# Characterization of barocaloric effect materials for solid state refrigeration

## INTRODUCTION

Refrigeration is of paramount importance to modern societies whether for air conditioning or food storage. It accounts for a significant portion of the world's energy consumption, primarily through vapor compression cycle technologies. These conventional systems use hydrofluorocarbons (HFCs), a controversial family of chemicals whose greenhouse effect is 1000 times greater than that of CO2.

Barocaloric effect materials can replace HFCs in solid-state refrigeration systems. These technologies take advantage of the thermal effects during a reversible solid-state phase transition induced by pressure changes. Active research is underway, because to produce the necessary cooling effect, currently available materials still require a high pressure change (1000 to 2000 bar), i.e. a high energy input.

High pressure calorimetry is an ideal tool to characterize new candidate materials for such applications, as it measures the thermal effect related to phase transitions at constant temperature under changing pressures, or under isobaric temperature scanning conditions.

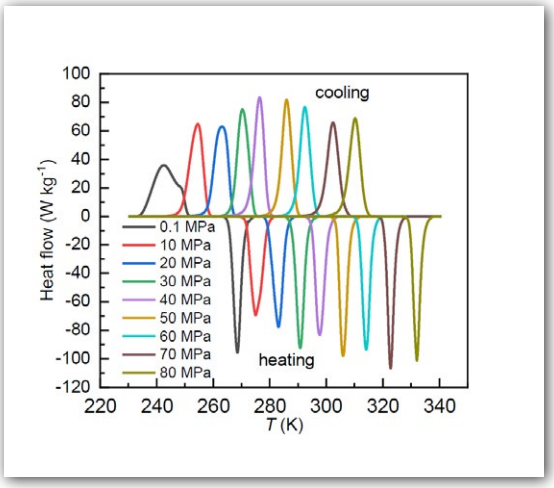


***Figure 1 – Reversible first order phase transitions of NH4I during heating and cooling at various pressures.***

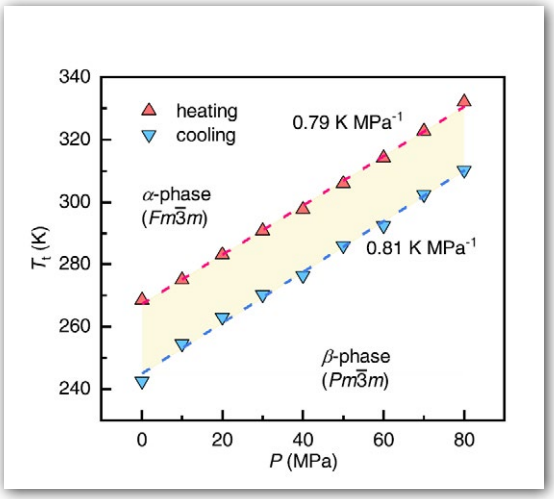


***Figure 2 – Corresponding phase diagram, plotting the onset temperatures of transitions measured vs. test pressure.***

## EXPERIMENT

- Instrument: MICROCALVET with 1000 bar cells and gas panel
- Sample: ammonium iodide (NH4I), 20mg
- Atmosphere: argon at constant pressure of 1, 100, 200, 300, 400, 500, 600, 700 and 800 bar
- Temperature profile:

1. Heating from -40 to 70°C at 1°C/min
2. Cooling from 70°C to -40°C at 1°C/min

## RESULTS AND CONCLUSION

The reversible solid-solid transition of NH4I was detected during each heating and cooling phases. The effect of pressure has also clearly been observed, with a shift from 270K at 0.1MPa to 330K at 80MPa as far as heating is concerned. A phase diagram could be plotted from these data, showing that the phase transitions could be triggered by a pressure change. Extra experiments (not shown) under isothermal conditions and pressure scanning from 50 to 90 MPa confirmed this.

*Reference : Ren, Q., Qi, J., Yu, D. et al. Ultrasensitive barocaloric material for room-temperature solid-state refrigeration. Nat Commun 13, 2293 (2022).*

## INSTRUMENT

**MICROCALVET**

***-45°C to 120°C***


HIGHEST HEAT MEASUREMENT ACCURACY
3D sensor based on Peltier elements with Joule effect calibration.

MODIFIABLE TEMPERATURE CONDITIONS
for increased flexibility and replication of real life conditions.

CONVENIENT INTERCHANGEABLE CRUCIBLES AND CELLS
to perform even the most demanding experiments using one instrument :
- high pressure (1000bar) and high vacuum
- pressure measurement and control
- mixing experiment

EXTERNAL COUPLING CAPABILITY
designed to increase your research options including manometry, BET instrumentation, gas analyzers, humidity controllers and gas panels