INTERNATIONAL JOURNAL OF REFRIGERATION 67 (2016) 69–76

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/ijrefrig

Solubilities of propane and cyclopropane in 1-hexyl-3-methylimidazolium tris(pentafluoroethyl)trifluorophosphate

Xiangyang Liu, Nan Lv, Lihang Bai, Maogang He *

Key Laboratory of Thermal Fluid Science and Engineering of MOE, School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an 710049, China

ARTICLE INFO

Article history:
Received 11 July 2015
Received in revised form 21 March 2016
Accepted 22 March 2016
Available online 29 March 2016

Keywords:
Refrigerant
Phase behavior
Hydrocarbon
Ionic liquid

ABSTRACT

Absorption refrigeration is an important energy saving technology that can utilize low-grade energy. A hydrocarbon and an ionic liquid are a promising working pair for the absorption refrigeration system. In this work, the solubilities of propane and cyclopropane in 1-hexyl-3-methylimidazolium tris(pentafluoroethyl)trifluorophosphate at temperatures from 302 K to 344 K and at pressures up to 0.9 MPa were measured. The experimental results were correlated successfully with a modified Krichevsky–Kasarnovsky equation. The mean absolute relative deviations and the maximum absolute relative deviations of the modified Krichevsky–Kasarnovsky equation from the experimental results are less than 1.4 % and 3.7 %, respectively.

© 2016 Elsevier Ltd and IIR. All rights reserved.

Solubilités du propane et du cyclopropane dans le 1-hexyl-3-méthylimidazolium tri (pentafluoroéthyl) trifluorophosphate

Mots clés : Frigorigène ; Comportement de phase ; Hydrocarbure ; Liquide ionique

1. Introduction

Absorption refrigeration offers a way to recycle waste heat because it can be driven by low-grade energy (Zhai and Wang, 2009). The working pair has an important influence on the performance of the absorption refrigeration system. NH_3+ H_2O and H_2O+LiBr are the most widely used working pairs in the absorption refrigeration system. However, they have many disadvantages such as toxicity, crystallization and corrosivity

* *Corresponding author.* Key Laboratory of Thermal Fluid Science and Engineering of MOE, School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an 710049, China. Tel.: +86 29 8266 3863; Fax: +86 29 8266 3863.
E-mail address: mghe@mail.xjtu.edu.cn (M. He).

http://dx.doi.org/10.1016/j.ijrefrig.2016.03.017
0140-7007/© 2016 Elsevier Ltd and IIR. All rights reserved.

Nomenclature

x	mole fraction
n_l	mole number of ionic liquid [mol]
n_g^l	mole number of gas absorbed by the ionic liquid [mol]
V	volume [m^3]
k	confidence coefficient
ρ	molar density [$mol \cdot m^{-3}$]
T	temperature [K]
p	pressure [MPa]
p_i^S	saturated vapor pressure of the solvent [MPa]
V_g^∞	partial molar volume of gas in the solvent at infinite dilution [$cm^3 \cdot mol^{-1}$]
R	universal gas constant [$J \cdot mol^{-1} \cdot K^{-1}$]
f	fugacity of gas [MPa]
H	Henry's constant [MPa]
u	standard uncertainty
U_r	relative expanded uncertainty
A, B, C, D, E	coefficients of the modified Krichevsky–Kasarnovsky equation
N	number of experimental points

Subscripts

GC	gas reservoir
EC	equilibrium cell
b	before loading the gas into the equilibrium cell
f	after loading the gas into the equilibrium cell
r	relative
l	liquid phase
g	gaseous phase
exp	experimental result
cal	calculated value

Abbreviations

[HMIM][FEP]	1-hexyl-3-methylimidazolium tris(pentafluoroethyl) trifluorophosphate
Dev	relative deviation
AAD	mean absolute relative deviation
MD	maximum relative absolute deviation

(Garousi Farshi et al., 2014; Srikhirin et al., 2001). Therefore, many efforts have been put into the development of new working pairs for the absorption refrigeration system.

Ionic liquids are considered as good refrigerant absorbents because they have high thermal and chemical stability, low vapor pressure, no corrosion to metals, low melting point, etc. (Afzal et al., 2014; Anderson et al., 2007; Zheng et al., 2014). Hydrocarbons, such as propane and cyclopropane, have good heat transfer characteristics, low toxicity, zero ozone depletion potential and very low global warming potential, which have attracted much attention as the refrigerants in the absorption refrigeration system (Fukuta et al., 2002; Kumar et al., 1993). A large amount of ionic liquids have high solubilities for the hydrocarbons like ethane, isobutane, propane, propene and cyclopropane (Camper et al., 2005; Costa Gomes, 2007; Florusse et al., 2008; Kim et al., 2007; Lee and Outcalt, 2006; Liu et al., 2014, 2015a, 2015b). Therefore, ionic liquids + hydrocarbons are considered as promising working pairs for the absorption refrigeration system that can overcome the drawbacks of NH_3+H_2O and H_2O+LiBr. (Zheng et al., 2014).

The solubilities of the refrigerants in ionic liquids are the key data for designing the refrigeration and separation processes. Moreover, the solubilities of the hydrocarbons in ionic liquids are necessary when ionic liquids are applied as the lubricants in the vapor compression system and used to separate the hydrocarbons (Fallanza et al., 2013a, 2013b; Zhou et al., 2009). Although a large amount of work have been conducted on the solubilities of the hydrocarbons in ionic liquids as the literatures reviewed (Lei et al., 2014; Liu et al., 2013), the solubility data of propane and cyclopropane in ionic liquids are still scarce, especially for cyclopropane.

1-Hexyl-3-methylimidazolium tris(pentafluoroethyl) trifluorophosphate ([HMIM][FEP]) has high solubility for gases, such as carbon dioxide and ethane (Almantariotis et al., 2012; Muldoon et al., 2007). It is considered to have high solubility for propane and cyclopropane. High solubility is helpful for improving the efficiency of the refrigeration system. Therefore, the solubilities of propane and cyclopropane in [HMIM][FEP] from 302 K to 344 K and at pressures up to 0.9 MPa were

Download English Version:

https://daneshyari.com/en/article/786668

Download Persian Version:

https://daneshyari.com/article/786668

Daneshyari.com