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file:///D:/Waset Istanbul 2013 Proceeding/index.html 8 of 14 6/2/2014 9:14 AM

Abstract— a -Pinene is the main component of the most turpentine oils.

The hydration of a -pinene with acid catalysts leads to a complex mixture of monoterpenes. In order to obtain more valuable products, the a -pinene in the turpentine can be hydrated in dilute mineral acid solutions to produce a -terpineol. The design of separation processes requires information on phase equilibrium and related thermodynamic properties.

This paper reports the results of study on liquid-liquid equilibriu m (LLE) of system containing a - pinene + water and a -terpineol + water. Binary LLE for a -pinene + water system, and a -terpineol + water systems were determined by experiment at 301K and atmospheric pressure. The two component mixture was stirred for about 30min, then the mixture was left for about 2h for complete phase separation.

The composition of both phases was analyzed by using a Gas Chromatograph. The experimental data were correlated by considering both NRTL and UNIQUAC activity coefficient models. The LLE data for the system of a -pinene + water and a -terpineol + water were correlated successfully by the NRTL model.

The experimental data were not satisfactorily fitted by the UNIQUAC model. The NRTL model (a =0.3) correlates the LLE data for the system of a -pinene + water at 301K with RMSD of 0.0404%. And the NRTL model (a =0.61) at 301K with RMSD of 0.0058 %. The NRTL model (a =0.3) correlates the LLE data for the system of a - terpineol + water at 301K with RMSD of 0.1487% and the NRTL model (a =0.6) at 301K with RMSD of 0.0032%, between the experimental and calculated mole fractions.

K e y w or ds— a -Pinene, a -Terpineol, Liquid-liquid Equilibrium, NRTL model, UNIQUAC model I. INTRODUCTION LPHA-PINENE, the major component of turpentine is important compound for fine chemical synthesis and important intermediate in pharmaceutical industry and perfumery [4]. The acid-catalyzed hydration and isomerization of a -pinene yield a complex mixture of monoterpenes, alcohols, and hydrocarbons.

The main products are a - Herti Utami is with the Lampung University, Bandar Lampung, Indonesia. She is now Ph.D student at the Chem ical Engineering Department, Gadjah Mada University, Indonesia. (Corresponding author to provide phone: +62-

0274-9232121; e-mail: hertie19@ hotmail.com, hertie19@yahoo.com).

Sutijan is with the Gadjah Mada University, Yogyakarta, 55281, Indonesia He is now with the Department of Chemical Engineering, Gadjah Mada University, Yogyakarta, Indonesia (e-mail: sutijan@chemeng.ugm.ac.id). Roto is with the Gadjah Mada University, Yogyakarta, 55281, Indonesia. He is now with the Department of Chemistry, Gadjah Mada University, Yogyakarta, Indonesia (e-mail: roto05@ugm.ac.id).

Wahyudi Budi Sediawan is with the Gadjah Mada University, Yogyakarta, 55281, Indonesia. He is now with the Department of Chemical Engineering, Gadjah Mada University, Yogyakarta, Indonesia (e-mail: wbsrsby@indosat.net.id) terpineol, limonene, and terpinolene [8]. By controlling the reaction variables it is possible to make the reaction highly selective towards the desired products.

a -Terpineol ($C_{10}H_{18}O$) is the most important of the monocyclic monoterpene alcohols. In the chemical process industries, fluid mixtures are often separated into their components by operations such as distillation and extraction. Design of such operations requires quantitative estimates of the partial equilibrium properties of fluid mixtures. Unfortunately, such data are often not available.

In the literature, it has been found that several LLE systems containing a -pinene and the other compounds such as the LLE data for ternary a -pinene + ? 3-carene + polar compound systems [2], LLE for linalool + ethanol + water, water + ethanol + limonene, and limonene + linalool + water ternary systems at 298.15K [3], ternary and quaternary LLE for (water + ethanol + a -pinene, + ß -pinene, or + limonene) and (water + ethanol + a -pinene + limonene) at the temperature 298.15K [6], and ternary liquid-liquid equilibrium for (water + terpene + 1-propanol or 1-butanol) systems at the temperature 298.15K [7].

This paper reports on the experimental data on LLE of binary mixtures of a -pinene + water and a -terpineol + water at the temperature of 301K. The experimental data have also been correlated using the NRTL [9] and UNIQUAC [1] activity coefficient models. II. EXPERIMENTAL a -Pinene was supplied by Aldrich with content of a -pinene of 99% w/w and a -Terpineol is 90% w/w (technical grade), distilled water was purchased from General Lab, Yogyakarta, Indonesia. Liquid-liquid equilibrium was determined at 301K and atmospheric pressure.

The two component mixture was stirred for about 30min, then the mixture was left for about 2h for complete phase separation. The composition of both phases was analyzed. The concentration of each component was determined by using a Gas Chromatograph

(GC). The analysis was performed with a Hewlett-Packard model 5890 gas chromatograph. The separation was performed using HP-5 capillary column and Flame Ionization Detector with helium as a carrier gas.

The GC oven temperature was set at initial temperature of 80 oC, held for 5min, increased at a rate of 5oC/min to 115 oC and then increased to 280 oC at a rate of 20oC/min. The injector and detector temperatures were set at 280oC respectively. Liquid-Liquid Equilibrium for the Binary Mixtures of a -Pinene + Water and a -Terpineol + Water Herti Utami, Sutijan, Roto, and Wahyudi Budi Sediawan A III.

RESULTS AND DISCUSSION LLE for binary system of a -pinene + water and a -terpineol + water were measured at temperature of 301K and atmospheric pressure. The experimental and calculated results were reported in Tables I to IV. The data have been correlated with the NRTL and UNIQUAC models. The optimum NRTL and UNIQUAC binary interaction parameters between a - pinene + water and a -terpineol + water were determined by minimizing the differences between the experimental and calculated mole fractions for each of the components over all the tie lines.

Comparison of the calculated and experimental data is expressed in the terms of root mean square deviations (RMSD). The RMSD equation has been defined as follows: RSD10 M M (1) where M is the number of tie lines, x exp indicates the experimental mol fraction, x calc the calculated mole fraction, and subscripts i,j and k denote, respectively, component, phase and tie line. It is expected that the RMSD can represent the goodness of fit.

TABLE I EXPERIMENTAL AND CALCULATED LLE DATA FOR THE BINARY OF ? LPHA-PINENE (1) + WATER (2) SYSTEM AT 301 K Aqueous phase (x1) exp (x1)calc NRTL (ALPHA=0.2) (x1)calc NRTL (ALPHA=0.3) (x1)calc NRTL (ALPHA=0.61) (x1) calc UNIQUAC 0.000014492 0.000000038 0.000000001 0.000051785 0.005204219 0.000111909 0.000000042 0.000000007 0.000098256 0.005163267 0.000298112 0.000000047 0.000000086 0.000265632 0.004699638 0.000346808 0.000000048 0.000000154 0.000335254 0.004607848 0.000452874 0.000000051 0.000000476 0.000524837 0.004292090 0.000469001 0.000000038 0.000000408 0.000408229 0.002638084 (x2) exp (x2)calc NRTL (ALPHA=0.2) (x2)calc NRTL (ALPHA=0.3) (x2)calc NRTL (ALPHA=0.61) (x1) calc UNIQUAC 0.999985508 0.999999962 0.999999999 0.999948215 0.994795781 0.999888091 0.999999958 0.999999993 0.999901744 0.994836733 0.999701888 0.999999953 0.999999914 0.999734368 0.995300362 0.999653192 0.999999952 0.999999846 0.999664746 0.995392152 0.999547126 0.999999949 0.999999524 0.999475163 0.995707910 0.999530999 0.999999962 0.999999592 0.999591771 0.997361916 TABLE II EXPERIMENTAL AND CALCULATED LLE DATA FOR THE BINARY OF

? LPHA-PINENE (1) + WATER (2) SYSTEM AT 301K Organic phase (x1) exp (x1)calc NRTL (ALPHA=0.2) (x1)calc NRTL (ALPHA=0.3) (x1)calc NRTL (ALPHA=0.61) (x1) calc UNIQUAC 0.703008812 0.690302595 0.702988402 0.702974820 0.745129803 0.700319819 0.689036618 0.700349682 0.700321045 0.366994075 0.654281431 0.650730366 0.654236485 0.654281226 0.591721065 0.645390460 0.643869079 0.645345964 0.645385824 0.652014059 0.613976758 0.617058688 0.613939939 0.613967360 0.755972947 0.444613146 0.457041243 0.444639064 0.444642049 0.478713128 (x2) exp (x2)calc NRTL (ALPHA=0.2) (x2)calc NRTL (ALPHA=0.3) (x2)calc NRTL (ALPHA=0.61) (x1) calc UNIQUAC 0.296991188 0.309697405 0.297011598 0.297025180 0.254870197 0.299680181 0.310963382 0.299650318 0.299678955 0.633005925 0.345718569 0.349269634 0.345763515 0.345718774 0.408278935 0.354609540 0.356130921 0.354654036 0.354614176 0.347985941 0.386023242 0.382941312 0.386060061 0.386032640 0.244027053 0.555386854 0.542958757 0.555360936 0.555357951 0.521286872 TABLE III EXPERIMENTAL AND CALCULATED LLE DATA FOR THE BINARY OF ? LPHA-TERPINEOL (1) + WATER (2) SYSTEM AT 301K Aqueous phase (x1) exp (x1)calc NRTL (ALPHA=0.2) (x1)calc NRTL (ALPHA=0.3) (x1)calc NRTL (ALPHA=0.6) (x1) calc UNIQUAC 0.000060053 0.075988881 0.000022525 0.000075592 0.017819894 0.000060865 0.075484361 0.000022255 0.000074990 0.017532644 0.000079222 0.075151992 0.000022253 0.000082626 0.017319046 0.000110107 0.074958436 0.000022453 0.000097784 0.017170614 0.000192846 0.074839525 0.000023234 0.000151496 0.017008580 0.000473016 0.071447000 0.000023699 0.000484802 0.014434744 (x2) exp (x2)calc NRTL (ALPHA=0.2) (x2)calc NRTL (ALPHA=0.3) (x2)calc NRTL (ALPHA=0.6) (x2) calc UNIQUAC 0.999939947 0.924011119 0.999977475 0.999924408 0.982180106 0.999939135 0.924515639 0.999977745 0.999925010 0.982467356 0.999920778 0.924848008 0.999977747 0.999917374 0.982680954 0.999889893 0.925041564 0.999977547 0.999902216 0.982829386 0.999807154 0.925160475 0.999976766 0.999848504 0.982991420 0.999526984 0.928553000 0.999976301 0.999515198 0.985565256 TABLE IV EXPERIMENTAL AND CALCULATED LLE DATA FOR THE BINARY OF ? LPHA-TERPINEOL (1) + WATER (2) SYSTEM AT 301K Organic phase (x1) exp (x1)calc NRTL (ALPHA=0.2) (x1)calc NRTL (ALPHA=0.3) (x1)calc NRTL (ALPHA=0.6) (x1) calc UNIQUAC 0.717401483 0.658237488 0.717253375 0.717378495 0.785992108 0.708333503 0.659435512 0.708577540 0.708312237 0.765648178 0.702047187 0.744039378 0.704409467 0.702037788 0.642906780 0.698117356 0.758504072 0.700000776 0.698123361 0.568382078 0.694981125 0.557419866 0.693803767 0.695002410 0.568952499 0.620884567 0.630676235 0.621028800 0.620880191 0.737680785 (x2) exp (x2)calc NRTL (ALPHA=0.2) (x2)calc NRTL (ALPHA=0.3) (x2)calc NRTL (ALPHA=0.6) (x2) calc UNIQUAC 0.282598517 0.341762512 0.282746625 0.282621505 0.214007892 0.291666497 0.340564488 0.291422460 0.291687763 0.234351822 0.297952813 0.255960622 0.295590533 0.297962212 0.357093220 0.301882644 0.241495928 0.299999224 0.301876639

0.431617922 0.305018875 0.442580134 0.306196233 0.304997590 0.431047501 0.379115433 0.369323765 0.378971200 0.379119809 0.262319215 In the UNIQUAC model, the values of volume and surface area parameter of pure component r i and q i, for water and a - pinene have been taken from literature [6].

The volume and surface area of the a -terpineol was estimated from the Bondi's method [5]. The pure-component molecular parameters, r i and qi were listed in Table V. In the NRTL model, for all binary pairs, the value of the non randomness parameter (a) was set as 0.2, 0,3 and obtained from fitting.

TABLE V THE VOLUME AND SURFACE AREA PARAMETERS FOR THE UNIQUAC MODEL a -Pinene a -Terpineol Water r 6.056 7.0389 0.920 q 4.760 5.8800 1.400 For binary system, a -pinene (1) + water (2), the result is shown in Fig. 1. The calculated points are relatively very close to the experimental ones for the NRTL model, so it proves that the model can well approximate the equilibrium data.

Fig. 1 Liquid – liquid equilibrium calculation and experimental data for the system a -pinene (1) + water (2) at 301K For binary system, a -terpineol (1) + water (2), the result is shown in Fig. 2.

The calculated values are in good agreement with experimental ones for the NRTL model, except the value of the non randomness parameter (a) = 0.2. The experimental data are not satisfactorily fitted by the UNIQUAC model. Fig. 2 Liquid – liquid equilibrium calculation and experimental data for the system a -terpineol (1) + water (2) at 301 K Tables VI, VII and VIII summarize the values of the binary parameters obtained fitting the models to the experimental binary LLE system.

The deviation between experimental and calculated values expressed in terms of the root mean square deviations (RMSD) defined by using (1). TABLE VI INTERACTION PARAMETERS OF THE NRTL MODEL FOR THE BINARY OF ? LPHA-PINENE (1) + WATER (2) SYSTEM AT 301K Parameters of NRTL a (alpha) pairs bij (Jmol-1) bji (Jmol-1) RMSD (%) 0.2 1-2 -8.127e-008 10015.5609 1.0528 0.3 1-2 -8.8127e-010 12165.3934 0.0404 0.61 1-2 -5.8505e-007 5752.8896 0.0058 0 0.1 0.2 0.3 0.4 0.5 0.6

0.7 0.8 0.9 1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 x (calc) x (exp) NRTL alpha 0.2 NRTL alpha 0.3 NRTL alpha 0.61 UNIQUAC 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 x (calc) x (exp) NRTL alpha 0.2 NRTL alpha 0.3 NRTL alpha 0.6 UNIQUAC TABLE VII INTERACTION PARAMETERS OF THE NRTL MODEL FOR THE BINARY OF ? LPHA-TERPINEOL (1) + WATER (2) SYSTEM AT 301K Parameters of NRTL a (alpha) pairs bij (Jmol-1) bji (Jmol-1) RMSD (%) 0.2 1-2 -36.8323 1483.9311 14.0594 0.3

1-2 -0.02847 6221.026 0.1487 0.6 1-2 -8.4082e-007 5693.1474 0.0032 TABLE VIII INTERACTION PARAMETERS OF THE UNIQUAC MODEL Parameters of UNIQUAC System pairs uij (Jmol -1) uji (Jmol -1) RMSD (%) a -Pinene+Water 1-2 -85.9232 361.0679 14.6751 a -Terpineol+Water 1-2 577.5684 -183.1829 14.9140 In fitting the models to the binary LLE data, it was satisfactorily fitted by the NRTL model.

The NRTL model (a =0.3) correlates the LLE data for the system of a -pinene (1) + water (2) at 301K with RMSD of 0.0404%. And the NRTL model (a =0.61) at 301K with RMSD of 0.0058%. The NRTL model (a =0.3) correlates the LLE data for the system of a - terpineol (1) + water (2) at 301K with RMSD of 0.1487% and the NRTL model (a =0.6) at 301K with RMSD of 0.0032%, between the experimental and calculated mole fractions.

The UNIQUAC model correlates the LLE data for the binary system of a -pinene (1) + water (2) at 301K with RMSD of 14.6751%, and the LLE data for the system of a -terpineol (1) + water (2) at 301K with RMSD of 14.914%. In the UNIQUAC model, it was found high deviations between the experimental and correlated data. IV.

CONCLUSION The experimental data on liquid-liquid equilibrium of binary mixtures of a -pinene (1) + water (2) and a -terpineol (1) + water (2) were obtained at the temperature of 301K and atmospheric pressure. The NRTL and UNIQUAC models were used to correlate the experimental LLE data. The optimum NRTL and UNIQUAC parameters were determined using the experimental liquid-liquid equilibrium data.

It was found that the NRTL model fitted satisfactorily to the experimental data. In the UNIQUAC model, it was found high deviations between the experimental and correlated data. The experimental data were not satisfactorily fitted by the UNIQUAC model.

NOMENCLATURE bij interaction parameter in the NRTL equation uij interaction parameter in the UNIQUAC equation LLE liquid-liquid equilibrium NRTL non random two liquid T temperature (K) UNIQUAC universal quasi chemical equation x composition in mole fraction a (alpha) non randomness parameter in the NRTL equation ACKNOWLEDGMENT The authors gratefully acknowledge the financial support from, Directorate General of Higher Education of Indonesia (DIKTI) Department of National Education Republic of Indonesia under Hibah Bersaing (HB 2012) Program with contract No. 038/UN26/KU/8/2012 9 February 2012, for supporting this research. REFERENCES [1] Abrams, D.S.,

Prausnitz, J.M., 1975, “Statistical thermodynamics of multi component liquid mixtures: A new expression for the excess Gibbs energy of partly or completely miscible systems”, AIChE J.,21, 116. [2] Antosik, M., Stryjek, R.,

1992, “Liquid-liquid equilibria in ternary a - pinene + ? 3 carene + polar compound systems, Fluid Phase Equilibria, 71, 321-331. [3] Arce, A., Marchiaro, A., and Soto, A., 2004, “Liquid–Liquid Equilibria of Linalool + Ethanol +Water, Water + Ethanol + Limonene, and Limonene + Linalool +Water Systems”, Journal of solution chemistry, Vol. 33, no.5 [4] Deliy, I.V., and Simakova, I.L.’Kine tics and Thermodynamic of Liquid Phase Isomerization of a and ß - Pinene Over Pd/C Catalyst”, React. Kinet.

Catal. Lett. 161-174 (2008) 95. [5] Fredenslund, A., Gmehling, J., and Rasmussen, P.,1977, “Vapor-Liquid Equilibria Using UNIFAC”, Elsevier, Amsterdam. [6] Li, H., Tamura, K., 2006, ‘Ternary and quaternary (liquid-liquid) equilibria for (water + ethanol + a -pinene, + ß -pinene, or + limonene) and (water + ethanol + a -pinene + limonene) at the temperature 298.15 K”, J.Chem. Thermodynamics 38, 1036-1041. [7] Li, H., Tamura, K.,

2008, ‘Ternary li quid-liquid equilibria for (water + terpene + 1-propanol or 1-butanol) systems at the temperature 298.15 K”, Fluid Phase Equilibria 263, 223-230. [8] Monteiro, J.L.F, and Veloso, C.O., Catalytic Conversion of Terpenes Into Fine Chemicals, Topics in Catalysis. 1-4 (2004) 27. [9] Renon, H., Prausnitz, J.M., 1968, “Local compositions in thermodynamic excess functions for liquid mixtures”, AIChE J., 14, 135-144. Herti Utami is Ph.D

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