# FTIR Spectroscopic Analysis of Gamma-Irradiated Lithium Aluminium Borosilicate Glasses

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Received: Nov. 08, 2017 Accepted: Dec. 15, 2017

**ABSTRACT** *Transparent Borosilicate Glass samples containing $Al_2O_3$ and $Li_2O$ as network modifiers with composition $xAl_2O_3$ – $2xLi_2O$ – ½(1-3x)$B_2O_3$ – ½(1-3x)$SiO_2$were prepared successfully by using melt quench technique. FTIRspectra in the range 400-4000 nm have been measured before and after gamma-ray irradiation of the samples in order to study the effect of radiations.*

**Key words:** *Borosilicate, FTIR Spectroscopy, Gamma Irradiation.*

## I. INTRODUCTION

Glass materials play an important role in the modern world of technology. Among the oxide glasses, borosilicate glasses are exploited the most and have wide range of applications because these glasses are more stable than other glasses.Lithium is an important alkali cation and $Al_2O_3$ is an important modifier. The addition of alkali oxides can improve many properties of borate glasses as well as modify-even-improve their preparation conditions.Glasses based on the lithium aluminium system have attracted considerable interest in recent years due to their significant applications in science and industry. Glasses containing $Li^+$ ions are considered to be potential candidates for electrolytes of thin film batteries as they exhibit isotopic ion conductivity and stability at high voltage.These glasses are chemically stable over a wide range of composition.Structural analysis of glasses before and after irradiation is a prerequisite to understand the structural evaluation of glasses. Interactions with high energy radiations help us to understand the intrinsic structure of these glasses.[1-8]

## II. EXPERIMENTAL

Glass samples were prepared by conventional melt quench technique. Lithium Oxide, Aluminium Oxide, Boric Acid, Silicon Dioxide of analytical grade were obtained from Aldrich Chemical Co. Appropriate amounts of chemicals were weighed by using an electric balance. The weighed samples were mixed and melted in Alumina crucible at temperature 1250°C for 30 minutes until a bubble-free liquid was formed. The melt was then poured into preheated graphite mould. The mould was moved into an annealing furnace at annealing temperature of 350°C to avoid breaking of the sample.The obtained samples were grinded using different grades of emery and then polished with cerium oxide. The nominal composition along with the thickness of prepared glasses is given in Table 1. FTIR Spectroscopy was carried out at room temperature in the range 400-4000 $cm^{-1}$ using a spectrometer Shimadzu FTIR-8700 model. 4.0 mg of each sample was mixed with 20 mg of KBr in an agate mortar and then pressed to a pressure of 100kg $cm^{-1}$ and the resultant pellets of 13 mm diameter were used for recording the absorption spectra. For each sample the spectrum represents an average of 20 scans, which were normalized to the spectrum of the blank KBr pellet.

**Table 1.** Nominal composition (mole fraction) of glass samples.

| Sample Code | $Al_2O_3$ *(x)* | $Li_2O$ *(2x)* | $B_2O_3$ *(1-3x)/2* | $SiO_2$ *(1-3x)/2* |
|---|---|---|---|---|
| LS1 | 0.100 | 0.200 | 0.350 | 0.350 |
| LS2 | 0.120 | 0.240 | 0.320 | 0.320 |
| LS3 | 0.150 | 0.300 | 0.275 | 0.275 |
| LS4 | 0.170 | 0.340 | 0.245 | 0.245 |

All the prepared samples were irradiated using $^{60}Co$ radioisotope. The dose rate was 1.77Gy/min. The samples were irradiated for the necessary time interval to achieve the desired overall total dose of 2.5 kGy.

## III. RESULT AND DISCUSSION

The IR absorption curves for Lithium Aluminium Borosilicate glasses are shown in Fig. 1. A number of peaks have been observed at different wavelengths,however, the major absorption peaks (or bands) are - first centred around 1050cm$^{-1}$ and second centred around 1500cm$^{-1}$ are important for discussion. In the present system the intensity of peak centred at around 1050 cm$^{-1}$ is very large which indicates the presence of strong tetrahedral coordinated network structural groups. With increasing MO contents, a small band centred at around 1250 cm$^{-1}$ has been created, the intensity of which increases with the increase in MO contents. Khalifa and El-Batal (1997) [9] assigned the peak at 1250 cm$^{-1}$ to boroxol rings, tri-, tetra-, and pentaborate groups. Further, they assigned the peak extending from 1225 – 1270 cm$^{-1}$ to pyro- and orthoborate units for BO3 stretching vibrations while analysing Lithium Aluminium Borate glasses.

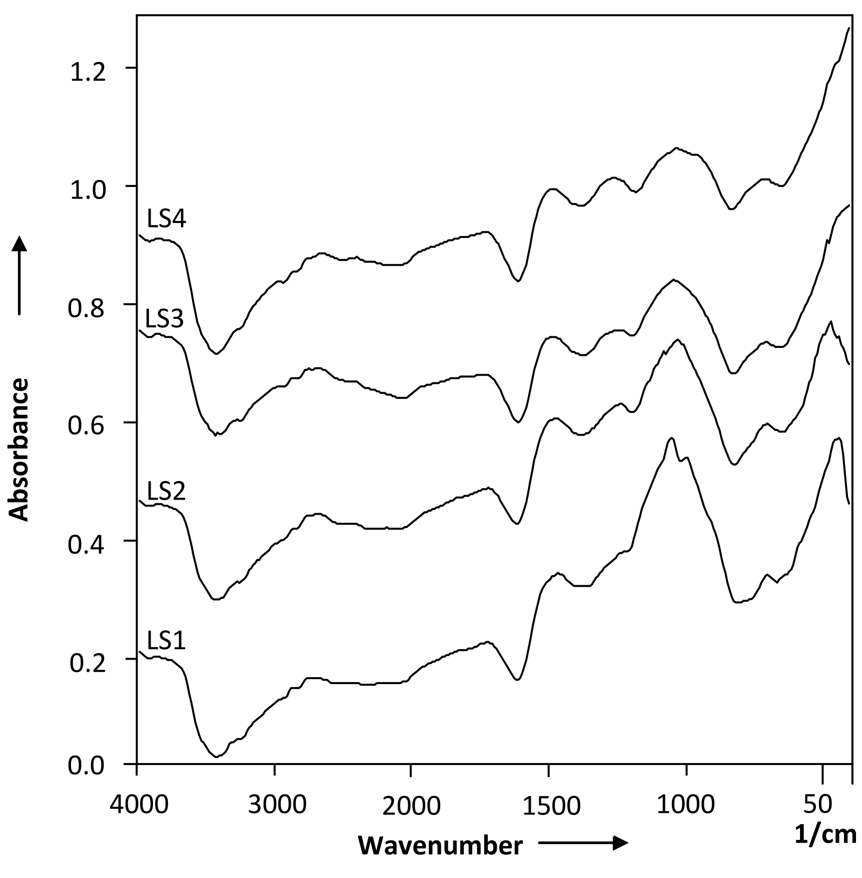


**Fig. 1.**The IR spectra of $Li_2O$-$Al_2O_3$-$B_2O_3$-$SiO_2$ before irradiation.

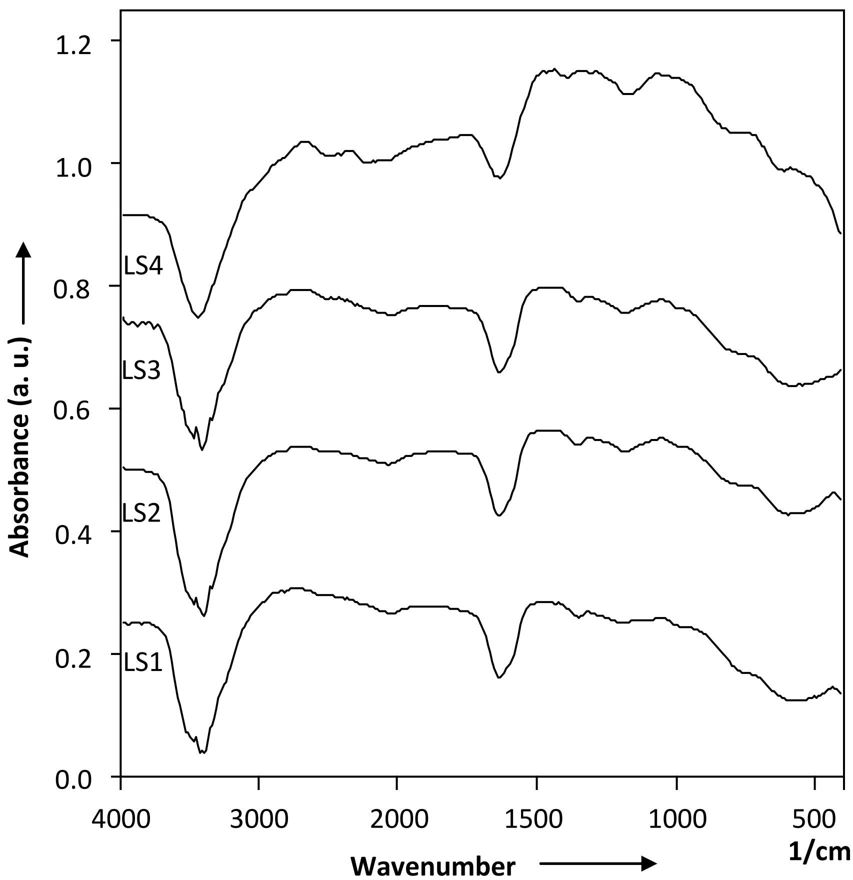


**Fig. 2.**The IR spectra of $Li_2O$-$Al_2O_3$-$B_2O_3$-$SiO_2$ after irradiation.

The effects of radiation on the glasses have been summarized by Friebele (1991) [10] to fall into three categories: (1) atomic displacement by momentum and energy transfer, (2) ionization and charge trapping and (3) radiolytic or photochemical effects. However, the relative contribution to the net damage depends on the type and energy of the radiation, as well as on the total dose. The effect of $\gamma$ - radiation in the infrared spectra of the studied borate glasses is shown in Fig. 2.

This effect is attributed due to the weakening of the network grouping vibrations. It is believed that the bond strengths in the already random network in glasses are somewhat weak to be affected or overcome by the resultant energy due to $\gamma$ - irradiation. However, another theory suggested that $\gamma$ - rays irradiation causes many disruption of the already distorted network and the arrangement of groups becomes more unsymmetrical leading to the possible weakness of the network grouping vibrations.Experimental results indicate that $\gamma$-irradiation has no effect on the position of the IR absorption spectra of the main structural building groups but a large decrease in the in the intensities of all the bands are observed for all the present glass samples. According toHobbs (1995) [11],this lowering in the intensities of the infrared absorption bands with radiation is due to the loss of orientational and translational order.

## IV. CONCLUSION

Stable tertiary glasses using $B_2O_3$ and $SiO_2$ as network former and $Li_2O$ & $Al_2O_3$ as network modifiers have been achieved by the melt-quench technique. A significant change in structural properties has been observed with systematic variation of composition and with the effect of $\gamma$ -irradiation on the prepared glasses.The change depends upon energy of radiation and is considered due to the weakening of network grouping vibrations which is shown by weakening of all the bands by the effect of these radiations on glass structure.

## REFERENCES

1 B. V. R. Chowdari, S. K. Akhter, Thermal, physical and electrical characterization of lithium boroarsenate glasses, Journal of Non-Crystalline Solids **116,** 16-26 (1990).
2 A. Pradel, T. Pagier, M. Ribes, Effect of rapid quenching on electrical properties of lithium conductive glasses, Solid State Ionics **17,** 147-54 (1985).
3 B.V. R. Chowdari, S. K. Akhter, J. Non-Cryst. Solids **116**, 16 (1990).
4 A. Pradel, T. Pagier, M. Ribes, Solid State Ionics **17**, 147 (1985).
5 W. A. Weyl, Colored Glasses, Dawson's of Pall Mall, London, (1959).
6 G. H. Sigel, Treatise on Material Science and Technology, AcademicNew York (1977).
7 T. Bates, Modern Aspects of the Vitreous state,Butterworths, London,
8 N. A. El-Alaily, R. M. Mohamed, Mater. Sci. Eng., B,**98**, 193 (2003).
9 F. A. Khalifa, H. A. El-Batal, Vibrational spectra of some binary and ternary borate glasses and their corresponding glass – ceramics, Indian Journal of Pure and Applied Physics **35,** 579-86 (1997).
10 E. J. Friebele, Optical properties of glasses, American Ceramic Society, Westerville, U S A 205-62 (1991).
11 L.W. Hobbs, The role of topology and geometry in the irradiation-induced amorphization of network structures, Journal of Non-Crystalline Solids **182**,27-39 (1995).