Evaluation Of A Series Of Imidazolium Based Ionic Liquids As Solvents For Nucleic Acids

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Introduction

Nucleic acid has equal or more excellent characteristics to synthetic polymers as materials. In recent years, DNA has been studied as functional materials, for example, electro-conductive materials or ionic conductors. Since nucleic acid is known to be soluble only in water, limited investigation of nucleic acid has been carried out in water. Development of non-aqueous solvents for nucleic acid should be an attractive approach in view of further applications inducing electrochemistry.

On the other hand, ionic liquids attract increasing attention due to their potential possibility. Recently, ionic liquids that can dissolve biomaterials have been reported. Thus, ionic liquids are expected as novel non-aqueous solvents for biomaterials. In this study, a series of imidazolium-type ionic liquids were investigated as solvents for nucleic acids.

Experimental

Ionic liquids (Chart 1) were prepared by reported procedure. Every 5mg of DNA or RNA Na salts was mixed with 1.0g of a series of dried ionic liquids, stirred under gradual heating until the mixture became clear on the temperature-controlled hot plate.

Results and Discussion

First, influence of anion species of ionic liquids on the dissolution of nucleic acids was investigated. Dissolution temperature is summarized in table 1. Dissolution temperature of nucleic acid depended on the anion species. Dissolution temperature of nucleic acid depended on the anion species. Ionic liquids having smaller anion such as chloride or bromide solubilized DNA and RNA. On the other hand, nucleic acid was hard to be soluble in salts having $TFSI^-$ or $BETI^-$ anions. Smaller anion had higher surface charge density, and it worked as hydrogen bond acceptor. The hydrogen bond basicity of ionic liquid was important for the dissolution of nucleic acids.

Secondly, the relation between cation structure of the ionic liquid and dissolution temperature of DNA was analyzed (Figure 1). The cation structure certainly influenced the dissolution temperature of nucleic acids. The dissolution temperature elevated with the increase in the alkyl chain length. This is attributable to the increase of hydrophobicity of cations with the increase of alkyl chain length. The dissolution temperature was also elevated by substituting proton at 2-position of the imidazolium cation with methyl group. Lack of this proton raised the dissolution temperature due to less interaction with nucleic acids.

When the hydroxyl group was introduced at the end of alkyl chain, the dissolution temperature was lowered. The same tendency was also observed for RNA (Figure 2). These results also confirmed that hydrogen bonding ability of ionic liquid is important for the dissolution of nucleic acids.

For the lowering of the dissolution temperature, the effects of introduction of hydroxyl group and anion substitution to Cl^- were examined. As shown in Table 2, the dissolution temperature was decreased by the introduction of hydroxyl group. Furthermore, it was also lowered by using Cl^- instead of Br^-. Introduction of functional groups that can interact through hydrogen bond is concluded to be effective to improve solubility of DNA and RNA.

[RMIm] $^+$ [X] $^-$

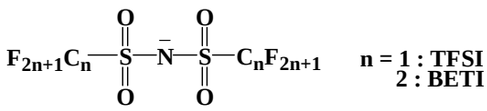

Chart 1. The structure of ionic liquids evaluated in this investigation

Table 1. Dissolution temperature of DNA and RNA in ionic liquids containing different anions

Anion / X^-	Dissolution temperature* / °C			
	Cation / RMIm			
	C_3H_7MIm		C_4H_9MIm	
	DNA	RNA	DNA	RNA
Cl^-	102	82	107	95
Br^-	118	107	125	115
$TFSI^-$	insol.	insol.	insol.	insol.
$BETI^-$	insol.	insol.	insol.	insol.

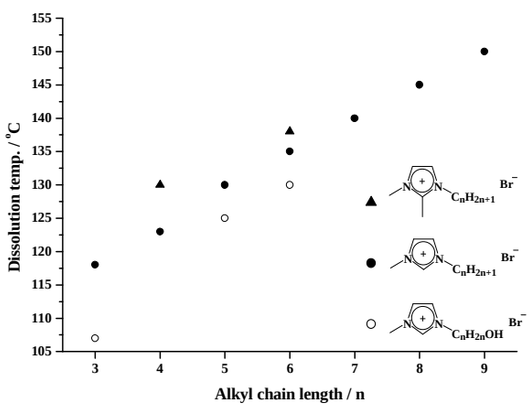

Figure 1. Correlation between dissolution temperature of DNA and the structure of ionic liquids

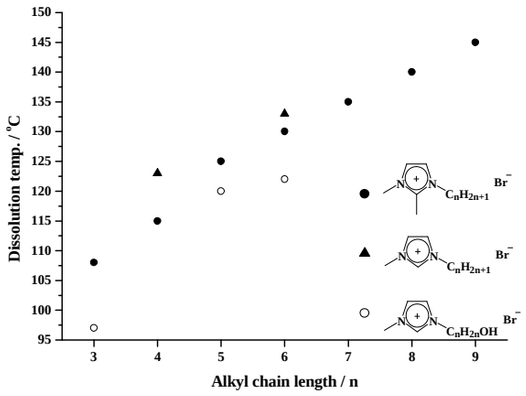

Figure 2. Correlation between dissolution temperature of RNA and the structure of ionic liquids

Table 2. Effect of cation and anion on dissolution temperature of DNA in the ionic liquids

Ionic liquids	R	X	Dissolution temp. / °C	
			DNA	RNA
1	C_3H_7	Br	118	107
2	C_3H_6OH	Br	107	97
3	C_3H_7	Cl	102	82
4	C_3H_6OH	Cl	89	78