Title: Study the infrared spectra of xLi₂O.ySiO₂.zCaO(1-x-y-z)B₂O₃ glasses

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Abstract.

The xLi2O.ySiO2.zCaO (1-x-y-z)B2O3 glass system (where x = 0, 5, 10, 15, 20 and 25 mol%, y=60 mol% and z=10 mol%) was processed through a dissolved quench technique. To acquire the structural performance of silica, calcium, boron and oxygen were minutely observed by using Fourier transform infrared spectroscopy (FTIR) and X-ray diffraction. The position and relative quantities of IR bands responsible for the distinct silicate and borate units were determined using deconvoluted spectra. For the increased amount of B2O3 the results show that BO3 occupies the network position and creates the linkage Si-O-Ca. The bands related to the bending mode of H2O molecules and the stretching mode of B–O–H groups forming hydrogen bonding are shown to result in several bands: 2300-2380cm-1 and 2820-3505 cm-1 respectively. The XRD order of the base samples exhibited homogeneous glasses and also an optical reconnoitre, but did not show any phase separation record.

Keywords: Crystallization; glass ceramics; borosilicate; FTIR measurement

Introduction

The formations of lithium, calcium borate, glass, and glass ceramics have accepted appreciable devitalisation due to their oddities (Kindrat et al., 2015). These glassceramics possesses large scientific and industrial benefit when used in the area of bioactive and biomedical (Hench, 1998) (Rahaman et al., 2006) (Wang et al., 2006) (Fu et al., 2010), individual natural and medicinal emission therapy utilization (Rammadhan et al., 2018), use as acousticoptic equipment's (Centre et al., n.d.), and White Light Emitting Diode (WLED) (Narwal et al., 2017). In accordance with the broad analysis practicing various methods, such a Raman and FTIR (Salinigopal et al., 2020)(Lai et al., 2016), ultraviolet-visible spectroscopy (UV)(Rojas et al., 2008), XRD (Huang et al., 2008)(Anjana et al., 2013), Peak shape (PS), Various heating rate (VHR) and initial rise (IR) techniques(Jose et al., 2011), ²⁹Si and ¹¹B nuclear magnetic resonance spectroscopy (Osipov et al., 2018), molecular dynamics simulation analysis (Shih & Jean, 2018), the formational and physical features of these glass and glass-ceramics showed a large composition extent of 0-33mol% CaO (Pimentel et al., 2018). As its concentration, usually CaO is

able to penetrate the network of LiB₂O₃ glass in the role of a network transformer either in the form of a network former (Rojas et al., 2006). The BO₄ tetrahedra are formed at the amount of two BO4 groups per CaO molecule at low concentration of CaO(Yiannopoulos et al., 2001) (Rejisha & 2011). The Santha, lithium-calcium borosilicate glasses (LCBS) can be used as tight electrolytes in Li-ion batteries and in low temperature co-fired ceramics as aids of sintering (Zhou et al., 2016) (Kim et al., 2011) (Kluvánek et al., 2007) on an account of its important chemical persistence, wonderful electrical resistance and dielectric characteristics. The characteristics of those glasses are governed by formational units. Boron and silicon formational units are familiar to understand the character of these glass states. To design and control the properties of borosilicate glasses, these units are used (Smedskjaer et al., 2011). Different methods are widely used to characterize the borate network (Ferlat et al., 2012)(Lee et al., 2005). The initial structure contains BO₄ and BO₃ units and another important diversity, like unique diborate $[B_4O_7]^{2-}$, $[B_3O_5]^-$, tetra-borate $[B_8O_{13}]^{2-}$, triborate pyroborate $[B_2O_5]^{4-}$ and pentaborate $[B_5O_8]^{-}$ units. By conjoining the system of M_2O_x (M=alkaline earth metal and x=valence state

of M) with B₂O₃, BO₄ formed by BO₃ units, preferably the production of non-bridging oxygen (NBO). The structural groups of BO₃, BO₄, and SiO₄ in a borosilicate glass act as a silicate and borate network formers (Freitas et al., 2012) . The sequence of polymerization of lithium sodium borosilicate glasses (LNaBS), the boron coordination and silicate network are actively reliant on glass structure was reported by Feng He et al. (He et al., 2013). Using MIR spectra, they observed that with the increase of Li₂O, free oxygen decreased by the asymmetric stretching vibration of B-O bond of BO₃. The crystallization properties of Calcia Lithia Magnesia borosilicate glass were investigated by Salama et al. (Salama et al., 1995). The system of crystallization of these glasses settled on the Li borosilicate structure holding MgO and/or CaO has been observed by scanning electron microscopy (SEM), DTA, and X-ray diffractometry (XRD). In lithium-calcium borosilicate glass, which has a composition of $0.4[(1-x)Li_2O$ xCaO]-0.6[(1-y)B₂O₃-ySiO₂] with x in the range of 0~land y in the range of 0.33~0.83, the mixed modifier effect has been observed by using X-ray absorption spectroscopy (XAS) and nuclear magnetic resonance (NMR) Shih Y-T et al. (Shih & Jean, 2017). It is necessary to think that, dealing with the qualitative and quantitative based on the position and alteration of the infrared absorption bands, limited the paper

published in the literature. Some authors (Moustafa & El-Egili, 1998) took attention to the quantitative studies of IR spectra of glass by applying a deconvolution process. To extract the fact about glass formation, the deconvoluted IR spectra of glasses could be an effective tool more than traditional studies of IR spectra. Now, in this article we have accumulate IR spectra of xLi₂O.ySiO₂.zCaO. (1-x-y-z)B₂O₃ glass with variation of Li₂O and B₂O₃ by spectroscopic technique. The quantitative and qualitative studies of these spectra were operated to explain the characteristics frequencies of vibrational chemical bonds, the bonding mechanisms, which are responsible for the spectral and constitutional change. X-ray diffraction arrangements of heat-treated and base glasses are more practised for analysis phases and amorphocity of that glass.

Materials and Methods:

To avoid humidity volume in those glasses, the glass models of B_2O_3 (99.97%, Alfa Aesar) were formerly processed at 1100 °C for 2.5 hr. and preserved in a desiccator for employed as a coarse material. The Li₂CO₃ (Sigma-Aldrich-PA, 99%), CaCO₃ (99.5% CRQ-PA), SiO₂ (99.95% Sigma-Aldrich-PA) and formerly processed B_2O_3 glasses were correctly measured in necessary mol. percentages. Suitable amounts of powder raw materials, normally 20 gm. Batches of the powder raw goods which were initially refined powder by mortar and pestle, and later homogenized by involution agitation in contact with a ball milled machine for 6-7 hours after that tempered by an electric furnace within a platinum crucible. The required temperature level of the furnace was raised within 4 hours and the required temperature was maintained for half an hour by keeping the sample in a crucible in the furnace.

10-25mol% B₂O₃ containing glass systems were high melting temperature. To melt those compositions, an oxyacetylene flame was used. Nevertheless the thawed temperature of that glass quantity consist of 0-5 mol% B₂O₃ is lower, and was tempered in an electric furnace which is enclosed within an alumina crucible. The melting temperature and content together with their classification have been exhibited in Table 1. For the production of glass-ceramic in some portions of the base the glasses was early crushed with mortar and later heat treated at 600 °C for 10 hr. by an electric furnace. Nevertheless, to examine in contrasts few glasses was further heat treated at various temperature and times. To heat treatment, a digital furnace Carbolite of model CTF12/65, Eurotherm 91 controllers, and porcelain crucible was operated. KBr pellet technique is signed to acquire the infrared absorption of a sampled glass. In order to

get a weighed quality (

0.003 g) and a fine powder of that powder the glasses were well blended with the desiccation of highly absolved (99.98%) KBr powder (0.01 g), the glass samples was landed into a clarity mortar. The blends were then rushed within a high weight to produce a translucent pellet near 0.01 mm thickness, which is acceptable to climb onto the spectrometer. A total IR spectrum of those glasses was possessed to the extent of wave number 4000-400 cm⁻¹.

To measure the XRD of that, stocked samples were transported away by using XRD method. By analyzing the intensity of the diffraction form and the experimental interplaner spacing within the approved JCPDS data, the devitrification of those specimens was determined.

Results and discussion FT-IR analysis

IR absorption spectra of low (0-10 mol%) and high (15-25 mol%) B₂O₃ including $Li_2O-SiO_2-CaO-B_2O_3$ quaternary glass alongside with the twofold CaO-SiO₂ are displayed in fig 1. At the frequency of low and high area, the IR spectrum of 30LSC0B has two major bands. The frequency at low cm⁻¹ were additional 1500-450 band apparent than the frequency at high band at 3600-2200 cm⁻¹ also subsist of several amount of shoulder and peaks about the couple of the middle maximum at 1100 cm⁻¹. In the region of low frequency band, the peak height are larger than the band of high frequency. Adding a small quantities (0-10 mol%) of B_2O_3 changes that status. With the increase of B_2O_3 the sharpness of the spectra are increased and in the area of high frequency the absorption is greater than in the frequency of low band. By the small shoulders and peaks on the couple of sides of them, all frequency bands are convoluted in Gaussian apparent. The heavy shoulder recognized of the 30LSC0B at 1117 cm⁻¹ is vanished in 25LSC5B and at 1000 cm⁻¹ the new weak shoulders is appearing.

Furthermore, the positions of the two major bands are shifted lightly. In the 20LSC10B, only low frequency band is switched to the large wave number, but the high frequency is relatively consistent weak shoulder appears in 25LSC5B at 917 cm⁻¹ comes vigorous and resolved into a peak in the 20LSC10B glass. The frequency of the low band of 20LSC10B became turned into three imbricated Gaussians with the maximum band at 1123, 1260 and 1463 cm⁻¹. Nevertheless, the frequency of low bands of 25LSC5B and 20LSC10B vary in form, and the frequency of high band are very much alike but vary in intensity absorption.

The variations of absorption spectra of the high amount B_2O_3 (15–25 mol%) including glasses are remarkably distinct from the low

 B_2O_3 including glasses. The active peak noticed in the 20LSC10B glass at 730 cm⁻¹ and 751 cm⁻¹ in 15LSC15B glass. In addition to the frequency of higher bands subsists of immense overly Gaussian with maximum absorption at 1380 and 1550 cm⁻¹. The developed band in the area of frequency 450-1600 cm⁻¹ in the 15LSC15B, 10LSC20B and 5LSC25B and the peaks of shoulder at 738 turn into robust. cm⁻¹ Moreover the frequencies of low band undertake into various overly Gaussian with maximum at 738, 1072 and 1473 cm⁻¹.In addition of high B_2O_3 , these glasses are almost similar. In the high frequency area, the absorption patterns of all glass samples are very much alike with differing intensities except 20LSC10B glass. While a consequence, spectrum subsists in other than one band, each of two, shoulder or the peak location does neither come into sight at the centre of gravity about the particular band, instead they generally progress close to the centre of gravity of all other band instants in that spectrum. As a result, the deconvoluted experimental spectra supply along the accurate location of the absorption band.

The widths and band location attained taking away from the deconvolution are so treated to exist the true description of the spectra. The deconvolution band location with their allowed chemical bonds is outlined in Table 2. A typical deconvoluted spectra with residual is shown in Fig. 2.

CaO-SiO₂ binary glass

IR spectra of twofold glass essentially subsist on the impact of nonbridging and bridging oxygens. Ahsan et al. (Moustafa & El-Egili, 1998) noticed that the band at 465 cm⁻¹ is bending vibration Si-O-Si in the rare earth aluminosilicate glass including 10-20 mol% Samaria in a period 451-480 cm⁻¹. The band intensity is much weak when it is correlated with bridging oxygen in Si–O–Si of SiO₄ tetrahedra. The deconvoluted bands with the comparative intensities at 650 and 720 cm⁻¹ are high in that glass, can be ascribed to the asymmetric bending modes of Si-O-Ca that subsist in that glass. This can be concurring with the wanted increase in nonbridging combinations when the silica system is depolymerized through calcium. Within this close area, the two shoulders are compensation to the asymmetric in the Si-O-Ca bond allocation while an area of the surroundings can in addition to subsist in the glazed elements. Tsvetan et al. (Vassilev et al., 2016) noticed that the bands with maxima at 960 cm⁻¹ can be allowed to Si-O-Si bending vibration. By a different appearance of H₂O molecules in those structures, the noticed absorption bands in the region of high frequency encase can be assumed. The broad band ordering from 3600 to 2300 cm⁻¹ are ascribed to water assemble, when the hydrogen bonding ascribed at 3510-3490

 cm^{-1} . In precise, climatic humidity is calmly absorbed by the pellets or by the sample, bringing about the coming into sight of the infrared band association to H₂O molecule even if the sample below the analysis does not include H₂O as unit in the structure. Water related as many as four bands in the region 3000-1200 cm⁻¹ area designed by 2950-2600 (A), 2460-2200 (B), and 1950-1500 (C) for the hydrates of silicate and borate crystals was noticed by Ryskin [33]. Now the bands at 1290 and 1630 cm⁻¹ based on over the investigation can be attributed to the stretching and bending form of the group forming hydrogen bonding Si-O-H. Another band ranging from 2460-2200 cm⁻¹ Ryskin describes the bending form of H₂O molecule. Since the upper limit of that range is 2460 cm⁻¹, so band at 2380 cm⁻¹ may be allowed to bending the form of H₂O molecule. The distinct wide bands comparatively free of acute characteristics in the area of high frequency signifies that a broad allocation of nonbridging type oxygen ions subsist in those glass.

Alkali calcium borosilicate glasses (0-10 mol%), B₂O₃

In the quaternary glass system, the ratio of CaO/SiO_2 was fixed at 0.167, but B_2O_3 and LiO_2 was substituted systematically in the system. Infrared spectra exposes that the comparative intensities of the absorption

bands in the area of low and high frequency of 30LSC0B- 20LSC10B, 25LSC5B and 20LSC10B are almost similar but 30LSC0B are different. In the low frequency area, the IR spectrum of 15LSC10B is defined by a coupled. There are 5 to 6 Gaussian are suited to 30LSC0B - 20LSC10B spectra with carefully supervision of a shoulder and outmost peaks. The comparative intensities of the frequency of the high band of glass 30LSC0B are greater than 20LSC10B- 20LSC10B along with the edge of the bands raised necessarily. To estimate the comparative amount and band position of different mechanism, the analogous patterns of the high frequency spectrum are deconvoluted to 4 Gaussian. The familiar peaks SiO₂ at 1025 and 960 cm⁻¹ are commonly for Si–O–Si stretching band and O-Si-O band bending vibrational forms, respectively (Chryssikos et al., 1996) [37]. Due to the vibrational modes of a nonlinear molecular unit of Si-O-Si vibrations, the existence of interstitial oxygen is characterized (Nu / OA2 Co C, 1980)(BOSOMWORTH DR et al., 1970) ("Near IR Absorption in Films of Silicon Containing Oxygen," 1978). In the 30LSC0B - 20LSC10B glasses, based on these inspections, the weak bands at 465, 470 and 477 cm⁻¹ may be allowed to Si-O-Si bending vibration. In this case, the calcium oxygen silicon oxygen and structures can be able to twist to form a

fixed glass. Awfully, in those glass the band at 650 cm⁻¹ may be attributed to asymmetric bending vibration of Si-O-Ca. The band at 705 and 713 cm⁻¹ are very adjacent to the bending vibration of B-O-B (Agathopoulos et al., 2006). The bending vibration of Si-O-Si matched to close the peak at 460 cm⁻¹ depleted with growing B_2O_3 volume as SiO₂/ B_2O_3 proportion decreased from the sample 30LSC0B-20LSC10B, leading to an increasing B₂O₃ content. Increasing and indicating the amount of BO₃, the bending vibration of B-O-B (BO₃ triangles) situated near 700 cm⁻¹ progressively increased. The bond position nearly at 800 cm⁻¹ the stretching vibration of O-Si-O stands for the nonbridging oxygen bonds, as the free oxygen from alkali oxides, destroyed SiO₄ bonds, and more associated to B ions form BO₄ modes; that stretching vibration weakened with growing B_2O_3 volume. For the overlapped bands of the antisymmetric stretching vibration of Si-O-Si and the antisymmetric stretching vibration of BO₄, the peak represented near 1036 cm⁻¹. The bond B–O damaged about the Si-O-Si, and with the growing of B₂O₃ the SiO₄ reduced. Concede to earlier stated outcomes [21], in borate glass, the bands of absorption near to 1280 cm⁻¹ depicted to the BO₃ bonding about the adjacent band, and that the vibrational frequency band was overwhelmed through the types of coupling atom. Because of the

antisymmetric stretching vibration of BO_3 , the peaks area appears from 1435 cm⁻¹ to 1456 cm⁻¹.

With increasing sum of B_2O_3 , this peak switching close to lower wave number concede that the BO3 occurred in a triangular composition to an assured degree. Notwithstanding, in the vitrified bonds, the tetraborate and diborate groups were developed with a growing sum of B_2O_3 , and BO_3 correlated precisely with BO₄ units. Our outcomes can be interpreted through an integrated impact of B-O and Li–O interplay in this glass network, as Li⁺ ion contributes crosslink а lower effectiveness when distinguished to Ca²⁺ so exhibits a higher coordination number along oxygen atoms, even though the little alternation noticed in the infrared spectra and Raman can be assumed through the isomerization reaction $B\mathscr{Q}_4^{-ii} \leftrightarrow B\mathscr{Q}_2O^-$.

Alkali calcium borosilicate glasses (15-25 mol% B₂O₃)

The orderly alternation in the growth of new peaks and the absorption spectra in the area of low frequency (Fig. 1) supplied more information about the structural change of high amount B_2O_3 including glasses. In the low frequency area, the change of absorption spectra is systematic and much informative. The noticed high frequency band in the large B_2O_3 including glasses turns into wider than that in the binary lithium silicate glasses. In the 15-25 mol% B₂O₃ including glasses, the growth of acute peak bands in the area of 1500-400 legitimized nearly the identical cm⁻¹ structure. On the basis of spectral shape, several Gaussians are suited to the low and high frequency area for 15LSC15B to 5LSC25B glasses (Table 2). Normally, in the silicate glasses, the bond rocking vibration Si-O-Si was noticed within the 481-500 cm⁻¹. Notwithstanding, the possible modes of B-O-B linkage, Raluca and Padmaja have picked the bands in the area of 550-450 cm⁻¹ (Subhadra & Kistaiah, 2012)(Ciceo-Lucacel & Ardelean, 2007). For weak shoulder at 701 cm⁻¹ in 5LSC25B glass the ascribed harmonic of bending vibration is B-O-B. The effect of installation of alkali oxides into B₂O₃ glass is familiar to the transformation of sp^2 planar BO₃ units towards more stable sp³ tetrahedral BO₄ units and can also construct nonbridging oxygen's. Any BO₄ units are linkage to two such other units and from each unit's one oxygen to an alkaline ion and the structure surpass to the creation of a long tetrahedron chains.

In the borate network, the second group of bands is ascribed to such BO_4 units when in fact as the first group of bands is recognized as due to the stretching relaxation of the B–O bond of the trigonal BO_3 units and the band at 703 cm⁻¹ is due to the bending vibration of B–O–B linkage (Tandon & Hotchandani, 2001). The antisymmetric stretching vibrations $\sim 1467 \text{ cm}^{-1}$ ascribed at with three nonbridging oxygens of B-O-B groups. In view of this case, the alkali Li⁺ will prefer to silicon bonding other than to boron and new Si-O-Li bonds are created. Because of the smaller band areas, the bonds create nonbridging oxygens and reduce the connectivity of the borosilicate network to some range. In the area of high frequency, bands at 3500, 3505 and 3510 cm⁻¹ are owing to stretching vibrational mode of B-O-H. Its switch can be ascribed to grow up in the bond order of B-O bonds (Tandon & Hotchandani. 2001) Those strong overlapped Gaussian possess maxima within 2380–2320 and 3510–3500 cm⁻¹ may be allowed to components of the stretching vibrational modes of B-O-H group.

Effect of B₂O₃ on alkali calcium silicate glass

To act a significant role of BO₃, the effects of B_2O_3 are distinct for a certain bonding mechanisms. At low amount of B_2O_3 concentration, an extensive change is noticed in the variation of B–O–B, Si–O– Si, and Si–O–Ca bonds. The relative area and band location of Si–O–Ca and Si–O–Si are switched to minima at 0 mol% B_2O_3 including glass and then grown up to 15 mol% B_2O_3 including glasses. In the high B_2O_3 containing glasses, these two bands

noticed. Due were not to the dypolymerization of silicate matrix, this shows the change of glass structure. The variations in the band location of vibrational bonds of the main network assembled bonds B–O–B displays а remarkable alter at all levels of B₂O₃ concentration. The comparative intensities of B-O-B diminish up to 15LSC15B and then grow. Again, the B-O-B bond decreases up to 15 mol% B₂O₃ (Fig. 3.). The change can be elucidated through the fact that one of the borate species. The comparative intensities with the increase of B₂O₃ but the band location for B–O–Si bonds are almost remaining unchanged. The alternation in the comparative intensity of B-O-Si bond may be elucidated as B⁺ fills SiO⁴⁺ lattice through cracking the tetrahedral network, as it persists as Si-O-B structure, and the creation of those bands recommends the bending vibration of SiO₆ octahedral rather than silicon tetrahedra. Increasing the intensity of B-O bonds makes the weak cationic effect in this glass matrix. While B_2O_3 rises the borate related band area increased, but the increasing rate of the concentration of BO₄ structural units is larger than the increasing rate of the amount of BO₃ structural units. Additionally, the band height connected to the vibration of Ca-O increased as the composition of B₂O₃ increased from 0 to 10 mol% and then decreased after this

Therefore proportion. increasing the amount of B_2O_3 exposes some observes; there are overlying bands connected to the vibration of calcium, borate and silicate structural units. That overlying is illusive in the narrowness of the reaching band from 1271-570 cm⁻¹ and the wideness of the extending band from 1200-800 cm⁻¹. The silicate network bands are imbricated with the related bands due to the vibration of the structural units BO₃ (Saddeek et al., 2010). This band area decreased through the destruction of the structural units BO₃ and silicate network. The devastation combined in the interruption linkage bonds SiO₄ and BO₃ groups and affected actively the local fields in the glass structure and altered the allocation of electrons form the Si-O-Si, B-O-B and Si-O-Ca bonds. The Li⁺ will assist bonding to silicon than to boron and the new bonds Si-O-Li will be made. With non-bridging oxygen's, this method makes a tetrahedral structural unit of SiO₄ and this conversion between the structural units of calcium can be designated from the reduced region and the band intensity at about 477 cm⁻¹ can away from the amount of 10 mol% B_2O_3 . Therefore, there will be copious in the environment of oxygen which combined in the creation of structural units and more BO₄ units. As a result, the bonding of alkali calcium borosilicate glasses will be strongly ionic. In this matter, connectivity of the network increased and the type of ring structure of borate glass will be intimately packed by the polymerization of the matrix. Therefore, the increase of connectivity of the examined network may be attained due to the presence of B–O to Si–O and altering from the regular Ca–O– Si and Si–O–Si networks to the regular B– O–Si and Ca–O–Si network.

As a result, that kind of glasses may be considered to be produced by two productive glass producers, for this reason B_2O_3 and SiO_2 with connected BO_3 , BO_4 , and SiO_4 structural units with one another to create a fixed structural arrange.

X-ray diffraction of heat treated specimen

At 550 $^{0}C/10$ hr., the Li₂O–SiO₂–CaO–B₂O₃ glasses are heat treated, again, in the analogy, samples like 10LSC20B and 5LSC25B are heat treated at various temperatures through various times. Low amount of B₂O₃ including samples, i.e., 25LSC5B-20LSC10B, displays different phase contains and crystallinity. The XRD arrangement of 25LSC5B and 20LSC10B are very much alike and α -SiO₄ and CaB₂O₄ phase is observed in it. In addition to Ca₃Si₂O₇ phase of 15LSC15B glass, the α -SiO₄ phase is shown. In addition to the amount of high B2O3 including glass samples 10LSC20B and 5LSC25B in spite of their heat treatment at various time and various temperatures, displays amorphocity

other than crystallization properties (Fig. 6 and 7).

Conclusions

Structural analyses on quaternary of Li₂O-SiO₂-CaO-B₂O₃ glass system have been performed. The B_2O_3 content is responsible for the variation of the structure the glasses. Inclusion of the low and high B₂O₃ including element recommend that B₂O₃ employs the network producer location and produce Si-O–B bonds. The relative intensities and band position with B_2O_3 concentration suggests that the glass system with z=0-5 mol% as an orthoborate compound, z=15 mol% as pyroborate compound and z=20-25mol% as metaborate compound. Instead of silicon the bond Si-O-B can be tetrahedra influenced to the bending vibration of SiO₆ octahedral. Due to B_2O_3 , it is a common tendency to shift the band location towards high frequency area by the effect of local field of the Si–O–Ca bonding. The

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M. F. (2006). Structural analysis and devitrification of glasses based on the CaO-MgO-SiO2 system with B2O3, Na2O, CaF2 and P2O5 additives. Journal of Non-Crystalline Solids, hygroscopic qualities of these glasses are expressed by the creation of B–O–H group. This knowledge is very convenient to draw conclusions about the chemical endurance of borosilicate glass.

Author's contribution statement

Md. Emran Hossain: Writing original draft, Discussion, Software, Writing – review & editing. Md. Rafiqul Islam: Investigation, Data curation, writing original draft. Goshtha Gopal Biswas, R. Majumder, Karimul Hoque, Md. Shahjahan, Mst. Halima Khatun: review & editing. Md. Rafiqul, Ahsan and M. Golam Mortuza: Characterizations, Discussion, Editing, Supervision.

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Title of	Given composition, mol%				Dissolving	Visible X-ray	X-ray
specimens	Li ₂ O	B_2O_3	SiO ₂	CaO	temperature, °C	status	diffraction
5LSC25B	5	25	60	10	x^{i}	Clear	Amorphous
10LSC20B	10	20	60	10	x^{i}	Clear	Amorphous
15LSC15B	15	15	60	10	x ⁱ	Clear	
20LSC10B	20	10	60	10	1275	Clear	
25LSC5B	25	5	60	10	1150	Clear	
30LSC0B	30	0	60	10	1100	Clear	

Table 1. Optical quality and melting temperature of the glasses of different configurations.

L for Li₂O, B for B₂O₃, S for SiO₂, C for CaO $\stackrel{\scriptstyle{\bullet}}{\bullet}$ 1200 $\stackrel{\scriptstyle{\circ}}{C}$ < x < 2000 $\stackrel{\scriptstyle{\circ}}{C}$.

	In the area of low	frequency	In the area of high frequency		
Samples	Band location	Vibrational	Band location	Vibrational	
	(cm ⁻¹)	Chemical bonds	(cm ⁻¹)	Chemical bonds	
	465	Si–O–Si	1290	Si-O-H	
	650	Si–O–Ca	1630	Si-O-H	
30LSC0B	720	Si–O–Ca	2300	H ₂ O	
	1025	Si–O–Si			
	470	Si–O–Si	1280	(BO ₃) ³⁻	
	705	В-О-В	1456	BO_4	
25LSC5B	800	Si–O–Si 2310		H ₂ O	
	660	Si–O–Ca	2900	В-О-Н	
	950	В-О-В	3490	В-О-Н	
	477	Si–O–Si	1263	(BO ₃) ³⁻	
	675	Si–O–Ca	1435	BO ₃	
20LSC10B	713	В-О-В	2360	H ₂ O	
	790	Si–O–Si	2910	В-О-Н	
	953	В-О-В	3495	В-О-Н	
	481	Si–O–Si	1301	$(BO_3)^{3-}$	
	640	B–O–Si	1438	BO_4	
15LSC15B	715	В-О-В	2350	H ₂ O	
	690	Si–O–Ca	2880	В-О-Н	
	1012	Si–O–Si	3500	В-О-Н	
	710	В-О-В	1280	$(BO_3)^{3-}$	
	690	B–O–Si	1467	BO_4	
10LSC20B	840	В-О-В	2380	H ₂ O	
	1050	В-О-В	2820	В-О-Н	
	700	B-O-Si	1324	$(BO_3)^{3-}$	
	701	В-О-В	1463	BO_4	
5LSC25B	961	В-О-В	2320	H ₂ O	
	1065	Si–O–Si	3505	В-О-Н	

Table 2. Deconvolution peak location and allowed chemical vibrational bonds ofxLi2O.ySiO2.zCaO.(1-x-z)B2O3 glasses.



Fig 1. Infrared spectra of xLi₂O.ySiO₂.zCaO.(1-x-y-z)B₂O₃ base glasses



Fig 3. Deconvoluted IR spectra of the effect of B₂O₃ in CaO-SiO₂ glasses and glass-ceramics



Fig 4. Fluctuation of band location of the different bonds with B₂O₃ combination.



Fig 5. Fluctuation of relative area in mol% of the different bonds along B₂O₃ concentration.



Fig 6. X-ray diffraction of the base sample.



Peak Position 2θ (°)

Fig 7. X-ray diffraction of the heat treated sample.