

C O N T E N T S

Chapter	Title	Page No.
CHAPTER - I: INTRODUCTION TO FERRITES		
1.1	Historical mile-stones	... 2
1.2	Crystal structure	... 3
1.2.1	Spinel structure	... 3
1.3	Magnetic properties of ferrites	... 8
1.3.1	Neel's theory	... 11
1.3.2	Susceptibility	... 13
1.3.3	Spontaneous magnetization	... 15
1.3.4	Yafet - Kittel theory	... 17
1.4	Electrical properties of ferrites	... 19
1.5	Orientation of work	... 21
References		... 24

LIST OF FIGURES

Figure No.	Title	Page No.
1.1	Spinel structure	... 5
1.2a	Tetrahedral lattice site	... 6
1.2b	Octahedral lattice site	... 6
1.3	Angle between A-A, B-B and A-B cations in spinel structure	... 10
1.4	Magnetic corresponding state (σ, γ) curve predicted by Neel's theory	... 16
1.5	Triangular spin configuration	... 18

**CHAPTER - II: PREPARATION AND CHARACTERIZATION
OF FERRITES**

2.1	Introduction	... 27
2.2	Preparation of ferrites	... 28
2.2.1	Ceramic method	... 28
2.2.2	Pre-sintering	... 30
2.2.3	Milling after pre-sintering	... 31
2.2.4	Sintering	... 31
2.2.5	Actual preparation of ferrite samples	... 31
2.2.6	Mixing after pre-sintering	... 33
2.2.7	Sintering	... 33
2.3	X-ray diffraction studies	... 34
2.3.1	Diffraction condition	... 34
2.3.2	Diffraction methods	... 35
2.3.3	Infra-red studies	... 38
2.3.4	Results and discussion of x-ray diffraction	... 40
2.3.5	Results and discussion of IR	... 46
	References	... 52

LIST OF FIGURES

Figure No.	Title	Page No.
2.1	Flow chart of preparation method	... 29
2.2	Schematic diagram of x-ray diffractometer	... 36
2.3	X-ray diffraction pattern for $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{Fe}_2\text{O}_4$ system	... 41
2.4	X-ray diffraction pattern for $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{Fe}_{1.8}\text{Cr}_{0.2}\text{O}_4$ system	... 41
2.5	X-ray diffraction pattern for $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{Fe}_{1.2}\text{Cr}_{0.8}\text{O}_4$ system	... 42
2.6	IR spectra for $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{Fe}_2\text{O}_4$ system	... 47
2.7	IR spectra for $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{Fe}_{1.8}\text{Cr}_{0.2}\text{O}_4$ system	... 47
2.8	IR spectra for $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{Fe}_{1.2}\text{Cr}_{0.8}\text{O}_4$ system	... 48

LIST OF TABLES

Table No.	Title	Page No.
2.1	Masses of components in molecular proportion	... 32
2.2	Observed and calculated values of d in Å° for Ni _{0.5} Cu _{0.5} Fe ₂ O ₄ system	... 43
2.3	Observed and calculated values of d in Å° for Ni _{0.5} Cu _{0.5} Fe _{1.6} Cr _{0.2} O ₄ system	... 43
2.4	Observed and calculated values of d in Å° for Ni _{0.5} Cu _{0.5} Fe _{1.6} Cr _{0.4} O ₄ system	... 43
2.5	Observed and calculated values of d in Å° for Ni _{0.5} Cu _{0.5} Fe _{1.4} Cr _{0.6} O ₄ system	... 44
2.6	Observed and calculated values of d in Å° for Ni _{0.5} Cu _{0.5} Fe _{1.2} Cr _{0.8} O ₄ system	... 44
2.7	Observed and calculated values of d in Å° for Ni _{0.5} Cu _{0.5} FeCrO ₄ system	... 44
2.8	Values of lattice constant and bond lengths of Ni _{0.5} Cu _{0.5} Fe _{2-x} Cr _x O ₄	... 45
2.9	Data on x-ray density, actual density and porosity for Ni _{0.5} Cu _{0.5} Fe _{2-x} Cr _x O ₄ ferrites	... 45
2.10	Vibrational bonds in Ni _{0.5} Cu _{0.5} Fe _{2-x} Cr _x O ₄ ferrites	... 49

CHAPTER - III: MAGNETIC PROPERTIES

3.1	Introduction	... 54
3.2	Magnetization in ferrites	... 55
3.3	Hysteresis	... 56
3.4	Susceptibility	... 58
3.5	Permeability	... 59
3.6	Curie temperature	... 60
3.7	Experimental techniques	... 61
3.7.1	Magnetization measurement	... 61
3.7.2	A.C. susceptibility	... 63
3.8	Results and discussion	... 65
3.8.1	Magnetization	... 65
3.8.2	A.C. Susceptibility	... 70
References		... 73

LIST OF FIGURES

Figure No.	Title	Page No.
3.1	Magnetization curve and hysteresis loop	... 57
3.2	Experimental setup of hysteresis with high field loop tracer	... 62
3.3	Experimental setup of low field A.C. susceptibility measurement	... 64
3.4	Variation of magnetization with applied field	... 66
3.5	Variation of normalized ac susceptibility for the $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{Fe}_{2-x}\text{Cr}_x\text{O}_4$ system	... 71

LIST OF TABLES

Table No.	Title	Page No.
3.1	Variation of cation distribution and Curie temperature	... 67
3.2	Variation of saturation magnetization and magnetic moment (nB) for the $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{Fe}_{2-x}\text{Cr}_x\text{O}_4$ system	... 67

CHAPTER - IV: ELECTRICAL PROPERTIES

4.1	Conduction in metal oxides	... 76
4.2	Conduction in ferrites	... 77
4.3	Electron hopping and polaron	... 78
4.4	Thermoelectric power	... 80
4.5	Experimental techniques	... 82
4.5.1	D.C. Electrical resistivity	... 82
4.5.2	Thermoelectric power	... 85
4.6	Results and discussion	... 87
4.6.1	Electrical resistivity	... 87
4.6.2	Thermoelectric power	... 91
4.6.3	Polaron hopping	... 95
	References	... 101

LIST OF FIGURES

Figure No.	Title	Page No.
4.1	Experimental setup of d.c. resistivity	... 83
4.2a	Diagram for measurement of d.c. resistivity	... 84
4.2b	Conductivity cell for d.c. resistivity	... 84
4.3	Experimental set up of thermoelectric power	... 86
4.4 &	Variation of $\log \varphi$ versus $1/T$... 88
4.5	$Ni_{0.5}Cu_{0.5}Fe_{2-x}Cr_xO_4$ where $x = 0, 0.2, 0.4, 0.6$ and 0.8	... 89
4.6	Variation of thermoelectric power for <ul style="list-style-type: none"> i) $Ni_{0.5}Cu_{0.5}Fe_2O_4$ ii) $Ni_{0.5}Cu_{0.5}Fe_{1.8}Cr_{0.2}O_4$ iii) $Ni_{0.5}Cu_{0.5}Fe_{1.6}Cr_{0.4}O_4$... 92
4.7	Variation of thermoelectric power for <ul style="list-style-type: none"> i) $Ni_{0.5}Cu_{0.5}Fe_{1.4}Cr_{0.6}O_4$ ii) $Ni_{0.5}Cu_{0.5}Fe_{1.2}Cr_{0.8}O_4$... 93
4.8	Variation of thermoelectric power for <ul style="list-style-type: none"> i) $Ni_{0.5}Cu_{0.5}FeCrO_4$... 94
4.9	Variation of mobility with temperature of <ul style="list-style-type: none"> i) $Ni_{0.5}Cu_{0.5}Fe_2O_4$ ii) $Ni_{0.5}Cu_{0.5}Fe_{1.8}Cr_{0.2}O_4$... 97

4.10	Variation of mobility with temperature of i) $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{Fe}_{1.6}\text{Cr}_{0.4}\text{O}_4$ ii) $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{Fe}_{1.4}\text{Cr}_{0.6}\text{O}_4$... 98
4.11	Variation of mobility with temperature of i) $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{Fe}_{1.2}\text{Cr}_{0.8}\text{O}_4$ ii) $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{FeCrO}_4$... 99

LIST OF TABLES

Table No.	Title	Page No.
4.1	Variation of activation energy (ΔE), Curie temperature, thermoemf at 473° with Cr content of $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{Fe}_{2-x}\text{Cr}_x\text{O}_4$... 96
CHAPTER - V: SUMMARY AND CONCLUSIONS		... 103
References		... 109