Physical, structural, thermal, and optical spectroscopy studies of TeO2–B2O3–MoO3–ZnO–R2O (R = Li, Na, and K)/MO (M = Mg, Ca, and Pb) glasses

ABSTRACT

Six optically transparent zinc molybdenum borotellurite glasses containing different network modifier ions (alkali, alkaline, and heavy metal oxides) with compositions, 60TeO2–10B2O3–10MoO3–10ZnO–10M (mol%) (M = Li2O, Na2O, K2O, MgO, CaO, and PbO) were prepared by melt quenching technique. For all these glass matrices, physical, structural, thermal, and optical properties have been studied. The physical properties of all the glasses were evaluated with respect to the glass composition. The structure of the glasses was monitored by X-ray diffraction (XRD), Scanning electron microscopy (SEM) and Energy dispersive X-ray analysis (EDAX), Attenuated total reflectance-Fourier transform infrared (ATR-FTIR), and Raman spectroscopy. The XRD and SEM measurements reveal the amorphous nature for all the prepared glasses and EDAX confirms that all the elements present in the respective glasses. The presence of various functional groups such as stretching vibrations of the TeO4 trigonal bi-pyramid structure, asymmetrical stretching vibrations of the TeO3 trigonal structural units, B–O bond stretching in BO4 groups, asymmetric stretching vibrations of B—O bond in trigonal BO3 units from various types of borate groups, stretching vibrations of Mo–O–Mo linkages, corner shared MoO6 octahedra units, stretching vibrations of Mo–O− bonds in MoO6 units, including stretching vibrations of ZnO4− structural units, and non-hygroscopic nature of the glasses are confirmed by ATR-FTIR and Raman spectra, respectively. It is established that the glass network is primarily a mixture of TeO4, TeO3/TeO3+1 and BO4, BO3 structural units. The thermal properties of the glasses were obtained by performing simultaneous thermal analysis (STA). For these glasses, from the differential scanning calorimetry (DSC) profiles the glass transition temperature (Tg), onset crystallization temperature (Tx), crystallization temperature (Tc), and melting temperature (Tm) are identified and from these values, all relevant thermal parameters were evaluated to obtain complete thermal behavior of the synthesized glasses. The calculated thermal stability values have been varied in the temperature range of 106–189 °C with different modifier ions incorporation. For alkali metal oxides incorporated glasses reduced glass transition temperature (Trg) values almost coincide with classical two-third rule while alkaline and heavy metal oxides based glasses weakly obey this rule in our study of relationship between glass transition temperature (Tg) and melting temperature (Tm). From the measured optical absorption spectra of all the glasses, direct and indirect optical band gap energies were evaluated and the values of indirect optical band gap energies calculated from absorption spectra (Eopt) match well with the values of optical band gap energies calculated from absorption spectrum fitting (ASF) method. The optical absorption cut-off wavelengths have shown a gradual spectral red shift from Li to Pb oxides based glass compositions indicating the decrease of rigidity of the glasses. Optical band gap energies were calculated to be within the range of 2.325–2.655 eV for direct and 1.790–2.378 eV for indirect transitions and both direct and indirect band gap values decreases monotonically from Li to Pb oxides introduced glass. The

structural, thermal, and optical features of all the synthesized tellurite rich glasses with different modifier ions are understood and our comprehensive analysis could contribute towards the development of suitable fiber Raman amplifiers.

Keyword: Optical materials; Tellurite glasses; Fourier transform infrared spectroscopy; Raman spectroscopy; Simultaneous thermal analysis; Optical absorption spectroscopy