Anomalous dielectric constant and AC conductivity in mixed transition-metal-ion xFe$_2$O$_3$–(20–x)MnO$_2$–80TeO$_2$ glass system

ABSTRACT

Glasses with xFe$_2$O$_3$–(20–x)MnO$_2$–80TeO$_2$ (x=2, 5, 10, 15, and 20 mol%) composition were prepared by meltquenching technique to investigate the effects of mixed-transition metal ion Fe$^{2+}$/Mn$^{3+}$ on AC conductivity and dielectric properties using impedance spectroscopy. Dielectric constant showed strong variation with Fe$_2$O$_3$ at a frequency ≥10 kHz, where $\varepsilon$ decreased to a minimum value at $x = 10$ mol% before increasing for $x > 10\%$. The decrease in $\varepsilon$ may be attributed to some form of hindrance effect on heavy dipoles caused by the mixed transition-ion effect (MTE). Meanwhile, variation of AC conductivity with Fe$_2$O$_3$ showed non-linear increase for $x \leq 10$ mol% before dropping to a minimum at 15 mol% Fe$_2$O$_3$. This result was attributed to Anderson localization because of the disorder in the glass system. Conductivity analysis showed that the conduction mechanism at the dispersion region for $x = 2$ mol% followed the correlated barrier hopping (CBH) model, while the mechanism transformed to the overlapping large polaron tunnelling (OLPT) model at higher Fe$_2$O$_3$, content ($x > 2$ mol%). The electric modulus of the investigated samples showed asymmetric peak of the imaginary part of electric modulus (M*), which reflected a non-Debye type relaxation.

Keyword: Glasses; Dielectric properties; Electrical conductivity; Transport properties; Mixed transition-ion effect