

## List of Tables

Chapter	Table	Title	Page No.
2	2B.1	FT-IR assignments of the three ionic salts	2 22
	2B.2	ICP analyses of the three disulfoimidazolium chromometallates ( <u>2a-2c</u> )	2 25
	2B.3	Hammett acidity function H <sup>o</sup> of <u>2a-2c</u>	2 31
	2B.4	Optimization of the catalyst amount for the preparation of $\beta$ -amino ketone derivative at room temperature	2 33
	2B.5	Substrate scope study using <u>2a</u> , <u>2b</u> and <u>2c</u> as catalysts	2 34-35
	2B.6	Analysis and instruments	2 37
3	3B.1	Optical density calculation from IR absorbance spectra	3 25
	3B.2	Relative % crystallinity table for the hybrid materials	3 29
	3B.3	Hammett acidity values of the hybrid materials of [Dsim] <sub>2</sub> [NiCl <sub>4</sub> ]/HZSM-5	3 33
	3B.4	Summary of BET analysis	3 37
	3B.5	MB dye degradation rate (%) with reaction time	3 40
	3B.6	Calculation of degradation rate (%) of methylene blue for recycled catalyst	3 44
4	4B.1	FTIR peaks assignment of <u>1</u> @HZSM-5	4 14
	4B.2	Optical density calculation from IR absorbance spectra	4 15
	4B.3	Relative % crystallinity table for the hybrid materials	4 18
	4B.4	Hammett acidity values of [Dsim] <sub>2</sub> [ZnCl <sub>4</sub> ]/HZSM-5	4 20
	4B.5	Summary of BET analysis	4 23

Chapter	Table	Title	Page No.
	4B.6	Optimization of the catalyst amount for the synthesis of <b>3a</b>	4 25
	4B.7	Comparison of catalytic activity of <b>2d</b> with different catalysts	4 25
	4B.8	Substrate scope study of indole derivatives using <b>1</b> @HZSM-5 = 17% ( <b>2d</b> ) as catalyst	4 26
	4B.9	ICP-OES results of recycled <b>2d</b>	4 28
<b>5</b>	5B.1	Calculation of Hammett acidity function ( $H^0$ )	5 37
	5B.2	Optimization of POMs catalyst amount for nitration of naphthalene	5 38
	5B.3	Comparison of catalytic activity for nitration of toluene	5 38-39
	5B.4	Substrate scope study for nitration of aromatics compounds using hybrid catalysts	5 39
<b>6</b>	6B.1	FT-IR band assignments of piperazinium ionic liquids	6 18
	6B.2	Hammett acidity calculation ( $A_{\max} = 379 \text{ nm}$ )	6 22
	6B.3	Optimization of the reaction condition for the synthesis of <b>2a</b>	6 24
	6B.4	Substrate scope study for the synthesis of <b>2a</b> using 2.5 mol% of $[\text{TSPi}][\text{CF}_3\text{SO}_3]_2$ under solvent-free grinding condition	6 24

## List of Figures

Chapter	Figure	Title	Page No.
<b>1</b>	1.1	Three generations of ionic liquid	1 1
	1.2	Types of ionic liquids on the basis of their design	1 2
	1.3	Classification of ionic liquids based on functionality with examples	1 3
	1.4	Brönsted acidic ionic liquids of different types	1 4
	1.5	Structures of some Lewis acidic halometallates	1 5
	1.6	Various applications of halometallate ILs	1 6
	1.7	Schematic representation of SILPs	1 7
	1.8	Representation of semiconductor band gap excitation and photocatalytic activity	1 8
	1.9	(a) Keggin structure ( $\text{XM}_{12}\text{O}_{40}^{n-}$ ) & (b) Dawson structure ( $\text{X}_2\text{M}_{18}\text{O}_{62}^{n-}$ )	1 9
	1.10	Three catalysis models of solid POM catalysts	1 9
	1.11	Examples of (a) symmetrical DIL & (b) asymmetrical DIL	1 10
	1.12	Example of asymmetric heteroanionic DIL	1 10
<b>2</b>	2A.1	Summarized presentation of halometallate ILs as catalyst	2 2
	2A.2	Structures of diethyl disulfoammonium chlorometallates	2 6
	2A.3	Structure of $[\text{C}_3\text{SO}_3\text{Hmim}][\text{Cl}][\text{ZnCl}_2]$	2 9
	2A.4	Structures of $[\text{Bmim}]_2[\text{NiCl}_4]$ and $\text{ImimNi}^{2+}$ -IL/ $\text{SiO}_2$	2 11
	2A.5a	Structures of Brönsted acidic ionic liquids	2 16
	2A.5b	Structure of Mannich base	2 16
	2A.6	Structure of 1, 1, 3, 3-tetramethylguanidinium based ILs	2 16

Chapter	Figure	Title	Page No.
	2A.7	Structure of Carboxyl functionalized IL	2 17
	2A.8	Structures of –N alkylsulfonic functionalized imidazolium and phosphonium ILs	2 17
	2A.9	Structure of [TMBSA][HSO <sub>4</sub> ] IL	2 17
	2A.10	Structure of [DDPA][HSO <sub>4</sub> ] IL	2 18
	2A.11	Structure of geminal Brønsted acidic ILs (GBAILs)	2 18
	2A.12	1-methyl-3-(3-sulfopropyl)-imidazolium ionic liquids	2 19
	2A.13	Structures of –SO <sub>3</sub> H functionalized surfactant based ionic liquids	2 19
	2A.14	Structure of MSI <sub>3</sub> PW	2 20
	2A.15	Structure of [Ch-OSO <sub>3</sub> H]Cl·2ZnCl <sub>2</sub>	2 20
	2A.16	Structure of ILSO <sub>3</sub> H-TiCl <sub>5</sub> @Sn-MCM-41 catalyst	2 21
	2B.1	FT-IR spectra of 1, 3- disulfoimidazolium chlorometallates	2 22
	2B.2	<sup>1</sup> H NMR spectra of (a) <b>2a</b> and (b) <b>2c</b>	2 24
	2B.3	<sup>13</sup> C NMR spectra of (a) <b>2a</b> and (b) <b>2c</b>	2 25
	2B.4	(a) UV-visible absorbance spectra and (b) TAUC plot of <b>2a</b> , <b>2b</b> and <b>2c</b>	2 26
	2B.5	SEM images of (a) [Dsim] <sub>2</sub> [ZnCl <sub>4</sub> ], (b) [Dsim][FeCl <sub>4</sub> ] and (c) [Dsim] <sub>2</sub> [NiCl <sub>4</sub> ]	2 27
	2B.6	EDX images of (a) [Dsim] <sub>2</sub> [ZnCl <sub>4</sub> ], (b) [Dsim][FeCl <sub>4</sub> ] and (c) [Dsim] <sub>2</sub> [NiCl <sub>4</sub> ]	2 28
	2B.7	TGA curves of the three ionic solids	2 28
	2B.8	Powder XRD pattern of <b>2a</b>	2 29
	2B.9	Raman spectra of <b>2a</b> , <b>2b</b> and <b>2c</b>	2 30
	2B.10	Hammett plot for three ionic salts in ethanol	2 31

Chapter	Figure	Title	Page No.
	2B.11	Bar diagram for recyclability of catalysts	2 36
<b>3</b>	3A.1	(a) Tetrahedral structure of TO <sub>4</sub> unit ( T = Si, Al), (b) Single ring tetrahedron structure of zeolite framework & (c) Typical zeolite structure showing three dimensional cages and channels	3 1
	3A.2	(a) Pentasil unit of ZSM-5 and (b) Structure of ZSM-5	3 3
	3A.3	Metal immobilized ZSM-5	3 7
	3A.4	Chemical structures of 4, 4'-hexafluoroisopropylidene) diphthalicanhydride (6FDA)-2, 3, 5, 6-tetramethyl-1, 4-phenylenediamine (TeMPD) PI and 1-butyl-3-methyl-imidazolium bis(trifluoromethyl-sulfonyl)imide([C <sub>4</sub> mim][Tf <sub>2</sub> N])	3 10
	3A.5	Mechanism of photocatalytic degradation	3 14
	3A.6	Structure of methylene blue dye	3 15
	3A.7	Structure of [C <sub>8</sub> mim] <sub>2</sub> [Mo <sub>6</sub> O <sub>19</sub> ]	3 16
	3A.8	Structure of Rhodamine B	3 16
	3A.9	Structure of methyl orange	3 17
	3A.10	Structure of acid orange 7	3 19
	3B.1	IR spectra of <u>1</u> /HZSM-5 ( <u>2a-2e</u> )	3 23
	3B.2	IR absorbance spectra of <u>1</u> /HZSM-5 ( <u>2a-2e</u> ) with respect to parent HZSM-5 for optical density calculation	3 25
	3B.3	O-H stretching vibrations of <u>1</u> /HZSM-5 ( <u>2a-2e</u> )	3 26
	3B.4	TGA graph of <u>1</u> /HZSM-5 ( <u>2a-2e</u> ) with respect to parent HZSM-5	3 27

Chapter	Figure	Title	Page No.
	3B.5	PXRD pattern of <b>1</b> /HZSM-5 ( <b>2a-2e</b> ) with respect to parent HZSM-5	3 28
	3B.6	Percentage crystallinity graph of <b>1</b> /HZSM-5 ( <b>2a-2e</b> ) with respect to parent HZSM-5	3 28
	3B.7	Raman spectra of <b>1</b> /HZSM-5 ( <b>2a</b> & <b>2d</b> ) with respect to parent HZSM-5	3 29
	3B.8	SEM images of <b>2a</b> , <b>2d</b> & HZSM-5	3 30
	3B.9	EDX images of [Dsim] <sub>2</sub> [NiCl <sub>4</sub> ]/HZSM-5 composite <b>2d</b>	3 31
	3B.10	Low resolution TEM image of <b>2d</b> at 0.5 $\mu$ m & high resolution TEM images of HZSM-5, <b>2a</b> and <b>2d</b> at 20 nm	3 32
	3B.11	Hammett plot of <b>1</b> /HZSM-5 in ethanol	3 32
	3B.12	UV-Visible DRS spectra of <b>1</b> /HZSM-5 ( <b>2a-2d</b> ) and HZSM-5	3 34
	3B.13	N <sub>2</sub> -isotherm of (a) HZSM-5, <b>2c</b> and <b>2d</b> (b) <b>2a</b> and <b>2b</b>	3 34
	3B.14	BJH plots of <b>2a-2d</b> and HZSM-5	3 35
	3B.15	t-plots of HZSM-5, <b>2a-2d</b>	3 36
	3B.16	(a) Photoluminescence emission spectra of <b>1</b> /HZSM-5 ( <b>2a-2d</b> ) & (b) Gaussian fitting curves of <b>2b</b>	3 37
	3B.17	UV-Visible analysis of MB dye degradation using HZSM-5, <b>2c</b> and <b>2d</b>	3 38
	3B.18	(a) Plot of degradation rates (%) of MB with respect to reaction time for <b>2c</b> , <b>2d</b> and HZSM-5 (b) Plot of A <sub>t</sub> /A <sub>0</sub> versus irradiation time	3 40
	3B.19	1 <sup>st</sup> order regression plots of MB dye degradation	3 41
	3B.20	MB degradation using 20 mg of <b>2c</b>	3 41
	3B.21	Schematic representation of methylene blue degradation	3 42

Chapter	Figure	Title	Page No.
	3B.22	TOC removal percentage of <b>2c</b> and <b>2d</b> with respect to HZSM-5	3 43
	3B.23	FTIR spectra of methylene blue (MB) before degradation and after degradation	3 43
	3B.24	UV-visible analysis of MB dye degradation by recycled catalyst <b>2c</b>	3 44
	3B.25	Dye degradation rate (%) of <b>2c</b> for four consecutive cycles	3 45
	3B.26	(a) FTIR spectra & (b) PXRD pattern of <b>2c</b> (recycled) with the fresh <b>2c</b>	3 45
<b>4</b>	4A.1	Importance of indoles	4 2
	4A.2	Some examples of biologically active indole derivatives	4 3
	4A.3	Classification of indole synthesis	4 4
	4A.4	Structure of choline chloride.2ZnCl <sub>2</sub>	4 6
	4A.5	Structure of Brønsted acidic ionic liquids	4 6
	4A.6	Structure of [(HSO <sub>3</sub> -p) <sub>2</sub> im][CF <sub>3</sub> SO <sub>3</sub> ]	4 8
	4A.7	Structure of [cmmim][BF <sub>4</sub> ]	4 8
	4B.1	FTIR spectra of <b>1</b> @HZSM-5 ( <b>2a-2e</b> ) & HZSM-5	4 13
	4B.2	IR absorbance spectra of <b>1</b> @HZSM-5 ( <b>2a-2e</b> )	4 14
	4B.3	OH stretching vibrations of <b>1</b> @HZSM-5 ( <b>2a-2e</b> )	4 15
	4B.4	TGA graph of <b>1</b> @HZSM-5 ( <b>2a-2e</b> ), HZSM-5 & <b>1</b>	4 16
	4B.5	(a) PXRD patterns of <b>1</b> @HZSM-5 ( <b>2a-2e</b> ), HZSM-5 & <b>1</b> and (b) Percentage crystallinity graph of <b>1</b> @HZSM-5 ( <b>2a-2e</b> ) with respect to parent HZSM-5	4 17

Chapter	Figure	Title	Page No.
	4B.6	Raman spectra of <b>1</b> @HZSM-5 ( <b>2a</b> & <b>2d</b> ) with respect to parent HZSM-5	4 18
	4B.7	SEM & EDX images of <b>2a</b> , <b>2d</b> and HZSM-5	4 19
	4B.8	Hammett plot of <b>1</b> @HZSM-5 in ethanol	4 20
	4B.9	FTIR analysis of Lewis acidity determination of <b>1</b> @HZSM-5 using pyridine	4 21
	4B.10	UV-Visible DRS spectra of <b>1</b> @HZSM-5 ( <b>2a</b> - <b>2d</b> ) with respect to HZSM-5	4 22
	4B.11	(a) N <sub>2</sub> -isotherm of HZSM-5 and <b>2d</b> (b) BJH curve of HZSM-5 and <b>2d</b>	4 22
	4B.12	t-plots of HZSM-5 and <b>2d</b>	4 23
	4B.13	Recyclability profile of <b>2d</b>	4 28
	4B.14	PXRD pattern of recycled <b>2d</b> alternative cycles	4 28
<b>5</b>	5A.1	Structure of [MIMPSH] <sub>n</sub> H <sub>3-n</sub> PW	5 4
	5A.2	Structure of SWIL	5 7
	5A.3	Structures of heteropolyacid based ionic salts	5 9
	5A.4	Structure of P(VB-VMS)PW	5 10
	5A.5	Structures of heteropolyanion-based ionic hybrids S2SiIH, S2PIH and S4SiIH	5 13
	5A.6	Structures of gel electrolyte POM	5 13
	5A.7	Structures of general cations	5 17
	5A.8	Cation and anions of the two ionic liquids	5 18
	5A.9	Structure of caprolactum based ionic liquids	5 18
	5A.10	Structures of quaternary ammonium cations used by Wang <i>et al.</i>	5 19
	5A.11	Structure of [bmim][HSO <sub>4</sub> ] ionic liquid	5 19
	5A.12	Structure of -SO <sub>3</sub> H functionalized ionic liquids	5 21



Chapter	Figure	Title	Page No.
	5A.13	Structures of trialkanylammonium based sulfonic acid functionalized IL	5 21
	5A.14	Structure of [Msim]-NO <sub>3</sub>	5 23
	5A.15	Structure of [pyridine–SO <sub>3</sub> H][NO <sub>3</sub> ]	5 24
	5B.1	<sup>1</sup> H NMR spectra of (a) [mdsim] <sub>3</sub> [PW <sub>12</sub> O <sub>40</sub> ] & (b) [mdsim] <sub>3</sub> [PMo <sub>12</sub> O <sub>40</sub> ]	5 26
	5B.2	<sup>13</sup> C NMR of (a) [mdsim] <sub>3</sub> [PW <sub>12</sub> O <sub>40</sub> ] & (b) [mdsim] <sub>3</sub> [PMo <sub>12</sub> O <sub>40</sub> ]	5 27
	5B.3a	<sup>31</sup> P NMR spectra of (a) [mdsim] <sub>3</sub> [PW <sub>12</sub> O <sub>40</sub> ] & (b) phosphotungstic acid	5 28
	5B.3b	<sup>31</sup> P NMR spectra of (a) [mdsim] <sub>3</sub> [PMo <sub>12</sub> O <sub>40</sub> ] & (b) phosphomolybdic acid	5 29
	5B.4	FTIR spectra of [mdsim] <sub>3</sub> [PW <sub>12</sub> O <sub>40</sub> ], [mdsim] <sub>3</sub> [PMo <sub>12</sub> O <sub>40</sub> ], PTA, PMA and [mdsim][Cl]	5 30
	5B.5	TGA graph of POMs with respect to the parent [mdsim][Cl]	5 31
	5B.6	Powder XRD analysis of two polyoxometalate salts	5 32
	5B.7	Raman spectra of the polyoxometalates	5 32
	5B.8	UV-Vis diffuse reflectance spectra of (a) [mdsim] <sub>3</sub> [PW <sub>12</sub> O <sub>40</sub> ] with H <sub>3</sub> PW <sub>12</sub> O <sub>40</sub> (PTA) and (b) [mdsim] <sub>3</sub> [PMo <sub>12</sub> O <sub>40</sub> ] with H <sub>3</sub> PMo <sub>12</sub> O <sub>40</sub> (PMA)	5 33
	5B.9	SEM images of (a) [mdsim] <sub>3</sub> [PW <sub>12</sub> O <sub>40</sub> ] & (b) [mdsim] <sub>3</sub> [PMo <sub>12</sub> O <sub>40</sub> ]	5 34
	5B.10	EDX images of (a) [mdsim] <sub>3</sub> [PW <sub>12</sub> O <sub>40</sub> ] and (b) [mdsim] <sub>3</sub> [PMo <sub>12</sub> O <sub>40</sub> ]	5 35
	5B.11(a)	EDX mapping of N, S, O and W for [mdsim] <sub>3</sub> [PW <sub>12</sub> O <sub>40</sub> ]	5 35

Chapter	Figure	Title	Page No.
	5B.11(b)	EDX mapping of N, S, O, P and Mo for [mdsim] <sub>3</sub> [PMo <sub>12</sub> O <sub>40</sub> ]	5 36
	5B.12	Hammett plots of 2-methyl disulfoimidazolium POM salts with respect to the parent acids	5 36
	5B.13	Reusability profile of the [mdsim] <sub>3</sub> [PW <sub>12</sub> O <sub>40</sub> ] catalyst	5 41
	5B.14	(a) PXRD and (b) FT-IR spectra of fresh and recycled [mdsim] <sub>3</sub> [PW <sub>12</sub> O <sub>40</sub> ] catalyst	5 41
<b>6</b>	6A.1	Structure of N, N, N', N'-tetramethylpiperazinium dication	6 2
	6A.2	Structure of 1, 4-piperazinium hydrogen sulfate	6 4
	6A.3a	Some monosubstituted pyrimidine based antibacterial drugs	6 6
	6A.3b	Some disubstituted pyrimidine based drugs	6 6
	6A.3c	Some trisubstituted pyrimidine derivatives	6 6
	6A.3d	Some important tetrasubstituted pyrimidine derivatives	6 7
	6A.4	Pyrimidine molecules containing drugs with anti-cancer activities	6 7
	6A.5	Structures of Si-[sbSipim][PF <sub>6</sub> ] and MNPs-IL-HSO <sub>4</sub>	6 12
	6A.6	Structure of [msi] <sub>3</sub> [PW]	6 12
	6A.7	Structures of BAIL catalysts used for Biginelli-type reaction	6 13
	6B.1	FT-IR spectra of [TSPi][X] <sub>2</sub> (X = Cl, CF <sub>3</sub> SO <sub>3</sub> , TsO)	6 17
	6B.2	(a) <sup>1</sup> H NMR and (b) <sup>13</sup> C NMR of [TSPi][Cl] <sub>2</sub>	6 19
	6B.3	(a) <sup>1</sup> H NMR and (b) <sup>13</sup> C NMR of [TSPi][TsO] <sub>2</sub>	6 20

<b>Chapter</b>	<b>Figure</b>	<b>Title</b>	<b>Page No.</b>
	6B.4	TGA graph of [TSPi][X] <sub>2</sub> (X = Cl, CF <sub>3</sub> SO <sub>3</sub> , TsO)	6 21
	6B.5	Hammett plot of dicationic ionic liquids in ethanol	6 22
	6B.6	Recyclability profile of [TSPi][CF <sub>3</sub> SO <sub>3</sub> ] <sub>2</sub>	6 26
	6B.7	FTIR spectra of used catalyst (after 3 <sup>rd</sup> cycle) with parent IL	6 26

## List of Schemes

Chapter	Scheme	Title	Page No.
2	2A.1	Synthesis of $[\text{HO}_3\text{S}-(\text{CH}_2)_3-\text{NEt}_3]\text{Cl}-\text{FeCl}_3$ ( $x = 0.67$ )	2 4
	2A.2	Synthesis of 3-methyl-1-sulfonic acid imidazolium metal chlorides	2 4
	2A.3	Synthesis of <i>bis</i> (indolyl) methane derivative	2 5
	2A.4	Synthesis of triphenyl sulfo phosphonium chlorometallates $[\text{TPSP}]_n[\text{X}]$ where $n = 1$ or $2$ ; $\text{X} = \text{FeCl}_4^-$ , $\text{Zn}_2\text{Cl}_6^{2-}$ , $\text{NiCl}_4^{2-}$ , $\text{MnCl}_4^{2-}$	2 5
	2A.5	Three component synthesis of 2, 3-dihydro-1, 2, 3-trisubstituted-1 <i>H</i> -naphth [1, 2-e] [1, 3] oxazines	2 6
	2A.6	Synthesis of acridines using $[\text{DEDSA}][\text{FeCl}_4]$ and $[\text{DEDSA}]_2[\text{Zn}_2\text{Cl}_6]$ catalysts	2 6
	2A.7	Synthesis of (a) (3-sulfonic acid)-propyltriethyl ammonium chlorozincinates $[\text{HSO}_3-(\text{CH}_2)_3-\text{NEt}_3]\text{Cl}-\text{ZnCl}_2$ and (b) 1-(3-sulfonic acid)-propyl-3-methylimidazole chlorozincinates $([\text{HO}_3\text{S}-(\text{CH}_2)_3-\text{mim}]\text{Cl}-\text{ZnCl}_2)$	2 8
	2A.8	Dimerization of rosin	2 9
	2A.9	Synthesis of 1, 3-disulfoimidazolium chlorometallates	2 12
	2A.10	Synthesis of $\beta$ -amino carbonyl compounds	2 12
	2A.11	Three component Mannich reaction	2 14
	2A.12	One-pot Mannich-type reaction catalyzed by $\text{Yb}(\text{OTf})_3$ in ionic liquid	2 15
	2A.13	HPA catalyzed Mannich reaction in ionic liquid	2 15
	2A.14	$\text{H}_3\text{BO}_3-\text{SiO}_2$ /ionic liquid ( $[\text{bmim}][\text{PF}_6]$ ) catalyzed Mannich reaction	215

Chapter	Scheme	Title	Page No.
	2A.15	-SO <sub>3</sub> H functionalized morpholinium ILs synthesized by Yue <i>et al.</i>	2 18
	2A.16	Mannich reaction catalyzed by BASCs	2 20
	2A.17	Mannich reaction catalyzed by (MSI) <sub>3</sub> PW in [BMI][NTf <sub>2</sub> ]	2 20
	2B.1	Plausible mechanism of -SO <sub>3</sub> H bearing IL catalyzed Mannich-type reaction	2 35
<b>3</b>	3A.1	Formation of “hydroxyl nest”	3 5
	3A.2	Synthesis of [bmim][PF <sub>6</sub> ]- Pd(OAc) <sub>2</sub> immobilized ionic liquid functionalized MFI catalyst	3 8
	3A.3	Suzuki coupling reaction catalyzed by IL supported catalyst	3 8
	3A.4	ZSM-5-([mim][BF <sub>4</sub> ]) catalyzed synthesis of spiro[N-substituted indole-pyridothiazines]	3 9
	3A.5	Synthesis of spiro [pyrazolo[3, 4-e][1,5]benzothiazepine] derivatives	3 9
	3A.6	Photocatalytic degradation mechanism of [bmim][OH]-TiO <sub>2</sub> system	3 15
	3A.7	Mechanistic pathway of MO photodegradation over IL-BiOI	3 17
	3A.8	Synthesis of the catalytic membrane	3 18
	3A.9	Schematic illustration of PW <sub>12</sub> O <sub>40</sub> <sup>3-</sup> based PIL Janus nanosheets as a solid surfactant in degradation of MO	3 19
	3A.10	Stepwise synthesis of Silica-PIL-Au	3 21
	3A.11	Preparation of [Dsim] <sub>2</sub> [MCl <sub>4</sub> ]/HZSM-5 composites where M = Ni <sup>+2</sup>	3 22

Chapter	Scheme	Title	Page No.
	3A.12	Method of photocatalytic degradation of methylene blue (MB) using [Dsim] <sub>2</sub> [NiCl <sub>4</sub> ]/HZSM-5 composites	3 22
4	4A.1	Synthesis of [Dsim] <sub>2</sub> [ZnCl <sub>4</sub> ]@HZSM-5	4 2
	4A.2	Fischer indole synthesis reported by Rebeiro <i>et al.</i>	4 6
	4A.3a	Brönsted acidic ILs bearing two alkyl sulfonic acid groups	4 7
	4A.3b	Preparation of indoles using -N alkylsulfonic acid IL catalyst	4 7
	4A.4	(a) Synthesis of tetrahydrocarbazole derivatives and (b) synthesis of 2, 3-dimethyl indole derivatives	4 9
	4A.5	Synthesis of 1, 3-dialkylimidazolium bromide ILs	4 9
	4A.6a	Synthesis of supported ILSO <sub>3</sub> H-SiO <sub>2</sub>	4 10
	4A.6b	Fischer indole synthesis catalyzed by ILSO <sub>3</sub> H-SiO <sub>2</sub>	4 10
	4A.7a	Synthesis of [TMGH][Carboxylate]	4 11
	4A.7b	Synthesis of [TMGHPS][X] ionic liquids	4 11
	4A.7c	Synthesis of indoles from 7-methoxy-2-tetralones toward alkaloid core	4 11
	4A.8	Synthesis of DMAP based ionic liquids	4 11
	4A.9	Fischer indole reaction	4 12
	4B.1	Synthesis of 1, 2, 3, 4-tetrahydrocarbazole	4 24
	4B.2	Mechanism of Fischer indole synthesis catalyzed by <b>1</b> @HZSM-5 = 17% ( <b>2d</b> )	4 27

Chapter	Scheme	Title	Page No.
5	5A.1	Synthesis of heteropolyacid (HPA) salts	5 3
	5A.2	Three component Mannich and Hantzsch reactions catalyzed by (MSI) <sub>3</sub> PW supported in [bmim][NTf <sub>2</sub> ] ionic liquid	5 4
	5A.3	Synthesis of 2-arylbenzimidazoles using MSI <sub>3</sub> PW	5 5
	5A.4	Synthesis of [SO <sub>3</sub> H(CH <sub>2</sub> ) <sub>4</sub> Mim] <sub>n</sub> H <sub>3-n</sub> PMo <sub>12</sub> O <sub>40</sub> (n = 1, 2, 3)	5 6
	5A.5	Synthesis of (PYBS) <sub>3</sub> PW <sub>12</sub> O <sub>40</sub>	5 6
	5A.6	(PYBS) <sub>3</sub> PW <sub>12</sub> O <sub>40</sub> catalyzed synthesis of 14-aryl-14 <i>H</i> dibenzo[a, j]xanthenes	5 6
	5A.7	Synthesis of Poly(VMPS)-PW	5 7
	5A.8	Synthesis of SWIL/SiO <sub>2</sub>	5 8
	5A.9	Transesterification of trimethylolpropane	5 9
	5A.10	Preparation of poly(VPyPS)-PW	5 9
	5A.11	Poly(VPyPS)-PW catalyzed synthesis of 2,3-dihydroquinazolin-4(1 <i>H</i> )-ones	5 10
	5A.12	Synthesis of [Ch-OSO <sub>3</sub> H] <sub>3</sub> W <sub>12</sub> PO <sub>40</sub>	5 11
	5A.13	Synthesis of immobilized HPW-PMIMPS-SBA-15 materials	5 11
	5A.14	Synthesis of S4SiIL and S3PIL	5 12
	5A.15	Synthesis of [Simp] <sub>3</sub> PW <sub>12</sub> O <sub>40</sub>	5 14
	5A.16	Synthesis of N-SO <sub>3</sub> H functionalized 1, 3-disulfoimidazolium POM-salts [mdsim] <sub>3</sub> [PW <sub>12</sub> O <sub>40</sub> ] and [mdsim] <sub>3</sub> [PMo <sub>12</sub> O <sub>40</sub> ]	5 15
	5A.17	Reaction of toluene and 67% nitric acid in three different ionic liquids	5 17

Chapter	Scheme	Title	Page No.
	5A.18	Brönsted acidic ionic liquid catalyzed nitration by Qiao <i>et al.</i>	5 20
	5A.19	Mononitration of phenols using [Msim][Cl]	5 22
	5A.20	Mechanism of aromatic nitration catalyzed by PS-[SO <sub>3</sub> H PMIM][HSO <sub>4</sub> ]	5 23
	5B.1	Mechanism for nitration of naphthalene using POM salt as catalyst	5 40
<b>6</b>	6A.1	Synthesis of 1, 4-disulfopiperazine-1, 4-diumchloride	6 2
	6A.2	Preparation of 2, 2'-arylmethylene-bis(3-hydroxy-5, 5-dimethyl-2-cyclohexene-1-one) ( <b>I</b> ) & 1, 8-dioxooctahydroxanthene ( <b>II</b> ) derivatives using [H-pi]HSO <sub>4</sub>	6 3
	6A.3	[H-pi]HSO <sub>4</sub> catalyzed synthesis of imidazo [1, 2-a] pyrimidines ( <b>I</b> ) and triazolo [4, 3-a] pyrimidines ( <b>II</b> )	6 3
	6A.4	Synthesis of piperazine-1, 4-dium dihydrogenphosphate	6 4
	6A.5	Synthesis of 5-arylidene barbituric acid derivatives ( <b>I</b> ) & pyrano [2, 3, d] pyrimidinone(thione) derivatives ( <b>II</b> ) using [H <sub>2</sub> -Pip][H <sub>2</sub> PO <sub>4</sub> ] <sub>2</sub>	6 4
	6A.6	Synthesis of [TSPi][X] <sub>2</sub> (X = Cl, CF <sub>3</sub> SO <sub>3</sub> & TsO)	6 5
	6A.7	Classical Biginelli reaction	6 8
	6A.8	Synthesis of 5-unsubstituted-3, 4-dihydropyrimidin-2(1H)-ones	6 8
	6A.9	Synthesis of 5-cyano-dihydropyrimidinones reported by Schmidt <i>et al.</i>	6 8



Chapter	Scheme	Title	Page No.
	6A.10	Biginelli-type reaction mediated by Brønsted base	6 8
	6A.11	TMSCl catalyzed synthesis of DHPMs from dimedone	6 9
	6A.12	One-pot synthesis of dihydropyrimidines	6 9
	6A.13	Synthesis of 4, 6-(4-substituted aryl)-2-thioxo-1,2,3,4-tetrahydro-pyrimidin-5-yl-propanoic acid	6 9
	6A.14	Biginelli reaction involving cyclopentanone	6 9
	6A.15	Microwave assisted synthesis of DHPMs	6 10
	6A.16	Multistep route for 5-unsubstituted 3, 4-dihydropyrimidin-2(1 <i>H</i> )-ones	6 10
	6A.17	General scheme for Biginelli reaction	6 12
	6A.18	Conversion of dihydropyrimidones to 2-alkyl pyrimidines <i>via</i> Suzuki coupling	6 14
	6A.19	Transformation of dihydropyrimidones to pyrimidin-2-amines <i>via</i> Mitsunobu reaction	6 15
	6A.20	Synthesis of 2-amino-4-arylpyrimidines	6 15
	6A.21	One pot two step synthesis of 2-amino pyrimidine derivatives	6 16
	6B.1	Synthesis of 2-amino-4, 6-phenyl pyrimidine	6 23
	6B.2	Mechanism for two step synthesis of 2-amino pyrimidine derivative	6 25

## List of Abbreviations

$^1\text{H}$	Proton NMR
$^{13}\text{C}$	Carbon-13 isotope
MWI	Microwave Irradiation
NMR	Nuclear Magnetic Resonance
PXRD	Powder X-ray Diffraction
BET	Brunauer-Emmett-Teller
BJH	Barrett-Joyner-Halenda
SEM	Scanning Electron Microscopy
EDX	Energy Dispersive X-Ray
TEM	Transmission Electron Microscope
FT-IR	Fourier Transform-Infrared
CHN	Carbon Hydrogen Nitrogen
ICP-OES	Inductively Coupled Plasma Atomic Emission Spectroscopy
TOC	Total Organic Carbon
JCPDS	Joint Committee on Powder Diffraction Standards
TLC	Thin Layer Chromatography
ILs	Ionic Liquids
[Dsim]	Di-sulfonic Imidazolium
[Mdsim]	Methyl-disulfoimidazoium
[TSPi]	Tetrasulfopiperazinium
PTA	Phosphotungstic acid
PMA	Phosphomolybdic acid
POMs	Polyoxometalates
BAILs	Brönsted Acidic Ionic Liquids
<i>p</i> -TSA	Para Toluene Sulfonic acid
$\text{CDCl}_3$	Deuterated chloroform (used as NMR solvent)
$\text{DMSO-d}_6$	Dimethyl sulfoxide (used as NMR solvent)
DCM	Dichloromethane
Me	Methyl
MeOH	Methanol
EtOH	Ethanol
m	Multiplet (NMR)

<i>o</i>	Ortho
<i>m</i>	Meta
i.e.	That is
<i>J</i>	Coupling constant (in NMR)
s	Singlet (NMR)
d	Doublet (NMR)
t	Triplet (NMR)
mg	Milligram
mL	Millilitre
mmol	Millimole
mol	Mole
Mp.	Melting Point
No.	Number
ppm	Parts per million (in NMR)
r.t.	Room Temperature
UV-Vis	Ultra Violet Visible
VOC	Volatile Organic Compound
W	Watt
°C	Degree Celsius
%	Percentage
<, >	Greater or smaller than
$\delta$	chemical shift (in NMR)
Fig.	Figure
$\lambda$	Wavelength