Visual investigation of solid-liquid phase equilibria for non-flammable mixed refrigerant

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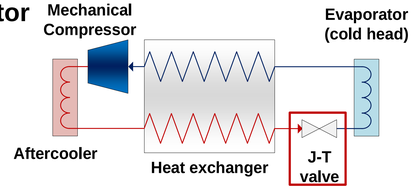
Introduction

Solid Liquid Equilibria (SLE) for Mixed refrigerant (MR) Joule-Thomson (J-T) refrigerator

- ✓Design of MR J-T refrigerator for high efficiency
- ✓Usage of high volatile refrigerant (Relatively high triple point temperature)
- ✓Clogging at the J-T expansion part due to freezing

Need Prevent clogging, Stable operation of non-flammable MR J-T refrigerator
SLE measurement for cryogenic, multi-component MR especially for Ar, R14 and R218

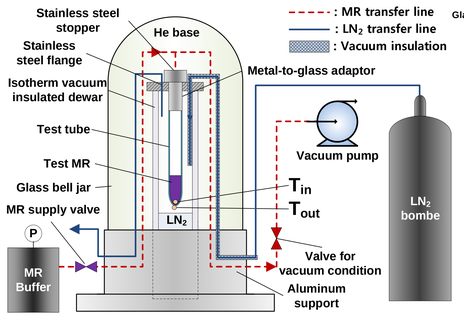


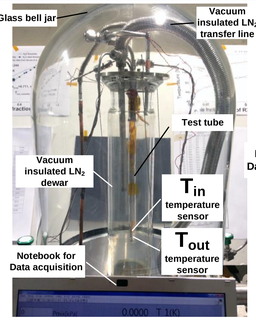
Component	Ar	R14	R218
Triple point temperature [K]	83.8	89.5	125.5

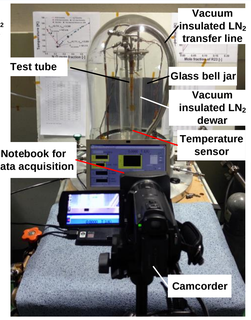
Need Freezing point depression?
The lowest temperature of fluid?

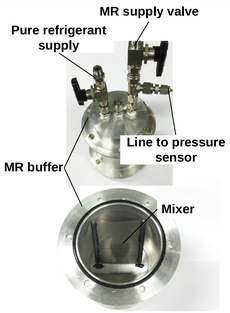
Research objective ✓**SLE measurement of MR for cryogenic MR J-T refrigerator especially for ternary MR of Ar, R14 and R218**

Experimental apparatus and methodology



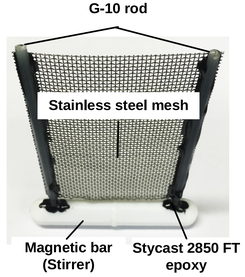




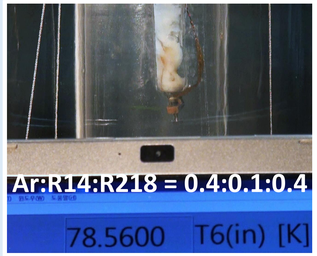


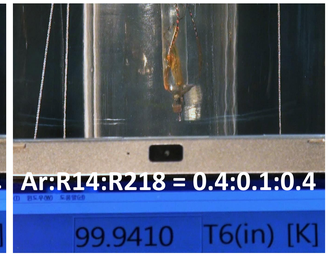
Experimental procedure

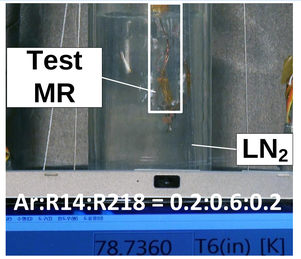
- ➡ Evacuate the MR test tube and buffer until 6 x10^{-4} kPa (5 mTorr) by vacuum pump.
- ➡ Close MR supply valve and prepare the target MR with the required molar composition.
- ➡ Blend the target MR in the MR buffer with mixer.
- ➡ Feed LN_2 in the LN_2 container.
- ➡ Stop feeding LN_2 if the level of LN_2 is reached to the sufficient height.
- ➡ Record the temperature of the whole solidified MR until melts completely.
- ➡ Perform the same experiment to achieve the reliability of experimental results (2-3 times).

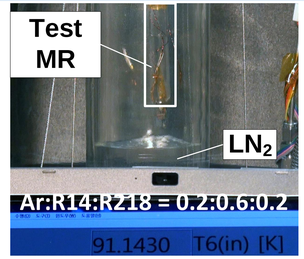


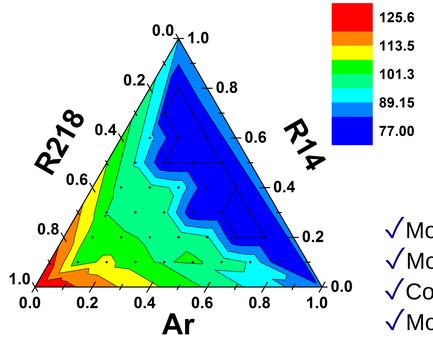
Experimental results and discussion

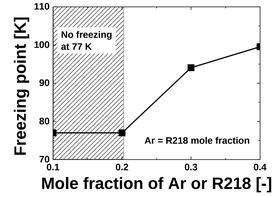


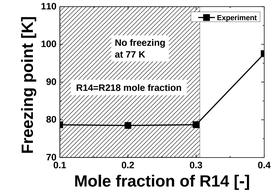












- ✓Mole fraction of R14 > 0.4 ➡ Lower than 77 K freezing point
- ✓Mole fraction of R218 > 0.4 ➡ Higher than 100 K freezing point
- ✓Contribution of Ar for freezing ➡ Almost negligible (near 1 ~ 2 K)
- ✓Molar ratio of R14/R218 > 2 ➡ Lower than 77 K freezing point

Conclusion

- ✓ The freezing point depression of ternary MR, which contain Ar, R14, and R218, were investigated by the visualized apparatus.
- ✓ The molar ratio between R14 and R218 is a key parameter to drop the freezing temperature.
- ✓ If the molar ratio of R14 and R218 is higher than 2, the freezing state of MR does not appear even at 77 K (LN_2 environment).

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