LIST OF FIGURES, TABLES AND SCHEMES

		CAPTIO	ON TO FIGURE	S		Pg. No.
		СНАР	TER I			
Figure 1.1	[0 1	0]	projection	of	the	4
	$Ce(PO_4)(HPO_4)$	$(H_4)_{0.5}(H_2O)_0$	_{0.5} structure. The r	andom succ	ession	
	of the intersla	b regions c	along the stacking	g a axis illus	strates	
	the disorder.					
Figure 1.2	View of the str	cucture of ($Ce(PO_4)(HPO_4)_{0.5}$	(H_2O) along	7	4
	[100]					
Figure 1.3	[1 0 0] proje	ction of the	e interslab regior	ns near x=0	0.5 for	4
	the $Ce(PO_4)(PO_4)$	$HPO_{4})_{0.5}(H_{2})_{0.5}$	$_2O)_{0.5}$ structure.	White and s	haded	
	units (H(P2)O	$(4)^{2}$ tetrahed	dra and OW (wat	ter oxygen a	itoms)	
	represents the	two possib	le and equiproba	ble zigzag m	nodels	
Figure 1.4	The two poss	tible and e	equiprobable env	vironments d	of the	5
	cerium atom i	n the Ce(Pe	$(O_4)(HPO_4)_{0.5}(H_2C)$)) _{0.5} structur	e	
Figure 1.5	Environment	of	the co	erium	atom	5
	$inCe(H_2O)(PC)$	$(D_4)_{1.5}(H_3O)_0$	$_{0.5}(H_2O)_{0.5}$			
Figure 1.6	View alor	ıg c	of the	structure	of	5
	$Ce(H_2O)(PO_4)$	$)_{1.5}(H_3O)_{0.5}$	$(H_2O)_{0.5}$ showing	g two plan	es of	
	rings (a+c an	d b). The	front and back p	lanes are in	ı light	
	grey and dark	grey, resp	ectively. The ring	s are compo	sed of	
	four Ce atom	s and four	PO ₄ tetrahedra	(P1), one r	ing is	
	highlighted in	the front p	lane (white)			
Figure 1.7	Representation	n of the stri	ucture of Th ₂ (PO ₄	$(HPO_4)_4 \cdot H$	H_2O	7
	along the b ax	is with the	c axis vertical (Pe	O_4 , tetrahed	ra;	
Figure 1.8	In, big rea cir Perpendicular	cies; Ow, view of on	smaii circies e hydrogennhosn	hate water l	aver	8
i iguite ito	of $Th_2(PO_4)_2(I)$	$(HPO_A)_A(H_2)$	л пуш оденрнозр Л		ayer	0
Figure 1 Q	Ronrosontation	$\frac{1}{2} = \frac{1}{2} + \frac{1}$	l nolvhødra			8
riguit 1.7	Representation	<i>i oj ine 11</i> .	Polyneuru			0

	CHAPTER II	
Figure 2.1	<i>pH titration curves of (a) CP and (b) TP</i>	29
Figure 2.2	Concentration ($a \& b$) and volume ($c \& d$) optimization of	31
	eluent for determination of CEC	
Figure 2.3	(a)EDX of CP (b) TGA of CP (c) DSC of CP, (d) FTIR	37
	spectrum of CP and (e) FTIR spectra of calcined CP	
Figure 2.4	(a)XRD of CP, (b) XRD of CP_M , (c) SEM of CP, (d) SEM of	38
	$CP_{M}(e)$ NH ₃ -TPD curve for CP and (f) NH ₃ -TPD curve for	
	CP_M	
Figure 2.5	(a) EDX of TP, (b) TGA of TP, (c) DSC of TP, (d) FTIR	40
	spectrum of TP and (e) FTIR spectra of calcined TP	
Figure 2.6	(a)XRD of TP, (b) XRD of TP_M , (c) SEM of TP, (d) SEM of	41
	TP_M ,(e) NH_3 -TPD curve for TP and (f) NH_3 -TPD curve for	
	TP_M	
Figure 2.7(a-e)	Proposed structures for CP and TP	43
	CHAPTER III	
Figure 3.1	Ion exchange equilibrium	50
Figure 3.2	Types of elution curve (a) linear isotherm (b) classical	64
	isotherm and (c) anti classical isotherm	
Figure 3.3	Types of elution curve with (a) controlled flow (b)	65
	tailing/not good flow and (c) ideal time break	
Figure 3.4	A plot of the fractional attainment of equilibrium for Co^{2+} -	69
	H^+ exchange verses time using (a) CP and (b) TP	
Figure 3.5	% Uptake of Co ²⁺ on CP	76
Figure 3.6	% Uptake of Ni ²⁺ on CP	76
Figure 3.7	% Uptake of Cu ²⁺ on CP	76
Figure 3.8	% Uptake of Zn^{2+} on CP	77
Figure 3.9	% Uptake of Cd ²⁺ on CP	77

Figure 3.10	% Uptake of Hg ²⁺ on CP	77
-------------	------------------------------------	----

- Figure 3.11% Uptake of Pb^{2+} on CP78
- Figure 3.12(a-g) Langmuirplots for (a) Co^{2+} ; (b) Ni^{2+} ; (c) Cu^{2+} ; (d) Zn^{2+} ; 79 (e) Cd^{2+} ; (f) Hg^{2+} and (g) $Pb^{2+}using CP$
- **Figure 3.13(a-g)** Freundlichplots for (a) Co^{2+} ; (b) Ni^{2+} ; (c) Cu^{2+} ; (d) Zn^{2+} ; 80 (e) Cd^{2+} ; (f) Hg^{2+} and (g) $Pb^{2+}using CP$
- **Figure 3.14(a-g)** Breakthrough curves for, (a) Co^{2+} ; (b) Ni^{2+} ; (c) Cu^{2+} ; (d) 85 Zn^{2+} ; (e) Cd^{2+} ; (f) Hg^{2+} and (g) Pb^{2+} using CP
- **Figure 3.15(a-g)** Elution behaviour oftransition and heavy metal ions with 86 0.2 M HNO₃, (a) Co^{2+} ; (b) Ni^{2+} ; (c) Cu^{2+} ;(d) Zn^{2+} ;(e) Cd^{2+} ; (f) Hg^{2+} and (g) Pb^{2+} using CP
- Figure 3.16(a-f) Binary separations of transition and heavy metal ions using 88 CP, (a) $Co^{+2}-Zn^{+2}$, (b) $Cu^{2+}-Zn^{2+}$, (c) $Ni^{2+}-Zn^{2+}$, (d) $Hg^{2+}-Pb^{2+}$, (e) $Hg^{2+}-Cd^{2+}$ and (f) $Cd^{2+}-Pb^{2+}$
- **Figure 3.17(a-b)** Ternary separation of transition and heavy metal ions using 89 $CP_{,}(a) Ni^{2+}-Cu^{2+}-Zn^{2+}$ and (b) $Hg^{2+}-Cd^{2+}-Pb^{2+}$
 - **Figure 3.18** A plot of % retention in K_d values versus number of cycles 89 using CP
 - Figure 3.19% Uptake of $Co^{2+}on TP$ 94
 - Figure 3.20% Uptake of Ni^{2+} on TP94
 - Figure 3.21% Uptake of Cu^{2+} on TP94
 - Figure 3.22% Uptake of Zn^{2+} on TP95
 - Figure 3.23% Uptake of Cd^{2+} on TP95
 - Figure 3.24% Uptake of Hg^{2+} on TP95
 - Figure 3.25% Uptake of Pb^{2+} on TP96
- **Figure 3.26(a-g)** Langmuirplots for (a) Co^{2+} ; (b) Ni^{2+} ; (c) Cu^{2+} ; (d) Zn^{2+} ; 97 (e) Cd^{2+} ; (f) Hg^{2+} and (g) $Pb^{2+}using TP$
- **Figure 3.27(a-g)** Freundlichplots for (a) Co^{2+} ; (b) Ni^{2+} ; (c) Cu^{2+} ; (d) Zn^{2+} ; (e) Cd^{2+} ; (f) Hg^{2+} and (g) $Pb^{2+}using TP$
- **Figure 3.28(a-g)** Breakthrough curves for, (a) Co^{2+} ; (b) Ni^{2+} ; (c) Cu^{2+} ; (d) 103

	Zn^{2+} ; (e) Cd^{2+} ; (f) Hg^{2+} and (g) Pb^{2+} using TP	
Figure 3.29(a-g)	Elution behaviour of transition and heavy metal ions with	104
	$0.2 M HNO_3$, (a) Co^{2+} ; (b) Ni^{2+} ; (c) Cu^{2+} ;(d) Zn^{2+} ;(e) Cd^{2+} ;	
	(f) Hg^{-1} and (g) Pb^{-1} using IP	
Figure 3.30(a-f)	Binary separations of transition and heavy metal ions using $TD(x) = 2^{+} + 2^{+} + 4^{+} + 2^{+} + 4^{+} + 2^{+} + 4^{+} +$	106
	$TP_{r}(a) Co^{2+}-Cu^{2+}, (b) Ni^{+2}-Cu^{+2}, (c) Ni^{2+}-Zn^{2+}, (d) Hg^{2+}-$	
	Pb^{-1} , (e) $Cd^{-1} - Hg^{-1}$ and (f) $Cd^{-1} - Pb^{-1}$	
Figure 3.31(a-b)	Ternary separation of transition and heavy metal ions using	107
	$TP_{,(a)} Ni^{2+} - Co^{2+} - Cu^{2+} and (b) Hg^{2+} - Cd^{2+} - Pb^{2+}$	
Figure 3.32	A plot of % retention in K_d values versus number of cycles	107
	using TP	
	CHAPTER IV	
Figure 4.1	Reaction time optimization for EA synthesis using CP	128
Figure 4.2	Catalyst amount optimization for EA synthesis using CP	128
Figure 4.3	Mole ratio optimization for EA synthesis using CP	128
Figure 4.4	Comparative catalytic performance of CP and TP for	130
	synthesis of monoesters	
Figure 4.5	Comparative catalytic performance of CP_M and TP_M for	130
	synthesis of monoesters	
Figure 4.6	Reaction time optimization for DEM synthesis using CP	132
Figure 4.7	Catalyst amount optimization for DEM synthesis using CP	132
Figure 4.8	Mole ratio optimization for DEM synthesis using CP	132
Figure 4.9	Comparative catalytic performance of CP and TP for synthesis of diesters	134
Figure 4.10	Comparative catalytic performance of CP_M and TP_M for	134
	synthesis of diesters	
Figure 4.11	EDX of spent CP	136
Figure 4.12	EDX of spent TP	136
Figure 4.13	Reaction time optimization of for preparation of	145
	diacetalfrom benzaldehyde and PET using CP	

Catalyst amount optimization of for preparation of diacetal	145
from benzaldehyde and PET using CP	
Mole ratio optimization for preparation of diacetal from	146
benzaldehyde and PET using CP	
Comparative catalytic performance of CP and TP for	150
preparation of diacetals	
Comparative catalytic performance of CP_M and TP_M for	150
preparation of diacetals	
Reusability of CP and TP for preparation of diacetals	150
EDX of spent CP	150
EDX of spent TP	150
CHAPTER V	
Proton conduction by Grotthuss mechanism	174
Cooperative ion motion with reorientation and hopping	174
(Grotthus) mechanism	
Poly atomic ion transport (vehicle mechanism)	174
Transport Mechanism of a protonic defect in water	176
Proton transport in surface functionalized solid acid	176
membranes	
	Catalyst amount optimization of for preparation of diacetal from benzaldehyde and PET using CP Mole ratio optimization for preparation of diacetal from benzaldehyde and PET using CP Comparative catalytic performance of CP and TP for preparation of diacetals Comparative catalytic performance of CP _M and TP _M for preparation of diacetals Reusability of CP and TP for preparation of diacetals EDX of spent CP EDX of spent TP CHAPTER V Proton conduction by Grotthuss mechanism Cooperative ion motion with reorientation and hopping (Grotthus) mechanism Poly atomic ion transport (vehicle mechanism) Transport Mechanism of a protonic defect in water Proton transport in surface functionalized solid acid membranes

- Figure 5.6A schematic diagram of PEMFC182
- Figure 5.7Complex impedance plot[77]189Figure 5.8Complex impedance plot189Figure 5.9Complex impedance plots (at 30 °C) for (a) CP, (b) TP and
Arrhenius plots (temperature range 90-120 °C) for (c) CP
and (d) TP192
- Figure 5.10Complex impedance plots (at 30 °C) for (a) CP_M , (b) TP_M 193and Arrhenius plots (temperature range 90-120 °C) for (c) CP_M and (d) TP_M

	CAPTION TO TABLES	Pg. No.
	CHAPTER II	
Table2.1	Varying reaction parameters for synthesis of Cerium Phosphate	26
	(<i>CP</i>)	
Table2.2	Varying reaction parameters for synthesis of Cerium Phosphate	26
	(<i>TP</i>)	
Table2.3	Optimization of microwave irradiation for synthesis of CP_M and	27
	TP_M	
Table2.4	Characterization of CP	36
Table2.5	Characterization of TP	39
Table2.6	Surface acidity and CEC values at 150, 200 and 700 $^\circ C$	42
	preheating temperatures	
	CHAPTER III	
Table 3.1	Thermodynamic parameters for $M^{2+}-H^+$ exchange at various	73
	temperatures using CP	
Table 3.2	%Uptake of metal ions at various pH using CP	75
Table3.3	Time taken for attainment of equilibrium using CP	75
Table 3.4	% Uptake of Co ²⁺ on CP	76
Table 3.5	% Uptake of Ni ²⁺ on CP	76
Table 3.6	% Uptake of Cu ²⁺ on CP	76
Table 3.7	% Uptake of Zn^{2+} on CP	77
Table 3.8	% Uptake of Cd ²⁺ on CP	77
Table 3.9	% Uptake of Hg ²⁺ on CP	77
Table 3.10	% Uptake of Pb ²⁺ on CP	78
Table 3.11	Langmuir and Freundlichconstants for transition and heavy metal	81
	ions using CP	
Table 3.12	Distribution coefficient (K_d) values ($mL \cdot g^{-1}$) varying metal ion	84
	concentration using CP	

1 able 5.15	BTC (mmol g^{-1}) and K_d (mL. g^{-1}) values in aqueous and various	84
	electrolyte media using CP	
Table 3.14	% Elution (% E) of metal ions in different electrolyte media using	87
	СР	
Table 3.15	Binary separations of transition and heavy metal ions using CP	87
Table 3.16	Ternary separations of transition and heavy metal ions using CP	89
Table 3.17	Thermodynamic parameters for $M^{2+}-H^+$ exchange at various	91
	temperatures using TP	
Table 3.18	% Uptake of metal ions at various pH using TP	93
Table 3.19	Time taken for attainment of equilibrium using TP	93
Table 3.20	% Uptake of Co ²⁺ on TP	94
Table 3.21	% Uptake of Ni ²⁺ on TP	94
Table 3.22	% Uptake of Cu^{2+} on TP	94
Table 3.23	% Uptake of Zn^{2+} on TP	95
Table3.24	% Uptake of Cd ²⁺ on TP	95
Table 3.25	% Uptake of Hg ²⁺ on TP	95
Table 3.26	% Uptake of Pb ²⁺ on TP	96
Table 3.27	Langmuir and Freundlichconstants for transition and heavy metal	99
	ions using TP	
Table 3.28	Distribution coefficient (K_d) values $(mL \cdot g^{-1})$ varying metal ion	102
	concentration using TP	
	BTC (mmol·g ⁻¹) and K_d (mL·g ⁻¹) values in aqueous and various	102
Table 3.29		
Table 3.29	electrolyte media using TP	
Table 3.29 Table 3.30	electrolyte media using TP %Elution (% E) of metal ions in different electrolyte media using TP	105
Table 3.29 Table 3.30 Table 3.31	electrolyte media using TP %Elution (% E) of metal ions in different electrolyte media using TP Binary separations of transition and heavy metal ions using TP	105 105

CHAPTER IV

Table 4.1	Optimization of reaction conditions for monoesters using CP	129
Table 4.2	% yields of monoesters using CP, TP, CP_M and TP_M at optimized condition	129
Table 4.3	Optimization of reaction conditions for diesters using CP	133
Table 4.4	% yields of diesters using CP, TP, CP_M and TP_M at optimized condition	133
Table 4.5	Comparison of % yields of EA, BzAc, DEM and DOP using TMA salts	135
Table 4.6	Performance of recycled catalysts	136
Table 4.7	Optimization of reaction conditions for preparation of diacetal from benzaldehyde and PET using CP	146
Table 4.8	Optimization of reaction conditions for preparation of diacetal from cyclohexanone and PET using CP	147
Table 4.9	Optimization of reaction conditions for preparation of diacetal from acetophenone and PET using CP	148
Table 4.10	% Yields of diacetals from benzaldehyde/ketones and PET using CP, TP, CP_M and TP_M	149
Table 4.11	<i>Results for reusability of catalysts (with and without regeneration)</i> <i>in case of dibenzalacetal formation at optimized condition</i>	149
	CHAPTER V	
Table 5.1	Types of fuel cell and its applications	181
Table 5.2	Environmental overview	181
Table 5.3	Summary of the various proton conducting materials	184
Table 5.4	Specific conductance σ (S·cm ⁻¹) of CP, TP, CP _M and TP _M at various temperatures	194

	CAPTION TO SCHEMES	Pg. No.
	CHAPTER IV	
Scheme 4.1	Esterification reaction	119
Scheme 4.2	Di-esterification reaction	120
Scheme 4.3	Synthesis of monoesters (EA, PA, BA and BzAc)	127
Scheme 4.4	Schematic presentation of synthesis of DEM and DES	130
Scheme 4.5	Schematic presentation of synthesis of DOP and DBP	131
Scheme 4.6	Possible protonated intermediates in esterification reaction	137
Scheme 4.7	Proposed reaction mechanism for esterification	137
Scheme 4.8	Acetalization reaction	138
Scheme 4.9	General mechanism for acetalization of carbonyl compounds	142
Scheme 4.10	Reaction of a carbonyl compound and PET to form the	142
	corresponding diacetal derivatives	145
Scheme 4.11	Proposed mechanism for acetalization of benzaldehyde with	151
	PET catalyzed by CP and TP	131