Study of Different Refrigeration Cycles with CO_2 + Carrier-Fluid Mixtures using a Multi-Fluid Mixture Model and COSMO-SAC

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Due to new EU regulations [1] and climate considerations, there is a need for refrigerants with lower global warming potentials (GWP) than the commonly used fluorinated refrigerants. While the EU regulation applies to all refrigeration processes above -50 °C, an exception is made for processes below this temperature, which is due to the lack of alternatives to the refrigerant R23 (GWP = 14800). The usage of CO_2 (GWP = 1) as refrigerant could be an alternative for refrigeration processes below -50 °C. However, when expanding CO_2 below the triple point temperature of approximately -56.56 °C, dry ice forms. This could lead to some problems like unstable flow conditions, blockages, and low heat transfer. In order to avoid the mentioned problems, a carrier fluid could be introduced to the refrigeration cycle. Determining suitable carrier fluids requires thermodynamic calculations of a proposed refrigeration cycle with different CO_2 + carrier-fluid mixtures. In this work, various theoretical refrigeration cycles with different CO_2 + carrier-fluid combinations have been calculated. For all calculations, the thermophysical property software TREND 3.0 [2] has been used which allows for calculations of phase equilibria of mixtures in which solid CO_2 [3] forms. Furthermore, in the cases where no models for the binary mixture of certain carrier-fluids and CO_2 are available, a new predictive mixture model was used (see talk "*A theoretically based departure function for multi-fluid models*" by our group) which was combined with the g^E model COSMO-SAC [4].

References:

[1] EU regulation Nr. 517/2014 for fluorinated greenhouse gases.
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[4] S.-T. Lin, S. I. Sandler, Ind. Eng. Chem. Res. 41 (2002) 899.