Low temperature energy storage PCM systems

Phase Equilibrium Studies

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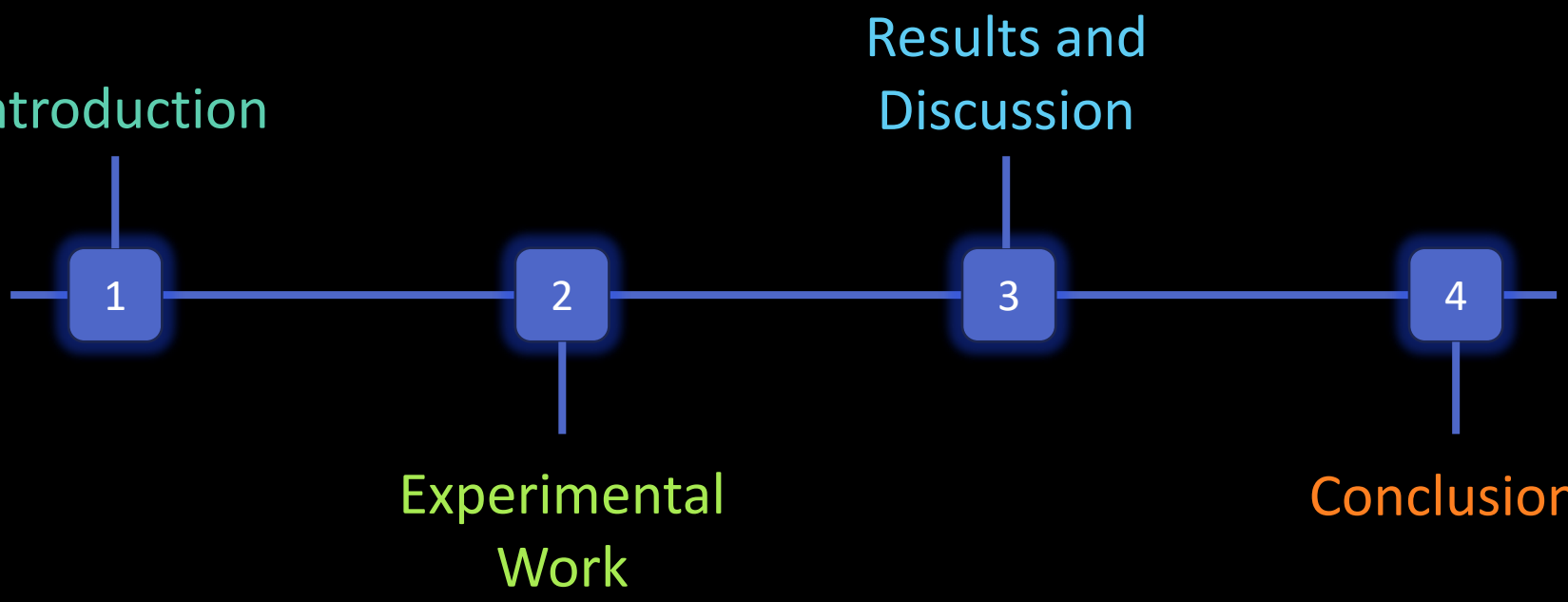
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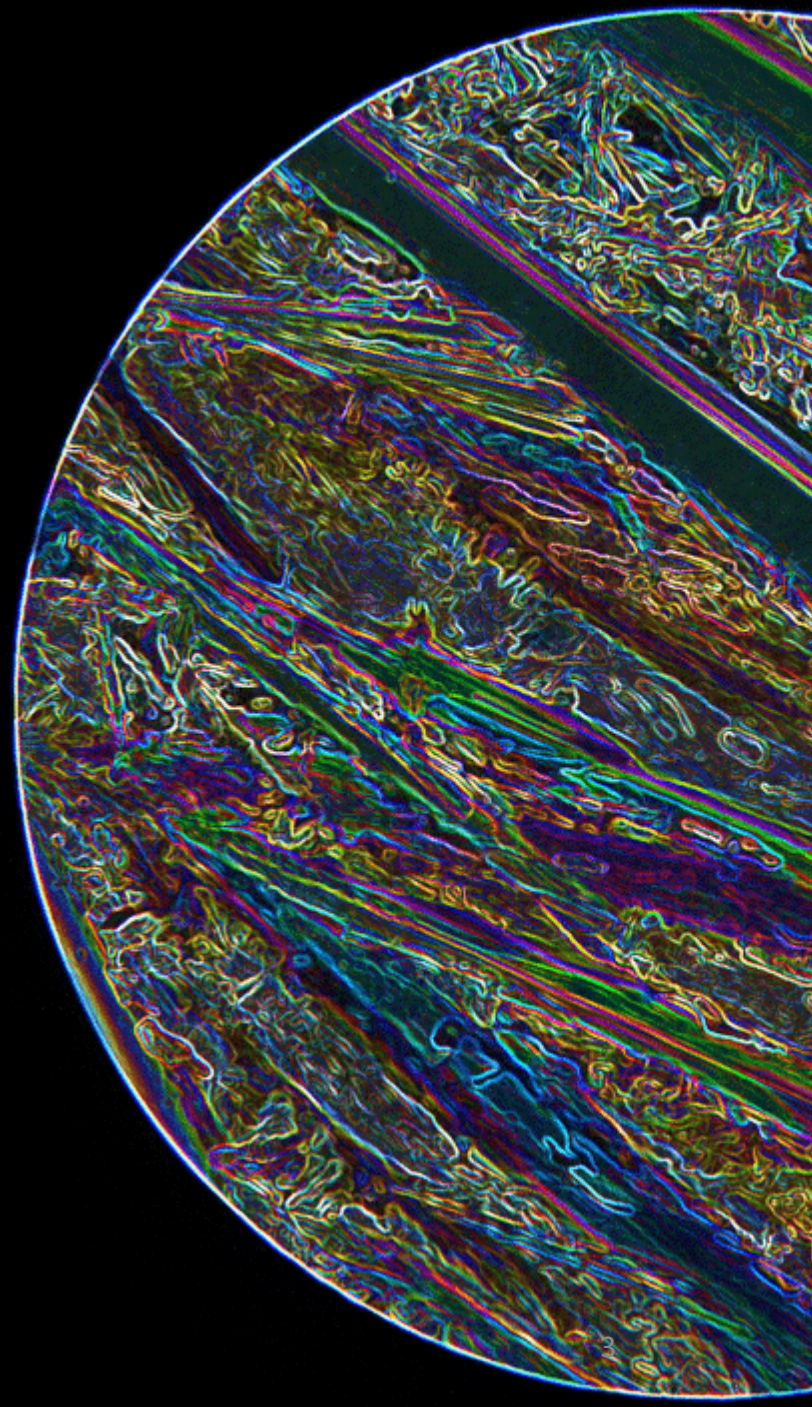
1. Introduction

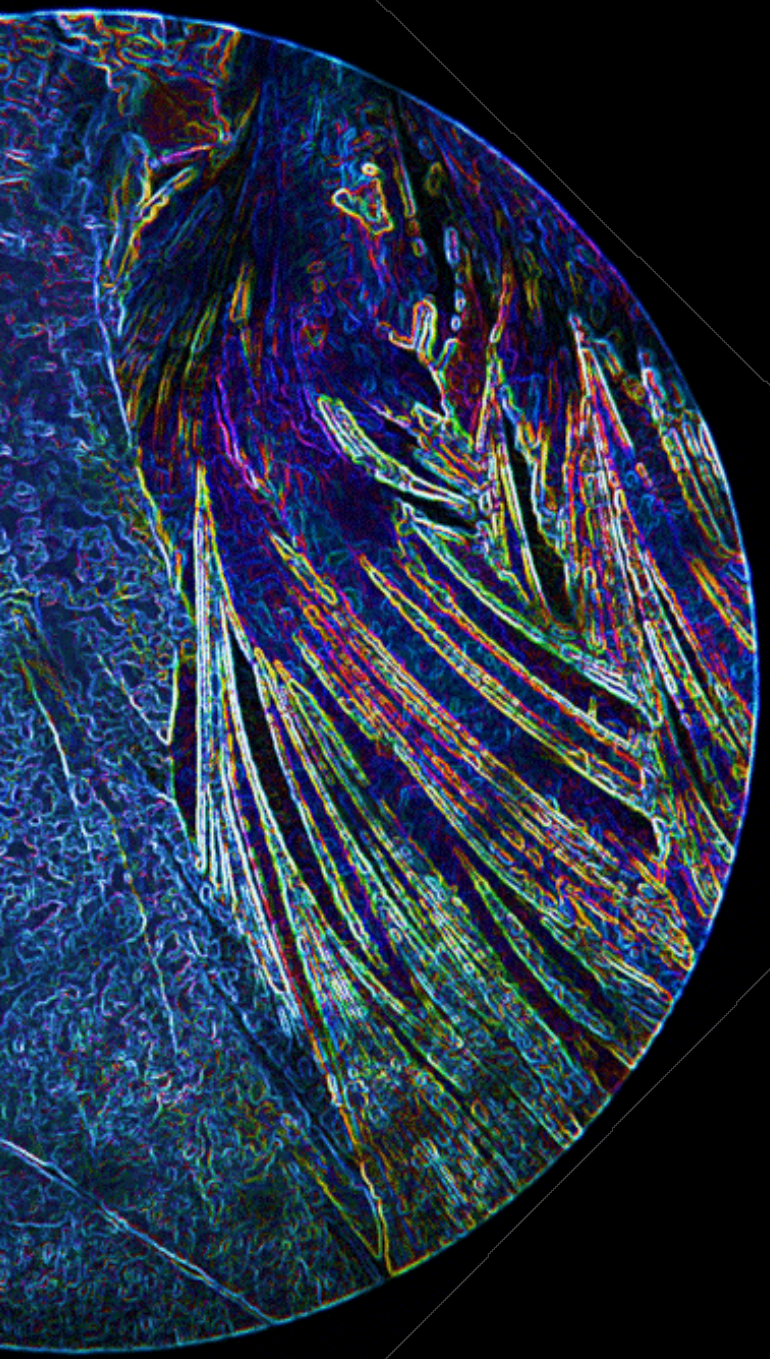
Increasing Energy Needs

Energy Storage – Thermal Energy Storage

Phase Change Materials – Latent Heat Storage

Binary system of *n* – alkyl - adipates (continuation of the last year's work)





2. Experimental Work

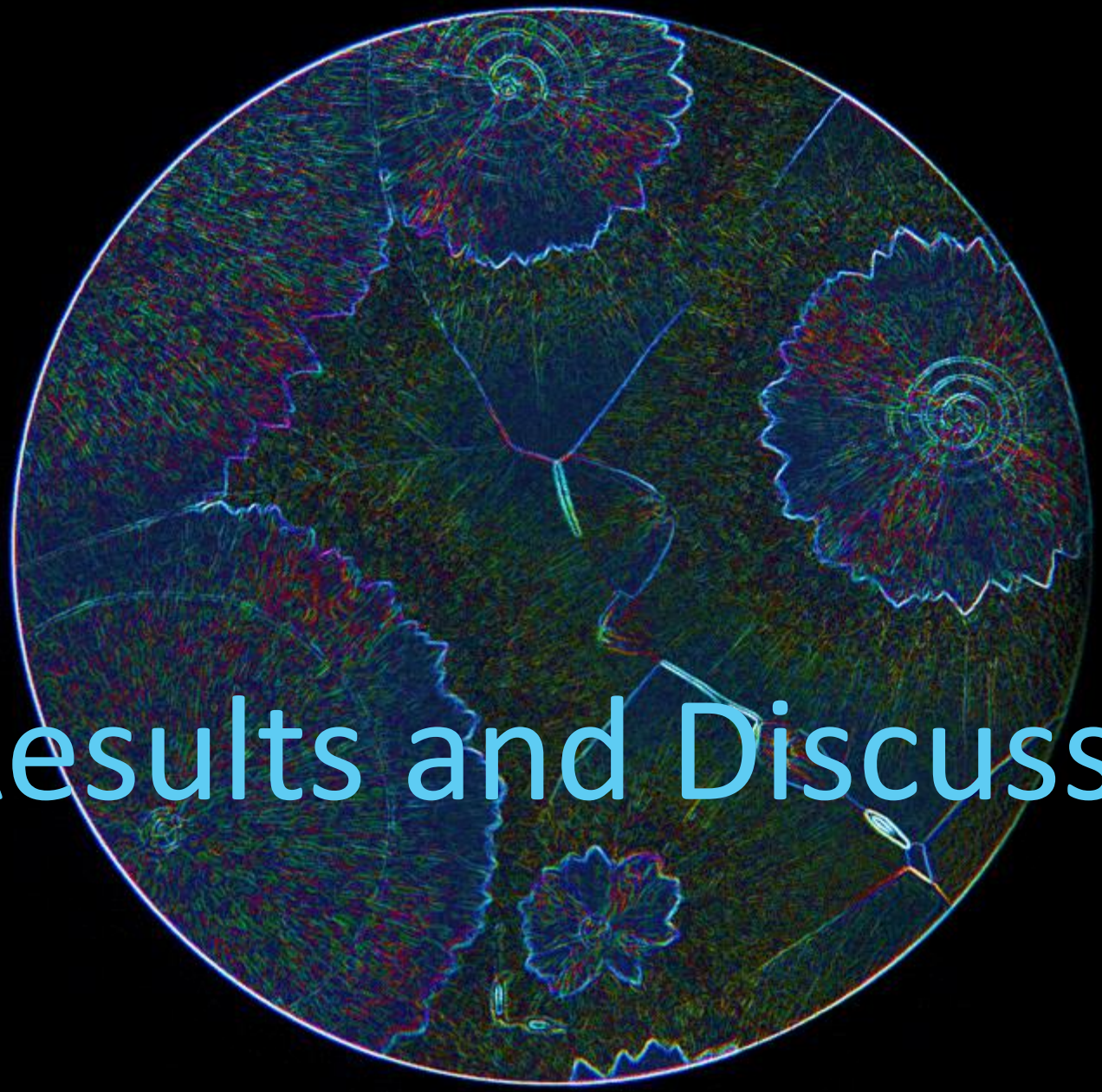
Diethyl + Dibutyl adipates

Differential Scanning Calorimetry

Hot Stage Microscopy

Raman Spectroscopy

Binary Phase Diagram



3. Results and Discussion

Differential Scanning Calorimetry

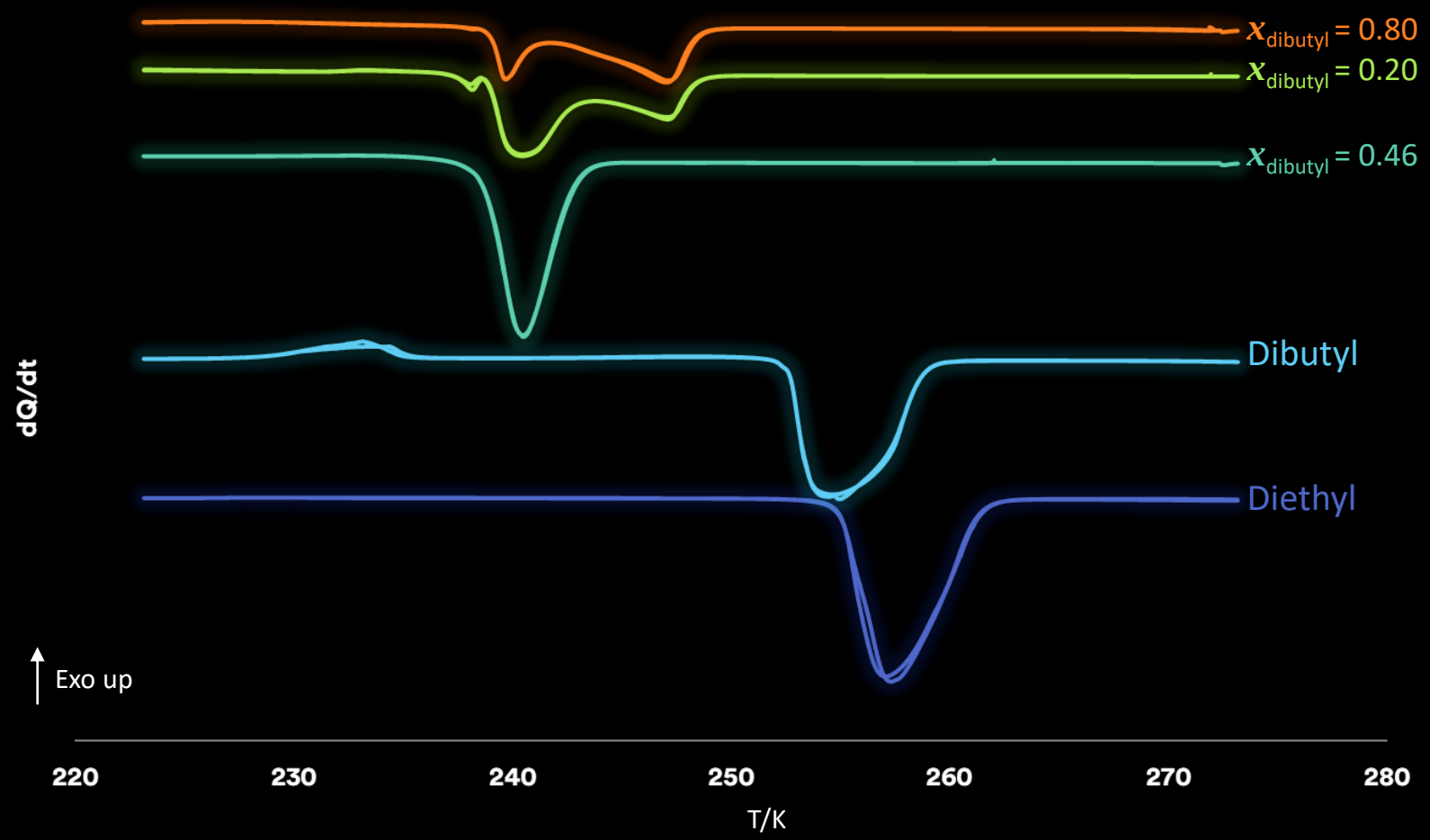
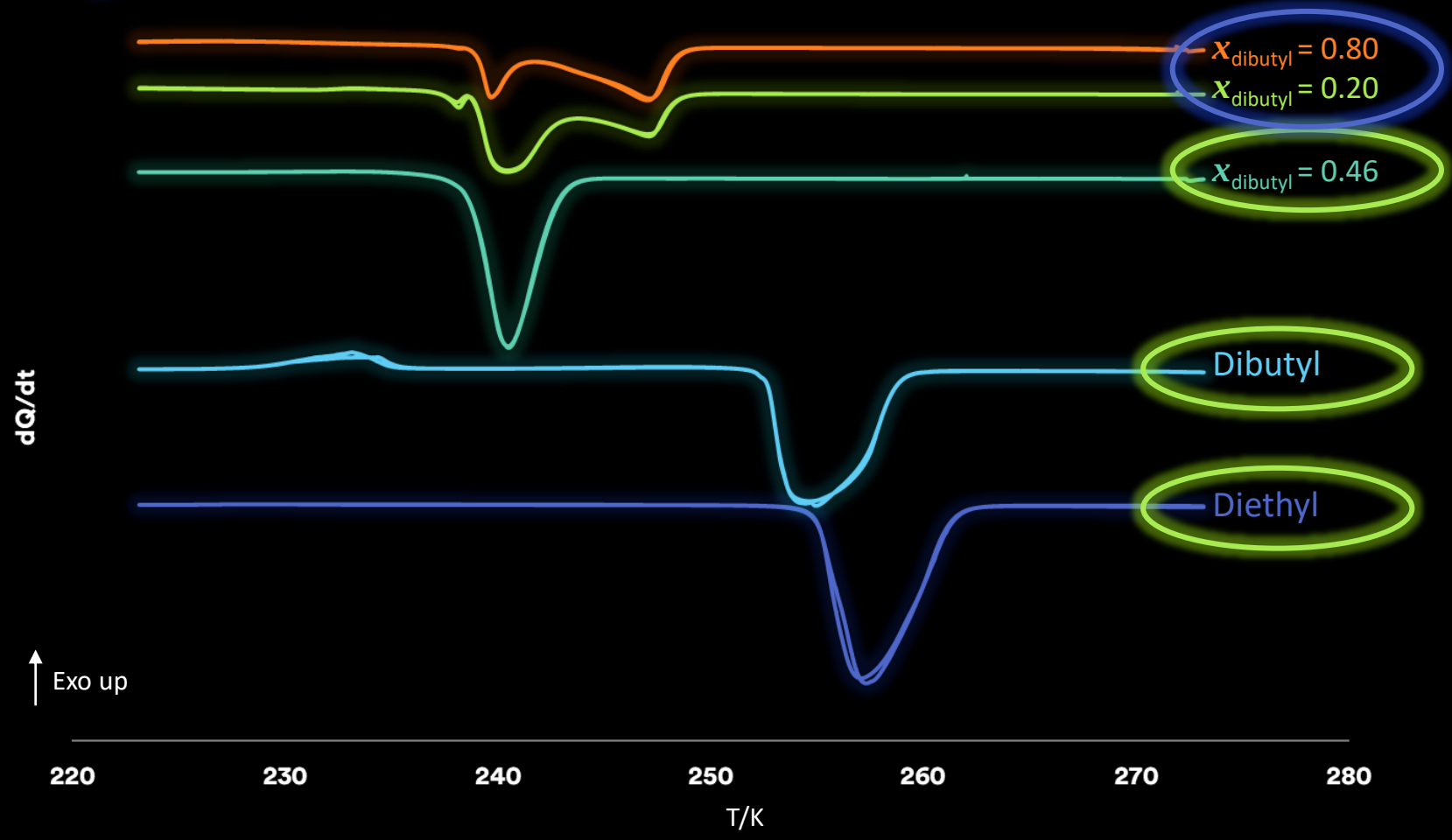


Fig. 1 – DSC heating curves of pure diethyl, dibutyl, and of selected binary mixtures, with dibutyl molar fraction $x_{dibutyl}$.

Differential Scanning Calorimetry



For pure compounds and the eutectic mixture: only a single peak for the phase transition

For binary mixtures ($x_{dibutyl}$ = 0.20 and 0.80): two peaks for the phase transition

Fig. 1 – DSC heating curves of pure diethyl, dibutyl, and of selected binary mixtures, with dibutyl molar fraction $x_{dibutyl}$.

Differential Scanning Calorimetry

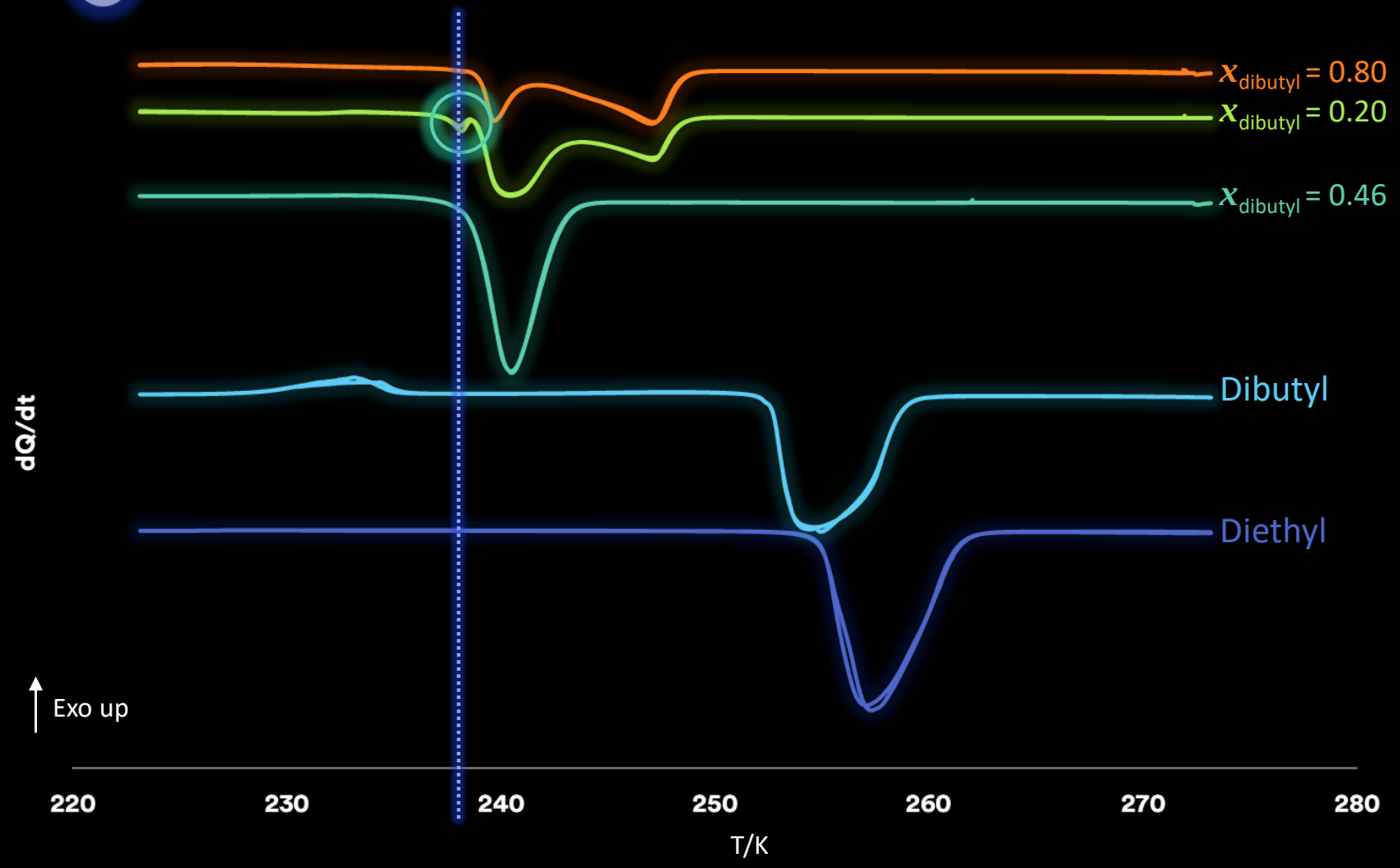
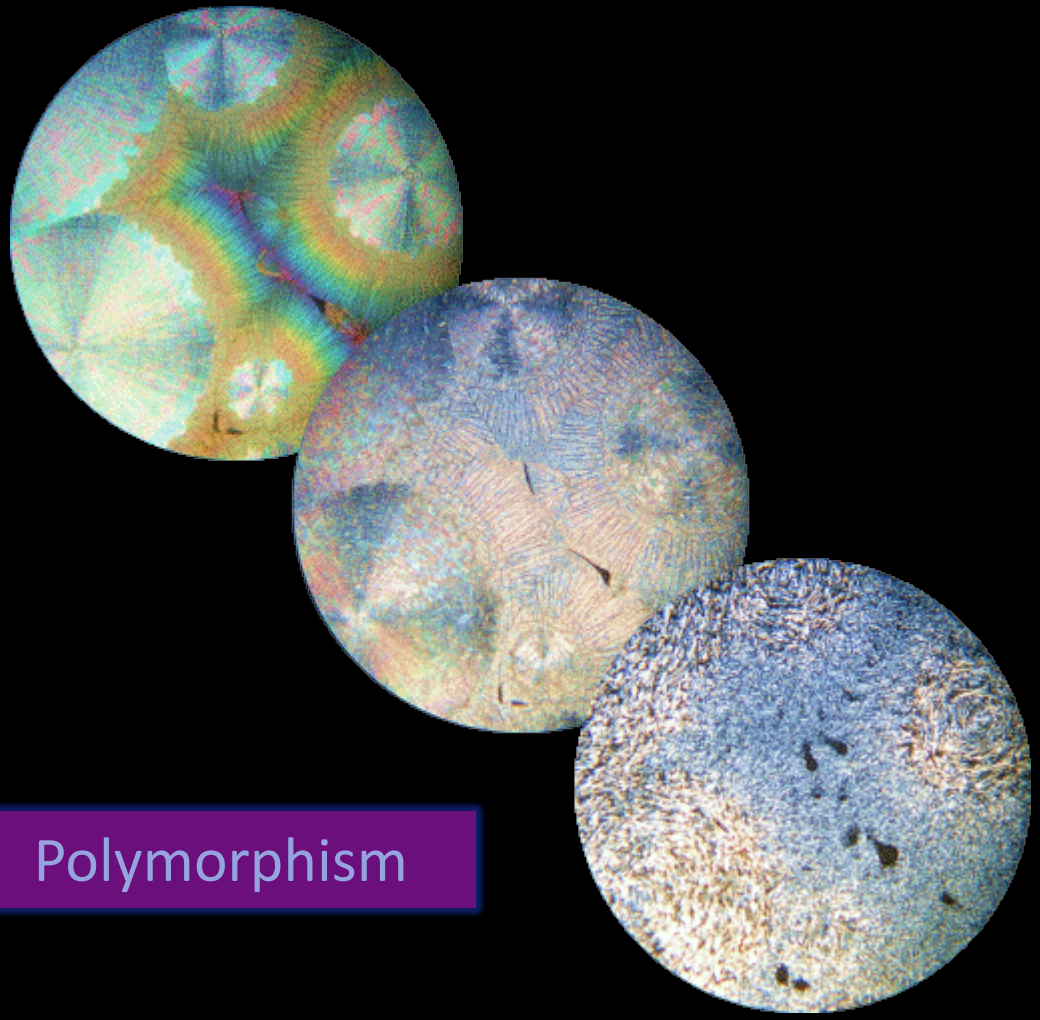


Fig. 1 – DSC heating curves of pure diethyl, dibutyl, and of selected binary mixtures, with dibutyl molar fraction $x_{dibutyl}$.

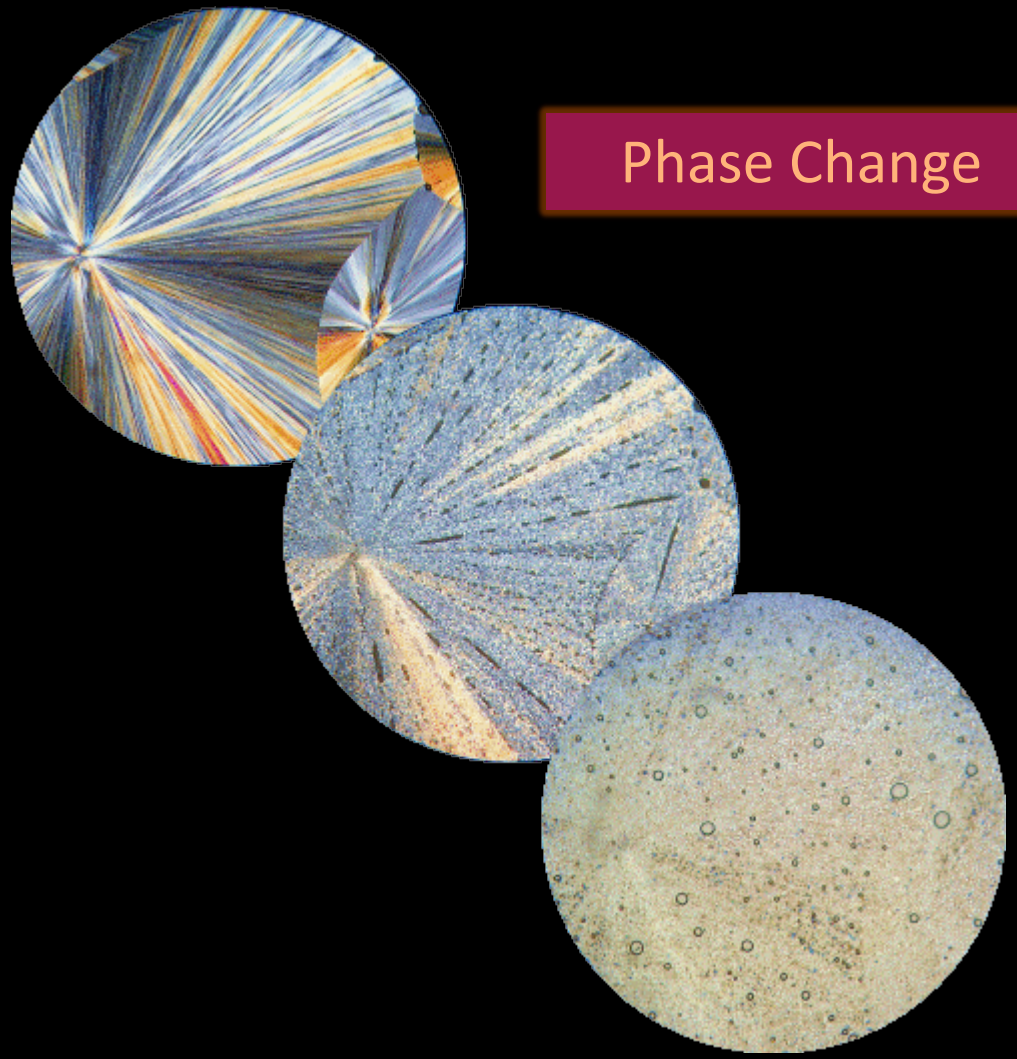
Polymorphism: is detectable for the mixture $x_{dibutyl}$ = 0.20 and for other mixtures.

Polymorphism occurs always at the same T without compromising the solid-liquid phase transition

Hot Stage Microscopy



Polymorphism



Phase Change

Raman Spectroscopy

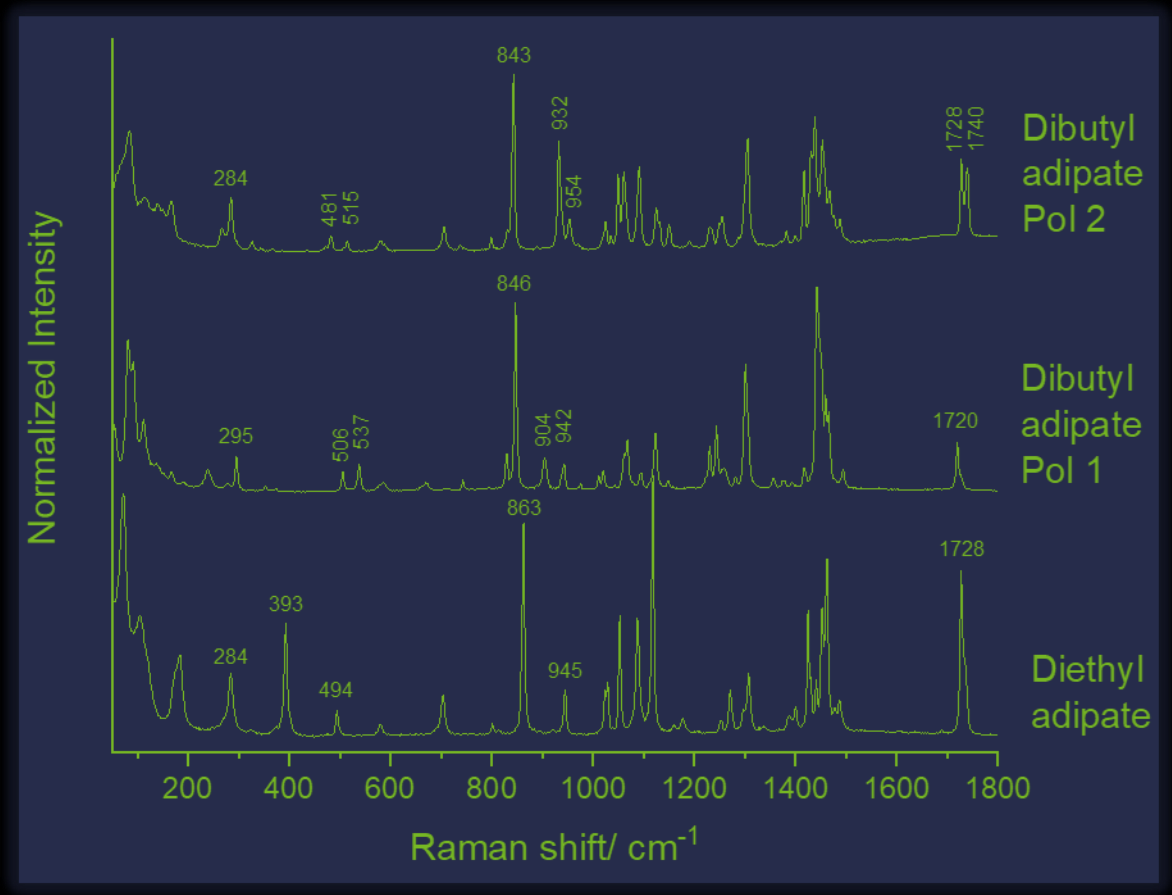


Fig. 2 – Raman spectra of the solid-state pure diethyl adipate and dibutyl adipate samples.

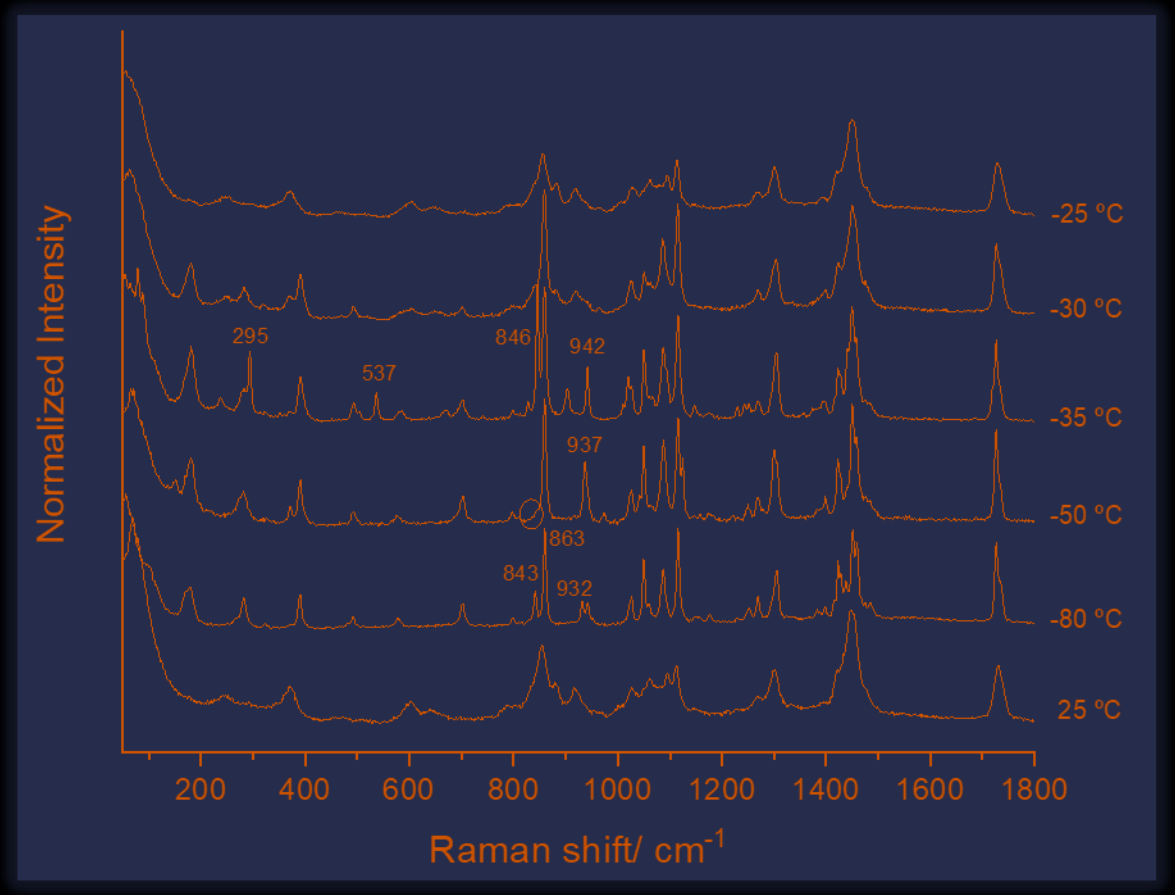


Fig. 3 – Temperature-variation Raman spectra the 80:20 diethyl adipate:dibutyl adipate mixture sample.

Binary Phase Diagram

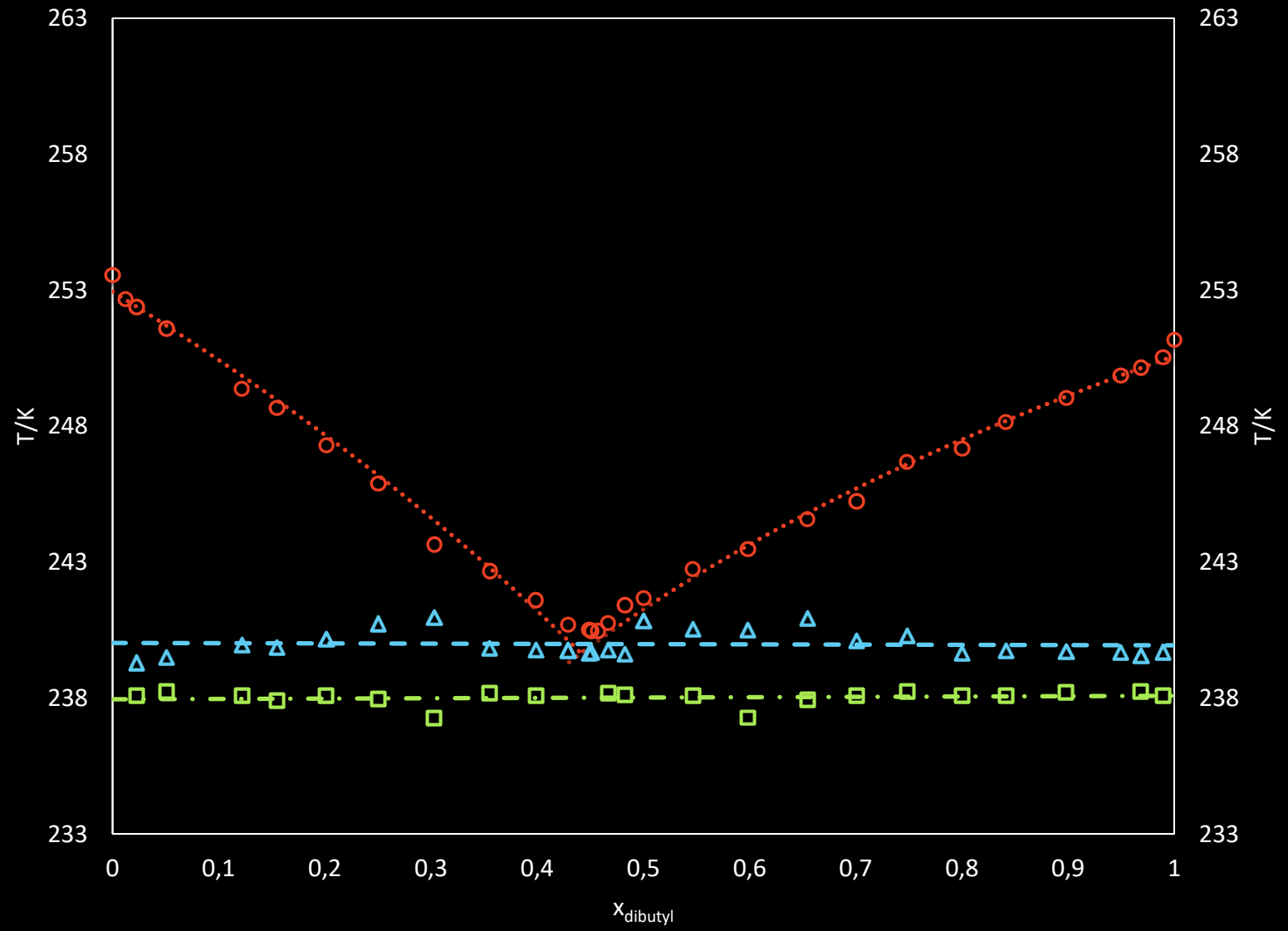


Fig. 4 – Binary solid-liquid phase diagram of the system of diethyl and dibutyl adipates.

Binary Phase Diagram obtained with 30 mixtures and 2 pure compounds

1 Liquid zone
2 Bipahsic zones
2 Solid zones (because of the polymorphism)

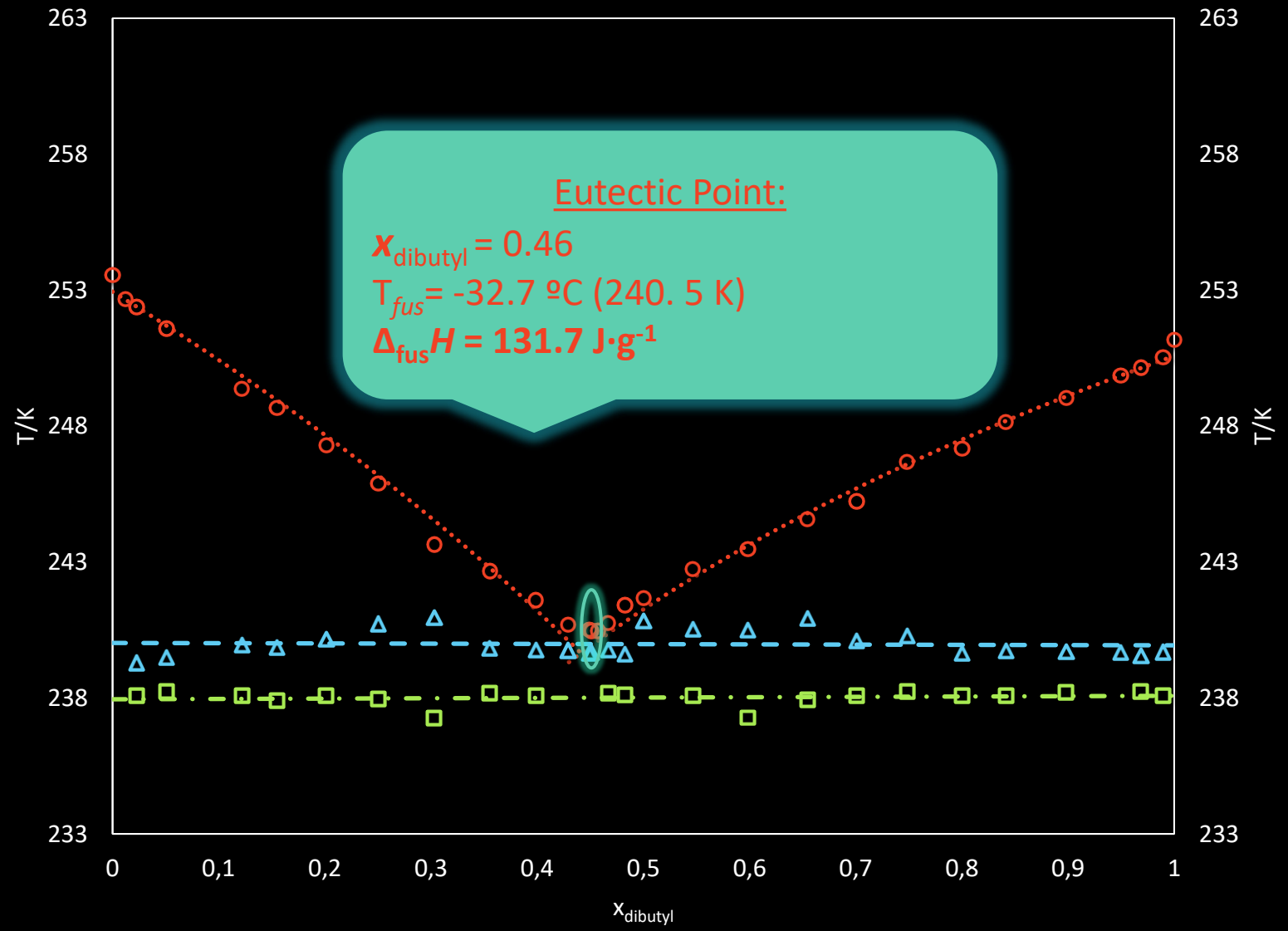


Fig. 4 – Binary solid-liquid phase diagram of the system of diethyl and dibutyl adipates.

Freezing-point depression curve[1]

$$\ln\left(\frac{1}{x}\right) = \frac{L_{Mi}}{R}\left(\frac{1}{T} - \frac{1}{T_{Mi}}\right)$$

Characterize the *liquidus* line of a solid-liquid binary phase diagram

Fitted Eutectic Point:

$x_{dibutyl}$ = 0.44

T_{fus} = -33.4 ºC (239. 8 K)

-- 0.54 ºC abs. Deviation --

(Max. Abs. Deviation ±1.5 ºC)

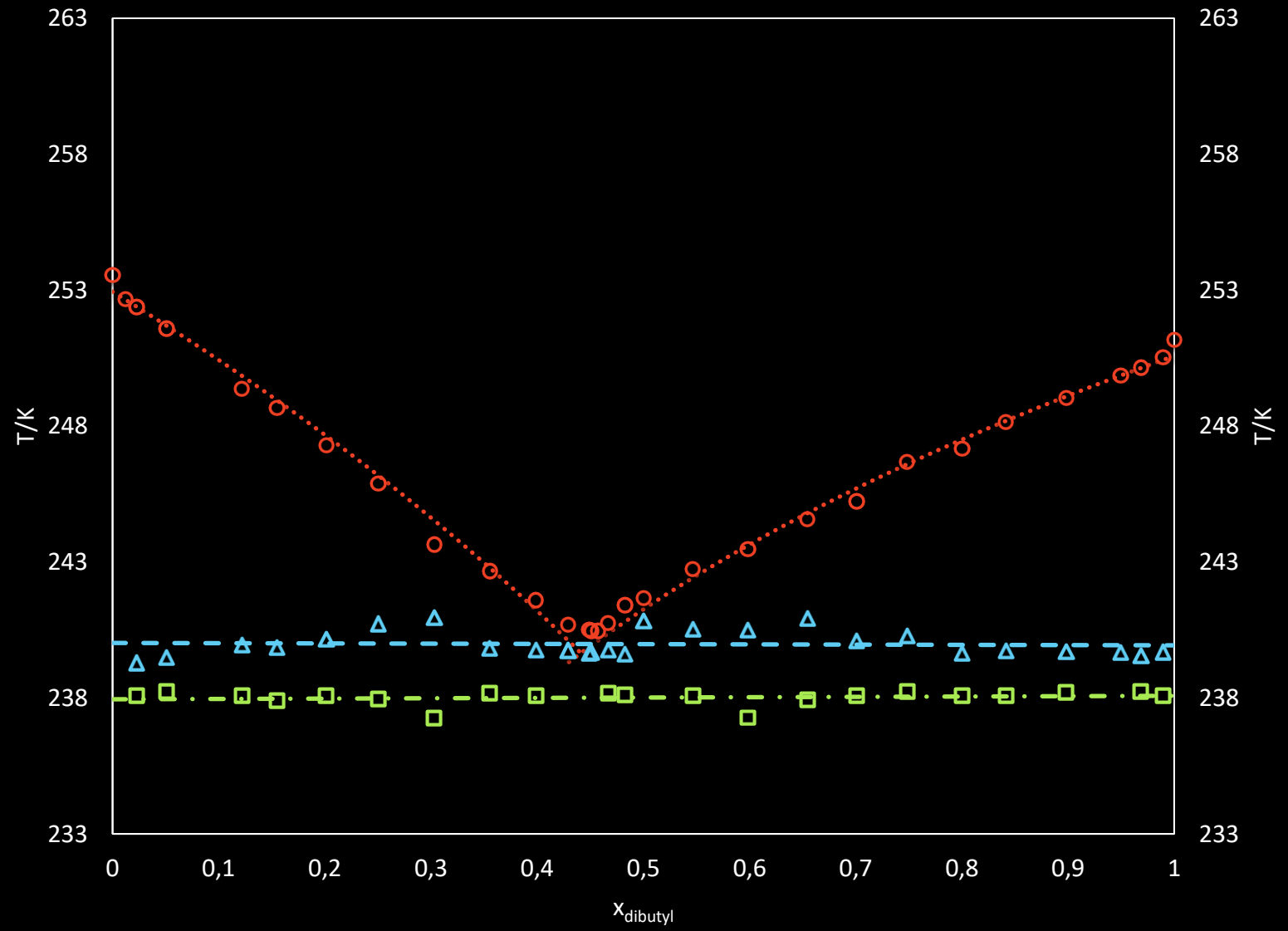


Fig. 4 – Binary solid-liquid phase diagram of the system of diethyl and dibutyl adipates.

[1]K. Denbigh, Principles of Chemical Equilibrium, 2nd Ed. London, United Kingdom: Cambridge University Press, 1966.

5. Conclusions

Binary System of two di-*n*-alkyl adipates: Diethyl and Dibutyl

Construction of the Solid-Liquid Binary Phase Diagram

Eutectic Behaviour for Low Temperatures

Eutectic Point: $\boldsymbol{x}_{\text{dibutyl}} = 0.46$; $T_{max} = -32.7$ ºC (240. 5 K); $\boldsymbol{\Delta_{fus}H = 131.7\ J \cdot g^{-1}}$

Good Candidate for Low Temperature Energy Storage Applications

Acknowledgments

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