# PERFORMANCE ANALYSIS OF A SINGLE-EFFECT ABSORPTION COOLING CYCLE WITH 2,2,2-TRIFLUOROETHANOL + 1-ETHYL-3-METHYLIMIDAZOLIUM TETRAFLUOROBORATE SYSTEM

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**Introduction:** Ionic Liquids (ILs) have been introduced as new absorbents to overcome the problems of thermal instability, high volatility and low system performance that the organic working fluids show in absorption cooling systems [1]. The special properties of ILs, as powerful solvent and non-volatility due to its low vapour pressure make then very interesting absorbents in absorption heat pumps and refrigeration systems. In absorption cooling cycles several physical processes occur, such as the absorption of refrigerant vapour by the solution rich in absorbent in the absorber and the regeneration of the solution rich in refrigerant at the generator. The performance and operating conditions of the cycle depends basically on the thermodynamic properties of the working fluid mixture. For this reason, accurate thermodynamic properties of pure and mixture fluids are necessary for suitable design and optimization of the absorption cooling systems.

In this paper, we analysed the thermodynamic performance of a single-effect absorption cooling cycle using: 2,2,2-trifluoroethanol (TFE) + 1-ethyl-3-methylimidazolium tetrafluoroborate ([emim][BF4]) working fluid pair, where [emim][BF4] is the absorber and TFE as a refrigerant.

**Simulation:** A thermodynamic model of the steady-state operation of the cycle has been developed and a sensitivity analysis has been done to show how the steady-state performance of the cycle is affected by changes in the design parameters or operating conditions. Fig. 1 illustrates the cycle configuration. The model is based on the thermodynamic properties of the working pair and on the mass and energy balances of each component in the system. The output of the model includes the heat loads in the absorber, condenser, evaporator and generator as well as the temperature, pressure, concentration and mass flow rate in each stream in the absorption cycle. The performance of the system is analysed using parameters useful for evaluating working fluid pairs such as coefficient of performance (COP), exergy efficiency (ECOP), solution circulation ratio (*f*) and the minimum heat source temperature ($T_{g,\ min}$) necessary for firing the system. Vapour-liquid equilibria and liquid enthalpies for the mixture have been modelled with the NRTL equation from experimental data [1- 4]. Results of the simulation have been compared with the conventional working pairs ($H_2O$ + LiBr, $NH_3$ + $H_2O$) and organic working pair (TFE + TEGDME) used in absorption cooling cycles.

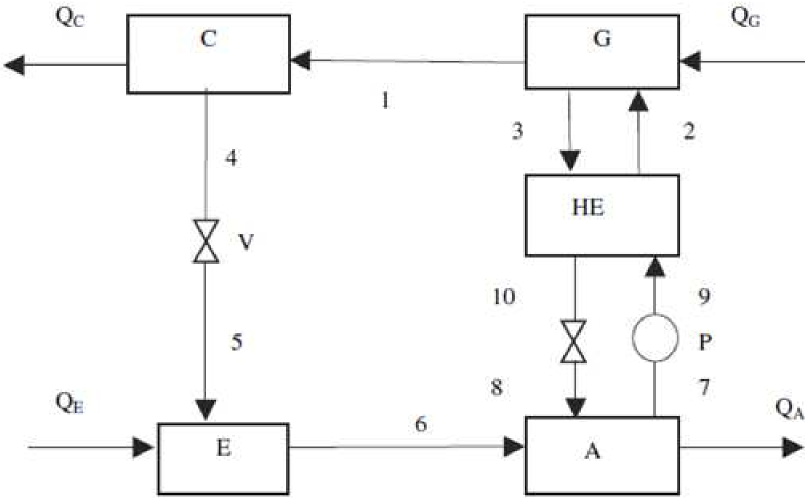


**Figure 1.** Schematic diagram of the single-effect absorption cycle.

Results and discussion: From the simulation results the effect of the generator temperature ($T_{gen}$) on the COP of the cycle using the new working fluid pair, TFE + [emim][BF4], is shown in Fig. 2. From Fig.2, it can be seen that the COP of the system using TFE + [emim][BF4] is slightly lower than $H_2O$ + LiBr about the generator temperature of 90-100$^0$C, typical single-effect absorption cycle firing temperature, for the condenser (and absorber) temperature of 35$^0$C and 5$^0$C evaporator temperature. Therefore, one can get a wider solution field (operating range) and a COP closer to $H_2O$ + LiBr with minor corrosion problems and a relatively higher operating pressure that prevents problems related with the high vacuum in conventional $H_2O$ + LiBchillers.

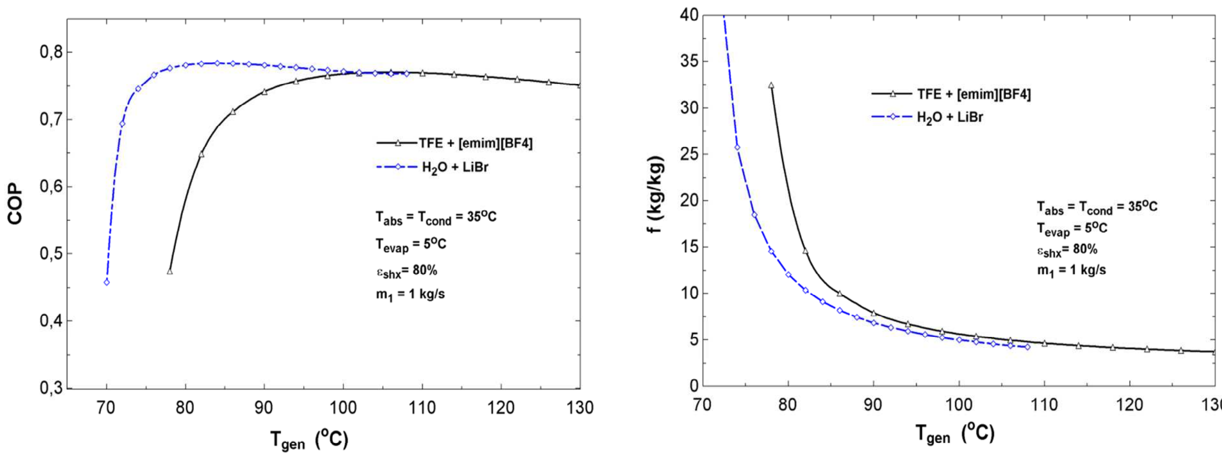


**Figure 2.** Effect of generator temperature on COP and solution circulation ratio (*f*).

**Conclusion:**

- The working fluid pair containing IL (TFE + [emim][BF4]) shows a COP comparable to $H_2O$ + LiBr system, higher than 0.7 for typical operating conditions of single-effect absorption chillers. Therefore, with a reasonable cycle performance it can solve the crystallization, corrosion and very low system pressure problems associated with $H_2O$ + LiBr system.

- The absorption cycle performance with the new working pair (TFE + [emim][BF4]) can be improved by including additional internal heat integration (subcooler) through the subcooling of the refrigerant condensate entering the evaporator, which is not possible in $H_2O$ + LiBr system due to very low system pressure.
- The cooling effect per unit mass of refrigerant for $H_2O$ + LiBr system is 2363kW, which is six times larger than TFE + [emim][BF4] system for $T_{evap} = 5\,^{o}C$, $T_{abs} = T_{cond} = 35^{o}C$. Therefore, under the same cooling output effect the amount of refrigerant (TFE) circulate in the system is much larger in TFE + [emim][BF4] than $H_2O$ + LiBr system.

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