**Review study the physicochemical properties of ionic liquids and its tremendous significant**

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**Abstract**

Ionic liquid is defined as a salt with a melting point below the boiling point of water. Ionic liquids are also referred to as molten salts, designer solvents, neoteric solvents, and ionic fluids. The majority of ionic liquids are made up of inorganic anions and organic cations. This review examines the various physicochemical characteristics of ionic liquids as well as their incredibly important aspects.This review is focus on the physicochemical properties of ionic liquids and significant of ionic liquids.

Keyword: Ionic liquid, catalyst, Biocatalytic Reactions in Ionic Liquids.

**1.Introduction**

The “Ionic liquids” what are they? Simply said, an ionic liquid is any liquid that is made completely of ions. Ionic liquids that are fluidlike at or near room temperature might be referred to as room-temperature ionic liquids using the same logic. Ionic liquid and room-temperature ionic liquid will both be utilized interchangeably throughout this dissertation. Salts are high melting solids, as is widely known They are extremely toxic and corrosive when in their liquid condition, which is typically well above 500 °C. However, the ionic environments that these liquid salts, commonly referred to as molten salts, offer might present special media for organic reactions and separation procedures. The salts' uses are severely constrained by the high temperatures needed to transform them into a fluid-like condition. Such media cannot be used for synthetic transformations. A salt that has a melting point lower than the boiling point of water is said to be an ionic liquid [1]. Salts that melt below 100 °C have been referred to as ionic liquids (ILs). ILs melts with melting points lower than room temperature are typically referred to as room temperature ionic liquids (RTILs). Ionic liquids are also referred to as molten salts, designer solvents, neoteric solvents, and ionic fluids. The majority of ionic liquids are made up of inorganic anions and organic cations. ILs are electrolytes that exclusively include cations and anions and produce liquid electrolytes. The cation should ideally be unsymmetrical, meaning that the alkyl groups should differ, in order to be liquid at ambient temperature. Ionic liquids' polarity and hydrophilicity/hydrophobicity can be adjusted by choosing the right cation and anion combination. Ionic liquids have the characteristic that has made them known as "designer solvents" Ionic liquids are used in a variety of reactions as solvents. The “ionic liquid” One of the twelve guiding principles of green chemistry states that the usage of auxiliary materials like solvents and separation agents should be minimised and, when essential, made harmless [2]. Numerous solvents, in particular chlorinated hydrocarbons, have poisonous and dangerous qualities that raise serious environmental issues such atmospheric emissions and water effluent contamination. It is understood that using unconventional solvents as alternatives to conventional, environmentally harmful solvents can greatly minimise waste solvent production and, consequently, the adverse effects on the environment. Ionic liquids have shown the most promise among the non-conventional solvents of interest discussed above. Similar to the majority of non-aqueous electrolytes, ionic liquids (ILs) often exhibit a broad electrochemical window of stability and a respectable ionic conductivity. Since their expanding use doesn't cause air pollution, ILs hold promise as many, environmentally friendly reaction media that are anticipated to offer an alluring substitute for traditional volatile organic solvents (VOSs) in contemporary synthetic organic chemistry.

**2. Definitions**

An ionic liquid is defined as a salt with a melting point below the boiling point of water. Salts that melt at temperatures lower than 100 °C are referred to as ionic liquids (ILs). As opposed to this, the term "room temperature ionic liquids" (RTILs) is typically used to refer to IL melts with melting points lower than room temperature.

**3. History**

Ionic liquids were utilized for some organic transformation two decades ago by a small number of researchers as an alternative to routinely used volatile organic solvents. ILs have been referred to as effective molecular and/or environmentally friendly solvents with particular physicochemical and thermal properties [3]. ILs are known as fused/molten/liquid organic salts, etc. because they are ions and liquid at room temperature or below 100 C. Ammonium salts, which have lower melting points than room temperature, were first presented in 1914. Analogs of pyridinium were later reported. These ammoniums and pyridinium ionic liquids appear to satisfy every need for an appropriate ionic medium. Using binary and tertiary systems, as illustrated in Table 1.2, is another strategy for lowering the melting points of inorganic salts. It seemed quite promising to employ aluminum (III) chloride (m.p. 192 oC). Although the melting point values decrease dramatically, they are still high enough to make these systems useful as reaction media. However, it shows that low melting point systems made entirely of inorganic components are theoretically possible. In the 1980s, at that time, the phrase "ionic liquid" gained more traction to define organic salts with a liquid range and a melting point below 100 0C.

**4. Properties of ionic liquids**

**4.1 Melting points (MP)**

The “Ionic liquids” (ILs) solid-liquid transition temperatures can (ideally) drop as low as -100 °C. DSC, or differential scanning calorimetry, is the most effective technique for determining the transition temperatures. NMR, X-ray scattering, and cold-stage polarising microscopy are some more techniques that have been employed. Numerous ionic liquids display thermal behaviour that is relatively complex. When the liquid state is cooled in a normal IL, glass forms because the solidification kinetics are slow. After cooling from a liquid, the low-temperature region is often not limited by the phase diagram liquidus line but instead extends to a lower temperature limit determined by the glass transition temperature. Salt mixing and lattice-destabilizing additives like organic solutes exacerbate this tendency. After cooling, glass solidification temperatures are kinetic transitions rather than precise measurements of melting or heating Tg values [4]. In order to produce accurate results, thermodynamic data must be collected while heating. In order to quench non-equilibrium states in mixtures, lengthy equilibration times with tiny samples that enable quick cooling are required in order to collect valid transition data. Glasses that are metastable usually form in molten salts. Salts of 1-alkyl-3-methylimidazolium are one well-known example of a low glass transition temperature, with typical glass transition temperatures between -70 and -90 °C. Samples usually undergo an exothermic transition when heated from a glassy state, which results in crystallisation and subsequently melting.

**4.1.1 The upper limit “Decomposition Temperature”**

The thermal decomposition temperature of the ionic liquid frequently acts as the upper limit of the liquidus range because the majority of ionic liquids are non-volatile. Contrary to molten salts, which form tight ion-pairs in the vapour phase, the reduced Coulombic interactions between ions energetically restrict the ion-pair formation required for salt volatilization, leading to low vapour pressures. Due to the IL's breakdown rather than vaporisation, this leads to severe upper temperature constraints. The nature of ionic liquids, which contain organic cations, places a restriction on the upper stability temperatures; pyrolysis normally occurs between 350 and 450 °C if no other lower temperature breakdown pathways are present. The volatilization of the component fragments and total mass loss are typical effects of decomposition [5].

**4.1.2 The effect of Ion Sizes on the Melting Points**

The choice of anion and cation has a well-known effect on the specific properties of ionic liquids. The melting point and liquidus ranges of an ionic liquid are directly influenced by the structure of the substance. The motivations for lowering battery electrolyte melting points have already been discussed. Ionic liquids with a range of properties can be made by utilising the changes in these factors [6]. The charge, size, and distribution of charge on the corresponding ions are the main factors affecting the melting points of the salts as general classes. However, even little changes in the geometry of the uncharged, covalent portions of the ions can have a sizable effect on the melting points of the salts within a given salt series.

**4.1.2.1 Anion size**

By lowering the Coulombic attraction contributions to the crystal's lattice energy and enhancing ion covalency, increases in anion size result in decreases in salt melting temperatures. As anion size shrinks, the melting points of ionic liquids frequently fall. **4.1.2.2 Cation size**

The sizes and shapes of the cations in ionic liquids have a considerable impact on the "melting points" of the salts. Simply put, reductions in melting points are often caused by large ions.

**4.1.3 Imidazolium salts**

The melting points of imidazolium salts can be significantly affected by changes in the substitution patterns of imidazolium rings, such as substitution at the C (2,4,5)-positions on an imidazolium ring, in addition to simple symmetry shifts or H-bonding interactions. For instance, substitution at the C (2)-position of the imidazolium ring raises the melting temperatures of the salts. This is not typically a clear or easy outcome, although it could be brought on by cation structural alterations that lead to aromatic stacking or methyl-interactions between cations. Due to the inclusion of new capabilities, the environment of the ions may vary. The most frequent additions are ether groups, which raise melting points by increasing the number of connections [7].

**4.2 Viscosity of “Ionic Liquids (ILs)”**

Internal friction is the root cause of a fluid's viscosity, which shows itself externally as the fluid's resistance to flow. Fluids can be divided into Newtonian and non-Newtonian groups based on their viscosity. The viscosity of Newtonian fluids is constant and unaffected by the rate of strain. Among the Newtonian fluids are pure liquids with low molecular weight. Under strain, non-Newtonian fluids don't maintain their viscosity; instead, they either become thicker or thinner [8].

 $F=μA\frac{u}{y}$………………. (1)

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|  | Where F= | [force](https://www.google.com/search?sca_esv=560585411&sxsrf=AB5stBieomw33FVEoidll5FdR2Otdkr0cg:1693197369916&q=Force&stick=H4sIAAAAAAAAAOPgE-LQz9U3SDIqrlICs4wqk420tLKTrfRTU0qTE0sy8_P00_KLcktzEq2gtEJmbmJ6qkJiXnF5atEjRmNugZc_7glLaU1ac_IaowoXV3BGfrlrXklmSaWQGBcblMUjxcUFt4BnESurW35RcioAzfn824AAAAA&sa=X&ved=2ahUKEwiHzpLew_6AAxVHzjgGHefCB_8Q24YFegQIHhAC) |
|  | µ= | viscosity of the fluid |
|  | A= | area of each plate |
|  | u/y= | [rate of shear deformation](https://www.google.com/search?sca_esv=560585411&sxsrf=AB5stBieomw33FVEoidll5FdR2Otdkr0cg:1693197369916&q=Deformation&stick=H4sIAAAAAAAAAOPgE-LQz9U3SDIqrlLiArFMctIN4tO1tLKTrfRTU0qTE0sy8_P00_KLcktzEq2gtEJmbmJ6qkJiXnF5atEjRlNugZc_7glL6Uxac_IaoxoXV3BGfrlrXklmSaWQBBcblMUnxcOFZAXPIlZul1SQgWArAHMdzcmKAAAA&sa=X&ved=2ahUKEwiHzpLew_6AAxVHzjgGHefCB_8Q24YFegQIHhAD) |

**4.3 The “Density measurement”**

Use a pycnometer to precisely measure density with a small sample size. In glassware that has been calibrated with aqueous solutions that may have slightly varied surface tensions, the bottom of the meniscus can be precisely measured using a pycnometer. The Ostwald-Sprengel and the Weld, or stopper, pycnometer are the two most used types of pycnometers. These instruments typically consist of glass, with a reservoir connected to a fiducial-marked capillary or capillaries. The pycnometer is filled with the test fluid after being weighed empty, and thermal equilibrium is then allowed to occur. The pycnometer is weighed after the liquid from above the fiducial marks has been removed. To determine the accurate volume, pycnometers must be calibrated before use. The density is then calculated by dividing the mass of the fluid by the volume of the pycnometer.

 $P=\frac{m}{V}$………. (2)

Where;

P= Density

M=Mass

V=Volume

**4.3.1 Ionic liquid densities**

Ionic liquid densities seem to be the physical characteristic least susceptible to changes in temperature. during instance, a 50.0:50.0 mol% [EMIM]Cl/AlCl3 only experiences a 0.3% drop in density during a 5-degree temperature change from 298 to 303 K. Furthermore, compared to viscosity, pollutants seem to have a far less substantial effect. It has been shown that the density of "Chloroaluminate ionic liquids" can change based on the substituents on the imidazolium cation. Within a series of non-halo aluminate ionic liquids transporting the same cation species, increased anion mass corresponds to increased ionic liquid density. The kind of organic cation has an impact on the non-haloaluminate ionic liquids' densities as well. The density drops as the size of the cation rises, just like in haloaluminate ionic liquids.

**4.4 Solubility**

Regarding the stoichiometric chemical synthesis and catalytic processes, ionic liquids (ILs) play a crucial role in the solubilities of both organic molecules and metal salts. In order to effectively separate and isolate products, it is necessary for reagents, products, and catalysts to have varied solubilities in the solvent [9]. The catalysts and reagents also need to be suitably soluble in the solvent. Evaluation of the relative merits of a particular ionic liquid (IL) for chemical or separation processes also necessitates knowledge of relative solubility and partitioning data about the preference of the solutes for ionic liquids (ILs) phases relative to extractants, in addition to the knowledge of solute solubility in ionic liquids (ILs). In the literature, there isn't a lot of systematic support for these traits, though. Instead of using compositional analysis to determine the boundaries of solubility or co-miscibility, solutes and solvents are frequently defined as immiscible in a certain ionic liquid (IL) based on the observation that two phases form.

**4.5 “Separations & Extraction”**

Studies of extractions and separations provide the partitioning data—information on the relative solubilities of solutes between two phases—needed to create systems in which a solute is either immobilised in one phase or removed from another phase in a selective manner. Investigations into liquid/liquid separation of metal ions mostly concentrate on aqueous/organic two-phase systems, with implications for the extraction and concentration of metal ions in the organic phase. Regarding ionic liquids (ILs) /aqueous partitioning, there is a lot of interest in the use of ionic liquids (ILs) for the immobilisation of transition metal catalysts, the reprocessing of nuclear fuel and waste, and the recovery of metals from waste water in mining. In ionic liquids (ILs) systems where hydrated metal ions do not partition into the ionic liquids (ILs) from water, most metal ions' hydrated natures reduce their affinity for the less-polar extraction phases, with the exception of the most hydrophobic cations. By altering the hydration environments of the metal ions, either with organic ligands that provide more hydrophobic regions around the metal or with inorganic anions that form softer, more extractable anionic complexes with the metal, the affinity of meta ions for less polar phases can be increased [10].

**4.6 The Solubilities of gas**

Despite the importance of gas solubilities in ionic liquids (ILs), there haven't been many studies on the topic published as of this writing. the stoichiometric technique used to gauge different gases' solubilities in distinct ionic liquids (ILs). Henry's law provided the constants for H2 in two ionic liquids (ILs).

**4.7 Separations of gas**

On the other hand, ionic liquids (ILs) are ideal for use as gas separation solvents. They cannot evaporate and contaminate the gas stream since they are non-volatile. If supported liquid membranes or traditional absorbers are utilised with particular solvents, this is crucial [11]. In conventional absorbers, only the relationship of the Henry's law constants between two gases' respective solubilities may be used to distinguish between them. Additionally, due to their ability to be extremely stable, ILs are particularly attractive for supported liquid membranes. Conventional liquids used in supported liquid membranes eventually degrade because the liquid gradually evaporates. Furthermore, the maximum membrane thickness is constrained by this finite evaporation rate. This shows that there has been a decrease in the net flux across the membrane. A non-volatile liquid could be used to alleviate these issues. Gas permeability via supported liquid membranes depends on both solubility and diffusivity in the absence of aided transport (such as the complexation of CO2 with amines to generate carbamates). A streamlined solution-diffusion model can be used to determine the flow of one gas in relation to the other.

**4.8 Electrochemical Properties of Ionic Liquids**

Ionic liquids are desirable as solvents for studying electrochemical processes because they have a number of characteristics. A wide range of inorganic, organic, and organometallic compounds can be solvated by them, and they frequently have broad electrochemical potential windows, decent electrical conductivity, and solvent transport capabilities.

**4.9 Ionic Conductivity**

When choosing a solvent for an electrochemical application, a solvent's ionic conductivity is crucial. Ionic conductivity can be measured using a wide range of DC and AC techniques.

**4.10 Transport Properties**

The behaviour of an ionic liquid as an electrolyte is strongly influenced by the ionic components' transport properties. These transport characteristics have to do with the speed and direction of ion transportation (solute, in pairs, or in aggregates). For instance, conductivity is influenced by the quantity and mobility of charge carriers. There will be few accessible charge carriers and a low conductivity in an ionic liquid if highly mobile yet neutral ion-pairs predominate. The ion-diffusion coefficients and the ion-transport numbers are the two metrics that are generally employed to assess the transport properties of electrolytes. The transport number is a measurement of the proportion of charge carried by that ion in the presence of an electric field, whereas the diffusion coefficient is a measurement of the velocity of ion movement in a solution [12].

**4.11 Liquid crystals**

Liquid-crystalline phases can be produced by a wide variety of ionic liquids. Usually, this is done by adding longer, linear alkyl groups to the cation to make it more amphiphilic. The salts have relatively low melting temperatures that are close to ambient temperature when the alkyl chain length (Cn) is short (n 10), and when n > 12 they display liquid crystal mesomorphism.

**4.12 Electrical conductivity**

How quickly an electrical current can flow through a material or how easily electrical charge may be transferred across it is determined by the substance's electrical conductivity. High value materials are those that easily conduct electricity and do not easily retain an electrical charge. This performance suggests that certain batteries might make excellent use of this material as an electrolyte [13].

**4.13 Micelle formation in ionic liquids**

Surface tension data were used to calculate surfactant CMC values. It has been demonstrated that the solvatophobic interactions of the ionic liquids with the hydrocarbon part of the surfactants cause the surfactants to dissolve in ionic liquids to reduce their surface tension [14]. The CMC values of surfactants have been determined using a wide variety of techniques. To find the CMC values, many physicochemical parameters are often monitored for changes.

**5. Ionic liquids (ILs) applications**

Ionic liquids have their unique features, ILs have been highlighted as the green option in chemistry while yet having the capacity to dissolve a wide variety of organic and inorganic molecules. Ionic liquids (ILs) have unique physicochemical characteristics and excellent application possibilities. Researchers from all around the world are very interested in surface active ILs as a unique class of surfactants, and this interest has increased as a result of their propensity to self-assemble. These ILs have been shown to exhibit surface activity when dissolved in water, which is shown by a drop in surface tension. It is noteworthy that the ILs can form micellar nano-aggregates in aqueous solution and have characteristics that are similar to those of surface-active (SA) agents. Ionic liquids (ILs) have become intriguing and adaptable reaction media for a variety of bio-applications, most notably enzyme catalysis, as potential environmentally friendly solvents [15].

**5.1 Ionic liquids (ILS) as reaction media**

Neutral ILs have been referred to as "environmentally benign solvents" because of their simple recyclable makeup, good thermal stability, and low vapour pressure. These ILs have been employed as superior and reusable catalysts for a number of processes, such as the Heck reaction (Park & Alper, 2003), the Bischler-Napierlaski cyclisation (Judeh et al., 2002) [16], and the Beckmann rearrangement (Ren et al., 2001) [17].

**5.2 Hydrophobic ionic liquid recycling**

The ease of recycling ILs is extensively acknowledged in the written literature. This is unquestionably the case for some IL-containing biphasic systems, particularly for hydrophobic ILs like [PF6]- and [(CF3SO2)2N]-ILs [Wu et al. 2009] [18]. Liquid-liquid extraction has been employed in palladium coupling procedures to recycle the catalyst and the IL solvent [Handy & Zhang, 2001]; [19] These ILs' capacity for recycling is aided by the fact that several important organic solvents, including diethyl ether, are insoluble in them. While byproducts contained in water-immiscible ILs can be washed out using water with minimal IL loss, products and residual organics can be recovered using an organic solvent due to their lack of solubility Birdwell et al. (2006) [20] created a centrifugal solvent-extraction contactor recycle method that was successfully used for separation of dispersions containing immiscible organic IL/hydrocarbon/and aqueous systems in order to offer significant advantages over conventional technologies for extraction processes.

**5.3 The “Hydrophilic ionic-liquid recycling”**

Hydrophobic ILs can be extracted with water to segregate water-soluble solutes into the aqueous phase, whereas hydrophilic ILs generally cannot be extracted in this way. Research in this area is still in its early stages, and recovery of hydrophilic ionic liquids (ILs) is more challenging than recovery of hydrophobic ILs.

**5.4 The Membrane technology for “Ionic-liquid (ILs)” recovery**

Volatile solutes have been selectively removed from Ionic-liquid (ILs) using membrane techniques, which have been used to generate exact separation of undesired components. In order to recycle ILs from water, Haerens et al. (2010) studied the use of pressure-driven membrane technologies, nano-filtration, reverse osmosis, and pervaporation. The findings of these tests were compared to those described in the literature using Ethaline200, a deep eutectic composed of choline chloride (a quaternary amine salt) and ethylene glycol. Osmotic pressure was discovered to be a limitation of reverse osmosis or nano-filtration when utilised for concentrating ionic liquid (ILs). [Haerens et al., 2010] investigated the potential of pervaporation but found that the excessive water content had limited applicability. Pervaporation can be employed for low water levels even when the flow is very low because of the presence of ionic liquids (ILs), which decreases the activity of the water and therefore the flux through the membrane. Due to the enormous membrane area requirement, pervaporation would be highly unfeasible [Haerens et al, 2010] [21]. The most important of all performance benefits is that only distillation processes can provide a comparable level of fluid purity for the removal of salt and other materials in the ionic size range. Since distillation cannot be used to recycle ILs from non-volatile compound/IL complexes, this method is crucial. Therefore, research into innovative membrane treatment methods is required for IL recovery. It can be challenging to separate, recover, and reuse ILs from particular process mixes because they have a high viscosity that is often 2-3 orders of magnitude higher than water [Wu et al. 2009].

**5.5 The CO2 cycloaddition catalysed by immobilized ILs**

Simple filtration can be used to quickly and easily remove heterogeneous catalysts from reaction mixtures. Immobilising IL catalysts on solid substrates can boost this benefit. The impregnation procedure is one simple way to immobilise. Using this technique, Wang et al. [22] produced silica gel-supported ammonium and imidazoilium IL catalysts. Similar to this, Zhu et al. [23] created a [Chol]Cl-urea IL catalyst supported by a molecular sieve. In these formulations, the IL and the support components were dissolved in a methanol- or acetone-based solution, and the solvent was then removed. These supported IL catalysts could be recycled numerous times without significantly losing their activity for the PC synthesis under solventless conditions, despite the fact that the active ingredient of IL over them was fixed on the surface of the support by weak physical adsorption. Inorganic materials made of silica, mesoporous silicates, aluminosilicate, and alumina can also covalently immobilise ILs. On the latter, inorganic materials that have been treated with alkyl halides—typically propylchloride—can be immobilised and quaternized with matching amine, phosphine, or pyridine. Imidazole is fixed on the altered support when alkali compounds are present, resulting in imidazolium-based immobilised IL that is then quaternized with alkyl halides. Immobilising ILs on solid materials has the advantages of making the catalyst separation process easier and allowing continuous operation in a fixed-bed flow reactor. The application of silica-immobilized phosphonium-based IL for a flow reactor was initially covered by Takahashi et al. For more than 1000 hours, they synthesised PC using 10 MPa of CO2. But throughout the reaction run, the selectivity to PC was kept over 99.9%. Unfortunately, the reaction temperature has to be raised from the initial 90°C to 160°C in order to maintain a yield above 80%, which increases the likelihood that some IL may leach off the support.

**5.6 The “Ionic liquids” used in batteries**

Quaternary ammonium (Mastumoto, 2001) [24], pyridinium (Xiao & Malhotra, 2005) [25], pyrrolidinium (Forsyth, 2001) [26], pyrazolium (Alarco, 2004) [27], imidazolium (Ito, 2000) [28], and [BF4]- and [PF6]- anions are the most researched “Ionic liquids (ILs)” for application in batteries. Numerous physical and chemical properties of “Ionic liquids (ILs)” that might be employed for electrolysis, electrochemical deposition, and the manufacture of batteries were revealed by Hagiwara and Ito in 2000 (Hagiwara & Ito, 2000). According to studies by Stracke and colleagues using “Ionic liquids (ILs)” as electrolytes in hazardous compound-free Leclanché batteries, better ionic conductivities were associated with higher Leclanché battery potentials (Stracke, 2009) [29].

**5.7 The “Ionic liquid (ILs)” as solvent and co-catalyst**

Ionic liquids, such as melts of chloroaluminate or chlorostannate, are frequently utilised in transition metal catalysis as both a co-catalyst and a solvent. A Lewis acid and halide salt react to produce them. This is because the Lewis acidity or basicity, which is always present (at least latently), has a significant impact on the catalyst complex. The Lewis acidity of an ionic liquid is typically used to convert the neutral catalyst precursor into the equivalent cationic active form [30]. The increased electrophilicity of the catalytic centre, which results in increased catalytic activity (as in the majority of olefin oligomerization processes, for example), increases the likelihood that the catalyst system will be activated in a mildly acidic ionic liquid.

**5.8 The “Ionic liquid (ILs)” as solvent and ligand precursor**

The cation and anion of an ionic liquid can act as ligands or ligand precursors for a dissolved transition metal complex. Depending on their degree of coordination, the anions of the ionic liquid may, to some extent, operate as ligands if the catalytic centre is cationic. Actually, it has been sufficiently demonstrated that the anion of an ionic liquid can, if it is different, take the place of the anion of a cationic transition metal complex. The bulk of ionic liquid anions used in catalysis are selected to interact with the catalytic centre as little as possible, however if the ionic liquid's (ILs) anion goes through breakdown processes, this scenario may radically change. For instance, the hexafluorophosphate anion in an ionic liquid hydrolyzes when it comes into contact with water, releasing fluoride ions. Many transition metal complexes use these fluoride ions as potent ligands and catalyst poisons. The situation is a little bit different in terms of the cation of the ionic liquid because catalytic interactions with anionic transition metal complexes are still not very common in ionic liquids. The ligand precursor for an imidazolium molecule can, however, be a transition metal submerged in an ionic liquid [31]. Three alternative methods have been used to observe its transformation into a ligand during reaction conditions: (1) Deprotonating the imidazolium cation yields metal-carbene complexes; (2) Oxidatively adding the imidazolium cation to the metal centre yields metal-carbene complexes; and (3) Dealkylating the imidazolium cation yields metal-imidazole complexes.

**5.9 The “Ionic liquid” as solvent & transition metal catalyst**

Acidic chloroaluminate ionic liquids have already been utilised as both solvents and catalysts for processes that are frequently catalysed by AlCl3, such as catalytic Friedel-Crafts alkylation or stoichiometric Friedel-Crafts acylation. Complex anions can be produced in similar ways by Lewis-acidic transition metal complexes and organic halide salts. For instance, Seddon and associates have obtained a patent for a Friedel-Crafts acylation technique based on an acidic chloroferrate ionic liquid catalyst. But not all ionic liquids that act as catalysts for transition metals are based on regular Lewis acids. Recently, the ionic liquid [BMIM][Co(CO)4] was described. A vibrant blue-green liquid was produced by metathesising [BMIM]Cl and Na[Co(CO)4 It acted as an initiator for the ketonization of the corresponding 2-bromoketones. When a high catalyst concentration is desired, it generally appears like a good idea to add an active transition metal catalyst to the anion of an ionic liquid [32].

**5.10 Significant of the “Ionic Liquids” in Transition Metal Catalysis**

**5.10.1 Hydrogenation Reactions**

The hydrogenation reactions involving "ionic liquids (ILs)" that are catalysed by transition metals are generally quite promising. Ionic hydrogenation catalysts are widespread and well-known, on the one hand. However, given the solubility of many alkenes and the availability of hydrogen in many ionic liquids, it appears that good reaction rates can be achieved. It is intriguing in this regard that the solubility of hydrogen under equilibrium conditions and the ease with which it can be incorporated into the melt both affect the amount of hydrogen that is available. Since it has been discovered that hydrogen migrates into ionic liquids very quickly, the latter aspect is crucial. A biphasic technique is frequently practical because the miscibility gap between the saturated reaction products and the ionic liquid is typically significant. The first successful hydrogenation processes in ionic liquids were studied in 1995 by the de Souza and Chauvin groups [33]. De Souza and associates investigated how Rh affected the hydrogenation of cyclohexene in 1-n-butyl-3-methylimidazolium ([BMIM]) tetrafluoroborate.

**5.10.2 Oxidation reactions**

Techniques for catalytic oxidation using ionic liquids have only lately been studied. Given the well-known oxidation stability of ionic liquids from electrochemical research and the significant commercial impact of oxidation reactions, this comes as a bit of a surprise. The nonvolatile property of the ionic liquid is also a key benefit for the reaction's safety in oxygen oxidation processes. While the possibility of explosive mixtures in the gas phase may limit the use of volatile organic solvents, this issue is not present when a nonvolatile ionic liquid is employed as the solvent. Ley et al. claim that the oxidation of alcohols was catalysed by an ammonium perruthenate catalyst that was dissolved in [NEt4] Br and [EMIM][PF6] [34]. oxygen or N-methylmorpholine The authors describe the possibility of reusing the ionic catalyst solution and simple product recovery via solvent extraction while using N-oxide as the oxidant. Additionally, the oxidation of alkenes and allylic alcohols employing methyltrioxorhenium (MTO) distributed in [EMIM][BF4] as the catalyst and the urea-H2O2 adduct (UHP) as the oxidant. Both MTO and UHP were completely dissolved by the ionic liquid. The solubility of the olefinic substrate in the reactive layer and the olefin's reactivity were shown to affect conversions. Overall, it was determined that the reaction rates of the epoxidation procedure were comparable to those of conventional solvents.

**5.10.3 Hydroformylation**

A tried-and-true method for effective catalyst separation and recycling in hydroformylation is biphasic catalysis. The Ruhrchemie-Rhône-Poulenc process technically implements this concept by using water as the catalyst phase in Rh-catalyzed hydroformylation operations. Sadly, this method is limited to C2-C5-olefins because higher olefins have a low water solubility. But there is commercial interest in hydroformylating a number of higher olefins.

**5.10.4 The Immobilization of Catalysts in “Ionic Liquids” (ILs)**

There are two basic approaches that have been established for using ionic liquids in organic or catalytic reactions. Ionic liquid serves as both the catalyst and the reaction solvent in the first case. In acid-catalyzed reactions, Lewis acidic ionic liquids like acidic chloroaluminates act as both solvents for the carbenium ions and active catalytic species. AlCl3 is an example of an inorganic Lewis acid that does not dissolve in the organic phase under this situation. In the second method, the homogeneous catalyst is placed in the “Ionic liquid (ILs)”, which serves as a "liquid support" for it.

**5.10.5 The “Dimerization & Oligomerization” reactions**

Ionic liquids have already shown themselves to be a very promising solvent class for transforming tried-and-true catalytic systems into biphasic catalysis through the "dimerization and oligomerization" processes. The idea of biphasic catalysis is not new in the field of oligomerization chemistry. On the other hand, ethylene oligomerization was the first catalytic, biphasic process to take place in a commercial setting. In those records, the procedure is referred to as the "Shell Higher Olefins Process (SHOP)" and was first patented in the late 1960s. It was later discovered that a number of highly attractive catalyst systems for dimerization and oligomerization were incompatible with polar organic solvents or water, despite the fact that 1,4-butanediol is the catalyst phase in the SHOP. [35].

**5.11 Industrial use of ionic liquids**

A higher cost-effectiveness is undoubtedly one important factor. This may happen as a result of increased reaction speeds and selectivity, which are connected to more effective catalyst recovery and higher environmental compatibility. Of course, the price of ionic liquids may be a barrier to their development. The cost of the ionic liquid must be compared to that of present chemicals or catalysts, and if it is shown to have a long enough lifetime, then its initial cost is probably not an important factor. For instance, in Difasol technology, the cost of the ionic liquid is lower than the cost of the catalyst components when stated in terms of the amount of octene generated. It is also important to take into account the industrial production of ionic liquids [36]. For use in electrochemical devices (like capacitors), some ionic liquids have previously been commercialised. The extrapolation of chloroaluminate laboratory preparations to a large scale was found to be simple. In the presence of protons, these chloroaluminate salts are corrosive liquids. Similar to aluminium chloride, they create hydrochloric acid when exposed to moisture. However, this can be prevented by including a proton scavenger, such as derivatives of alkylaluminum.

**5.12 The “Multiphasic Catalysis” with “Ionic Liquids (ILs)” in Combination with Compressed CO2, The “Catalytic Reaction” with Subsequent Product Extraction**

Jessop et al. published the initial application in 2001 [37], which featured a catalytic reaction in an ionic liquid and a subsequent extraction step using scCO2. The catalyst [Ru (OAc)2(tolBINAP)] was used by these authors in two separate asymmetric hydrogenation processes, and it was dissolved in the ionic liquid [BMIM][PF6]. In a [BMIM][PF6]/water biphasic combination, the asymmetric hydrogenation of tiglic acid was accomplished with remarkable yield and selectivity. To avoid contaminating the catalyst or ionic liquid, the product was extracted using scCO2 after the reaction was finished. Similar to this, the anti-inflammatory medication ibuprofen was created through the asymmetric hydrogenation of isobutylatropic acid. To learn more about these hydrogenation processes, the reaction was conducted here in a [BMIM][PF6]/MeOH combination, again followed by product extraction with scCO2. [38].

**5.13 The “Aluminium Electrodeposition (AE)”**

Ex situ techniques, potential step experiments, and conventional electrochemical techniques like cyclic voltammetry have all been used in numerous articles to study aluminium (Al) electrodeposition from chloroaluminate ionic liquids. aluminium (Al) deposition was only ever observed in acidic environments, and the deposits' quality was always thought to be superior to that of deposits created by organic solutions. aluminium (Al) is a granular metal, and the cluster size varies with current density, with greater current densities typically producing smaller crystals. When the liquid is combined with toluene or benzene that has been dried, mirror-bright deposits have been observed. Organic substances acting as brighteners are probably present [39]. Since organic materials like crystal violet are frequently used in aqueous electroplating techniques to create beautiful coatings of Cu, Ag, etc., these effects have long been known to occur. Another benefit of the chloroaluminates' miscibility with toluene, xylene, and other organic solvents is the ease with which the liquid may be easily removed from the samples after electrodeposition. As a result, the preparation of clean substrates from aqueous solutions can proceed virtually as quickly..

**5.14 Free Radical Polymerization**

The polymer industry relies heavily on free radical polymerization to create a wide variety of polymers. For the addition polymerization of vinyl monomers such styrene, vinyl acetate, tetrafluoroethylene, methacrylates, acrylates, (meth)acrylonitrile, and (meth)acrylamides, it is used in bulk, solution, and aqueous methods. The chemical is simple to use and is unaffected by contaminants or numerous functional groups [40].

**6. Conclusion**

The "ionic liquids" (ILs) have some advantageous qualities, making daily usage of them almost necessary. The wide applications of the “Ionic liquids” (ILs) such as the “Ionic liquids” (ILs) are among the most essential ingredients encountered in Free Radical Polymerization, Role in “Electrodeposition” of less noble elements, Catalytic Reaction, Industrial use of ionic liquids, Oxidation reactions, these are the main applications of the “Ionic liquids” (ILs).

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