

LIST OF TABLES

Table No.	Title	Page No.
3.1.1	Values of Density (ρ), Molar Volume(V_m), Longitudinal Velocity (U_l), and Shear Velocity (U_s) of Pure NCPB glass and CuO doped NCPBC glasses	91
3.1.2	Values of Longitudinal Modulus (L), Shear Modulus (G), Bulk Modulus (K) and Young's Modulus (E) of Pure NCPB glass and CuO doped NCPBC glasses	92
3.1.3	Values of Poisson's ratio (σ), Acoustic impedance (Z), Micro hardness (H), Thermal expansion coefficient (α_p) and Debye temperature (θ_D) of Pure NCPB glass and CuO doped NCPBC glasses	93
3.2.1	Values of Micro hardness (H_v) of pure NCPB glass and CuO doped NCPBC glasses	100
4.1.1	Crystallite Size for different glass samples	110
4.2.1	Elemental (EDS) Analysis of Materials	113
4.4.1	Direct Energy Band Gap of Pure and CuO doped Borate Glasses	123
5.1.1	Glass Transition(T_g), Crystallization(T_c) and Melting(T_m) Temperatures of Pure and CuO doped Borate Glasses	132
5.2.1	Observed FT-IR band positions of Pure NCPB glass and CuO doped NCPBC glasses	138
5.2.2	Observed FT-IR band positions of Pure NCPB glass and CuO doped NCPBC glasses	139
5.2.3	Observed FT-IR band positions of Pure NCPB glass and CuO doped NCPBC glasses	140
6.1.1	The values of K_T at different temperatures	151
6.1.2	Density (ρ), viscosity (η) and velocity (U) of pure components	154

Table No.	Title	Page No.
6.1.3	Density (ρ), viscosity (η) and velocity (U) of system I: 1-propanol + methylbenzene + 2,2,4-trimethylpentane	155
6.1.4	Density (ρ), viscosity (η) and velocity (U) of system II: 1-butanol + methylbenzene + 2,2,4-trimethylpentane	156
6.1.5	Density (ρ), viscosity (η) and velocity (U) of system III: 1-pentanol + methylbenzene + 2,2,4-trimethylpentane	157
6.1.6	Density (ρ), viscosity (η) and velocity (U) of system IV: 1-hexanol + methylbenzene + 2,2,4-trimethylpentane	158
6.1.7	Adiabatic compressibility (β), free length (L_f), free volume (V_f) and internal pressure (π_i) of pure components	159
6.1.8	Adiabatic compressibility (β), free length (L_f), free volume (V_f) and internal pressure (π_i) of system I	160
6.1.9	Adiabatic compressibility (β), free length (L_f), free volume (V_f) and internal pressure (π_i) of system II	161
6.1.10	Adiabatic compressibility (β), free length (L_f), free volume (V_f) and internal pressure (π_i) of system III	162
6.1.11	Adiabatic compressibility (β), free length (L_f), free volume (V_f) and internal pressure (π_i) of system IV	163
6.1.12	Excess values of adiabatic compressibility (β^E), free length (L_f^E), free volume (V_f^E) and internal pressure (π_i^E) of System I	164
6.1.13	Excess values of adiabatic compressibility (β^E), free length (L_f^E), free volume (V_f^E) and internal pressure (π_i^E) of System II	165
6.1.14	Excess values of adiabatic compressibility (β^E), free length (L_f^E), free volume (V_f^E) and internal pressure (π_i^E) of System III	166
6.1.15	Excess values of adiabatic compressibility (β^E), free length (L_f^E), free volume (V_f^E) and internal pressure (π_i^E) of System IV	167
6.1.16	Acoustic impedance (Z), Relaxation time (τ), Gibb's free energy (ΔG^*) and absorption coefficient (α/f^2) of system I	168

Table No.	Title	Page No.
6.1.17	Acoustic impedance (Z), Relaxation time (τ), Gibb's free energy (ΔG^*) and absorption coefficient (α/f^2) of system I	169
6.1.18	Acoustic impedance (Z), Relaxation time (τ), Gibb's free energy (ΔG^*) and absorption coefficient (α/f^2) of system I	170
6.1.19	Acoustic impedance (Z), Relaxation time (τ), Gibb's free energy (ΔG^*) and absorption coefficient (α/f^2) of system I	171
7.1.1	The values of experimental and theoretical ultrasonic velocity for System I: 1-propanol + methylbenzene + 2,2,4-trimethylpentane	206
7.1.2	The values of experimental and theoretical ultrasonic velocity for System II: 1-butanol + methylbenzene + 2,2,4-trimethylpentane	207
7.1.3	The values of experimental and theoretical ultrasonic velocity for System III: 1-pentanol + methylbenzene + 2,2,4-trimethylpentane	208
7.1.4	The values of experimental and theoretical ultrasonic velocity for System IV: 1-hexanol + methylbenzene + 2,2,4-trimethylpentane	209
7.1.5	Molecular interaction parameter (α) and modulus of percentage deviation of velocity ($ \Delta U/U \%$) for System I: 1-propanol + methylbenzene + 2,2,4-trimethylpentane	210
7.1.6	Molecular interaction parameter (α) and modulus of percentage deviation of velocity ($ \Delta U/U \%$) for System II: 1-butanol + methylbenzene + 2,2,4-trimethylpentane	211
7.1.7	Molecular interaction parameter (α) and modulus of percentage deviation of velocity ($ \Delta U/U \%$) for System III: 1-pentanol + methylbenzene + 2,2,4-trimethylpentane	212
7.1.8	Molecular interaction parameter (α) and modulus of percentage deviation of velocity ($ \Delta U/U \%$) for System IV: 1-hexanol + methylbenzene + 2,2,4-trimethylpentane	213
7.1.9	Values of greatest percentage deviation and Chi-square for six theoretical models at 303K	214
7.1.10	Values of greatest percentage deviation and Chi-square for six theoretical models at 303K	215

LIST OF FIGURES

Figure No.	Title	Page No.
2.1	Photograph of NCPB and NCPBC glass samples	43
2.2	Experimental setup of PEO technique	48
2.3	Schematic diagram of Pulse echo setup	49
2.4	Block diagram of Pulse echo testing system	50
2.5	Cross-section of buffered ultrasonic transducer for material characterization using pulse echo method	51
2.6	Longitudinal wave form	54
2.7	Shear wave form	55
2.8	Photograph of SHIMADZU Model BMV-2T MICROHARDNESS TESTER Instrument	56
2.9	PANalytical XPERT PRO Diffractometer	58
2.10	FEI QUANTA FEG 200 - High Resolution Scanning Electron Microscope	60
2.11	High Resolution Transmission Electron Microscope (HRTEM) with EDAX	63
2.12	CARY 5E UV-VIS-NIR Spectrophotometer	64
2.13	LS 45 Fluorescence Spectrometer	66
2.14	Schematic diagram of FTIR spectrometer	67
2.15	Photograph of Perkin Elmer FTIR Spectrometer	69
2.16	Schematic diagram of powder TGA curve	70
2.17	Schematic diagram of powder DTA curve	71
2.18	Schematic diagram of powder TGA & DTA curve	72
2.19	NETZSCH – STA 449 F3 JUPITER Simultaneous Thermal Analyser Instrument	72
2.20	Experimental arrangement for the measurement of ultrasonic velocity in liquids	76

Figure No.	Title	Page No.
2.21	Cross – section of the liquid cell	77
2.22	Variation of crystal current with reflector position in an interferometer	78
3.1.1	Longitudinal wave form of pure NCPB glass (S_0)	85
3.1.2	Longitudinal wave form of CuO doped NCPBC glass (S_1)	85
3.1.3	Shear wave form of pure NCPB glass (S_0)	86
3.1.4	Shear wave form of CuO doped NCPBC glass (S_1)	86
3.1.5	Variation of density and molar volume of pure NCPB glass and CuO doped NCPBC glasses in mol%	94
3.1.6	Variation of longitudinal and shear velocity of pure NCPB glass and CuO doped NCPBC glasses in mol%	94
3.1.7	Variation of longitudinal and shear modulus of pure NCPB glass and CuO doped NCPBC glasses in mol%	95
3.1.8	. Variation of bulk and young's modulus of pure NCPB glass and CuO doped NCPBC glasses in mol%	95
3.1.9	Variation of Poisson's ratio of pure NCPB glass and CuO doped NCPBC glasses in mol%	96
3.1.10	Variation of acoustic impedance and microhardness of pure NCPB glass and CuO doped NCPBC glasses in mol%	96
3.1.11	Variation of thermal expansion coefficient and debye temperature of pure NCPB glass and CuO doped NCPBC glasses in mol%	97
3.2.1	Microhardness Vs Load of pure NCPB glass and CuO doped NCPBC glasses	100
4.1.1	Illustration of Brag's law	105
4.1.2	XRD pattern of pure NCPB glass (S_0)	107
4.1.3	XRD pattern of 0.05 CuO doped NCPBC glass (S_1)	108
4.1.4	XRD pattern of 0.1 CuO doped NCPBC glass (S_2)	108
4.1.5	XRD pattern of 0.15 CuO doped NCPBC glass (S_3)	109

Figure No.	Title	Page No.
4.1.6	XRD pattern of 0.2 CuO doped NCPBC glass (S ₄)	109
4.1.7	XRD patterns of 0.25 to 0.5 CuO doped NCPBC glasses (S ₅ – S ₁₀)	110
4.2.1	HRSEM micrographs and EDS of Pure NCPB glass (S ₀)	112
4.2.2	HRSEM micrographs and EDS of 0.1 CuO doped NCPBC glass (S ₂)	112
4.2.3	HRSEM micrographs and EDS of 0.2 CuO doped NCPBC glass (S ₄)	112
4.2.4	HRSEM micrographs and EDS of 0.3 CuO doped NCPBC glass (S ₆)	113
4.2.5	HRSEM micrographs and EDS of 0.5 CuO doped NCPBC glass (S ₁₀)	113
4.3.1	HRTEM image with EDS and SAED pattern of 0.05 CuO doped NCPBC glass(S ₁)	115
4.3.2	HRTEM image with EDS and SAED pattern of 0.1 CuO doped NCPBC glass(S ₂)	115
4.3.3	HRTEM image with EDS and SAED pattern of 0.15 CuO doped NCPBC glass(S ₃)	116
4.3.4	HRTEM image with EDS and SAED pattern of 0.2 CuO doped NCPBC glass(S ₄)	116
4.4.1	Reflectance spectra of Pure NCPB (S ₀) and 0.05 to 0.3 CuO doped NCPBC glasses (S ₁ – S ₆)	120
4.4.2	Reflectance spectra of 0.35 to 0.5 CuO doped NCPBC glasses (S ₇ – S ₁₀)	120
4.4.3	UV Spectra of Pure NCPB (S ₀) and 0.05 to 0.25 CuO doped NCPBC glasses(S ₁ –S ₅)	121
4.4.4	UV Spectra of 0.3 to 0.5 CuO doped NCPBC glasses (S ₆ – S ₁₀)	122
4.5.1	UV Transmittance Spectra of Pure NCPB glass and 0.05 to 0.5 CuO doped NCPBC glasses	124
4.5.2	Excitation Spectra of Pure NCPB glass and 0.05 to 0.5 CuO doped NCPBC glasses	125
4.5.3	Emission Spectra of Pure NCPB glass and 0.05 to 0.5 CuO doped NCPBC glasses	125
5.1.1	TG-DTA graph of NCPB (S ₀ – pure) glass	132

Figure No.	Title	Page No.
5.1.2	TG-DTA graph of NCPBC (S ₄ – CuO 0.2) glass	133
5.1.3	TG-DTA graph of NCPBC (S ₅ – CuO 0.25) glass	133
5.1.4	TG-DTA graph of NCPBC (S ₁₀ – CuO 0.5) glass	134
5.1.5	Compositional dependency of glass transition, crystallization and melting temperature	134
5.2.1	FT-IR Spectra of Pure NCPB glass (S ₀) and 0.05 to 0.1 CuO doped NCPBC glasses (S ₁ – S ₂)	141
5.2.2	FT-IR Spectra of 0.15 to 0.25 CuO doped NCPBC glasses (S ₃ – S ₅)	142
5.2.3	FT-IR Spectra of 0.3 to 0.4 CuO doped NCPBC glasses (S ₆ – S ₈)	143
5.2.4	FT-IR Spectra of 0.45 to 0.5 CuO doped NCPBC glasses (S ₉ – S ₁₀)	144
6.1.1	Adiabatic compressibility (β) and Intermolecular free length (L_f) Vs Mole fraction of System I at 303 K, 308 K, 313 K	175
6.1.2	Adiabatic compressibility (β) and Intermolecular free length (L_f) Vs Mole fraction of System II at 303 K, 308 K, 313 K	175
6.1.3	Adiabatic compressibility (β) and Intermolecular free length (L_f) Vs Mole fraction of System III at 303 K, 308 K, 313 K	176
6.1.4	Adiabatic compressibility (β) and Intermolecular free length (L_f) Vs Mole fraction of System IV at 303 K, 308 K, 313 K	176
6.1.5	Intermolecular free volume (V_f) and Internal pressure (π_i) Vs Mole fraction of System I at 303 K, 308 K, 313 K	178
6.1.6	Intermolecular free volume (V_f) and Internal pressure (π_i) Vs Mole fraction of System II at 303 K, 308 K, 313 K	178
6.1.7	Intermolecular free volume (V_f) and Internal pressure (π_i) Vs Mole fraction of System III at 303 K, 308 K, 313 K	179
6.1.8	Intermolecular free volume (V_f) and Internal pressure (π_i) Vs Mole fraction of System IV at 303 K, 308 K, 313 K	179
6.1.9	Acoustic impedance (Z) and Relaxation time (τ) Vs Mole fraction of System I at 303 K, 308 K, 313 K	182

Figure No.	Title	Page No.
6.1.10	Acoustic impedance (Z) and Relaxation time (τ) Vs Mole fraction of System II at 303 K, 308 K, 313 K	182
6.1.11	Acoustic impedance (Z) and Relaxation time (τ) Vs Mole fraction of System III at 303 K, 308 K, 313 K	183
6.1.12	Acoustic impedance (Z) and Relaxation time (τ) Vs Mole fraction of System IV at 303 K, 308 K, 313 K	183
6.1.13	Gibb's free energy (ΔG^*) and Absorption coefficient (α_p) Vs Mole fraction of System I at 303 K, 308 K, 313 K	185
6.1.14	Gibb's free energy (ΔG^*) and Absorption coefficient (α_p) Vs Mole fraction of System II at 303 K, 308 K, 313 K	185
6.1.15	Gibb's free energy (ΔG^*) and Absorption coefficient (α_p) Vs Mole fraction of System III at 303 K, 308 K, 313 K	186
6.1.16	Gibb's free energy (ΔG^*) and Absorption coefficient (α_p) Vs Mole fraction of System IV at 303 K, 308 K, 313 K	186
6.1.17	Excess Parameters (Adiabatic Compressibility (β^E), Free Length (L_f^E), Free Volume (V_f^E) and Internal Pressure (π_i^E)) Vs Mole fraction of System I at 303 K, 308 K, 313 K	189
6.1.18	Excess Parameters (Adiabatic Compressibility (β^E), Free Length (L_f^E), Free Volume (V_f^E) and Internal Pressure (π_i^E)) Vs Mole fraction of System II at 303 K, 308 K, 313 K	190
6.1.19	Excess Parameters (Adiabatic Compressibility (β^E), Free Length (L_f^E), Free Volume (V_f^E) and Internal Pressure (π_i^E)) Vs Mole fraction of System III at 303 K, 308 K, 313 K	191
6.1.20	Excess Parameters (Adiabatic Compressibility (β^E), Free Length (L_f^E), Free Volume (V_f^E) and Internal Pressure (π_i^E)) Vs Mole fraction of System IV at 303 K, 308 K, 313 K	192
7.1.1	Comparison of experimental ultrasonic velocity with theoretical ultrasonic velocity Vs Mole fraction of System I	216
7.1.2	Comparison of experimental ultrasonic velocity with theoretical ultrasonic velocity Vs Mole fraction of System II	216