Computational prediction of ammonium ILs and their catalytic effect on Mannich Reaction

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Abstract:
Background: *Ionic Liquids (ILs) can be a suitable candidate which can alter many conventional organic solvents owing to their negligible vapor pressure, versatility and recyclability.*
Materials and Methods: *A total of four new ammonium based ILs have been synthesized by Bronsted acid-base reaction and characterized by various common analytical techniques (FT-IR, ^{1}H-NMR, ^{13}C-NMR). The theoretical behaviors of new ILs were explored by Computational Simulation using DFT (B3LYP) method with 6-311G (d,p) basis set at Gaussian 09.*
Results: *A conceptual study on the geometry, thermochemistry, molecular electrostatic potential, vibrational spectroscopy analysis and also numerous properties of the synthesized ammonium based ILs were performed which can reveal and forecast the competent ILs for several types of applications with maximum outcome. The synthesized ILs were applied to understand the catalytic effect on Mannich reacton to synthesis of β-amino carbonyl compounds where they showed significant catalytic impact as well as solvent support.*
Conclusion: *The ILs can be reused at least four times and found less changes in their percent yield.*
Keywords: *Ammonium Ionic Liquid, Computational simulation, HOMO, LUMO, ADMET, Catalytic Effect.*

I. Introduction

Ammonium based ionic liquids (AILs) has generated comprehensive interest due to their beneficial characteristics which include excellent context of specificity and comparatively low toxicity. These are determinately bio-renewable and harmless compounds may act as organo-catalysts [1]. The characteristics of ILs can be muted to obtain the desired physicochemical properties by selecting the combinations and modifications of cations and anions to have more compatible in a wide range of applications [2]. Chhotaray and Gardas [3] discussed the thermophysical properties of ammonium and hydroxylammonium ionic liquids, found no appreciable effect of alkyl chain length on thermal decomposition. Hydroxyl substituent on cationic side chain has a pronounced effect on all the experimental properties studied due to additional hydrogen bonding apart from van der Waals and columbic interactions. Influence of hydroxyl group position has been monitored on thermophysical properties and found the hydrogen bonding effect due to positon. HyperChem 7 was used to estimate the hydrogen bonding features between ILs and alcohols in that study [4]. A series of ammonium-based ILs were synthesized and characterized, the densities, refractive indices were estimated to find the structure-activity relationship on these physical properties [5].

Computational Chemistry uses computer simulation to assist in solving chemical problems. It uses methods of theoretical chemistry, incorporated into efficient computer programs to calculate the physico chemical properties of the prepared ILs [6]. It is capable of predicting many properties of molecules and reactions, including molecular energies and structures, structures of transition states, bond and reaction energies, molecular orbitals in different solvent phase, vibrational frequencies, thermo-chemical properties, reaction pathways, spectroscopic quantities and numerous other molecular properties for systems in the solid, gas phase or in solution [7-10]. ADMET is a designed program of a computer for estimating pharmacokinetic parameters/properties of drug-like compounds from their molecular structures [11]. SwissADME web tool is freely available software utilized to predict the physicochemical properties, absorption, distribution, metabolism, elimination and pharmacokinetic properties of molecules, which are key determinants for more clinical trials. It takes into account six physico-chemical properties, which are very vital, like lipophilicity, flexibility, saturation, polarity, solubility, and size [12]. This study can be used to find a starting point for a laboratory synthesis and to assist in understanding experimental data.

The amino-alkylation of CH-acidic compounds was described by several authors as early as the 19th century. However, it was Carl Mannich who was the first to recognize the enormous significance of this reaction type, and it was he who extended the chemistry into a broad-based synthetic methodology through systematic research. Since then this reaction that now carries his name has developed into one of the most important C-C

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bond-forming reactions in organic chemistry [7, 8] Mannich reaction is one of the most important C-C bond forming reactions in organic synthesis for the preparation of secondary and tertiary amine derivatives [13]. In the classical intermolecular Mannich reaction, three-components, an aldehyde, amine and a ketone, react to form a β-amino carbonyl compounds in the presence of catalysts. This name reaction is enormously useful for the construction of nitrogenous molecules [14]. In this transformation, three components, a ketone, an aldehyde, and an amine, react to form a â-amino-ketone. The increasing popularity of this reaction has been fueled by the ubiquitous nature of nitrogen in drugs and natural products as well as by the potential of this multicomponent reaction to generate diversity [15].

This study reveals the synthesis of four new ammonium ionic liquids choosing the cations and anions from the alternate sources. Napthenic acids of different functionality were used as the anion source and substituted amines used as cations. Standard synthetic procedure was employed to prepare these solvents and the physico chemical properties were estimated using computational approach based on density functional theory. B3LYP method with basis set 6-311G (d,p) is used to predict the thermodynamic properties and charge densities. The applications of the synthesized ionic liquids were checked considering a name reaction where β-amino carbonyl compounds are the product.

II.   Materials and Methods

All the chemicals required in this study includes N-methyldiethanolamine, 2-(methylamino)ethanol, 2-(diethylamino)ethanol, 3-Methylbenzoic Acid, m-Toluic Acid, Salicylic Acid, 2-Chlorobenzoic Acid, Benzaldehyde, Aniline, Cyclohexanone, Methanol, TLC Powder etc. were obtained from Sigma-Aldrich and used without further purificaiton. FT-IR was recorded on 8400S Shimadzu IR spectrometer in Department of Chemistry, University of Chittagong, Chattogram. 1H-NMR and 13C-NMR data were examined at room temperature on Bruker Avance 400MHz spectrometer at Wazed Miah Science Research Center (WMSRC), Jahangirnagar University, Dhaka.

Ionic Liquids Synthesis and Purification:

The stoichiometric quantity of acid was added to a suitable solvent into round bottom flax at an ambient temperature [16]. Then the flux was placed in magnetic stirring with condenser for reflux and stirring for few minutes to dissolve the substrate rigorously. Then it was placed in Ice bath on magnetic stirring with reflux condenser and the environment was maintained inert (N_2 gas). Then ammonium bases were added to this mixture drop-wise. The stirring was kept for 6-12 h and even more until it was confirmed monitoring by TLC. Later on, the reaction mixture was heated 2-3 h with paraffin bath at 50-55 ℃ temperature. Then the solvent was removed by rotary evaporator and obtained viscous and colored ammonium ILs. For the further purification it was kept in vacuum oven at 90 ℃ temperature for two days where the obtained ILs has more than 200 ℃ temperature that indicates thermally stable condition of them. The ammonium salt formation was proved by various spectroscopic analysis.

III.   Characterization of Ionic Liquids

FT-IR Spectroscopy:

Infrared spectroscopy incorporates several types of measurement method, such as the diffuse reflection method and attenuated total reflection method. for our newly synthesized product we have selected the classical KBr pellet method. This method exploits the property that alkali halides become plastic when subjected to pressure and form a sheet that is transparent in the infrared region. Approximately 0.0 to 1.0% sample is well mixed into 200 to 250 mg fine alkali powder and then finely pulverized and put into a pallet-forming dye to form transparent pellet with the help of mechanical force. Drop of testing IL was added over the pellet to start the proceedings. Just before the experiment, background data was recorded with a pellet of KBr only to eliminate unwanted bands.

Functional groups present in synthesized products lead the confirmation of quaternary ammonium ILs. The IR spectra of alkylammonium ILs assured the presence of OH and N-H groups from portraying the broad absorption peak around 3500-3300 cm^{-1}. The peak at approximately 2970 cm^{-1} and 2930 cm^{-1} correspond to methyl and methylene group for C-H bonds at which 2995 cm^{-1} is for the stretching of Ar-H bond. The IR spectra of alkylammonium ILs confirmed the presence of carboxylate (COO-) from the symmetric and asymmetric stretching peak nearly 1600-1500 cm^{-1}, with the former being overlapped by N-H vibrations. The appearance of C-O bond has also ensured the peak at 1250-1000 cm^{-1} in the carbonate salts. The presence of PhCOO- group has confirmed the peak at around 1710 cm^{-1}. Peak in the region of 1300-1400 cm^{-1} revealed the bending of –C-H bond while C-O and C-N stretching were ascertained from the peak at neighboring 1000-1100 cm^{-1}. The amines, methyl, ethyl, and aromatic benzene ring structures detected via ^{1}H-NMR was consistent with IR absorption data.
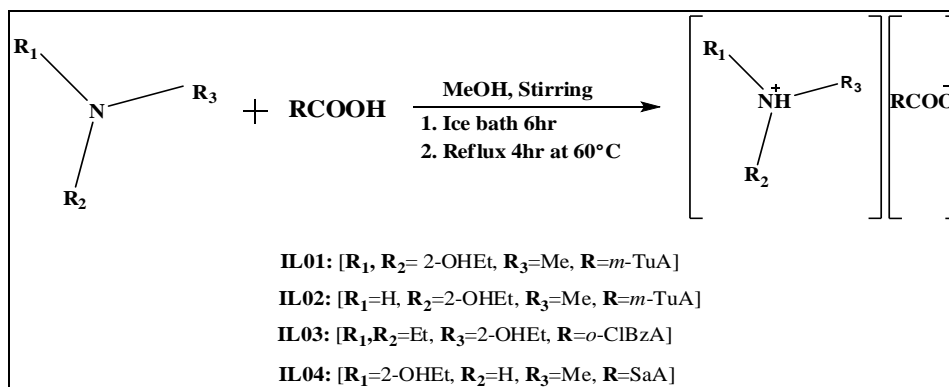
IL01: [R_1, R_2= 2-OHEt, R_3=Me, R=*m*-TuA]

IL02: [R_1=H, R_2=2-OHEt, R_3=Me, R=*m*-TuA]

IL03: [R_1,R_2=Et, R_3=2-OHEt, R=*o*-ClBzA]

IL04: [R_1=2-OHEt, R_2=H, R_3=Me, R=SaA]

Figure 1: Synthetic route of Protic Ammonium based Ionic Liquids.

2-hydroxy-N-(2-hydroxyethyl)-N-methyletanaminium 3-methylbenzoate (Yield **93%**)

2-hydroxy-N-methylaminium 3-methylbenzoate (Yield **91%**)

N,N-diethyl-2-hydroxyethanaminium 2-Cl benzoate (Yield **86%**)

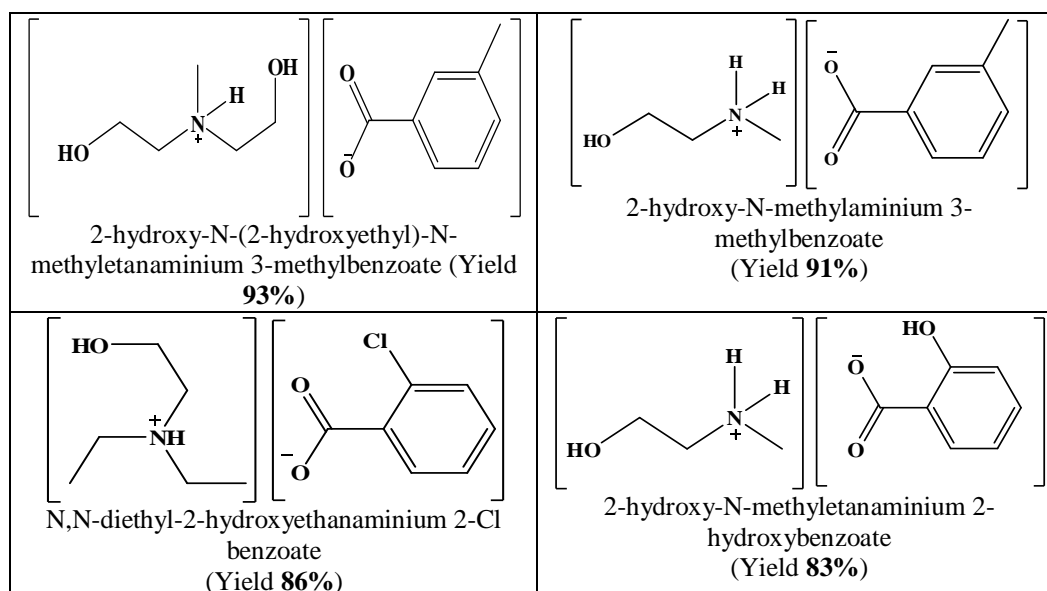2-hydroxy-N-methyletanaminium 2-hydroxybenzoate (Yield **83%**)

Figure 2: Structure of Synthesized Ionic Liquids.

NMR Spectroscopy:

The working methods of NMR spectroscopy is quite sophisticated. In NMR, 5 to 10 mg of sample was dissolved in chloroform ($CDCl_3$). The synthesized ionic liquids were characterized by using Spectroscopy Nuclear Magnetic Resonance (NMR). The 1H-NMR spectra were recorded at room temperature on Bruker Advance 400MHz spectrometer to understand the environments of the protons and confirm the structure. The chemical shifts (δ) are reported in parts per million (ppm) references with Tetra methylsilane (TMS) as an internal standard. Multiplicities are abbreviated as s, singlet; d, doublet; t, triplet; and *m*, multiplet. The recorded ^{1}H-NMR spectral data were summarized in Table 1, for all synthesized ILs. The ILs represents similar peaks that correspond to the necessary protons in the molecules given in Table 1 which confirm the structures. Similar ILs have been reported earlier which were in good evidence for the existence of ILs in this study.

Table 1: FT-IR and δ (ppm) value for ^{1}H-NMR Data of Synthesized Ionic Liquids

ILs Code	FT-IR (KBr) in cm^{-1}	^{1}H-NMR chemical shifts (400MHz, $CDCl_3$)
IL 01	O-H (3409.33), N-H (3391.00, 3338.92), C-H (2912.64), N-H (1594.23), C-H (1208.46, 1266.32), C-N (1082.11), C=O (1139.01), Aromatic C-H (899.83), Mono Substituent (760.95)	2.03 (1H, *d*, J=7.21 Hz), 2.34 (0 H, br s), 2.36 (4 H, br s), 2.37 - 2.50 (1 H, m), 2.85 (4 H, br s), 2.86 - 2.93 (1 H, m), 3.18 (5 H, br s), 3.96 (5 H, br s), 4.27 (1 H, br s), 6.63 (2 H, br s), 6.78 - 7.04 (3 H, m), 7.81 (2 H, br s), 7.83 (1 H, br s)
IL 02	O-H (3541.46, 3488.21), N-H (3367.86, 3325.42), C-H (2797.87), N-H (1627.99), C-H (1262.46), C-N (1084.04), C=O (1035.82), Aromatic C-H (928.76), Mono Substituent (786.03, 760.95)	2.25 (3 H, s), 2.48 (3 H, br s), 2.92 (2 H, br s), 3.76 (2 H, br s), 7.12 (2 H, br s), 7.68 (1 H, br d, J=5.87 Hz), 7.72 (1 H, br s), 8.18 (3 H, br s)

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IL 03	O-H (3492.27, 3439.23), N-H (3386.18, 3413.19), C-H (2994.62), N-H (1599.06), C-H (1261.50), C-N (1071.50), C=O (1025.21), Aromatic C-H (792.78), Mono Substituent (716.59)	1.22 - 1.43 (13 H, m), 3.05 - 3.16 (1 H, m), 3.17 (2 H, br d, J=4.03 Hz), 3.21 - 3.24 (1 H, m), 3.25 (3 H, br d, J=7.34 Hz), 3.28 (1 H, br s), 4.05 (2 H, br s), 7.36 - 7.46 (4 H, m), 7.48 - 7.63 (1 H, m), 8.10 (3 H, br d, J=7.34 Hz)
IL 04	O-H (3466.23), N-H (3382.32), C-H. (3007.15), N-H (1591.34), C-H (1251.84), C-N (1062.11), C=O (1031.96), Aromatic C-H (907.94), Mono Substituent (761.91)	2.70 (1 H, br d, J=13.20 Hz), 2.75 (1 H, s), 2.99 - 3.18 (1 H, m), 3.81 - 3.99 (1 H, m), 6.72 - 6.89 (1 H, m), 7.30 - 7.45 (1 H, m), 7.75 - 7.96 (1 H, m)
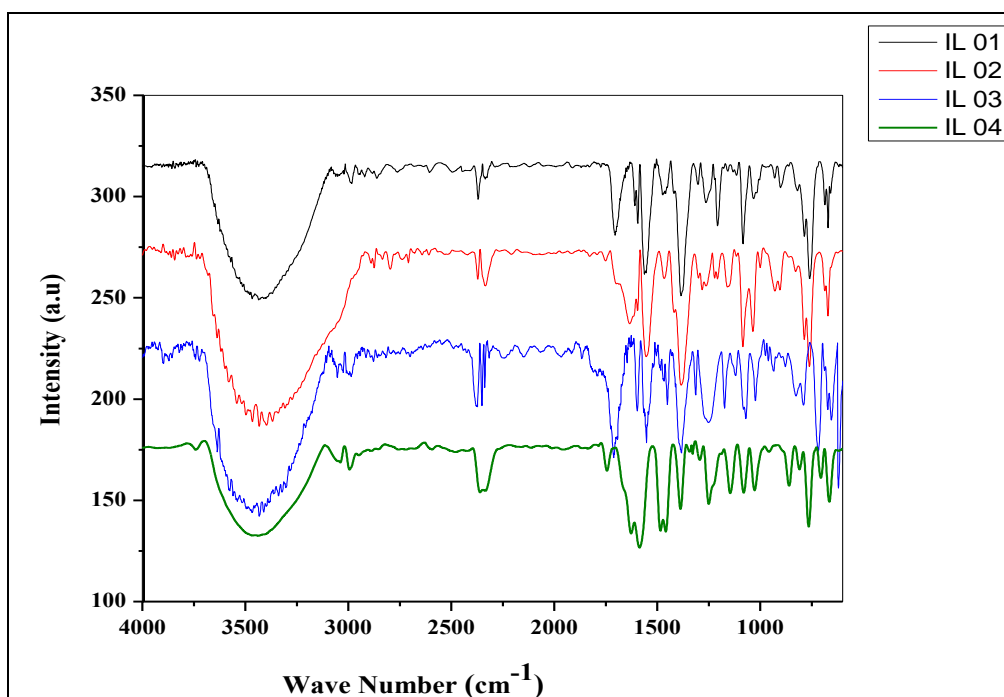
Figure 3: FT-IR Spectra of IL 01, IL 02, IL 03, IL 04

IV. Computational Overview of the Synthesized Ionic Liquids

In this work, computational method is employed on the synthesized ILs. This study was carried out on a series of molecules using the Gaussian 09 program at Ionic Liquid Research Laboratory, Department of Chemistry, Chittagong University, Chattogram. The structures were drawn in GaussView 6. The initial step in getting the leading characteristic parameters of ILs is to optimize the molecular structure to attain a configuration characterized by a minimum free energy through DFT along with B3LYP method using basis set 6-311G (d,p). After the completion of the optimization (Figure 4) , the theoretical properties of the studied ILs such as physico-chemical properties, thermophysical properties, electronic properties, ADMET properties are analyzed and presented in Figure 5, 6 and 7. Physico-chemical properties were estimated in terms of Hydrogen bonding parameters, HOMO-LUMO predictors, dipole moments, electrostatic potentials, whereas themochemical properties involved conformational analysis, Gibbs free energy, internal energy, entropy, molar heat capacity of the tested chemicals.

For predicting pharmacokinetic properties of drug/drug-like compounds from their structures, ADMET Predictor, a designed computer program, can be used. A drug/drug-like compound has to satisfy the "Rule of Five" [17] which is a well known parameter to examine whether it can be taken as a drug or not. Hence, ADMET properties of the synthesized compounds were evaluated using SwissADME web tool, a freely available software utilized to predict the physicochemical properties, absorption, distribution, metabolism, elimination and pharmacokinetic properties of molecules [18-20]. A representation of the molecular structure optimized which contains the values of the reactivity indices is called the reactive molecular diagram. The optimized structures of synthesized ILs using Gaussian 06 software are represented in Figure 4.

Extensive experimental and theoretical investigation has provided significant and convincing evidence that H-bonds possess a certain degree of covalent character. The strongest H-bonds include a substantial covalent contribution. In contrast, the weakest H-bonds are Vander Waals dominated, and have a more substantial dispersion contribution. Mid-range H-bonds tend to have a dominant ionic contribution. The

characterization of H-bonds is complicated by the variable contribution from each of these components (ionic, dispersive and covalent). Lowest distance indicates the strong hydrogen bond between the atom in ILs. Probable hydrogen bond in tested ILs were listed in Figure 5.

The energy levels of the molecular orbitals order HOMO and LUMO ILs give information on the possible electronic transition. The HOMO and LUMO also indicate the electrophilic and nucleophilic attraction region in molecule shown in Figure 6. The LUMO-HOMO gap is the most important parameter for the chemical reactivity. The shorter LUMO-HOMO gap is considered as the high reactivity. The data of HOMO, LUMO for synthesized compounds are listed in Table 3. Electrostatic potential maps illustrate the charge distributions of molecules three dimensionally. These maps allow us to visualize variably charged regions of a molecule. Knowledge of the charge distributions can be used to determine how molecules interact with one another. The total electron density and MESP surfaces of the molecules under investigation are constructed by using W method. The electrostatic potential increases in the order red<orange<yellow<green<blue. GaussView 6.0 visualization program has been utilized to construct the MESP surface and given in Figure 9.
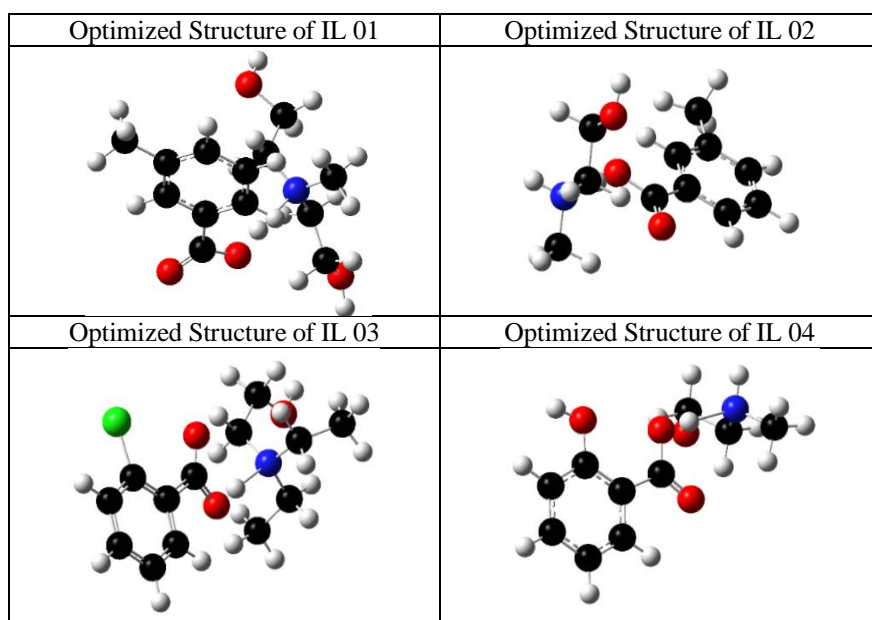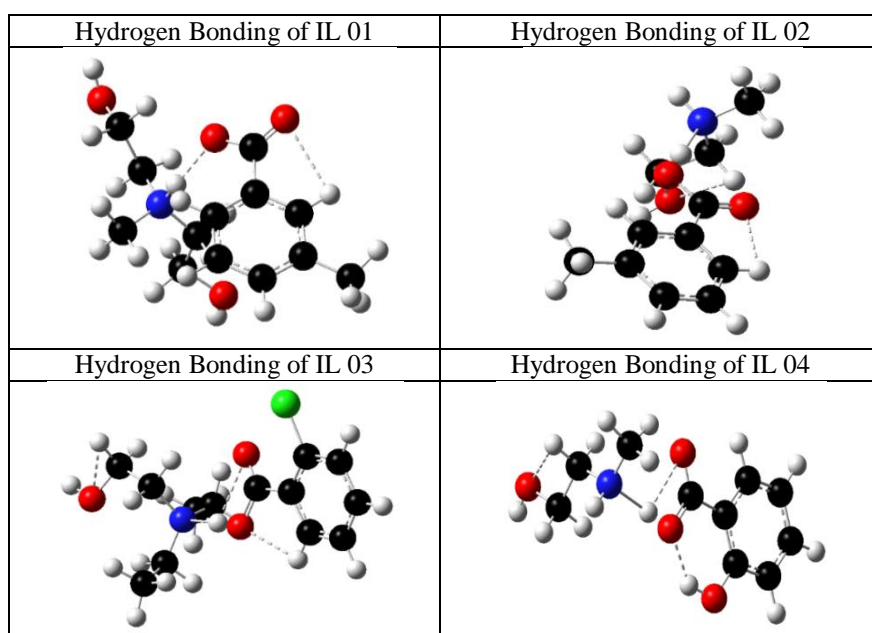

Figure 4: Optimized Structure of Synthesized ILs

Figure 5: Hydrogen Bonding of Synthesized ILs

The physicochemical properties of the synthesized ILs can be revealed from ADMET analysis which includes the rules of five (MW, iLOGP, HBAs and HBDs) and several other properties like molecular polar surface area (TPSA), number of rotatable bonds (ROTBs), number of aromatic heavy atoms, and number of alerts for undesirable substructures (PAINS and Brenk), among others as represented in the Table 2. All the compounds were in accordance with the rules That means MW, RB, HBD, HBA, TPSA, iLOGP, nAH and MR of the all compounds are within the acceptable range So we can say that all the compounds possess a good pharmacokinetic profile.
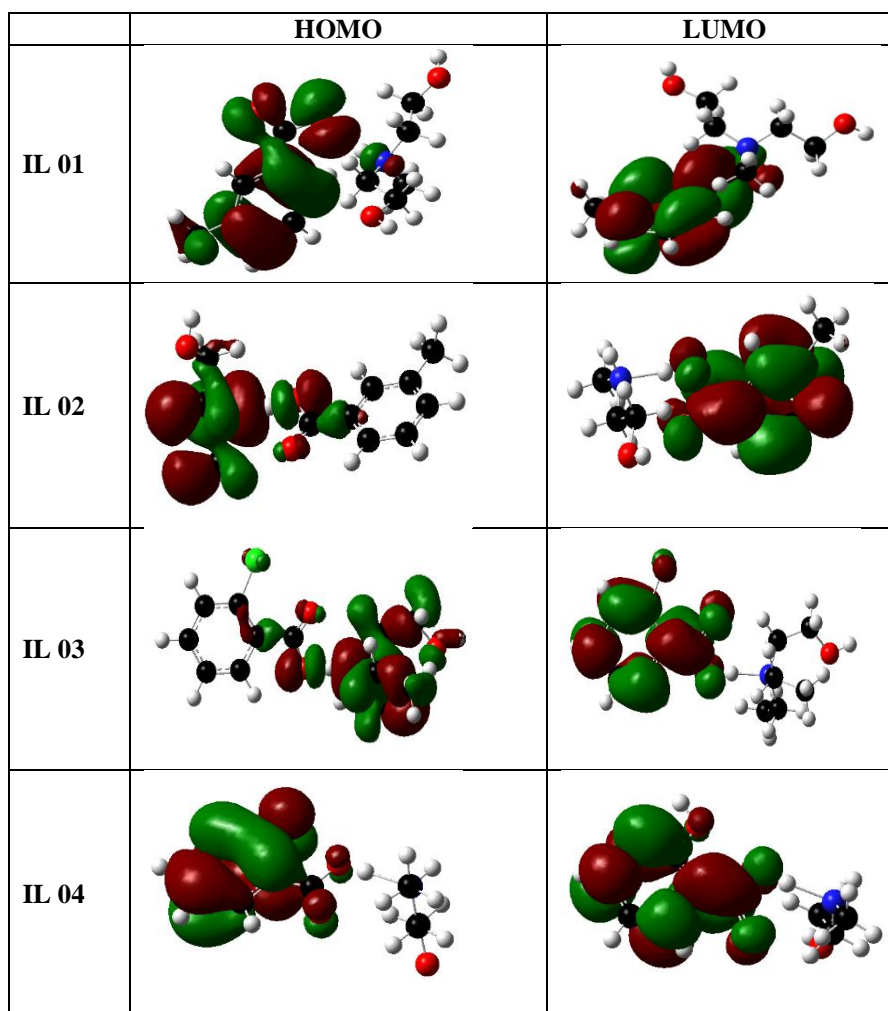
	HOMO	LUMO
IL 01		
IL 02		
IL 03		
IL 04		

Figure 6: HOMO and LUMO structures of the synthesized ILs.

Table 2: HOMO-LUMO data analysis

Ionic Liquids	IL 01	IL 02	IL 03	IL 04
ε_{LUMO} eV	-0.2011	-0.1855	-0.0489	-0.039
ε_{HOMO} eV	-0.3623	-0.3403	-0.2365	-0.2317
$\varepsilon_{LUMO} - \varepsilon_{HOMO\ (Gap)}$ eV	0.16	0.15	0.19	0.19

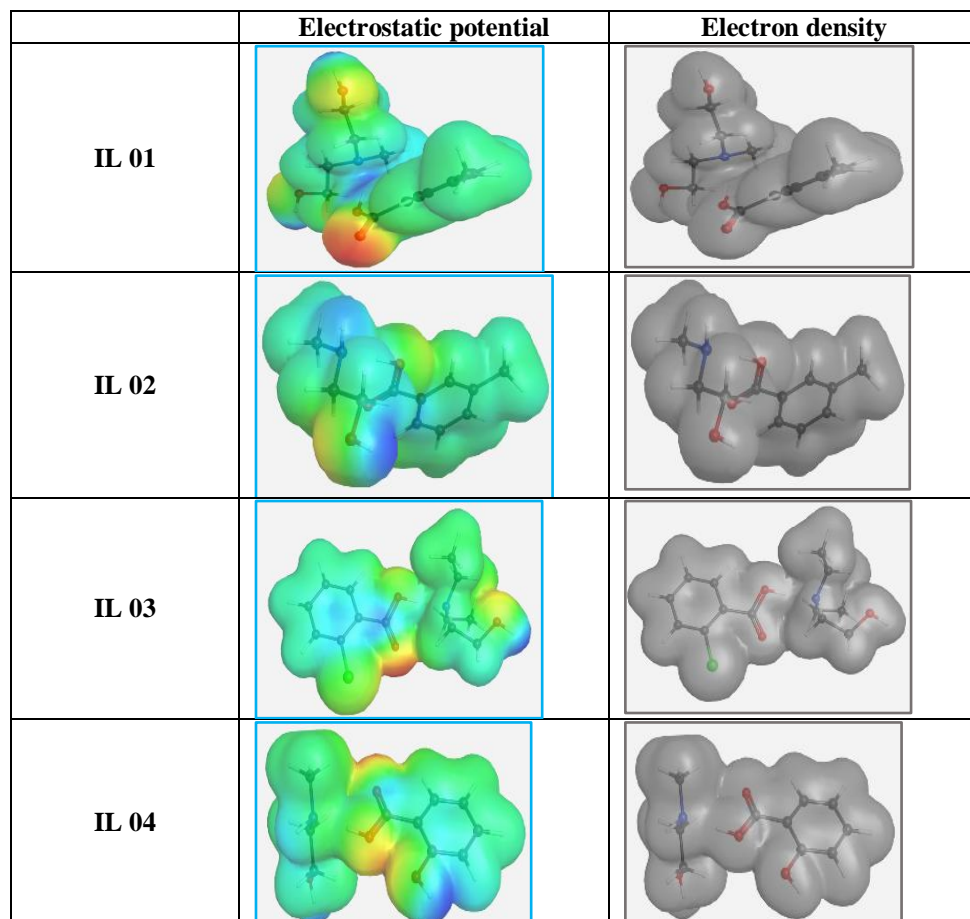|	Electrostatic potential	Electron density
IL 01		
IL 02		
IL 03		
IL 04		

Figure 7: Electrostatic Potential and Electron Density of Synthesized ILs

Table 3: Predicted physico-chemical properties of ILs

ILs Code	IL 01	IL 02	IL 03	IL 04
No. of conformations	164	79	152	56
Ionic Length	2.79	2.72	2.68	2.73
Dipole moment (Debye)	5.89	2.96	2.61	3.38
Polarizability (α) (a.u.)	166.36	143	175.98	134.47
Degree of Freedom	120	99	117	93

Table 4: Predicted thermochemical properties of ILs

ILs Code	IL 01	IL 02	IL 03	IL 04
Stable Energy of Conformations (Hartree)	-863.91	-710.05	-1248.3	-745.96
ΔE thermal (total) Kcal/mol	2.11	2.709	2.596	-12.12
ΔG Kcal\mol x 10^3	0.012	0.011	0.011	-0.002
ΔH Kcal\mol x 10^3	0.001	0.002	0.001	-0.013
$\Delta S = \frac{\Delta H - \Delta G}{T}$ Kcal/mol	-0.0369	-0.0302	-0.0335	-0.0369
Total Strain Energy (Kcal/mol)	91.93	140.27	167.67	143.51
Molar Heat capacity(cal/molkelvin)	74.51	60.02	73.01	58.49

Table 5: Calculated ADMET properties of the synthesized compounds

Ionic Liquid	IL 01	IL 02	IL 03	IL 04
MW (g/mol)	241.28	211.26	273.76	211.26
iLOGP	2.27	1.95	2.79	2.32
HBD	3	2	2	2
HBA	4	3	3	3
TPSA	85.03	76.97	64.8	76.97
RB	5	3	5	3
nheavy atoms	17	15	18	15
MR	64.09	58.18	72.74	58.18
PAINS (alert)	0	0	0	0
Brenk (alert)	0	0	0	0
GI absorption	Low	High	High	High

V.   Catalytic Effect Evaluation of ILs in Mannich reaction

In a typical reaction [13], benzaldehyde (6 mmol), aniline (6 mmol), cyclo-hexanone (6 mmol), and ionic liquids (0.6-0.8 g) as catalysts and solvent were stirred at room temperature (25 °C) in a round-bottomed flask. After a certain time, the reaction mixture became viscous and solidified. At this stage, the time was noted and the ionic liquid was separated from the reaction mixture by extraction with distilled water (5×3 ml). The ILs being soluble in water comes in the water layer. The solid was separated by filtration and product was recrystallized from 98% ethanol and vacuum dried for 5h. The product was identified using ^{1}H-NMR in $CDCl_3$ with TMS as reference (400 MHz) and by FT-IR on a Shimadzu (model 8400S) spectro-photometer using KBr plates in a frequency range. The ILs in the filtrate was separated from the unreacted starting materials by extracting the filtrate with petroleum ether. Then the water layer containing ionic liquid was kept in vacuum and dried at 70 °C for 5h to remove the residual water and the ILs have been reused.

The Mannich reaction of aldehydes, ketones and amines in presence of Bronsted acidic ionic liquids was conducted at room temperature and the results are summarized in Table 6. No Mannich product was observed in the absence of ionic liquids. The study portrays that catalytic amount of ammonium based ionic liquids catalyzed Mannich reaction in very less time and gives high isolated yield. All the above ionic liquids are suitable for Mannich reaction, however, catalytic amount of [N-MDEA][*m*-TuA], a liquid at room temperature, gave the highest yield in very short time (Figure 9) compared to other ionic liquids discussed in this study.
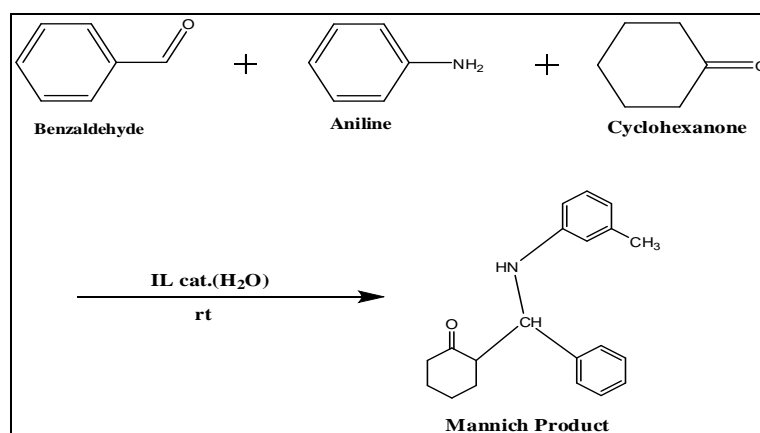

Figure 8: Mannich Reaction with ILs as solvent and catalyst.

Table 6: Catalytic Effect of ILs in Mannich Reaction*

Entry	Ionic Liquids (wt in g)	Time Required	Yield (%)
01	Nil	8 hrs	0
02	[N-MDEA][*m*-TuA] (0.70)	25 mins	90
03	[2-MAE][*m*-TuA] (0.71)	35 mins	82

| 04 | [2-DEAE][*o*-ClBzA] (0.75) | 18 mins | 88 |
| 05 | [2-MAE][SaA] (0.68) | 12 mins | 89 |

*Reaction condition: aldehyde:amine:cyclohexanone, (1:1:1) mole ratio; temperature at 25 °C; Two drops of water (0.06g) was added to the ionic liquid to allow proper mixing.

All the ionic liquids were easily recyclable after removing starting materials and water under vaccum line. [N-MDEA][*m*-TuA] has been recycled four times for the reaction of benzaldehyde, aniline and cyclohexanone. Even after four recycles, product was obtained with almost similar yield and purity of those obtained in the first recycle. The ionic liquid is retained its structure even after four times recycle as confirmed by spectroscopic analysis.

Table 7: [N-MDEA][*m*-TuA] as Catalyst recycling for Mannich reaction

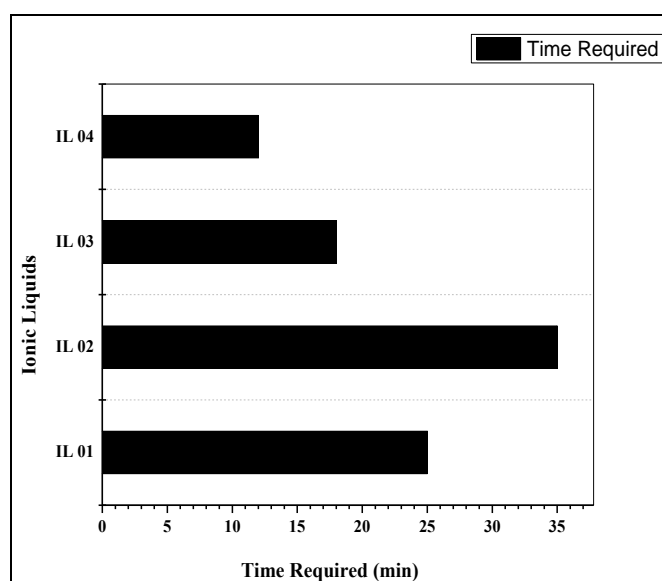| Entry	Cycle	Yield of Product(%)
01	Fresh	90
02	1st recycle	88
03	2nd recycle	87
04	3rd recycle	87
05	4th recycle	85

Figure 9: ILs *vs* Time Required for different ILs.

Characterization of Mannich Product
FT-IR:
The FT-IR (KBr) spectrum of Mannich Product exhibited a number of bands which includes 3481.66 cm^{-1}, -H bond stretching at 3027.41 cm^{-1}, -CH bond stretching of aromatic system at 2831.62 cm^{-1}, bond stretching of cyclic -CH$_2$ and aliphatic -CH group; 1767.84 cm^{-1}, cyclic carbonyl –CO- bond stretching; 1693.57 cm^{-1}, C=C double bond stretch of aromatic ring; 1452.46,1415.81 cm^{-1}, medium to strong absorptions of aromatic ring; 1206.53 cm^{-1},-CH$_2$ out of plane bending of cyclic methylene; 1124.55 cm^{-1},revealed the stretching of –C-O bond; 755.16 cm^{-1}, aromatic out of plane C-H bending.
^{1}H-NMR:
The ^{1}H- NMR spectrum of Mannich Product exhibited signals (in δ ppm) which were assigned as 1.88 (m, 4H, J = 5.6 Hz, C3,4), cyclic four protons of C-3 and C-4 methylene group; 1.80 (m, 2H, J = 5.6 Hz, C-5), methylene two protons of C-5 moiety; 2.32 (s, 3H, C-10), three C-10 methyl protons; 2.45 (t, 2H, J = 3.6 Hz, C-6), two protons of C-6 in cyclohexanone ring; 2.81 (t, 1H, J = 6.8 Hz, C-7), one aliphatic C-7 chiral proton; 4.68 (d, 1H, J =7.2 Hz, C-8), one proton of secondary –NH amine; 4.88 (d, 1H, J =4.4 Hz, C-2), chiral proton of C-2; 6.58 (m, 3H, J =7.2 Hz, C11-13), three protons of aromatic C-11,12,13; 7.08 (m, 1H, J =7.2 Hz, C9), -CH proton of C-9 in aromatic system; 7.34 (m, 5H, J =7.2 Hz, C14-18), five protons of phenyl ring C-(14-18).
^{13}C-NMR:

The ^{13}C-NMR spectrum of Mannich Product showed signals (in δ ppm) which were assigned as 23.705, one saturated aliphatic C-10 carbon; 24.9, 27.9, 28.8, five cyclic saturated carbons of C-(2-6); 31.334, one chiral carbon C-7, which is saturated; 41, 57, 58, 113, 117, six unsaturated aromatic ring carbons, C-(14-18); 127, 128, 137, 141, 147, six carbons of aromatic system C-(8-13); 212.872, one C=O carbon C-1, unsaturated in cyclohexanone.

Table 8: Spectral Analysis of Mannich Product in tabular form

FT-IR Frequency (cm^{-1})	^{1}H-NMR Shift (δ ppm)	^{13}C-NMR Shift (δ ppm)
3481.66, 3027.41, 2831.62, 1767.84, 1693.57, 1452.46, 1415.81, 1206.53, 1124.55, 755.16	1.88 (m,4H, J = 5.6 Hz, C3,4), 1.80 (m, 2H, J = 5.6 Hz, C-5), 2.32 (s, 3H, C-10), 2.45 (t, 2H, J = 3.6 Hz, C-6), 2.81 (t, 1H, J = 6.8 Hz, C-7), 4.68 (d, 1H, J =7.2 Hz, C-8), 4.88 (d, 1H, J =4.4 Hz, C-2), 6.58 (m, 3H, J =7.2 Hz, C11-13), 7.08 (m, 1H, J =7.2 Hz, C9), 7.34 (m, 5H, J =7.2 Hz, C14-18)	23.705, 24.9, 27.9, 28.8, 31.334, 41, 57, 58, 113, 117, 127, 128, 137, 141, 147, 212.872

The spectral data of UV, FT-IR, ^{1}H-NMR and ^{13}C-NMR data are compatible with the structure of the Mannich product.

VI.   Conclusion

Acid base proton transfer reaction has been employed in the synthetic procedure of ILs. Synthesized ionic liquids were purified under vacuum to dispel the moisture prior to their characterization and application. Ammonium based ILs are frequently applied due to their availablity, low toxicity and minimal price in recent time. Not particularly as solvents, ILs are nowadays finding use as catalysts and catalytic supports in organic chemistry. Hence, all the prepared ammonium ILs were used as solvent and acid catalyst in Mannich reaction to form a new class of β-amino carbonyl compounds. An effective catalytic activity has been observed whilst treating these ILs as catalyst. To assist in solving chemical problems computer simulation is conducted that uses methods of theoretical chemistry, incorporated into efficient computer programs to calculate the physico-chemical properties, thermophysical properties, electronic properties, ADMET properties are analyzed of the prepared ILs. This study can be used to find a starting point for a laboratory synthesis and to assist in understanding experimental data. The scope of ILs has marched beyond academic research laboratories to industries. Flexibility to modulate properties by changing design endows freedom to a chemist to design an IL according to one's own requirement. To conclude it can be said that the field of ILs in catalysis holds enormous possibilities to be explored.

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