

# Vapor Pressure of Ethylene Glycol Monoethyl Ether and Some of Its Chloride Solvates

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Ethylene glycol monoethyl ether (EGME), also called 2-ethoxyethanol, is used for the determination of the surface areas of powdered materials, mainly various soil species.<sup>1,2</sup> The sample is wetted with EGME, and the superfluous liquid is removed by pumping. The sample gradually gains a constant weight, and the area is computed from the mass of the retained EGME, assuming that a monolayer has been formed. To prevent over-pumping, the vapor pressure is usually regulated by another sample of EGME or its calcium chloride solvate (EGME saturated with  $\text{CaCl}_2$ ) present in the pumping chamber.

EGME may also be a suitable adsorbate for the determination of surface areas by the BET method. In the literature,<sup>3</sup> its vapor pressure is, however, reported only between 340–408 K, *i.e.* considerably above room temperatures. In this study, vapor pressures were measured below this region down to 273 K. Six EGME-chloride solvates with potential for vapor pressure regulation, were also included in the study.

All the reagents, as well as the glass wool, were Merck analytical grade chemicals. EGME was further purified by distilling with a long column, and the fraction boiling at the reported normal boiling point<sup>3</sup> (408.1 K) was used in the experiments.

Below room temperature, the vapor pressures of EGME were measured by the gas-saturation method.<sup>4,5</sup> The saturator was a 10-liter glass bottle half-filled with 340 g of EGME-wetted glass wool. It was submerged in a thermostated water bath ( $T \pm 0.02$  K). Before an experimental run, the saturator was left overnight (at least 16 h) at the measuring temperature. Prethermostated dry air flow was slowly led up through the glass wool bed having a large evaporation surface area. The air in the saturator was displaced only once during a run (4–8 h). Hence, the saturation was practically complete, which was verified by test runs.<sup>4</sup> The temperature remained essentially constant, since the required heat was taken from the bed, from the bottle, and also from the thermostat vessel. The transpired EGME was collected in a tared silica gel tube kept in a melting ethanol bath (about 150 K). After the run, the tube was warmed to the room temperature, and the pressure was released cautiously. Then the tube was wiped dry and weighed. The air flow into the saturator was accomplished by displacing dry air in another 10-liter glass bottle (A) with ethylene glycol streaming slowly from a plastic container (B). New air was drawn into container B through dry calcium chloride and concentrated sulfuric acid. Bottle A was weighed before and after the experimental run, and the volume of the air flow was computed by the mass of glycol and its measured density. After the run, glycol was drawn back into container B with a siphon, and the air then flowed from B into A. The vapor pressures were computed from the observations by ideal gas laws.<sup>4</sup> At 293 K, ethylene glycol has such a low vapor pressure (about 7 Pa)<sup>5</sup> that it has no practical effect on the present results.

Above room temperature, an isoteniscope was employed where the liquid in the U tube is the substance under the study.<sup>4</sup> The pressures were measured by a mercury barometer read with a vernier (accuracy 0.1–0.2 mmHg). The results were corrected for the temperature and the local value of the acceleration due to gravity (correcting factor 0.997).<sup>4</sup>

The results from both methods are in excellent agreement and obey the Clausius-Clapeyron equation. 16 observation points in the temperature region of 273.15–338.46 K were fitted to the equation  $\lg p = A/T + B$  by least squares. The parameters are reported in Table 1. Enthalpy of vaporization for EGME derived from parameter *A* is 46.6 kJ mol<sup>-1</sup>. The vapor pressures observed lie randomly within -4.5 to +3.9 % of the values computed from the regression line. At 298 K, the standard error<sup>6</sup> of *p* is 0.75 %. Thus the general precision of the values computed is about 1 %. Above 293 K, the values observed also fit equally well to the Antoine equation presented by Pick and co-workers<sup>3</sup> (here converted to

Table 1. Condensed results of the vapor pressure measurements. Parameters of equation.

Liquid	Parameters of eqn. $\lg p = A/T + B$		Pressures at 298.15 K	
	A	B	p/Pa	p/p <sub>o</sub>
EGME	-2431.8	11.0320	751±6	1.00
EGME+LiCl	-2564.2	10.9282	212±5	0.28
EGME+NaCl	-2506.2	11.2283	664±16	0.89
EGME+KCl	-2580.5	11.4779	665±7	0.89
EGME+CaCl <sub>2</sub>	-2602.5	11.4632	542±7	0.72
EGME+MgCl <sub>2</sub>	-2403.7	10.8967	683±9	0.91

Pascal units):  $\lg p = -1801.9/(t+230) + 9.9440$  ( $t$  in °C). Below 293 K, the vapor pressures observed are systematically a few per cent higher than the Antoine equation predicts, but in any case the equation represents fairly well the vapor pressures of EGME in the whole region of 273–408 K.

The chloride solvates were prepared by saturating EGME carefully with salts dried at 570 K. The vapor pressures were measured with the isoteniscope. 7–13 observation points for each solvate were determined in the region of 295–315 K. These results were also fitted to the linear equation. The parameters as well as the vapor pressures at 298.15 K and the corresponding relative vapor pressures are reported in Table 1. As can be seen, LiCl affects the pressure considerably.

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1. Carter, D.L., Heilman, M.D. and Gonzalez, C.L. *Soil. Sci.* 100 (1965) 356.
2. Eltantawy, I.M. and Arnold, P.W. *J. Soil Sci.* 24 (1973) 232.
3. Pick, J., Fried, V., Hála, E. and Vilím, O. *Chem. Listy* 49 (1955) 1720; *Chem. Abstr.* 50 (1956) 636i.
4. Thomson, G.W. In Weissberger, A., Ed., *Technique of Organic Chemistry*, Interscience, New York 1949, Vol 1, Part 1, Chapter 5.
5. Hales, J. L., Cogman, R.C. and Frith, W.J. *J. Chem. Thermodyn.* 13 (1981) 591.
6. Brookes, C.J., Betteley, I.G. and Loxston, S.M. *Mathematics and Statistics*, Wiley, London 1966.

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