

LiBr-LiI-HN(CH₂)₂OH-H₂O 및 LiBr-HO(CH₂)₃OH-H₂O 계의
Duhring (P-T-X) 선도

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Duhring (P-T-X) Charts for LiBr-LiI-HN(CH₂)₂OH-H₂O
and LiBr-HO(CH₂)₃OH-H₂O Systems.

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Introduction

A heat -powered absorption chiller is attractive in view of its low energy consumption. Recently, much effort (Iizuka et al., 1989, 1990; Inoue, 1993; Okano et al., 1994) have been made to develop an air-cooled absorption chiller. However, many additional problems occur in the construction of the air-cooled absorption cycle. The most serious problem becomes the crystallization of the working fluid because the high absorber temperature caused by air-cooling needs high absorbent concentration of the working fluid in order to maintain a low vapor pressure in the absorber. In this work LiBr-LiI-HN(CH₂)₂OH-H₂O (LiBr/LiI mole ratio 4:1 and (LiBr+LiI)/ HN(CH₂)₂OH mass ratio 4:1) and LiBr-HO(CH₂)₃OH-H₂O (LiBr/HO(CH₂)₃OH mass ratio 3.5:1) systems were selected using high boiling ethanolamine and 1,3-propandiol as anti-crystallization additives. The solubility and vapor pressures for each system were measured at various concentrations and temperatures. Each set of results was correlated with a proper equation and Duhring (P-T-X) charts were constructed. Duhring chart is a P-T-X diagram which gives the relations between the solution temperature and the vapor pressure at various concentrations including the crystallization line of the solution. So the operation range of an absorption cycle can be known from this chart.

Experiment

The visual polythermal method (Chou and Lee, 1983) was used to measure the solubility of each sample. The apparatus which is similar to that of Chou and Lee (1983) is shown in Figure 1. It consists of a Pyrex glass vessel (50 cm³) sealed by a Teflon adapter, a thermistor thermometer (Cole Parmer, 08502-16) of which the accuracy is ± 0.2 K, a constant temperature bath, a circulator for both cooling and heating, and two stirrers. The solution was first incrementally heated above the crystallization temperature to dissolve all the salts. Then the solution temperature was lowered slowly to nucleate a small amount of crystals. Through a series of dissolving and nucleation procedures, the temperature at which the last crystal disappeared was taken as the dissolution temperature for a given solution in this polythermal run. Vapor pressures were measured using the boiling point method. The schematic diagram of the experimental apparatus is shown in Figure 2. The apparatus consists primarily of an equilibrium vessel (500 cm³), a constant temperature bath, a

condenser, a U-tube mercury manometer, a K type thermocouple, and two stirrers. A sample solution (approximately 250 cm³) of a desired absorbent concentration was used in each run. At the thermal equilibrium, the pressure in the apparatus and the temperature of the sample solution were measured.

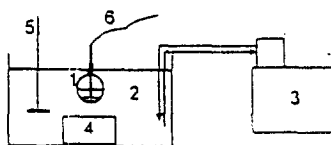


Figure 1. Experimental apparatus for the measurement of solubility: (1) equilibrium still; (2) constant temperature bath; (3) bath circulator; (4, 5) stirrers; (6) thermistor thermometer.

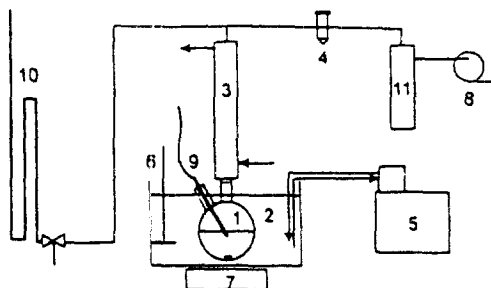


Figure 2. Experimental apparatus for the measurement of vapor pressure: (1) equilibrium still; (2) constant temperature bath; (3) condenser; (4) needle valve; (5) bath circulator; (6, 7) stirrers; (8) vacuum pump; (9) thermocouple; (10) mercury manometer; (11) cold trap.

Results and Discussion

The measured solubility values for each system were regressed by a least-square method represented by the following equation,

$$100S = \sum_{i=0}^2 a_i (T/K)^i$$

where S is the solubility represented by the mass fraction of absorbent ($\text{LiBr} + \text{LiI} + \text{HN}(\text{CH}_2)_2\text{OH}$ and $\text{LiBr} + \text{HO}(\text{CH}_2)_3\text{OH}$ respectively), T the absolute temperature, and a_i the regression coefficients. The average absolute deviations between experimental and calculated values are less than 0.16 % for all data sets. Each data set of vapor pressure was correlated with the following Antoine-type equation which expresses vapor pressure as a function of temperature and concentration,

$$\log(P / kPa) = \sum_{i=0}^4 [A_i + \{1000B_i / (T / K - 43.15)\}] (100w)^i$$

where P is the vapor pressure, T the absolute temperature, and w the mass fraction of absorbent. The parameters A_i and B_i were determined by a least-square method and the results. The average absolute deviations between experimental and calculated values are less than 0.94 % for all data sets.

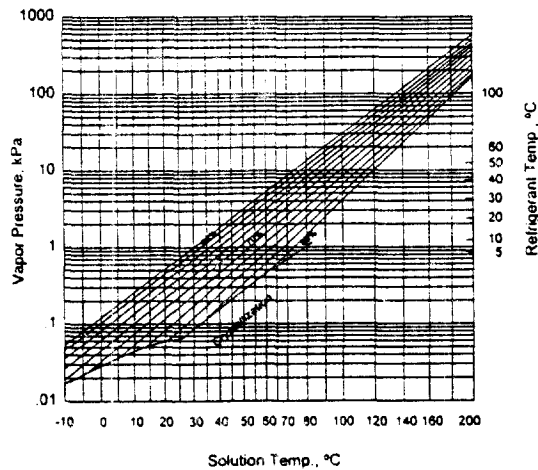


Figure 3. Dühring Chart of the LiBr + LiI + $H_2N(CH_2)_2OH$ + H_2O (LiBr/LiI mole ratio 4:1 and (LiBr+LiI)/ $H_2N(CH_2)_2OH$ mass ratio 4:1) System.

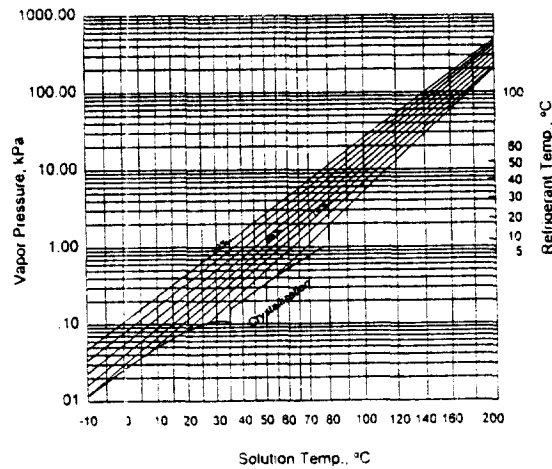


Figure 4. Dühring Chart of the LiBr + $HO(CH_2)_2OH$ + H_2O (LiBr/ $HO(CH_2)_2OH$ mass ratio 3.5:1) System.

For two systems LiBr-LiI-HN(CH₂)₂OH-H₂O (LiBr/LiI mole ratio 4:1 and (LiBr+LiI)/HN(CH₂)₂OH mass ratio 4:1) and LiBr-HO(CH₂)₃OH-H₂O (LiBr/ HO(CH₂)₃OH mass ratio 3.5:1), Duhring charts were constructed using the correlation results of the solubility and vapor pressure. Figure 3. and Figure 4. show the Duhring charts for these two systems respectively. These two charts also give the relations between the saturation temperature of refrigerant and the solution temperature. From two charts constructed, it is known that both two systems can be operated at the high absorber temperature (above 45 °C) and at the low pressure allowing appropriate concentration difference (about 5 %), which is essential for the construction of an air-cooled absorption chiller.

Conclusion

For two systems LiBr-LiI-HN(CH₂)₂OH-H₂O (LiBr/LiI mole ratio 4:1 and (LiBr+LiI)/HN(CH₂)₂OH mass ratio 4:1) and LiBr-HO(CH₂)₃OH-H₂O (LiBr/ HO(CH₂)₃OH mass ratio 3.5:1), vapor pressures and solubilities were measured, and Duhring charts for these two systems were constructed. From the Duhring charts for the selected systems, it was known that the operation range required for an air cooled-cycle operation could be obtained by adding ethanolamine and 1,3-propanediol to an appropriate ratio.

References

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