analyzed in order to identify the spectral contribution of each component on the structure and to point out the role of the Nd_2O_3 ions in glass network. It has been observed from the FTIR analysis of Fe_2O_3 - Bi_2O_3 - B_2O_3 glasses that BO_3 and BO_4 groups co-exist for the composition chosen for this work. It has also been observed Fe_2O_3 is not capable of converting all BO_3 groups to BO_4 groups. Nd_2O_3 shows a profound effect on converting BO_3 to BO_4 group. Another glass former Bi_2O_3 make bonds with B-O only. The effect of Nd_2O_3 on Bi_2O_3 are not prominent. In the investigated glass system the three-fold boron atoms are dominated compared with the fourfold ones.

REFERENCES:

1. H. B. Senin, G. Carini, J. Abdullah, and D. A. Bradley . Glass Formation and Elastic Behavior of Bismuth Borate Glass System American Institute of Physics
2. I Ardelean et.al , FTIR structural investigation of $3\text{B}_2\text{O}_3\text{-BaO}$ glass matrix containing manganese ions. *Journal of optoelectronics and advanced materials* .Vol. 8, no. 3, june 2006, [1118 – 1120]
3. Bale Shashidhar et. al Role of Bi_2O_3 content on physical, optical and vibrational studies in $\text{Bi}_2\text{O}_3\text{-ZnO-B}_2\text{O}_3$ glasses. *Journal of Alloys and Compounds* 460 (2008) 699–703
4. Anu Bajaj et al , Structural investigation of bismuth borate glasses and crystalline phases .*Journal of Non-Crystalline Solids* 355 (2009) 45–53.
5. D. Saritha , Y. Markandeya et al , Effect of Bi_2O_3 on physical, optical and structural studies of $\text{ZnO-Bi}_2\text{O}_3\text{-B}_2\text{O}_3$ glasses .*Journal of Non-Crystalline Solids*. 354. (2008) 5573–5579.
6. Yasser B. Saddeeka*, M.S. Gaafarb Physical and structural properties of some bismuth borate glasses *Materials Chemistry and Physics* 115 (2009) 280–286
7. H. Doweidar a, Yasser B. Saddeek , FTIR and ultrasonic investigations on modified bismuth borate glasses. *Journal of Non-Crystalline Solids* 355 (2009) 348–354
8. M. TODERAŞ et al. Structural study of the $\text{Fe}_2\text{O}_3\text{-B}_2\text{O}_3\text{-BaO}$ glass system by FTIR spectroscopy .*JOURNAL OF OPTOELECTRONICS AND ADVANCED MATERIALS* Vol. 8, No. 3, June 2006, p. 1121 – 1123
9. H.H. Qiu, T. Ito, H. Sakata. DC conductivity of $\text{Fe}_2\text{O}_3\text{-Bi}_2\text{O}_3\text{-B}_2\text{O}_3$ glasses *Materials Chemistry and Physics* 58 (1999) 243-248
10. M.M. El-Desoky et al. Iron doping of semiconducting bismuth alkali borate glasses .*Physica B* 383 (2006) 163–170
11. A. Pan, A. Ghosh, J. Non-Cryst. Solids 271 (2000) 157–161.
12. [3] D.W. Hall, M.A. Newhouse, N.F. Borelli, W.H. Dumbaugh, D.L. Weidman, *Appl.Phys. Lett.* 54 (1989) 1293.

13. C. Stehle, C. Vira, D. Vira, D. Hogan, S. Feller, M. Affatigato, Phys. Chem. Glasses (2) (1998) 83.
14. www.wikipedia.org