

# Micelle formation by *N*-alkyl-*N*-methylpiperidinium bromide ionic liquids in aqueous solution

Yurong Zhao, Xiu Yue, Xudong Wang, Dandan Huang, Xiao Chen\*

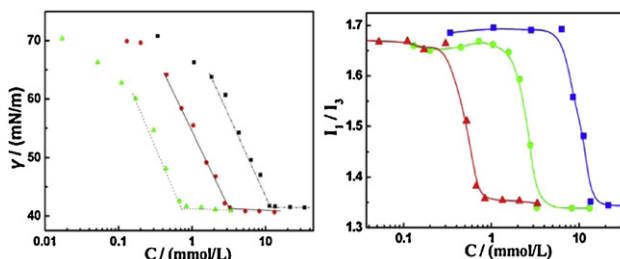
Key Laboratory of Colloid and Interface Chemistry, Shandong University, Ministry of Education, Jinan, Shandong, 250100, People's Republic of China

## HIGHLIGHTS

- ▶ Micelles are formed by *N*-alkyl-*N*-methylpiperidinium ( $C_n$ PDB) bromides in aqueous solution.
- ▶  $C_n$ PDB surface activity is compared with other surfactants of *N*-heterocycle headgroups.
- ▶ Micelle formation is entropy- or enthalpy-driven at low or high temperatures.

## GRAPHICAL ABSTRACT

The micelle formation by the surface active ionic liquids (ILs) *N*-alkyl-*N*-methylpiperidinium bromide  $C_n$ PDB ( $n = 12, 14, 16$ ) in aqueous solution is investigated through the characterizations of surface tension, electrical conductivity, and steady-state fluorescence measurements.



## ARTICLE INFO

### Article history:

Received 29 May 2012

Received in revised form 4 July 2012

Accepted 15 July 2012

Available online 27 July 2012

### Keywords:

Ionic liquid

Micelles

Piperidinium head group

Steady-state fluorescence measurement

## ABSTRACT

The micelle formation by the surface active ionic liquids (ILs) *N*-alkyl-*N*-methylpiperidinium bromide  $C_n$ PDB ( $n = 12, 14, 16$ ) in aqueous solution has been investigated through the characterizations of surface tension, electrical conductivity and steady-state fluorescence measurements. From the curves of surface tension vs  $C_n$ PDB concentration at 25 °C, the critical micelle concentration (cmc), the effectiveness of the surface tension reduction ( $\Pi_{cmc}$ ), the maximum surface excess concentration ( $\Gamma_{max}$ ) and the minimum area ( $A_{min}$ ) occupied per surfactant molecule at the air/water interface are calculated. Through the electrical conductivity measurements, the cmc values at different temperatures and a series of thermodynamic parameters ( $\Delta G_m^\circ$ ,  $\Delta H_m^\circ$  and  $\Delta S_m^\circ$ ) for the formation of micelles are evaluated in the temperature range of 25–45 °C. The steady-state fluorescence measurement is also employed to investigate the micelle formation of  $C_n$ PDB.

© 2012 Elsevier B.V. All rights reserved.

## 1. Introduction

Ionic liquids (ILs), a class of fascinating organic molten salts at ambient temperature, are the focus of many scientific researchers due to their extraordinary physicochemical properties, such as high ionic conductivity, negligible vapor pressure, nonflammability, low melting temperature, and wide electrochemical window [1]. They have therefore exhibited many potential applications in the areas

of catalysis, electrochemistry, preparation of novel nanomaterials, organic synthesis, liquid/liquid extraction, and green chemistry [2–5].

The great advantage of ILs is their structural designability. Their structures can be tailored by changing the cations (imidazolium, pyridinium, and pyrrolidinium) or anions ( $Br^-$ ,  $Cl^-$ ,  $BF_4^-$ ,  $PF_6^-$ ,  $CH_3COO^-$ ,  $CF_3COO^-$ ,  $CF_3SO_3^-$ , and  $(CF_3SO_2)_2N^-$ ), which are all referred in the previous studies [6–11]. Some ILs with novel structures are synthesized and show many interesting properties. Among them, the surface active ILs (SAILs) have been developed and attracted much attention [12]. Similar to the ionic surfactant, the SAILs also have a hydrophobic chain and a hydrophilic

\* Corresponding author. Tel.: +86 531 8836 5420; fax: +86 531 8856 4464.  
E-mail address: [xchen@sdu.edu.cn](mailto:xchen@sdu.edu.cn) (X. Chen).