Solubility of Carbon Dioxide in 2-Methylpropionic, 2-Methylbutyric, 2-Methylhexanoic, and 2-Methylvaleric Ester Oils

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Carbon dioxide can be considered, at present, the most promising natural refrigerant alternative to synthetic refrigerants, which are characterized by a consistent direct warming impact.

An unsolved technical problem with this refrigerant is the selection of the most suitable lubricant for each application. A good lubricant must simultaneously lubricate the mechanical moving organs and be soluble in the refrigerant, so as to ensure the return of oil to the compressor. Moreover, the presence of oil affects heat exchange, especially in the evaporators. To properly select the lubricant and design the refrigeration system taking into account these problems, a better knowledge of the thermodynamic behavior of the CO_2 + lubricant system, with particular attention to mutual solubility, is then required.

Unfortunately, only few experimental data are available in the literature, and they frequently refer to commercial oils with unknown structure. These data are not sufficient to build thermodynamic models able to predict the behavior of the considered systems. For this reason, some pure ester oils, i.e. pentaerithritol esters of 2-methylpropionic, 2-methylbutyric, 2-methylvaleric, and 2-methylhexanoic acid, were considered as precursors for commercial polyiolester lubricants (POE), and the solubility of CO_2 in these oils was measured at a temperature of 283 K.

The experiments have been performed in an apparatus specifically built for solubility measurements. It consists of a stainless steel equilibrium cell of about 120 ml capacity and is equipped with glass windows for the visual observation of the mixture and for the determination of the liquid phase level inside the cell. The equilibrium cell is equipped with a magnetic stirrer, which forces the vapor through the liquid phase, with a controlled speed of rotation. The total internal free volume of the cell was carefully calibrated to within ± 0.1 ml. The cell is maintained at constant temperature by a water thermostatic bath. The estimated accuracy of these kinds of measurements are ± 0.02 K for temperature, ± 2 kPa for pressure, and ± 0.005 for the liquid phase mass fraction.