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STUDYING ABOUT DIFFERENT APPLICATION AND CLASSIFICATION OF IONIC LIQUID BASED POLYMER GEL ELECTROLYTES

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ABSTRACT

Ionic liquids (ILs) are molten salts that are entirely composed of ions and have melting temperatures below 100°C. When immobilized in polymeric matrices by sol-gel or chemical polymerization, they generates gels known as ion gels, ionogels, ionic gels, and so on, which may be used for a variety of electrochemical applications. One of the most significant research domains for IL-based gels is the industry of energy, especially for energy storage and conversion devices, due to increasing demand for clean, sustainable and greener energy. Due to characteristics such as no volatility, high thermal stability, and strong ionic conductivity, IL-based gels appear to meet the stringent demands/criteria of these diverse application domains. This article focuses on the synthesis pathways of IL-based gel polymer electrolytes/organic gel electrolytes and their applications in batteries (Li-ion and beyond), fuel cells, and super capacitors. In addition, the limitations and the future possibilities of IL-based gels in the aforementioned application domains are discussed to support the rapid evolution of these materials in the appropriate applicable sectors.

Keywords:- Ionic Liquid, Polymer, Gel, Electrolytes, Liquid, Metal, Solid.

l. INTRODUCTION

The consumer demand for portable electronic devices, drones and all-electric vehicles has increased massively in recent years, and Li-on batteries (LIBs) have played a pivotal role in this direction. Conventional LIBs are close to their theoretical limits in terms of attainable energy density, thus requiring new chemistries that allow to store Li ion far beyond today's LIBs that operate based on the intercalation mechanism.

Metallic Li has been extensively studied as and anode material since the 1970s due to high theoretical capacity (3860 mAh g-1) and low electrode potential (-3.040 V versus standard hydrogen electrode).

Therefore, Li metal batteries (LMBs) that adopt metal anodes can be a game changer to overcome the energy density limitations of LIBs. There are however, several inherent technological barriers to overcome, such as Li dendrite growth and resulting uncontrolled solid electrolyte interface (SEI) formation.

This interfacial instability is also related with the high reactivity of metallic Li during cycling and overheating, which can potentially lead to a poor cycling performance and safety hazards.

II. IONIC LIQUID

ILs are the molten salts that remain in liquid state below 100°C. Sometimes these are also referred as room temperature molten salts, ionic fluids, fuses salts of organic salts. IL are generally formed by self-dissociated, poorly coordinated, bulky organic cations and organic/inorganic anions. Some of the common cations and anions of ILs are given in Figure 1. These ILs don't have strong ionic bond in between the cations and anions as in ionic salts (NaCl, KCl, etc.) and hence possess low lattice energy and remain in dissociated state. Therefore, they shows many desirable properties as high conductivity, low vapor pressure, melting and glass transition temperature, high thermal and electrochemical stability, easily recyclable and less polluting. Some of the common cations and anions or Ils are given in Figure1.

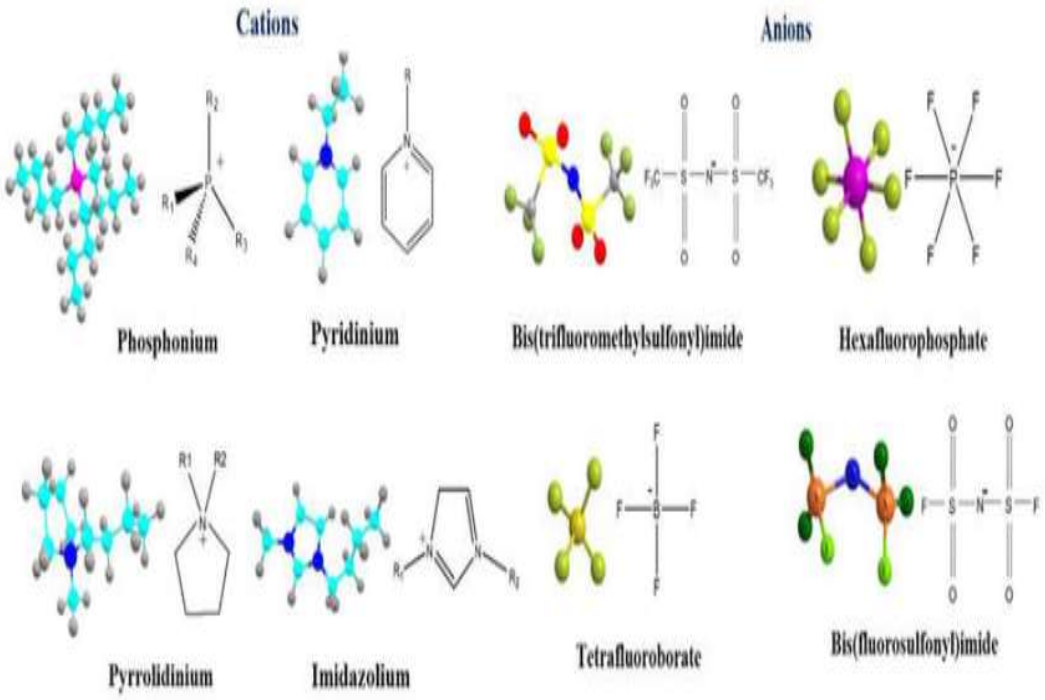

Fig 1. Common cations and anions of ionic liquids

III. CLASSIFICATION OF POLYMER ENECTROLYTES

The Polymer electrolytes are considered to be promising materials in the research and development of electrochemical devices. On the basis of materials, polymer electrolyte is classified into following categories Figure 2.

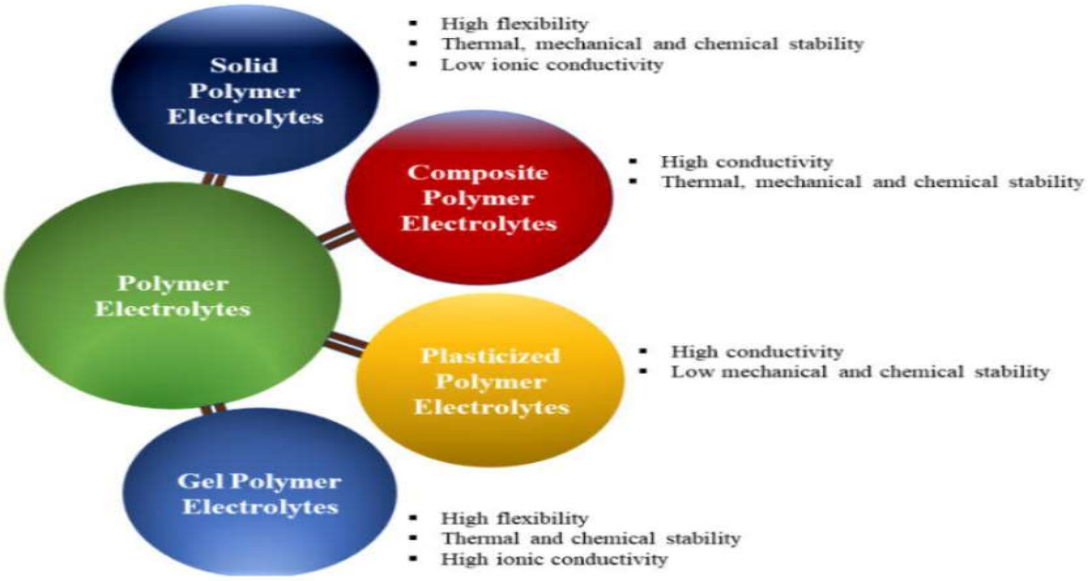

Fig 2. Different types of polymer electrolytes used in Li battery.

1. Dry solid polymer electrolytes

It is formed by incorporating inorganic salt into the polar polymer thus ion conducting electrolyte is known as solid polymer electrolyte (SPE). Electrostatic interaction between the metal ions of salt and the polar polymer results the formation of coordination bond. This metal polymer interaction can be affected by many factor such as nature and distance between the functional group of the polymer, nature of branching, molecular weight, charge on metal and counter ion.

2. Plasticized polymer electrolytes

The plasticized polymer electrolytes are formed by dissolving low molecular weight compounds for example, ethylene carbonate (EC), propylene carbonate (PC), poly ethylene glycol (PEG). These plasticizers reduce the inter and inter-molecular interaction between the polymer chain, thus reduce the Tg and crystallinity of polymer chain and enhance the salt dissociation ability.

3. Composite polymer electrolytes Conductivity of polymer electrolytes

Conductivity of polymer electrolytes also decreases due the presence of ion pair formation. This behavior is mainly observed because of the low dielectric constant of polymer matrix.

4. Gel polymer electrolytes in all the polymer based electrolytes

In all the polymer based electrolytes, gel polymer electrolytes (GPEs) are focusing much attention because they combine the advantages of liquid electrolytes such as high

conductivity, good electrode/electrolyte contact and solid electrolytes like as safety, thermal and mechanical stability.

In gel polymer electrolytes (GPEs), polymer is used to trap the liquid constituent and provides mechanical support, it is thus considered as safer than liquid electrolytes.

IV. APPLICATION OF IONIC LIQUID BASED GEL

IL-based gel electrolytes are gradually increase used in numerous applications such as lithium ion batteries, sodium batteries, solar cells, fuel cells, supercapacitors, micro-capacitors, ionic actuators, electrochromic devices, electrochemical sensors devices [15,24,73]. with advances in the technology of flexible electronic devices, such as smart electronics, stretchable devices, human body sensors, and internet of things, etc. IL-based gels become a thriving research area. IL-based gels is a new kind of soft material with the unique features such as high ionic conductivity, good electrolyte/ electrode contact, and solid electrolytes ensuring safety, a large electrochemical window, and mechanical and thermal stability.

1. Battery

The application of IL-based gel as a non-aqueous electrolyte and/or separator in batteries has been widely reported, especially in 2020; for e.g, in aluminium (Al) batteries, sodium (Na) batteries, calcium (Ca) batteries, organic batteries and, most of all, lithium (Li) batteries. Benefits such as a wide electrochemical window of relatively high ionic conductivity are the basic reasons for ionic liquid gel (ILG) composite modifications widely used as electrolytes in batteries.

2. Li-Ion Batteries

Li batteries are still the most widely developed and commercialized. The nano approach involving cathode and anode materials for examples CNT anodes, silicon anode, and cathode nano-particles, was revealed by Mekonnen et al, as the most promising for the development of Li-ion batteries. The development of IL-based gel in this type of battery also varies according to the trend of the Li battery itself.

3. Na-Ion Batteries

Following the good fortune of LI batteries, a new breakthrough, the rechargeable Na-ion batteries, promises a wider commercialization as according to the research community and industrial entities such as Electrochemical Energy Storage System (EESS). Future perspective and suitable materials for Na batteries have also been explained previously.

4. Al-Ion Batteries

Al-Ion batteries are a low-cost and rechargeable high-energy density battery option considering their abundance, high resistance to oxygen and moisture, and the four higher volumetric capacity of Al compared to LI Das and Lahan have summarized a number of proposed electrochemical reactions for various AI-ion cells, while Elia et al. reported their prospective related views on AI-battery technology..

5. Ca-Ion Batteries

Ca-Ion batteries are a prospect for a wide field of research, and there is so much scope for the development of electrodes and electrolytes that enable stable long-term battery operation. Due to this promising alternative to post- lithium-ion batteries that are more cost-effective and can be applied on a large scale, various designs of Ca batteries have been devised to facilitate the field of research. For the first time, liquid GPEs were used as electrolytes and separations in Ca-ion batteries at room temperature.

V. CONCLUSION

We demonstrated a new type of cross-linked gel polymer electrolyte containing imidazolium ionic liquid end groups having a fluorinated alkyl chain, providing both high ionic conductivity and high Li-ion transference number. Specially, these exceptional properties were enabled by the Lewis acidic nature of the polymer backbone that reduced the mobility of Li salt anion, and played a crucial role for uniform Li plating and for preventing Li dendrite growth during cycling. This study highlights the impact of molecular level engineering of polymer gel electrolytes in controlling the two critical parameters Li+ connectivity transference number to achieve stable cycling of Li metal anodes and can be expanded to other metallic anode systems that suffer similarly from dendrite growth and inter-facial instability.

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