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Novel Quaternary Phosphonium Ionic Liquids and Their Electrochemical Applications

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Considerable interests in quaternary phosphonium based ionic liquids have been increasing from the viewpoint of recyclable green solvents for organic synthesis [1]. The remarkable features of phosphonium ionic liquids are their chemical and thermal stabilities which are practical advantages for various applications. However, well known phosphonium ionic liquids are based on relatively large cations, and hence tend to have high viscosities due to their large molecular weights. Low viscosity is a major requirement for electrochemical applications since viscosity significantly influences the ionic conductivity, mass transfer of solutes, mixing, dispersion and the equipment selections. Despite an obvious advantage by decreasing viscosity, low-viscosity phosphonium ionic liquids remain rather undeveloped, and therefore electrochemistry of phosphonium ionic liquids is not adequately established. Nippon Chemical Industrial Co., Ltd., one of the major suppliers of organophosphorus derivatives, have been developing and routinely manufacturing quaternary phosphonium compounds [2]. We have been also concentrating on the development of low-viscosity phosphonium ionic liquids suitable for electrochemical applications.

Phosphonium ionic liquids we prepared are based on triethylalkylphosphonium (P_{222x}^+) and tri-n-butylalkylphosphonium (P_{444x}^+) cations as shown in Fig. 1. In our investigation, P_{222x}-based ionic liquids exhibited lowest viscosities and highest ionic conductivities. Interestingly, viscosities of the phosphonium ionic liquids were lower than those of the corresponding ammonium ionic liquids. It can be presumed that the weakened ionic interaction due to relatively large phosphorus atom results in reducing the viscosity of phosphonium ionic liquids. In voltammetric measurements, the wide potential window (-3.2 to +3.0 V vs. Fc/Fc^+ at a glassy carbon electrode) was observed, indicating the high electrochemical stability. The thermogravimetric analysis suggested the thermal stability up to nearly 400 °C. The low-viscosity phosphonium ionic liquids as electrolytes for various electrochemical devices are also of our current concerns. Examples of the potential application to electrolytes for lithium ion batteries and dye-sensitized solar cells [3] will be presented.

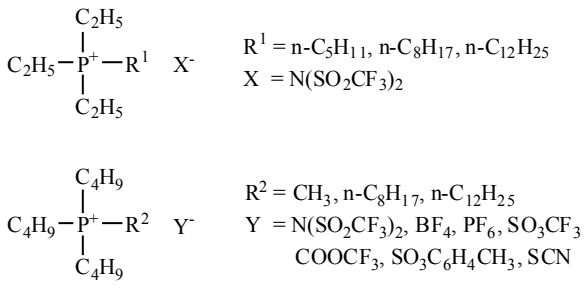

Fig.1 Phosphonium ionic liquids prepared.

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References:

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