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► **To cite this version:**

Cesari Laetitia, Dominique Alonso, Fabrice Mutelet. Experimental and Computational Investigation on the Glyceline – CO₂ Working Fluid in Absorption Chiller. 8th International Congress on Ionic Liquids, May 2019, Pekin, China. hal-03480333

HAL Id: hal-03480333

<https://hal.univ-lorraine.fr/hal-03480333v1>

Submitted on 4 Apr 2023

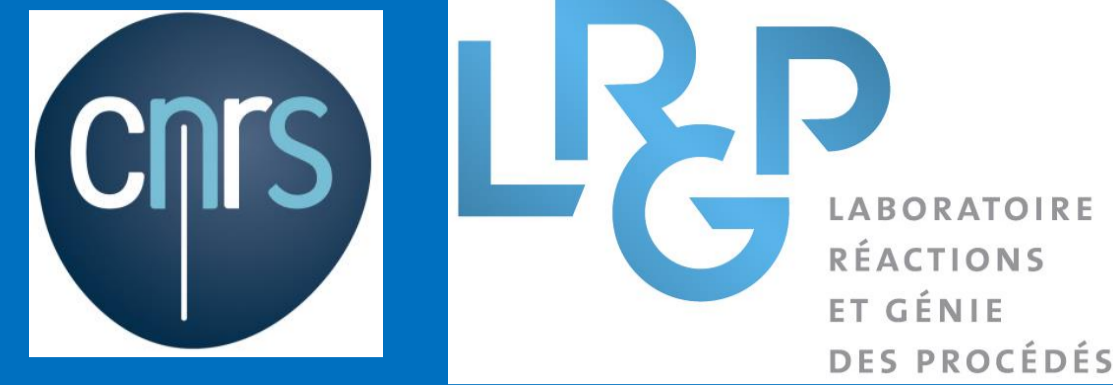
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Experimental and Computational Investigation on the Glyceline – CO₂ Working Fluid in Absorption Chiller



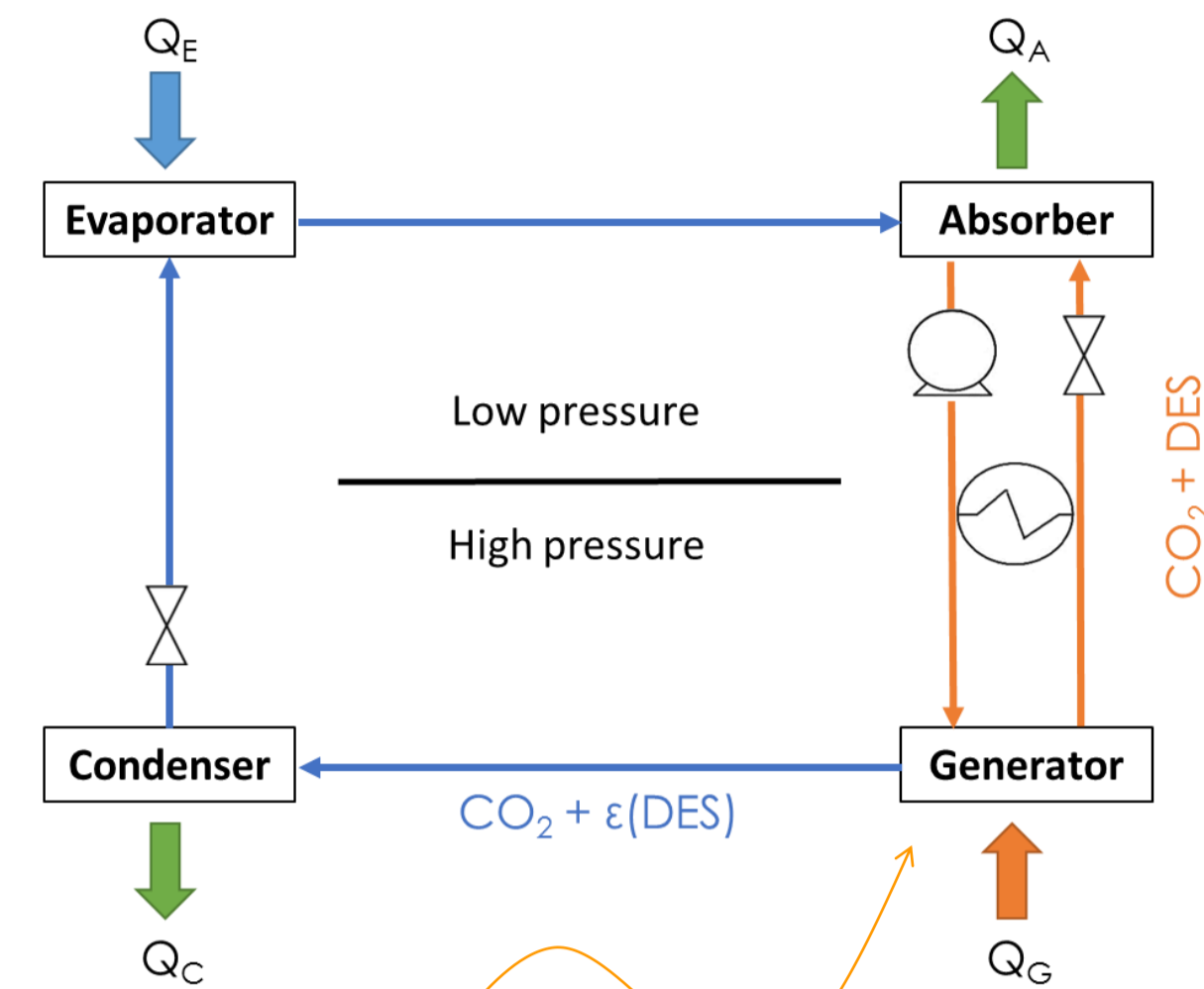
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Introduction

Absorption chiller
 Double thermodynamic cycle
Absorbent and **refrigerant**
 Cooling process by using wasted heats
 Low electric consumption

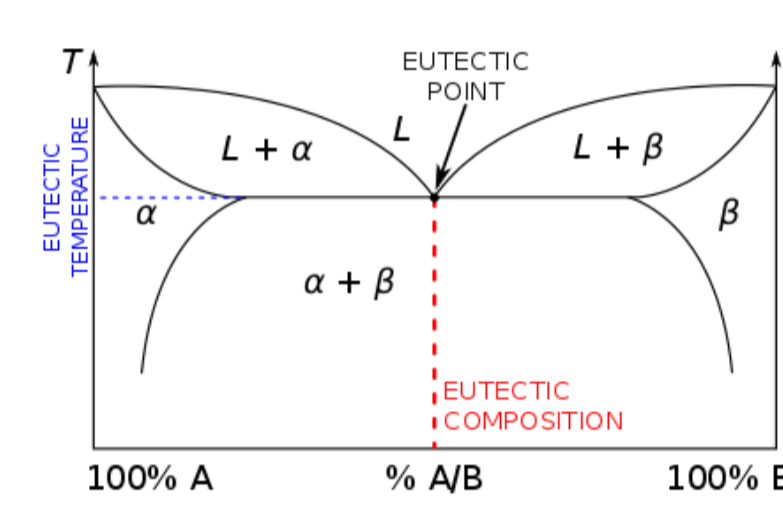
Usual working mixtures :
 {H₂O + LiBr} or {H₂O + NH₃}
 Effective **BUT** problems of corrosion,
 crystallization and toxicity



Idea: use of deep eutectic solvent as absorbent

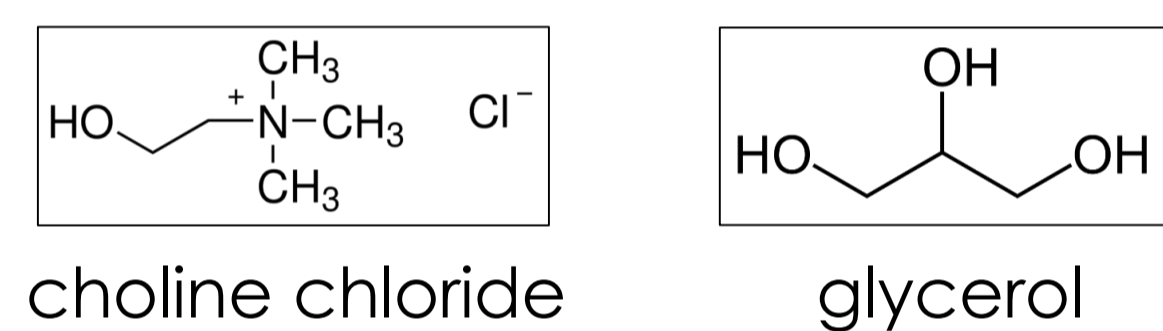
Deep Eutectic Solvent (DES)
 Mixing of compounds at the eutectic composition

Properties of DES:
 Low vapor pressure
 High thermal and chemical stability
 Cheaper than ionic liquids



Our working mixture: Glyceline + CO₂

Glyceline : 1 choline chloride + 2 glycerol



Simulation

Peng - Robinson equation of state

$$P = \frac{RT}{v-b} - \frac{a}{v(v+b)+b(v-b)}$$

With :

$$R = 8.314472 \text{ J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$$

$$b_i = \Omega_b \frac{RT_{c,i}}{P_{c,i}}$$

$$\Omega_b = 0.0777960739$$

$$a_i = \Omega_a \frac{R^2 T_{c,i}^2}{P_{c,i}} \left[1 + m_i \left(1 - \sqrt{\frac{T}{T_{c,i}}} \right) \right]^2$$

$$\Omega_a = 0.457235529$$

Mixing rules of **Van der Waals**

$$a = \sum_{i=1}^n \sum_{j=1}^n z_i z_j \sqrt{a_i a_j} (1 - k_{ij}(T))$$

$$b = \sum_{i=1}^n x_i b_i$$

Critical properties of DES components estimated using the **Lydersen-Joback-Reid** method

$$T_b = 198.2 + \sum n_i \Delta T_{bMi}$$

$$V_c = 6.75 + \sum n_i \Delta V_{Mi}$$

$$T_c = \frac{T_b}{0.5703 + 1.0121 \sum n_i \Delta T_{Mi} - (\sum n_i T_{Mi})^2}$$

$$P_c = \frac{M}{(0.2573 + \sum n_i \Delta P_{Mi})^2}$$

DES properties using the mixing rules of **Lee-Kesler**

$$T_{cDES} = \frac{1}{V_{cDES}^{0.25}} \sum_i \sum_j y_i y_j V_{cij}^{0.25} T_{cij}$$

$$T_{cij} = (T_{ci} T_{cj})^{0.25} k'_{ij}$$

$$V_{cDES} = \sum_i \sum_j y_i y_j V_{cij}$$

$$V_{cij} = \frac{1}{8} \left(V_{ci}^{\frac{1}{3}} + V_{cj}^{\frac{1}{3}} \right)^3$$

$$P_{cDES} = (0.2905 - 0.085 \omega_D) \frac{RT_{cDES}}{V_{cDES}}$$

$$\omega_D = \sum_i y_i \omega_i$$

Coefficient of performance

$$COP = \frac{Q_E}{Q_G + W}$$

Experimental measurements

Density



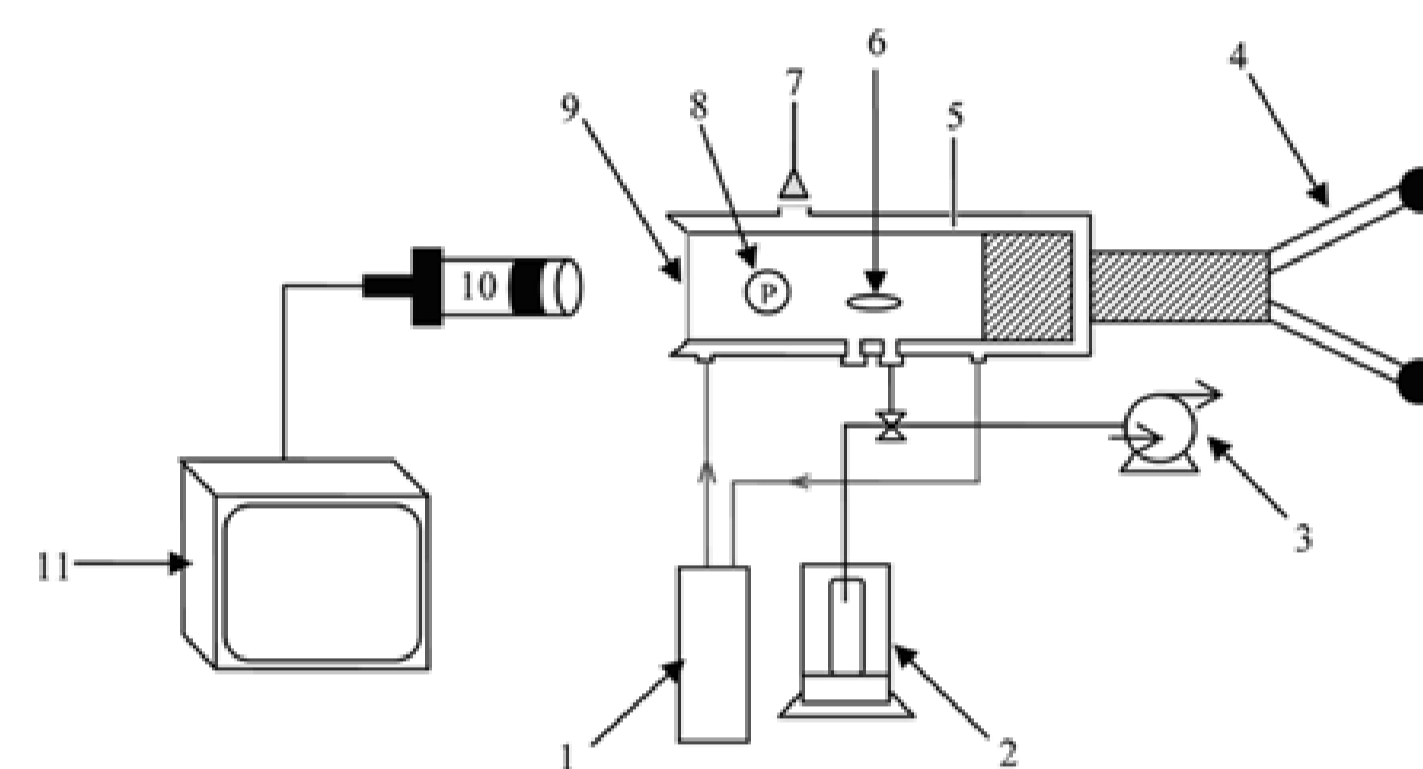
Anton Paar DMA 4500 density meter
 Principle based on electromagnetically induced oscillations of a U-shaped glass tube
 Temperature range : 293.15 – 313.15 K

Heat Capacity



C80 calorimeter
 Comparison of the heat flow signal between the reference and the sample cells
 Temperature range : 310.15 – 370.15 K

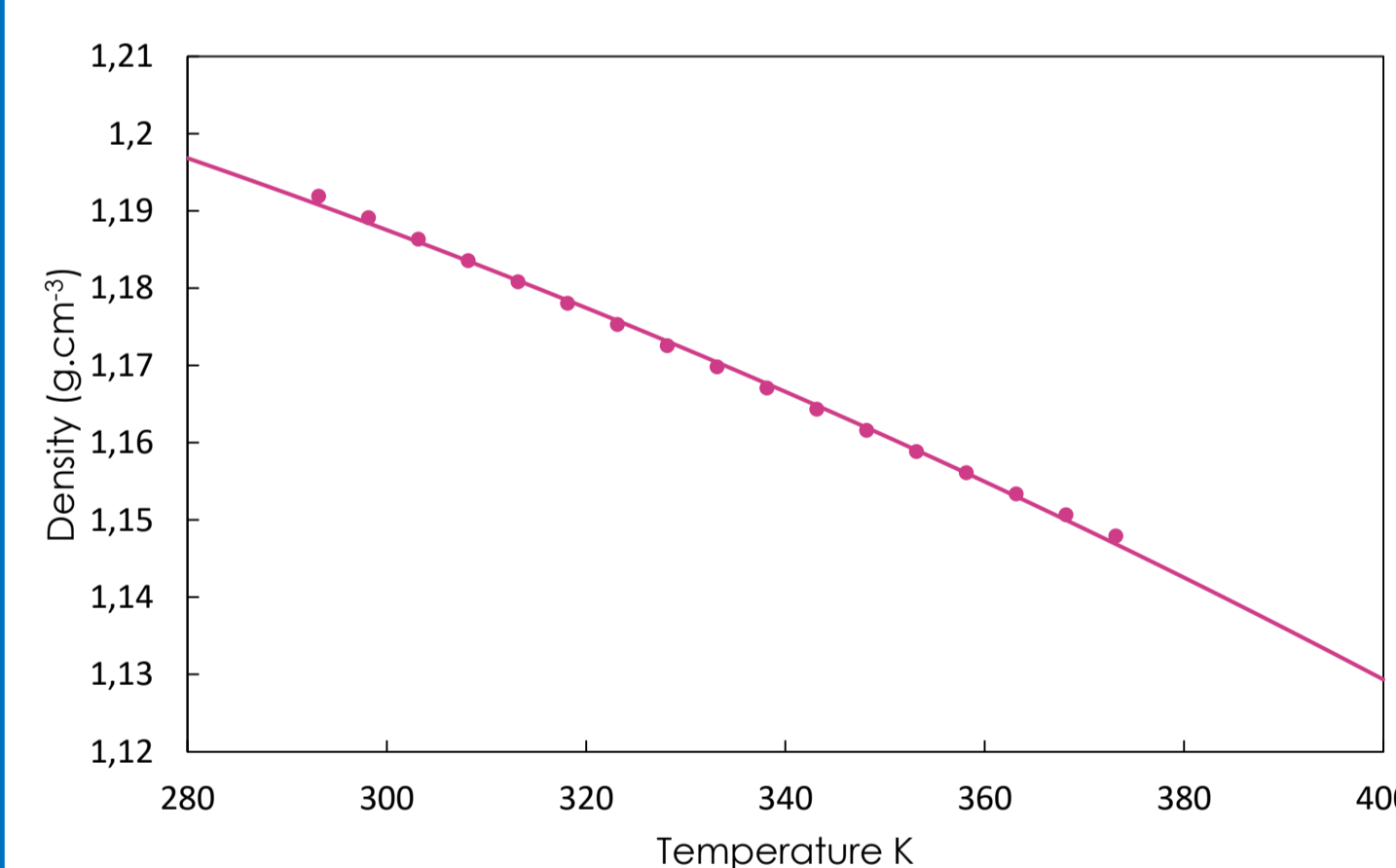
Vapor - Liquid Equilibria



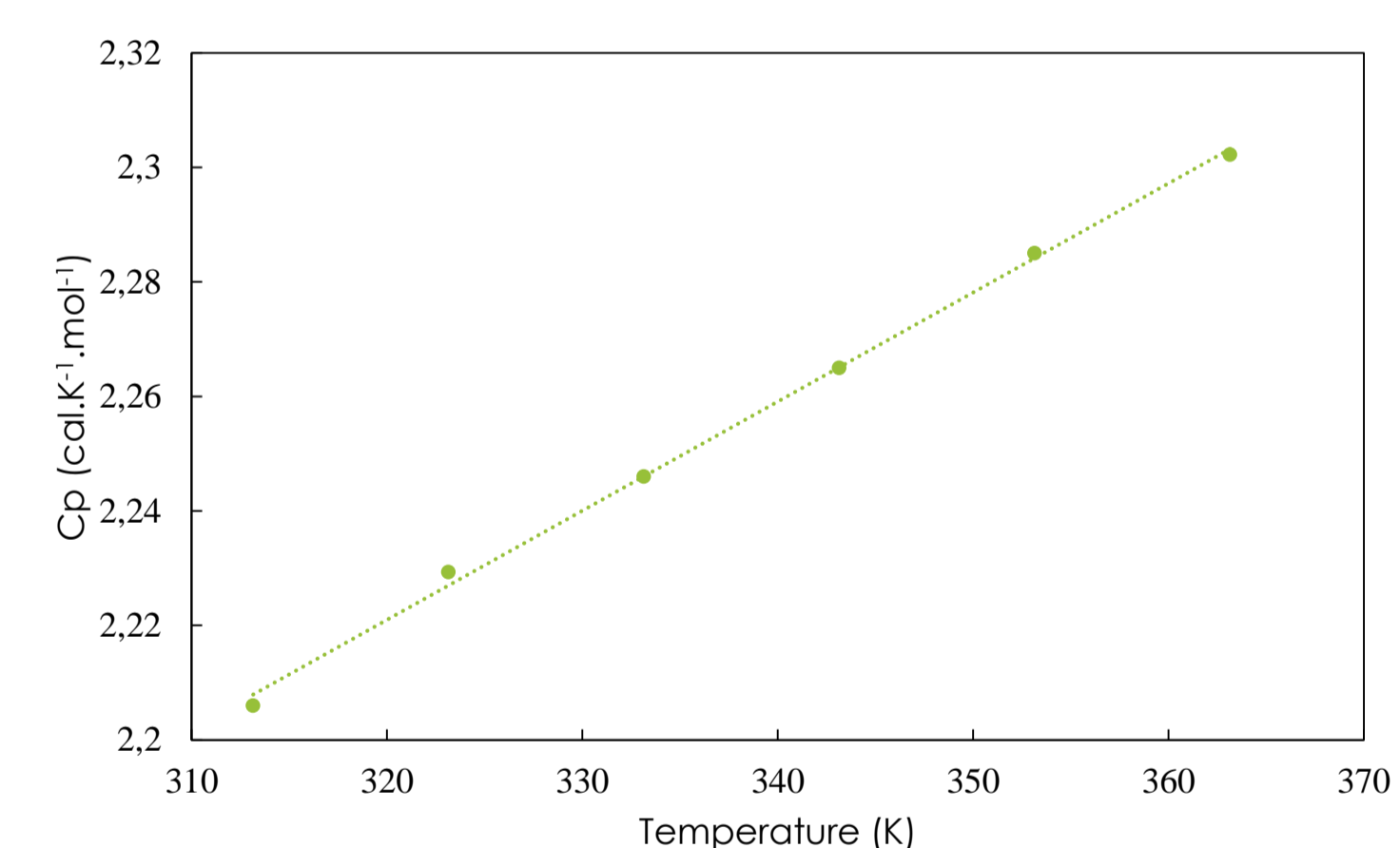
Schema of the VLE apparatus. 1, thermostatic bath; 2, analytical balance; 3, vacuum pump; 4, piston; 5, temperature probe (Pt100); 6, magnetic stirrer; 7, light source; 8, calibrated pressure sensor (0 < P < 340 bar); 9, sapphire window; 10, video camera; 11, monitor.

Results

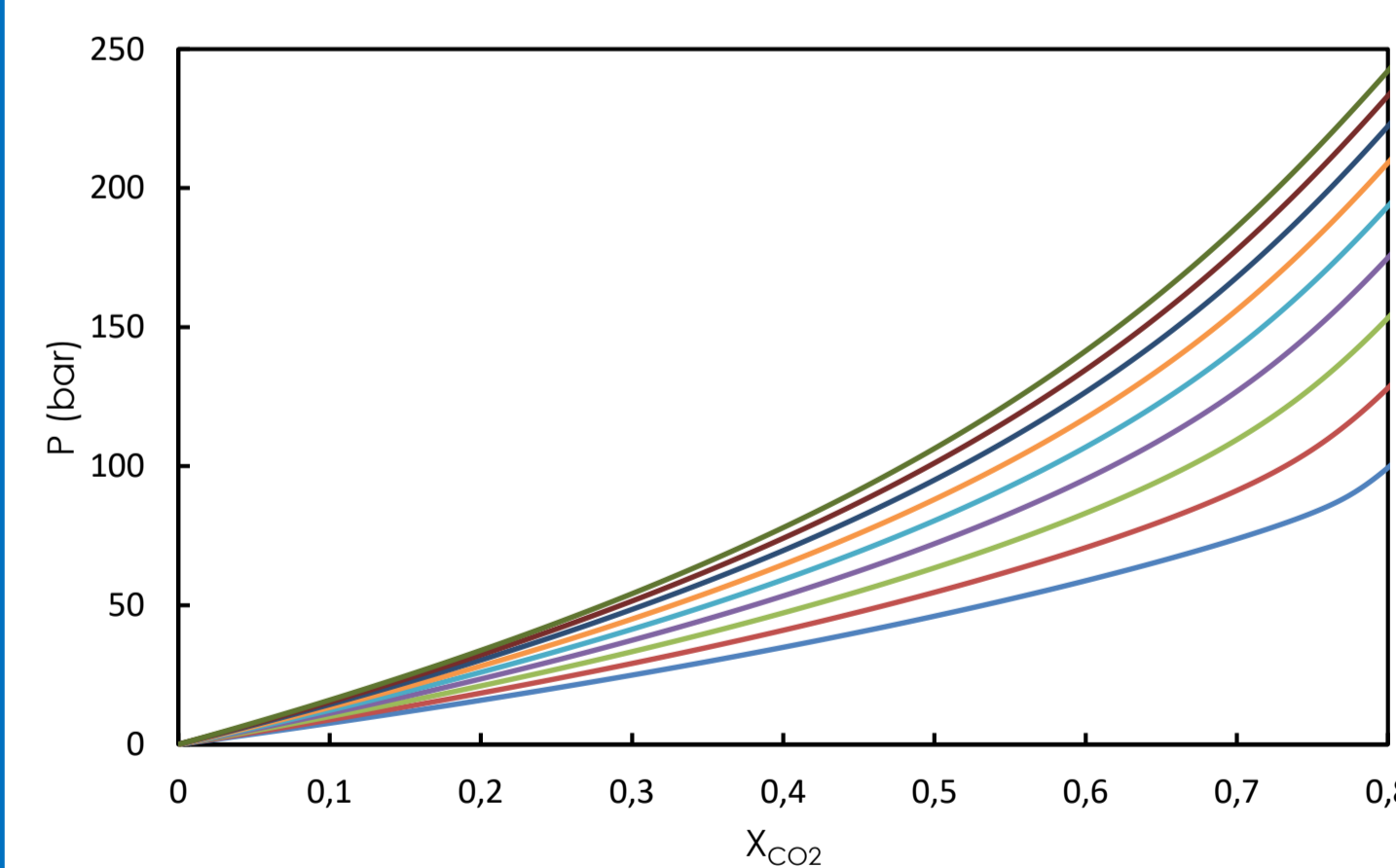
Density



Heat Capacity

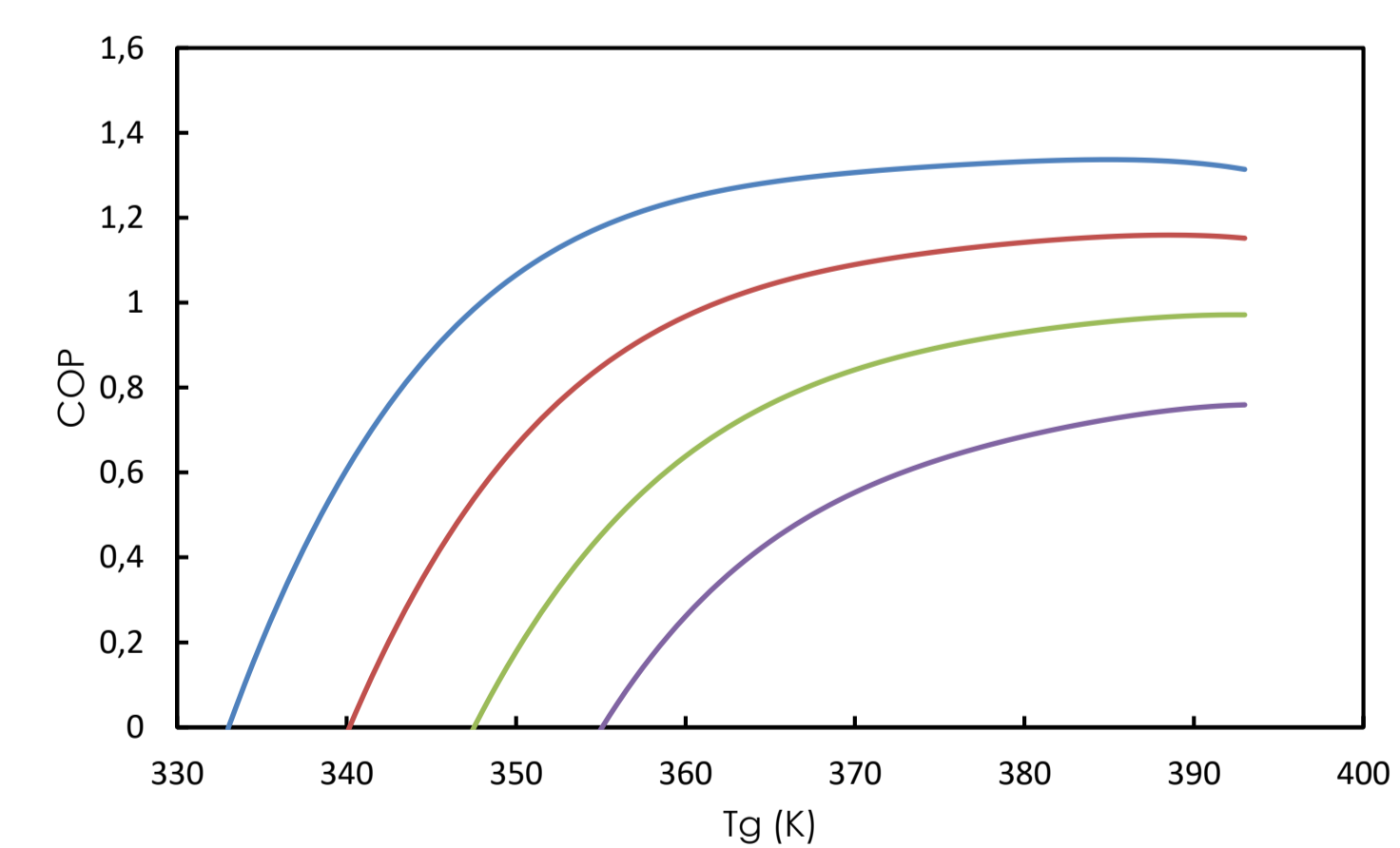


Vapor - Liquid Equilibria



Vapor-liquid equilibria of the {glyceline + CO₂} binary system: — 313.15K, — 323.15K, — 333.15K, — 343.15K, — 353.15K, — 363.15K, — 373.15K, — 383.15K, — 393.15K.

Coefficient Of Performance



Coefficient of performance as a function of the temperature of the generator for different pressures at the generator/condenser:
 — 55 bar (T_c = 291.4 K) — 60 bar (T_c = 295.15 K)
 — 65 bar (T_c = 298.61 K) — 70 bar (T_c = 301.9 K)
 Others operating conditions:
 P_{low} = 40 bar, T_e = 278.15K, T_a = 313.15K.

Conclusion

Experimental measurements of {CO₂ + glyceline} binary system were performed in order to evaluate its possible use as a working fluid in a **single-effect absorption chiller**.

In this work, the values of the COP easily higher than 0.7 strengthen the idea that deep eutectic solvent could be a **new alternative** for working mixture in absorption chiller.

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We would like to acknowledge support from CNRS (France) and TOTAL through the PEPS project

