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Using Scanning Transitiometry to Investigate the Thermal and Mechanical Changes for Energy Storage

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European Materials Research Society,

Central Campus - Warsaw University of Technology

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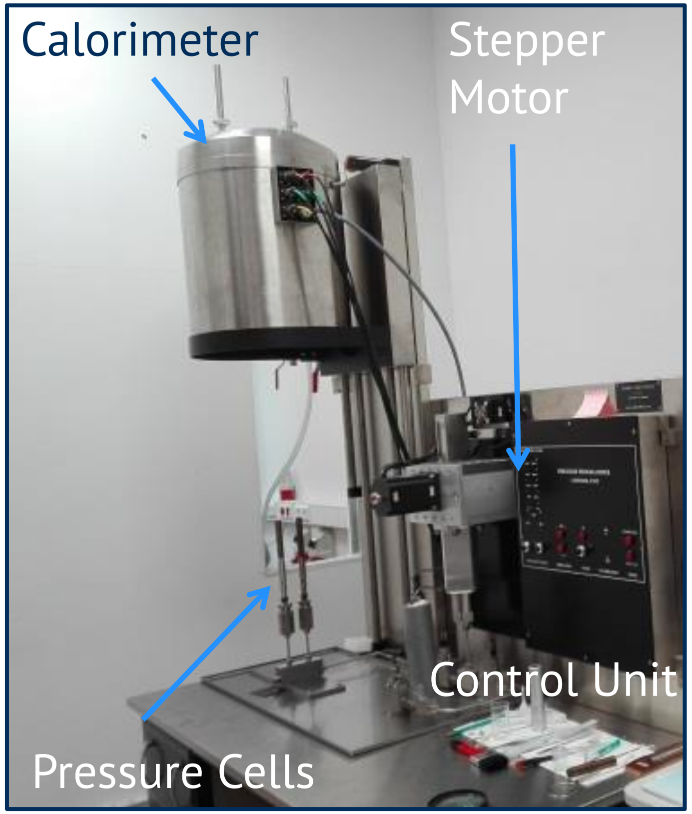
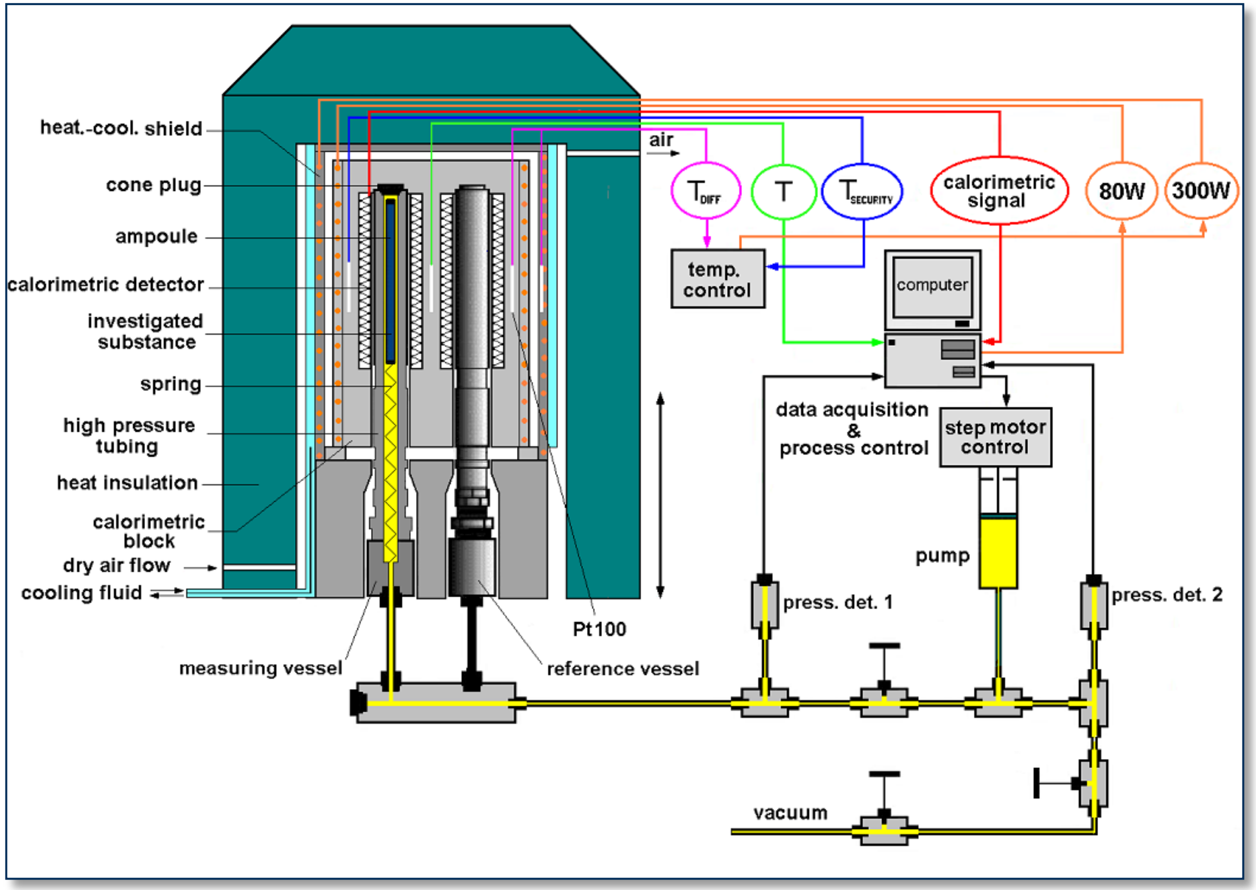
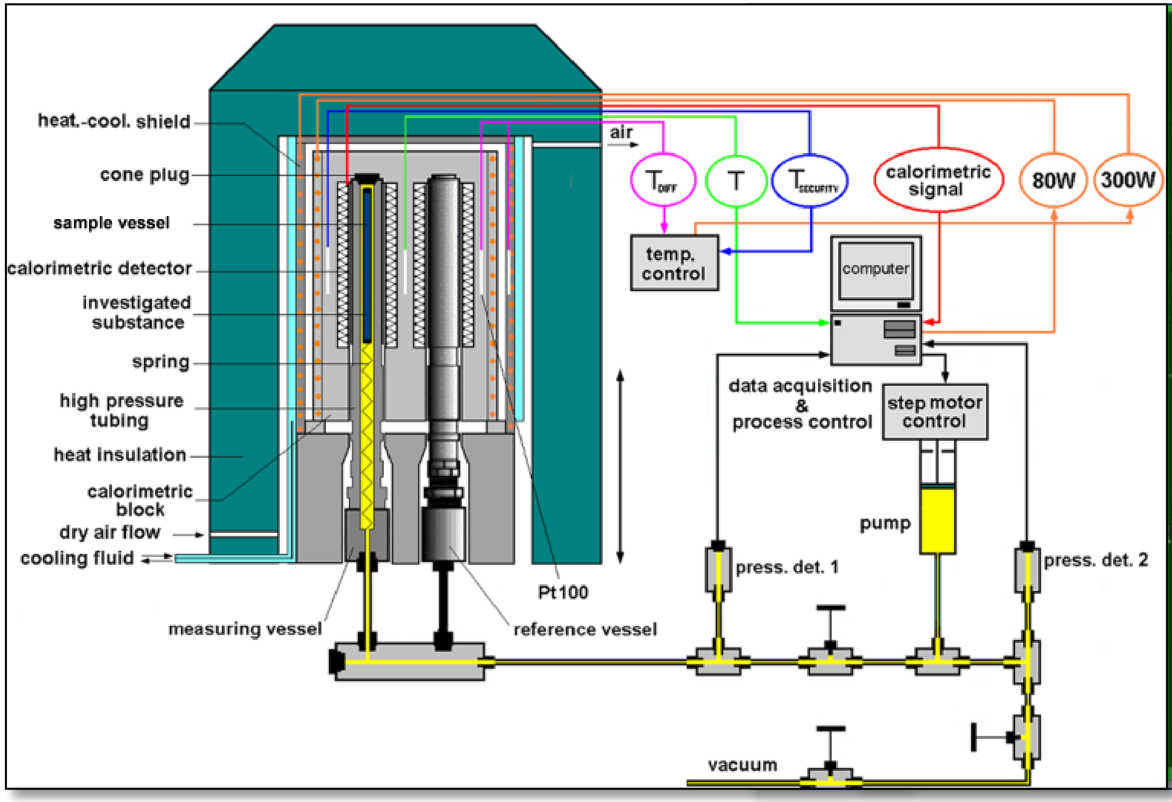
PVT-Calorimetry / Transitiometry

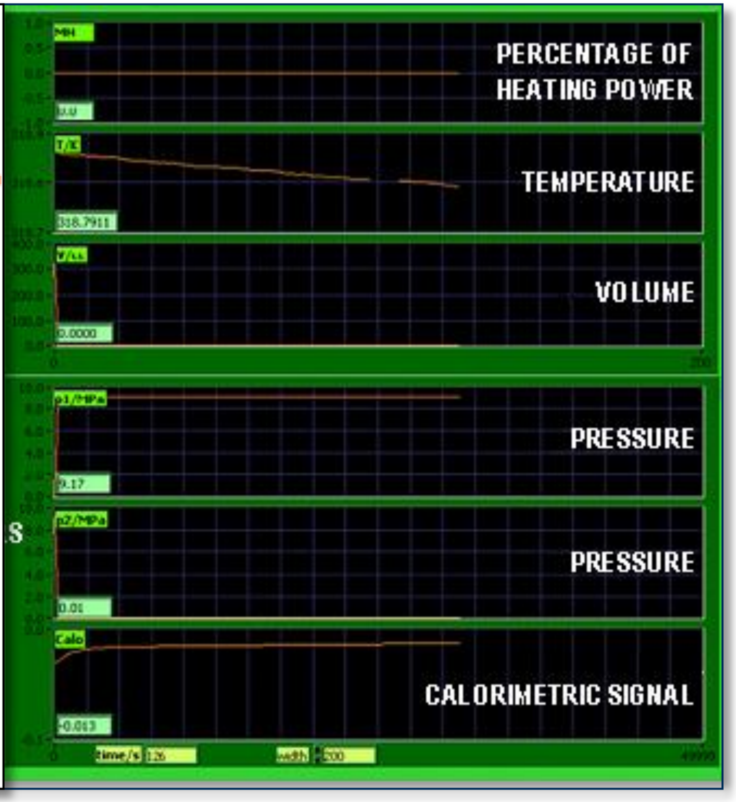




BRG TECH ST (Warsaw/Poland)
Chorążewski , Grolier, Randzio., J. Chem. Eng. Data 2010, 55, 5489−5496

Data Collection and Control Variables





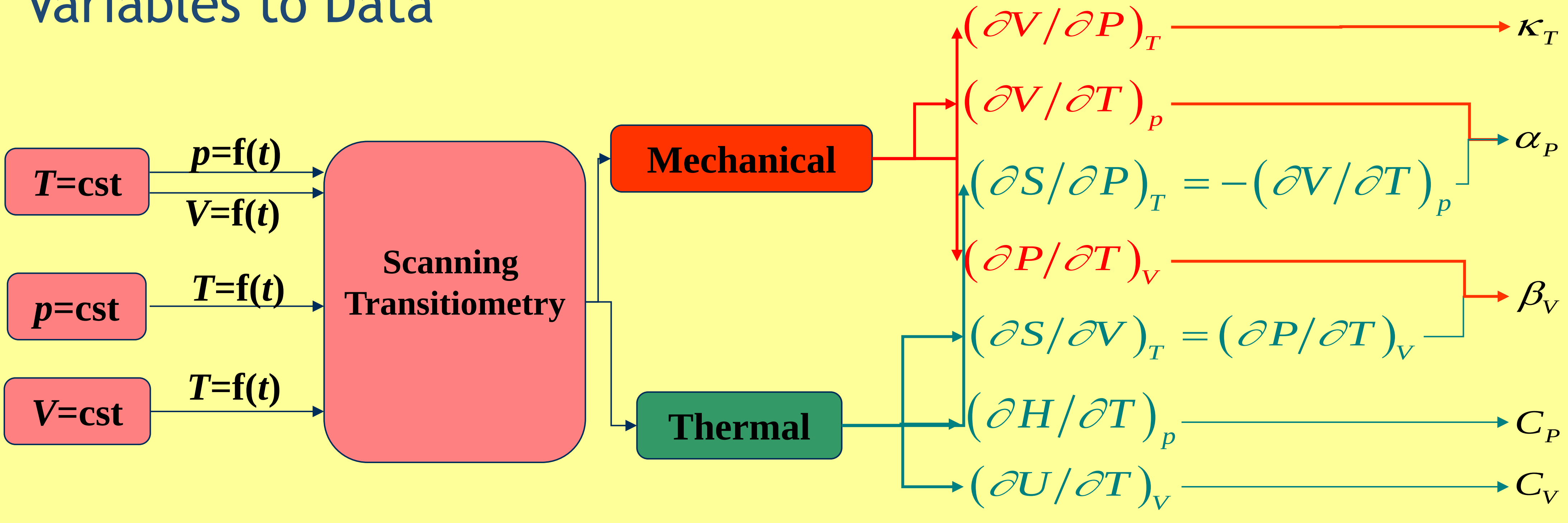
$dT/dt = K \cdot s^{-1}$

$dP/dt = MPa \cdot s^{-1}$

$dV/dt = cm^3 \cdot s^{-1}$

Heat Flux = *Volts* represents the heat flow difference into each cell

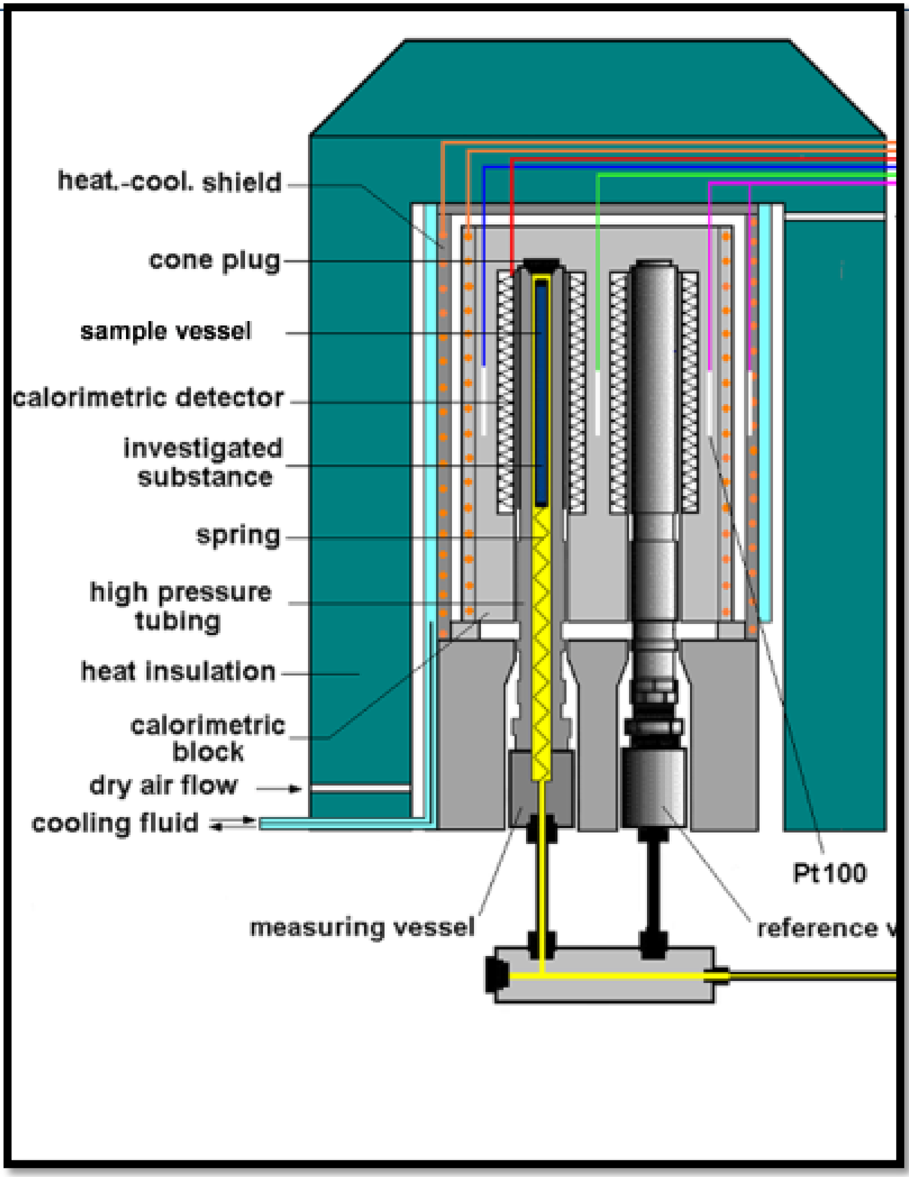
Variables to Data



Randzio S.L., Grolier J-P.E. and Chorążewski M., "*High-Pressure Maxwell Relations Measurements*". in "*Volume Properties: Liquids, Solutions and Vapours*", **Royal Society of Chemistry**, **2014**, 414-438, **Cambridge, UK**, ,
ISBN: 978-1-84973-899-6.
DOI: 10.1039/9781782627043-00414.

Differential Experiments
Unbalanced Cell

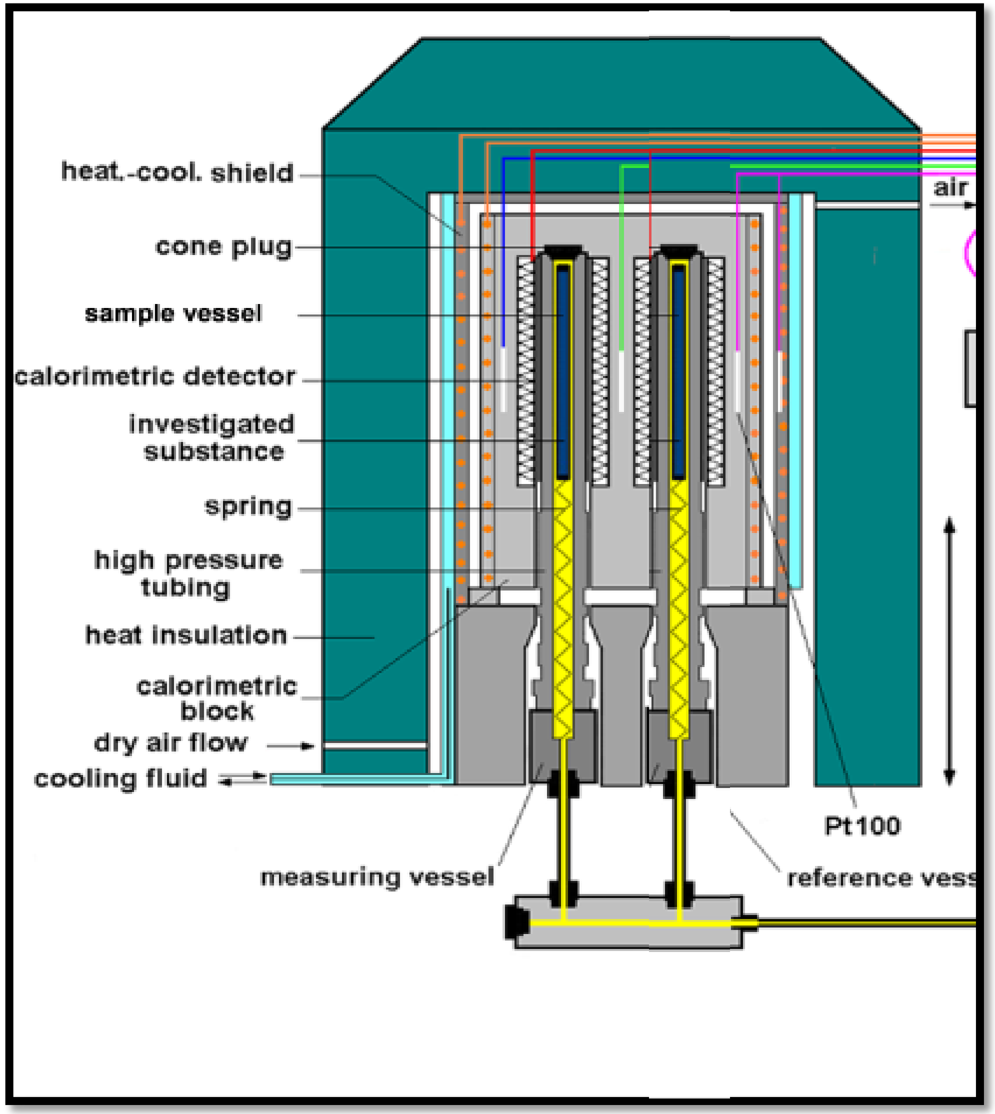
- **Sample Cell is Active** with respect to change in temperature.
- **Reference Cell** is **inactive** with respect to **changes in pressure**.



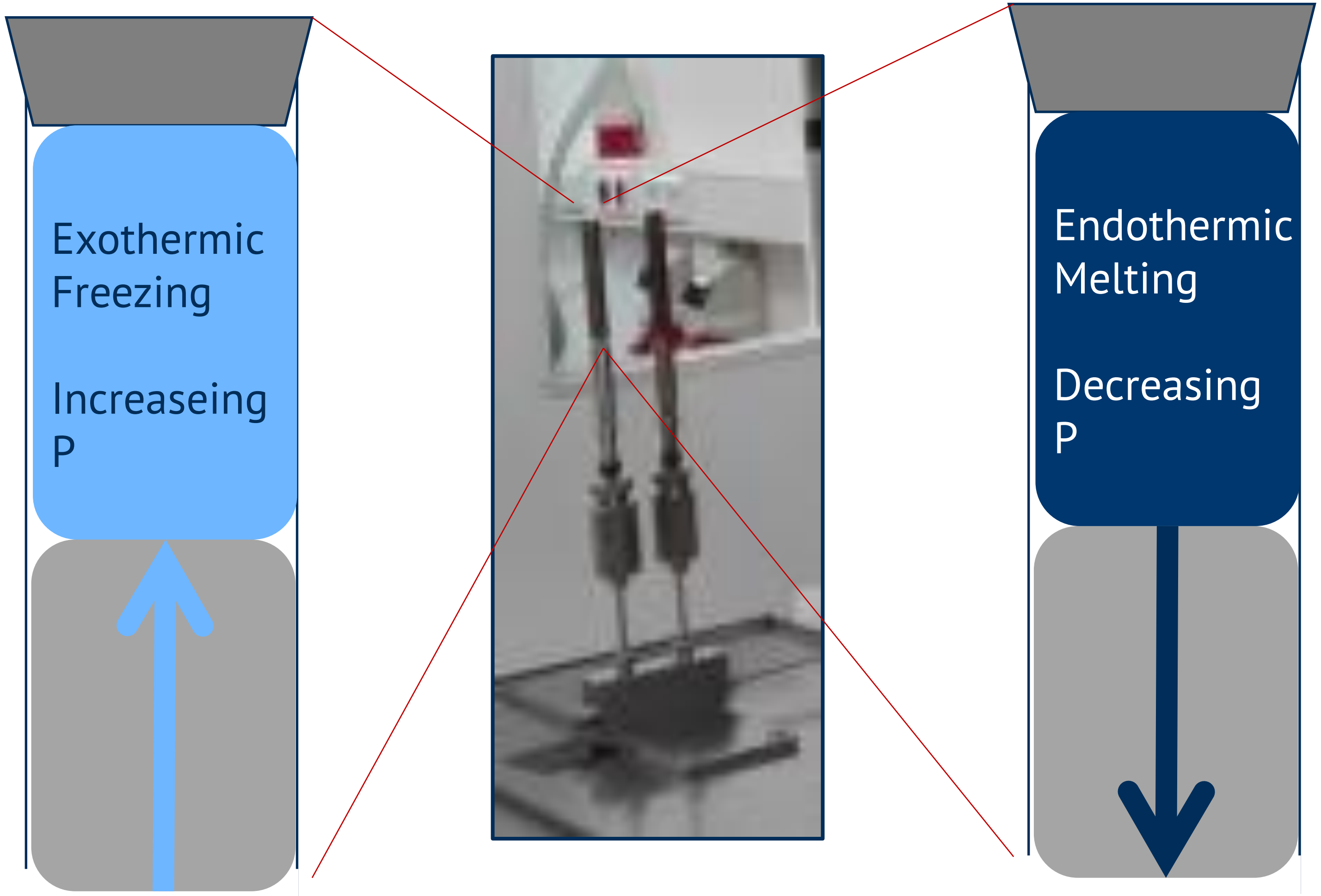
Differential Experiments
Balanced Cell

Both **Sample** and **Reference Cells** are **acted upon simultaneously to both changes in pressure and changes in temperature**

- This allow to directly compare the thermal effect between the compression medium and material of interest.

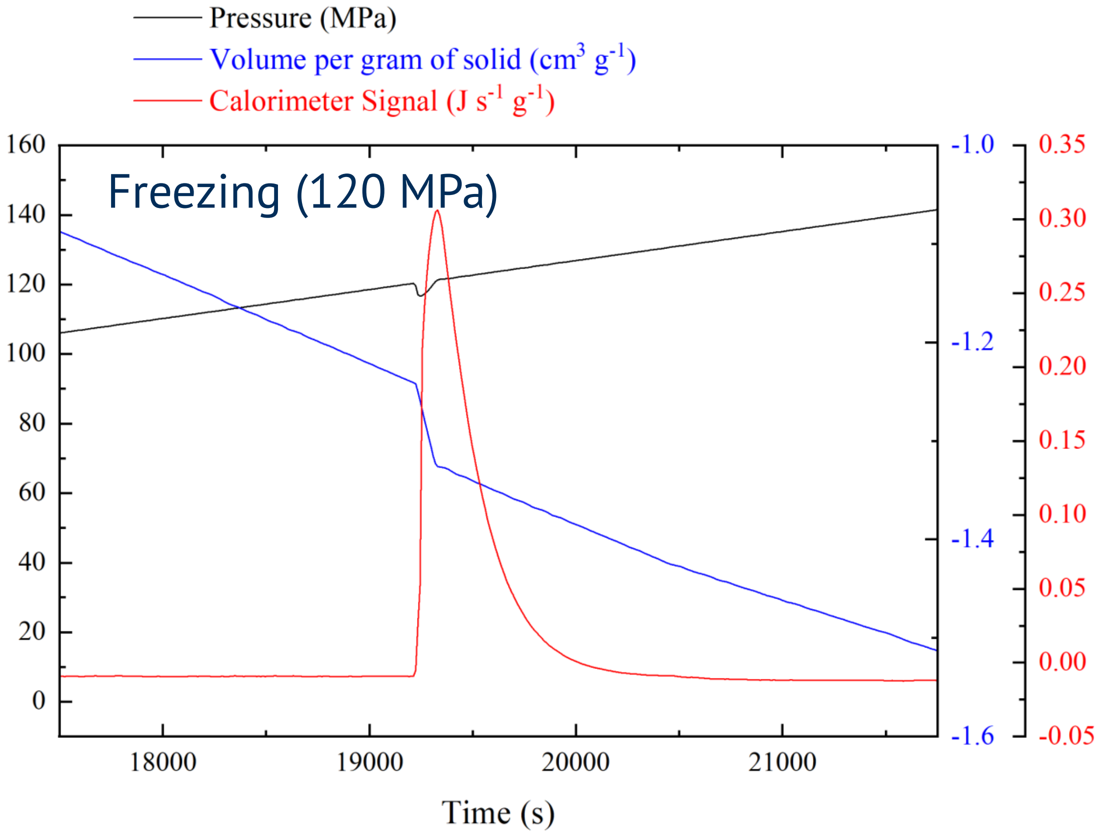


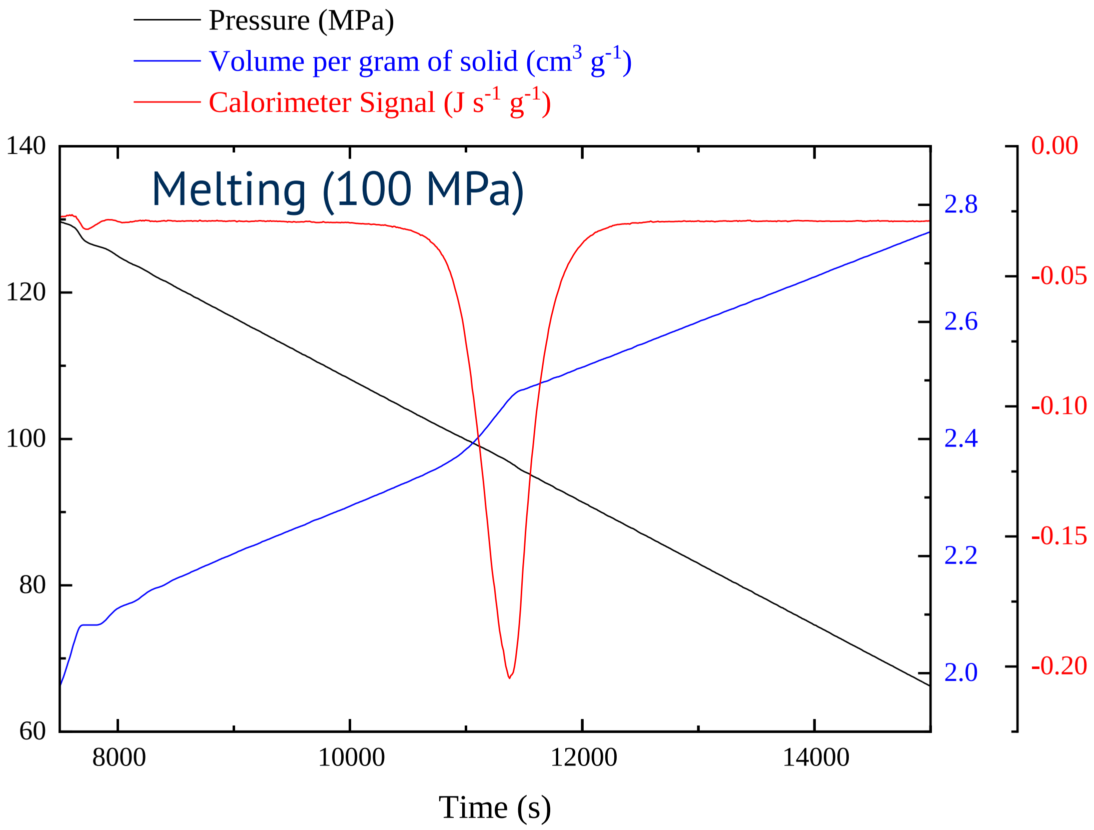
Heat of Fusion – Benzene



Our Equipment can go to 600 MPa and 400 °C

Reversible Fusion (Freezing/Melting at 303 K)



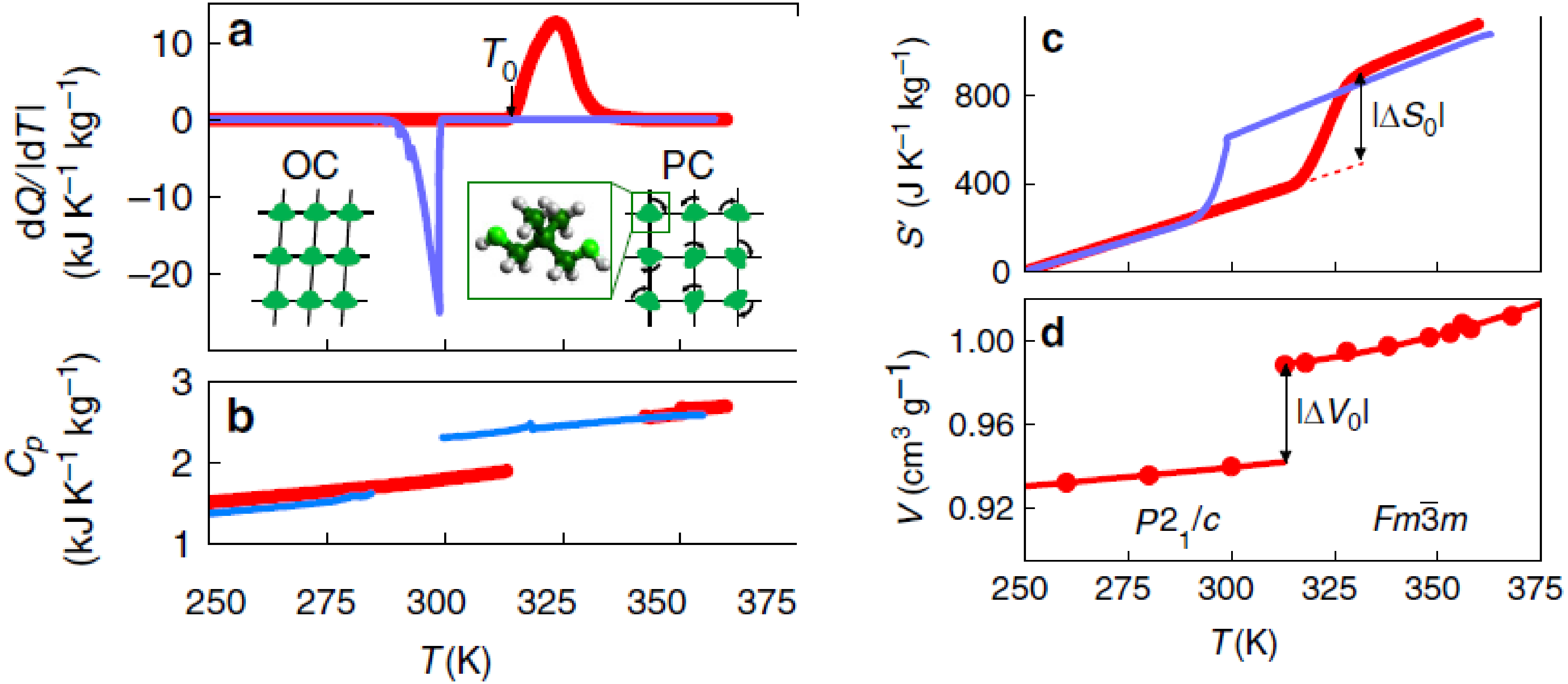


$\Delta_f H$ (exp) = 93.8/95.8 ($J \cdot g^{-1}$) $\Delta_f H$ (lit) = 127 ($J \cdot g^{-1}$)

$\Delta_f V$ (exp) = 0.12/0.14 ($cm^3 \cdot g^{-1}$) $\Delta_f V$ (lit) = 0.11 ($cm^3 \cdot g^{-1}$)

J. Chem. Eng. Data, Vol. 52, No. 5, 2007

Idea, Can this be used to Investigate Barocaloric Effects ?

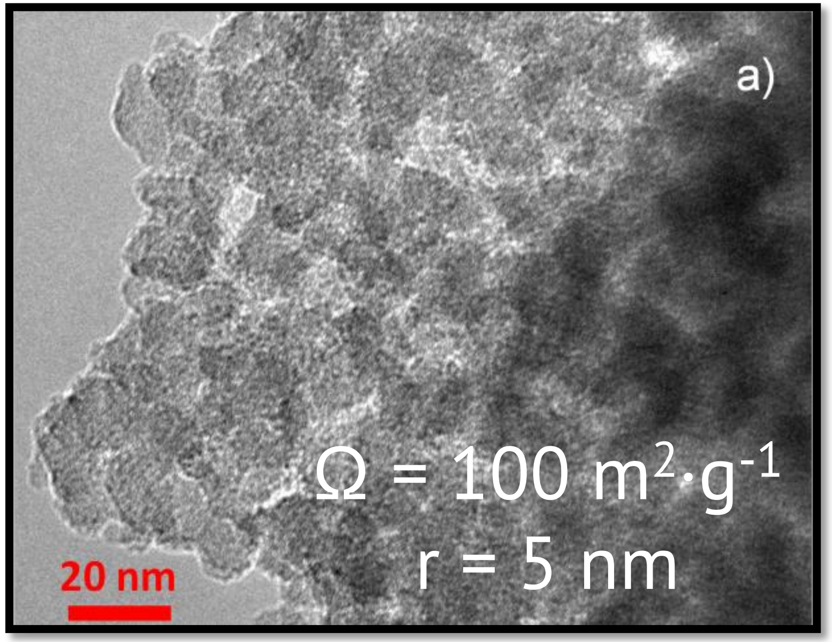


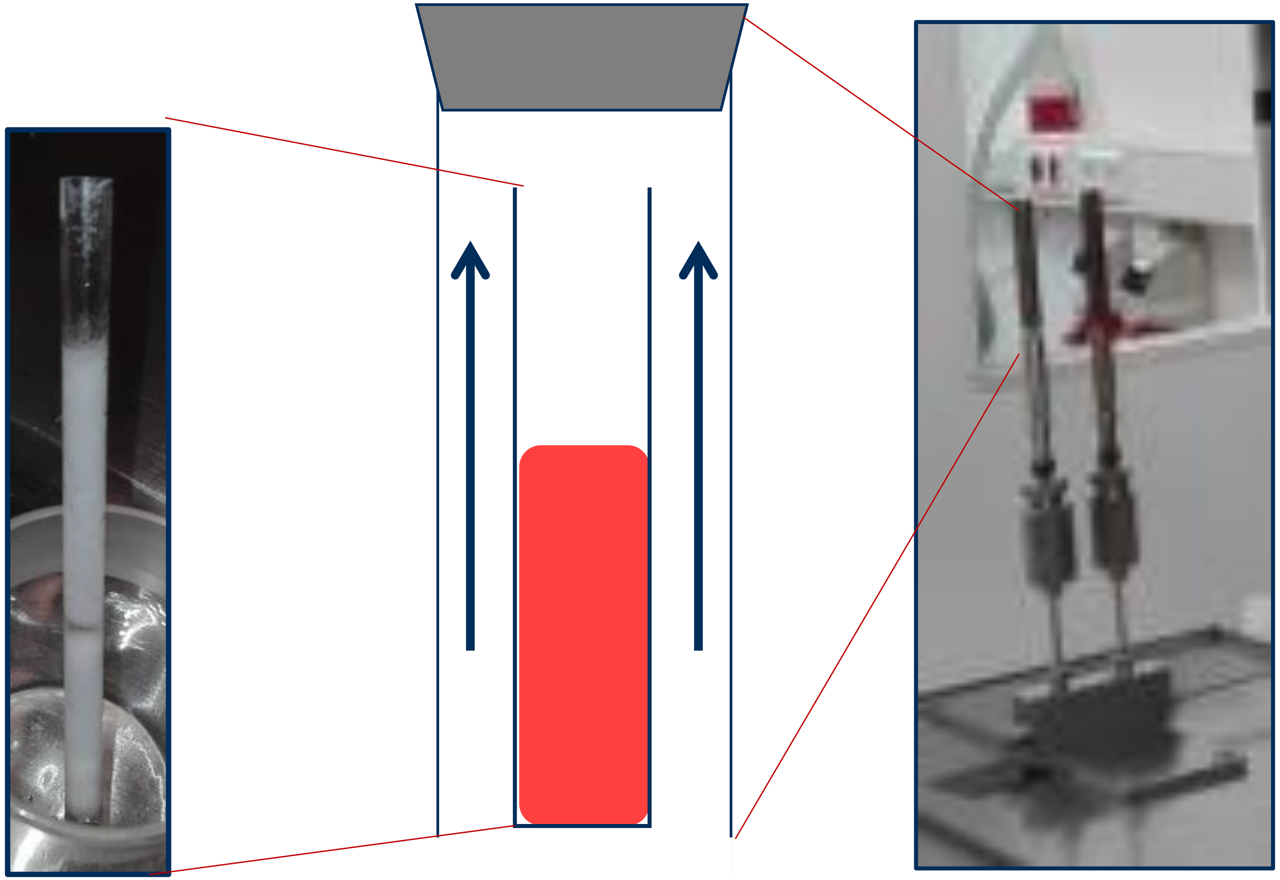
Yes,
Solid-Solid
Volumes and
Heats are large!

The example uses 3 pieces of equipment

NATURE COMMUNICATIONS | (2019) 10:1803 | https://doi.org/10.1038/s41467-019-09730-9 | www.nature.com/naturecommunications

Grafted GR-15 (Macroporous System)





Sample

Langmuir 2021, 37, 4827−4835

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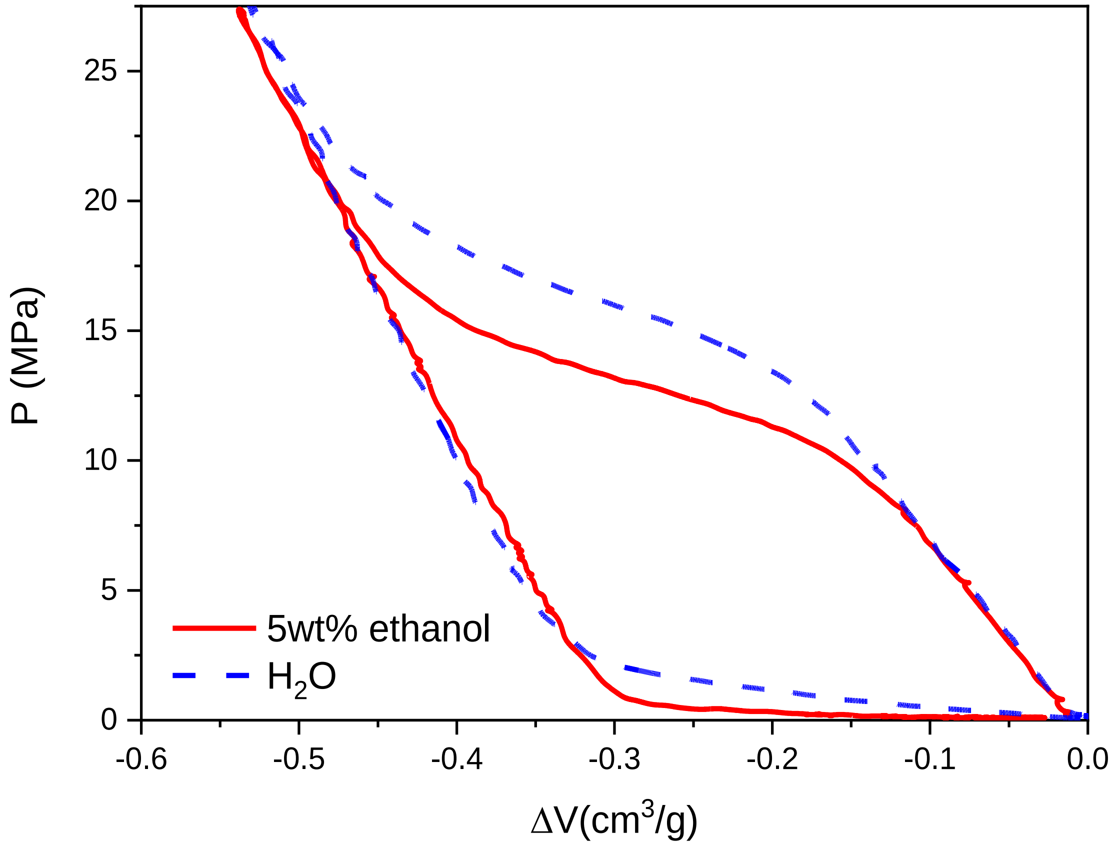
Pressure Volume Isotherm

We can classify this system as a **molecular bumber**...Energy is absorbed and dispersed

Under **fast conditions**, liquids and solutions can enter and exit the porous solids.

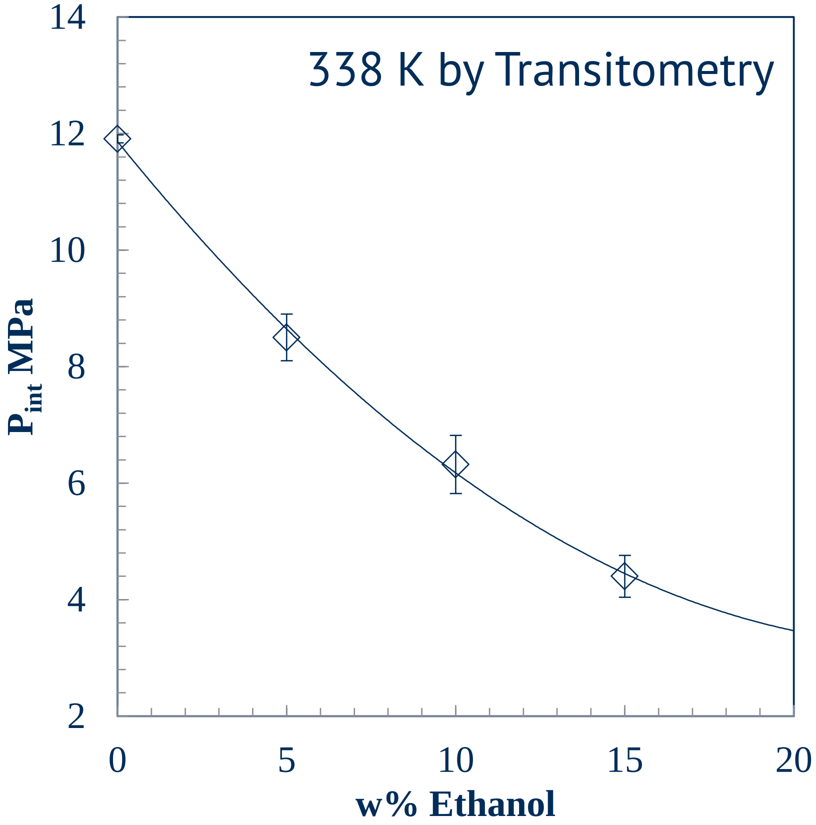
The **pure liquid** has a higher intrusion pressure compared to the solution.

The **aqueous ethanol solution** has a lower intrusion pressure.



Langmuir 2021, 37, 4827−4835

Concentration Effects on Intrusion Pressure (P_{int})



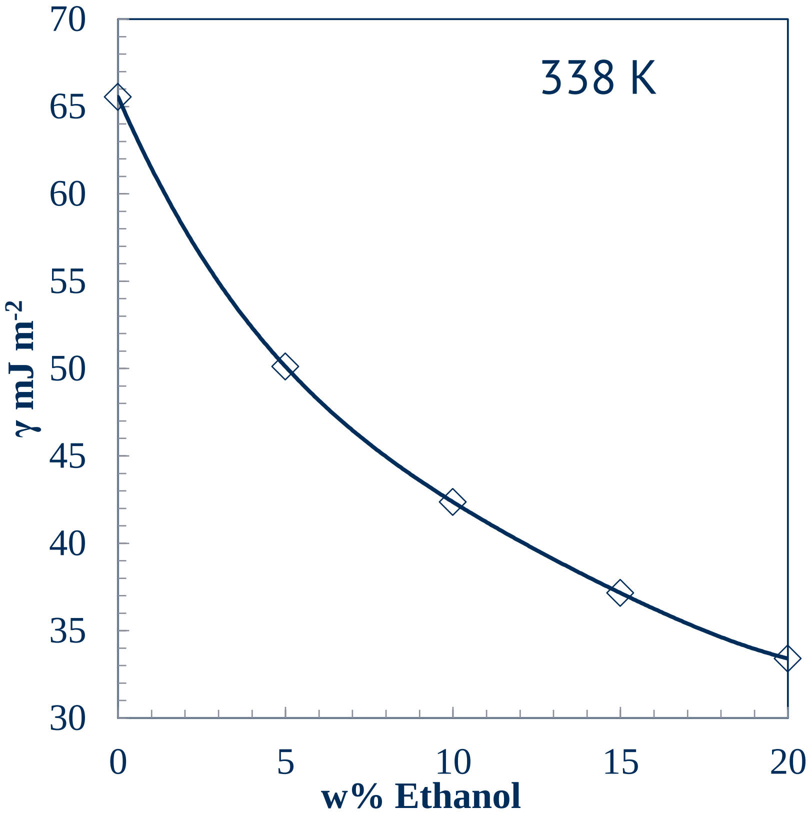
$$P_{int} = -\gamma_{LV} cos\theta (kr)^{-1}$$

γ – is the surface tension of the solution
θ – is the non-wetting contact angle
r – is the pore radius
k – is geometry parameter set to 2

$$W = P_{int} \times v$$

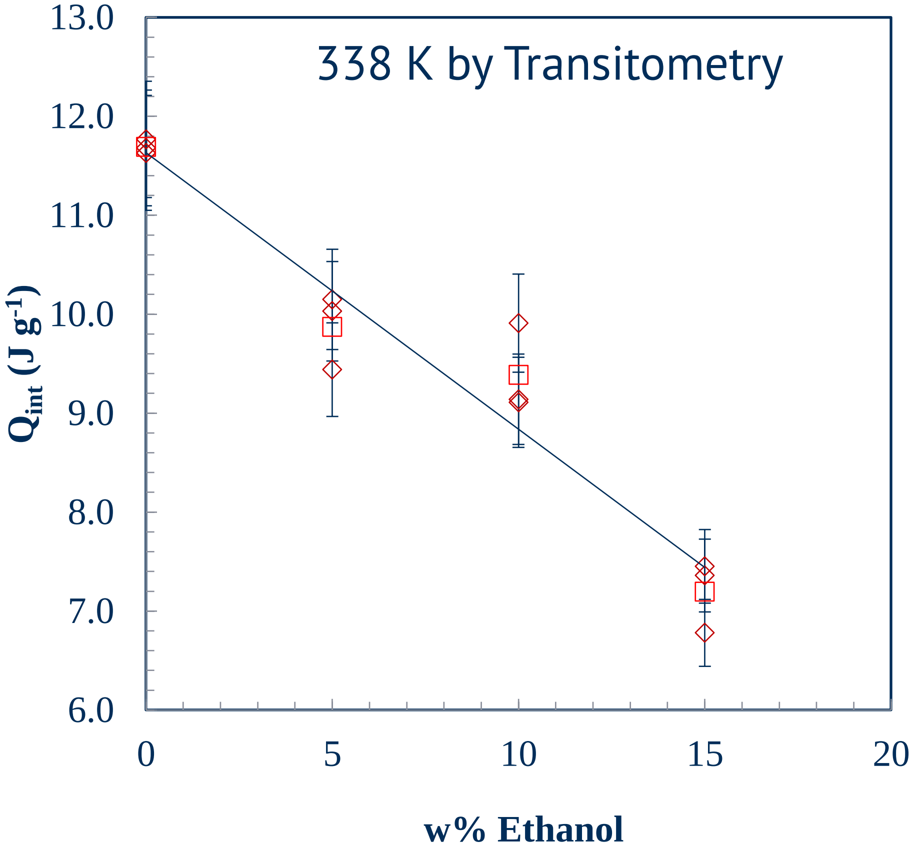
v – specific pore volume (0.35 $cm^3 \cdot g^{-1}$)

W_{int} = -4.2 $J \cdot g^{-1}$ for water



Langmuir 2021, 37, 4827−4835
J. Chem. Eng. Data, 1995, 40 (3), pp 611–614

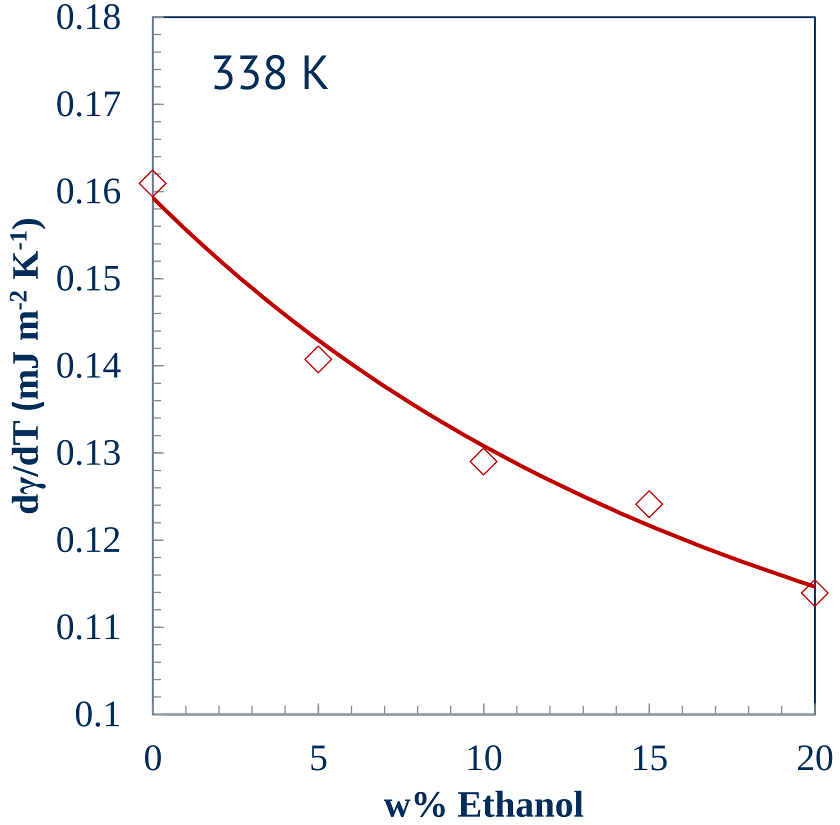
Concentration Effects on Intrusion Heat



$$Q_{int} = T\frac{d(\gamma_{LV}cos\theta)}{dT}\Omega$$

T – Temperature
Ω – is the pore surface area

The energy absorbed is endothermic



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Thank you For Your Attention

Thermodynamic in Action

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