Structural and kinetic studies of the cubic and hexagonal phases of MNd

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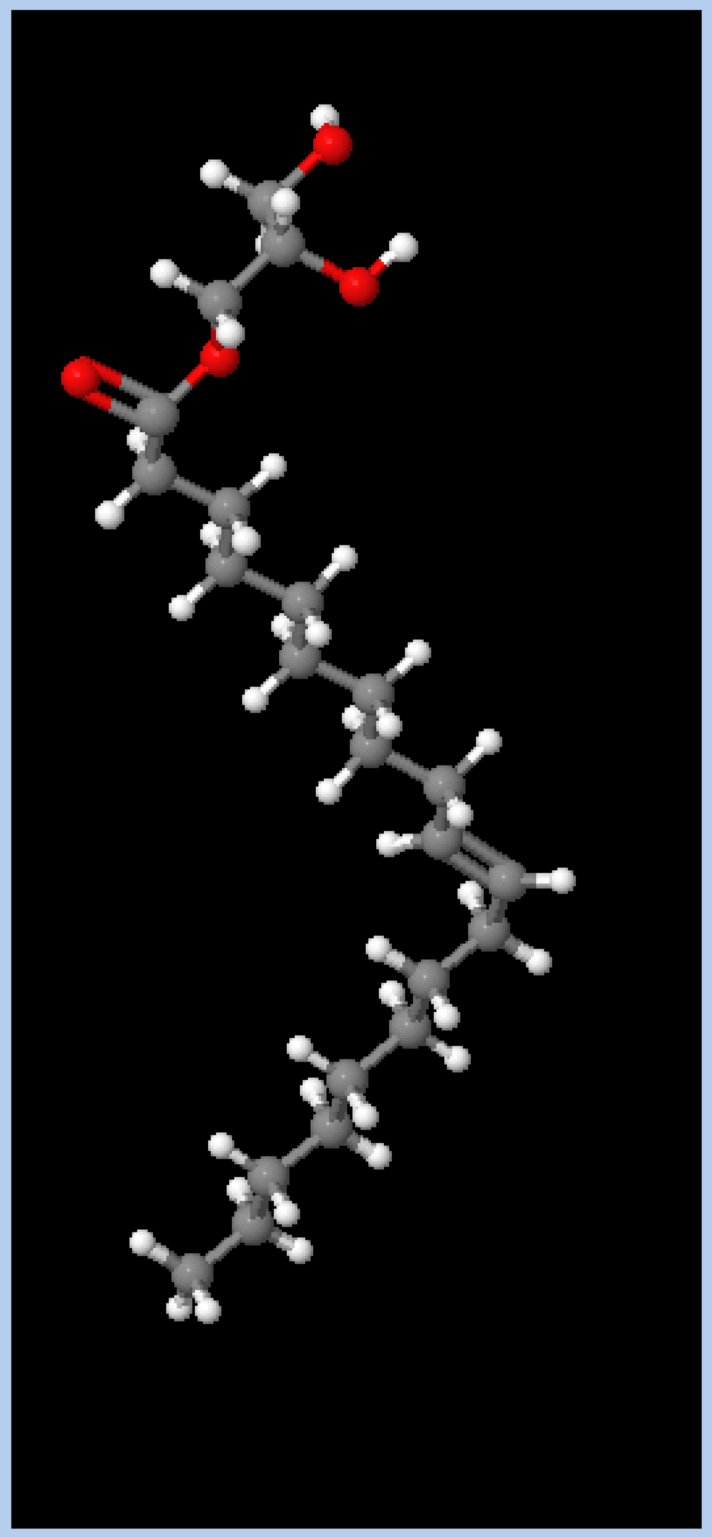
Introduction

We examined a lipid known as Mononondecenoin (MNd). The molecular structure of MNd and two of the phases it can form are shown below in Figure 1. Lipids can be used to encapsulate drugs, allowing a constant slow delivery of drugs. This slow release helps for efficacy, lowering the amount of drug used, and limiting side effects.

In this study, we were looking at how differing sucrose concentrations affect the location of the phase transition. By studying the lipids and the phases they form it would be possible to design lipids to get the optimal structure for different applications.



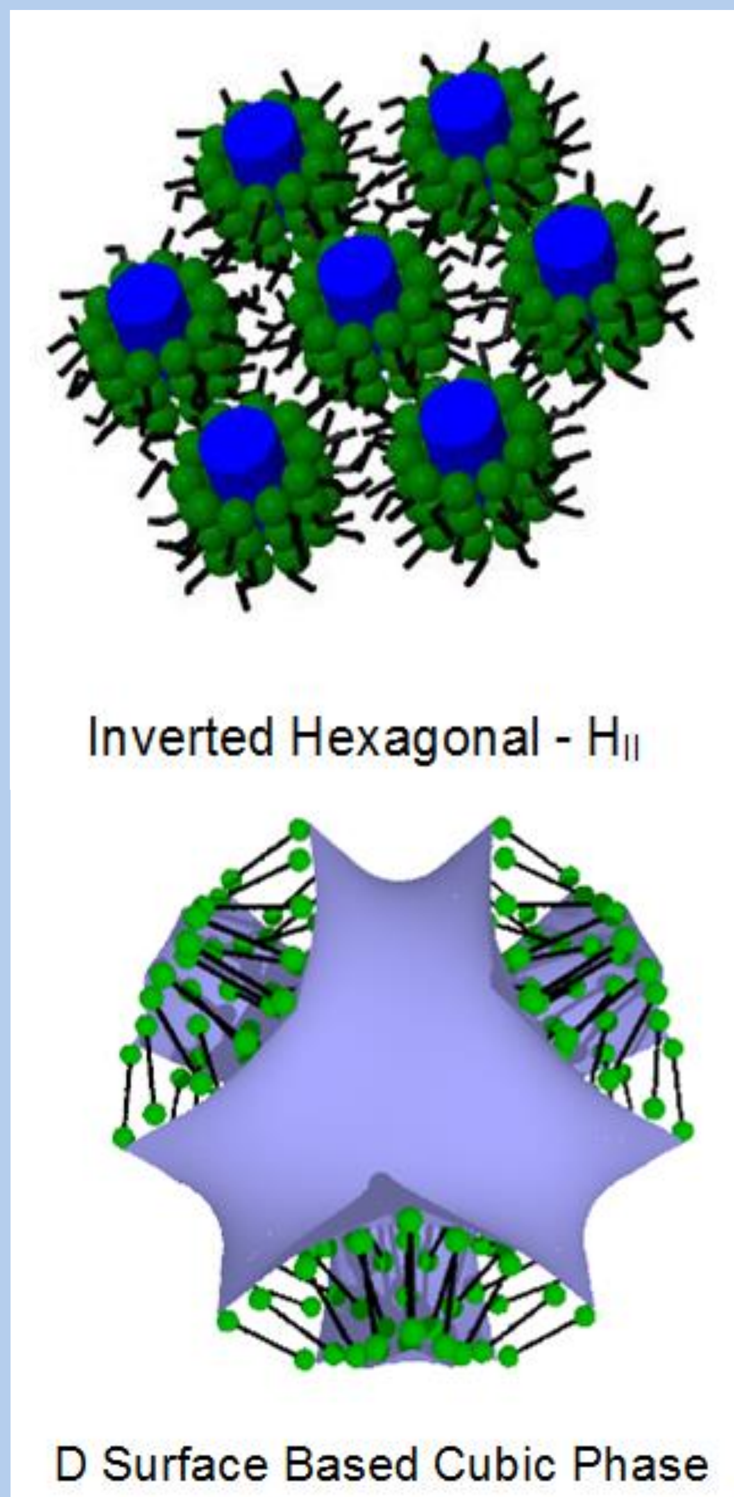


Figure 1. The left image is the molecular structure of the lipid MNd. The top-right image is the high temperature hexagonal phase and the bottom-right is the lower temperature cubic phase. Phase images from Reese, C.W., Strango, Z.I., Dell, Z.R., Tristram-Nagle, S., Harper, P.E., 2015. Structural insights into the cubic-hexagonal phase transition kinetics of the monoolein modulated by sucrose solutions. Phys. Chem. Chem. Phys. 17, 9194-9204.

Differential Scanning Calorimeter (DSC)

We made thermal scans of the lipid and looked at the heat flow in and out of the lipid at a variety of scan rates. The results of these scans, shown in Figure 2, were used to find information on phase transitions. The bumps on the scan are where there was a difference in heat flow as the lipid underwent a phase transition. We found that as sucrose concentration increased the transition temperature decreased as shown in Figure 3.

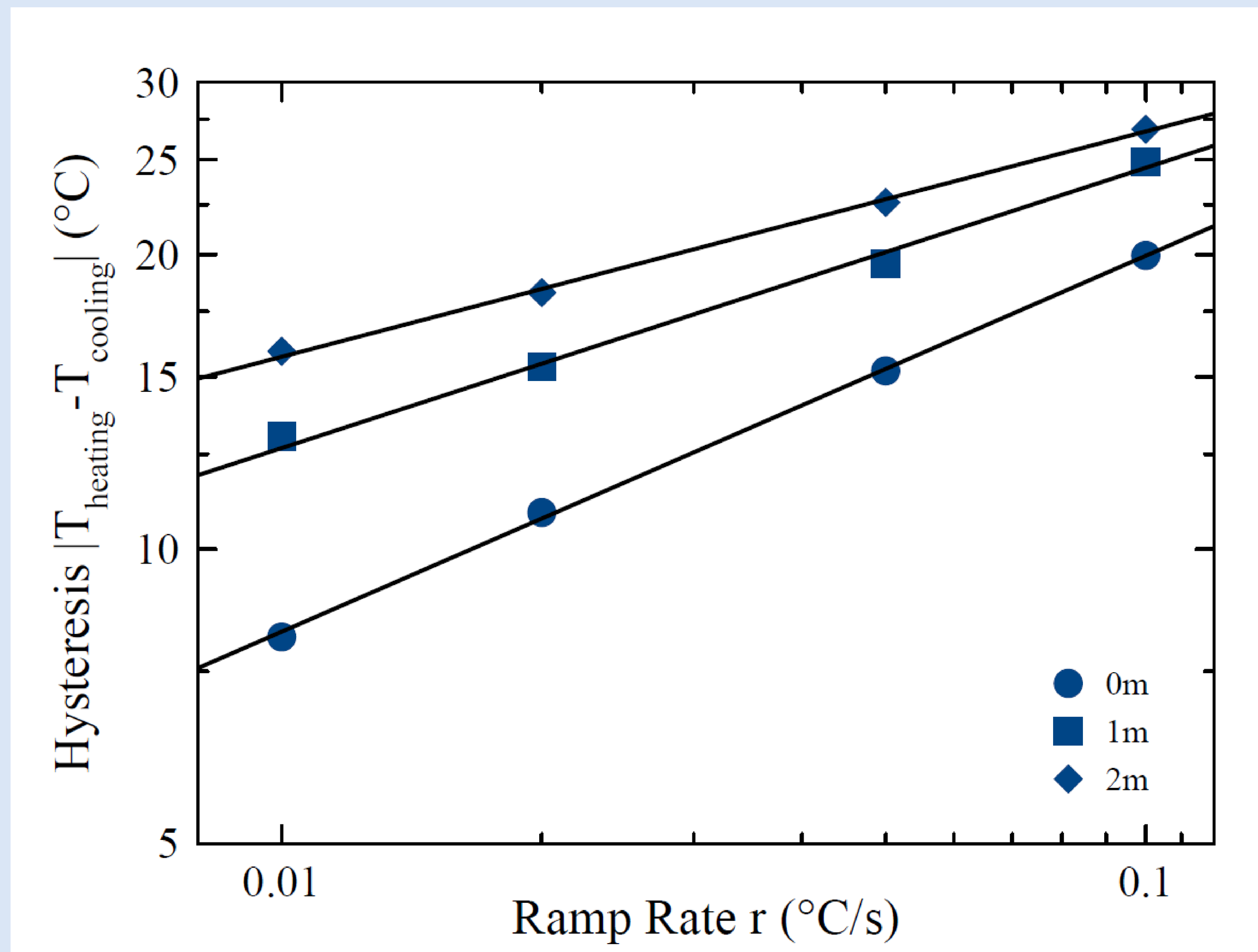


Figure 2. This graph shows what the DSC heat transitions look like for different ramp rates. Each cycle has had a linear baseline subtracted from the data and was offset for all to be shown at once.

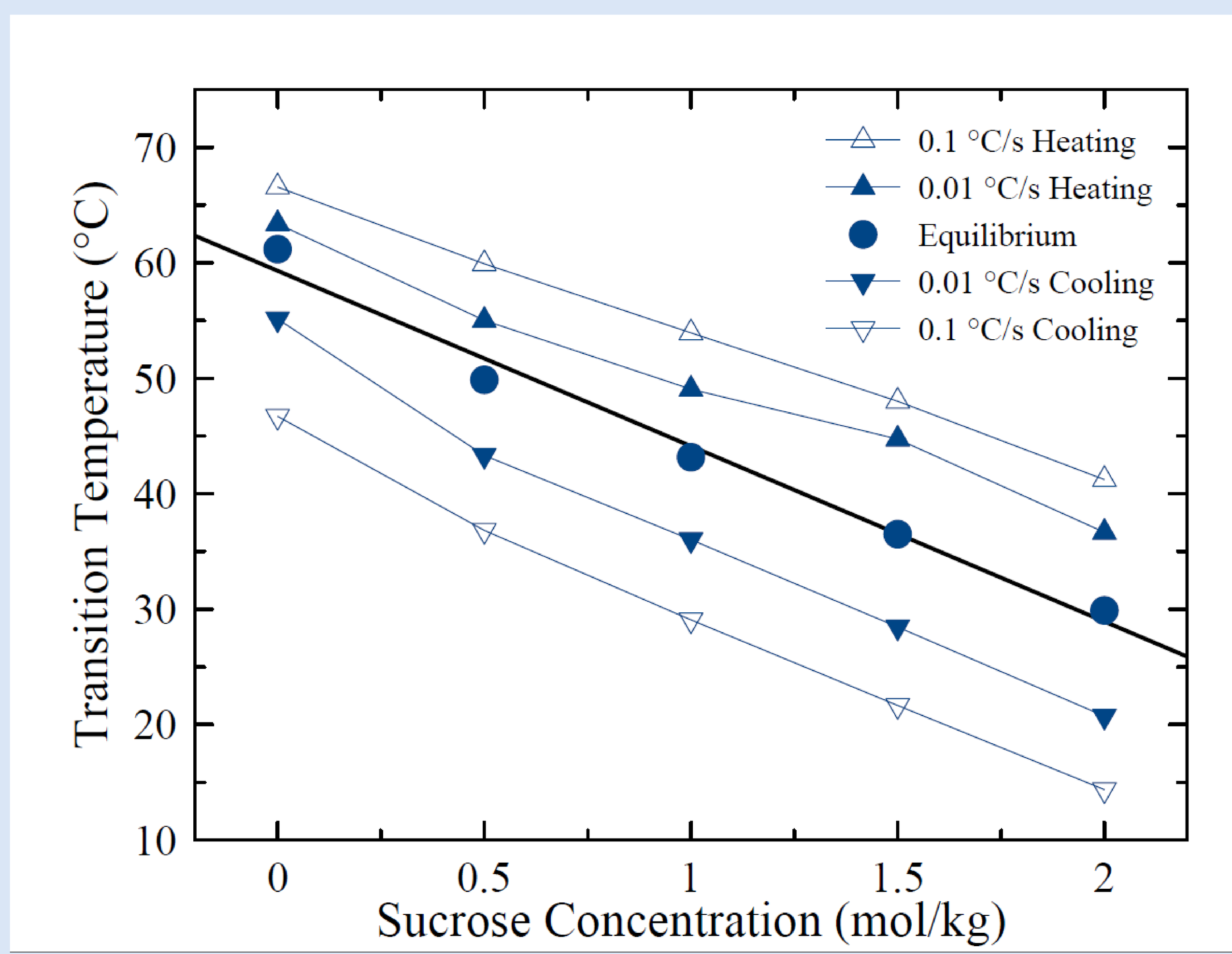
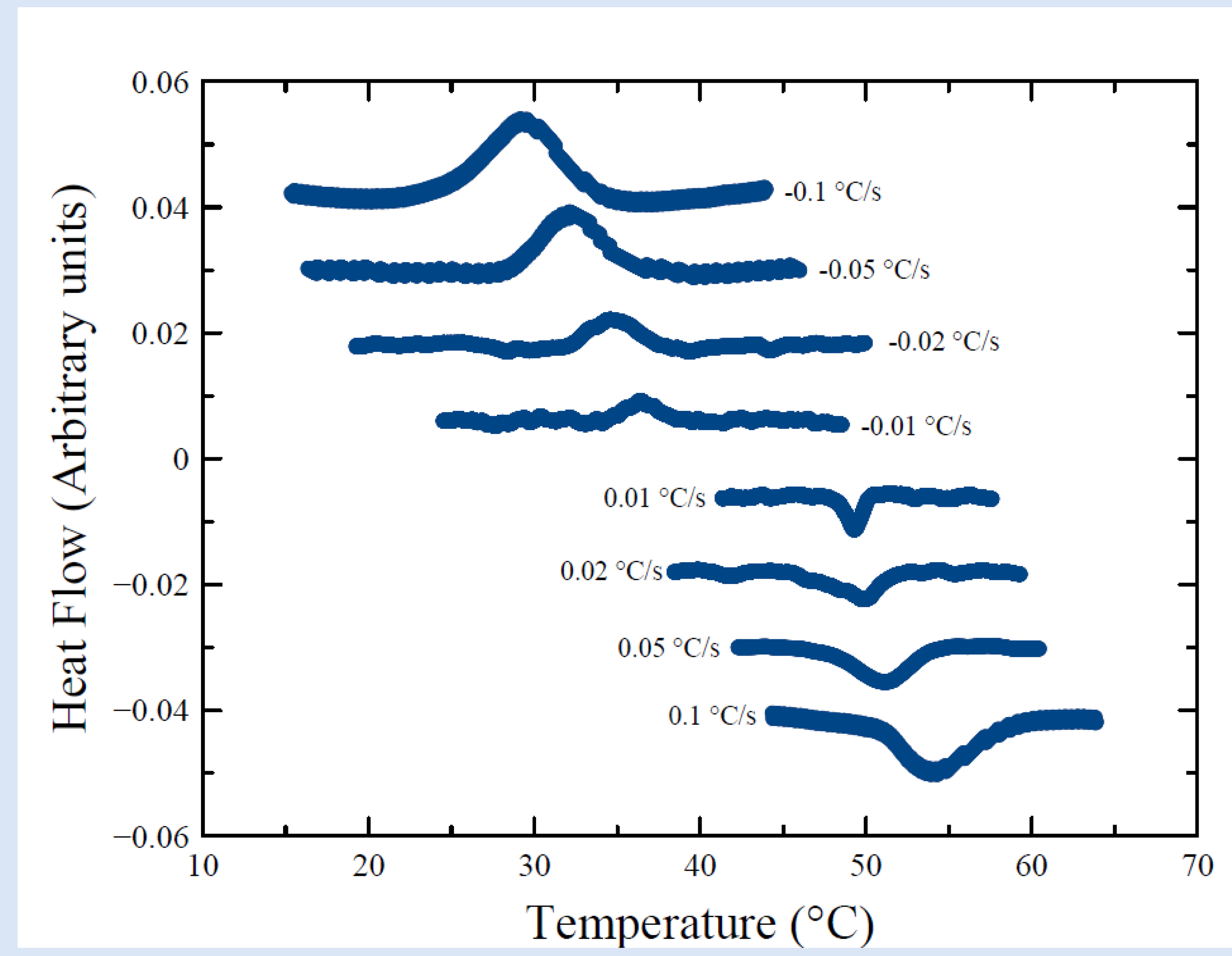


Figure 3. This kinetic phase diagram graph shows how the temperature of the phase transition decreases with increasing sucrose concentrations.

Results

We found that the hysteresis, or the difference of the transition temperature from the equilibrium, follows a very clear trend as shown in Figure 4. The exponent of these fits, which we call β, follows the same dependence on transition temperature as a sister lipid Monoolein (See Figure 5).



Figures 4. The total hysteresis, or difference from the equilibrium phase transition, follows a power law. The β values are the exponent from this fit. Error bars are comparable to the symbol size and so are omitted.

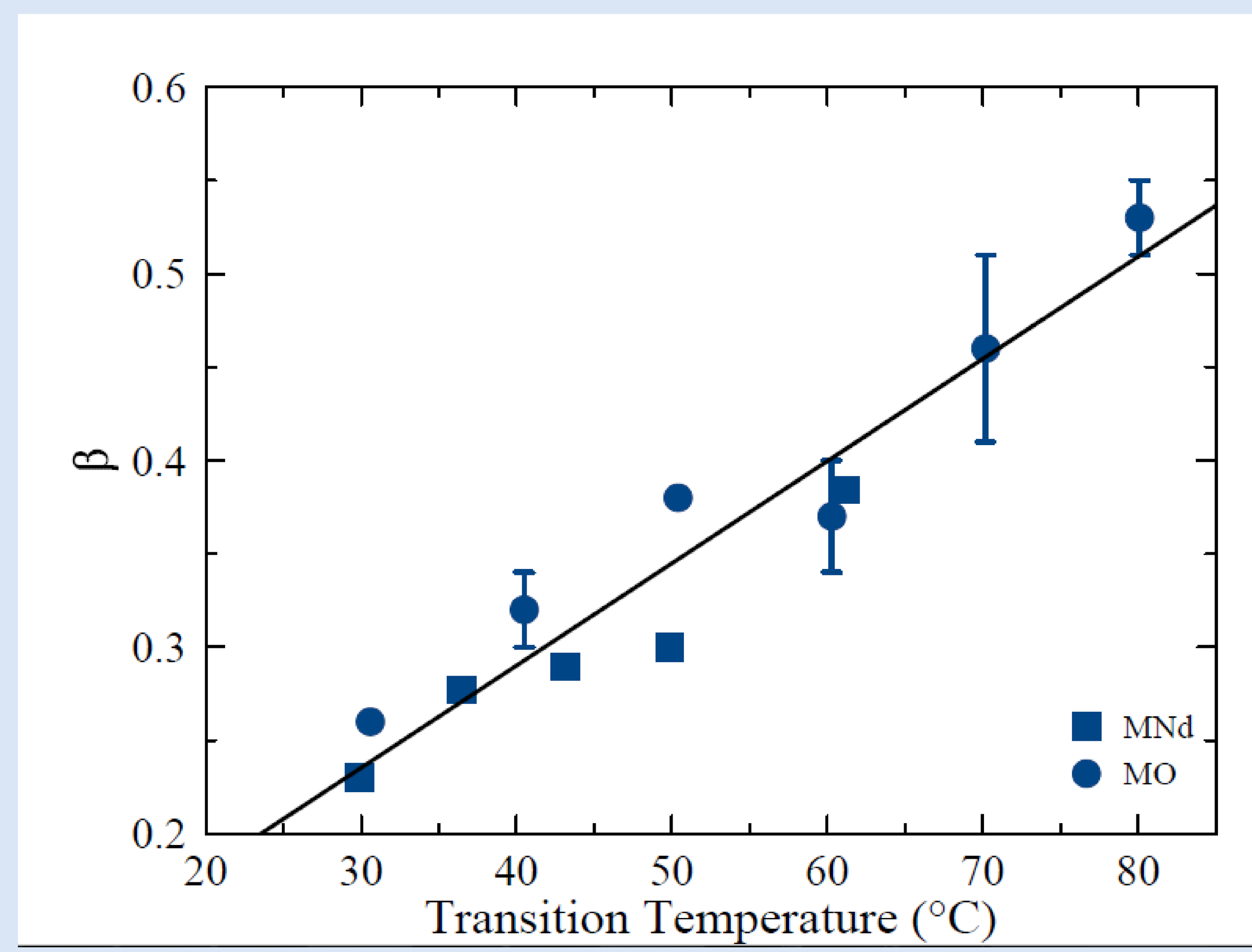


Figure 5. β values of MNd follow the same trend line as the β values of Monoolein. Further work will see if this pattern also true for other lipids and sugars.

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