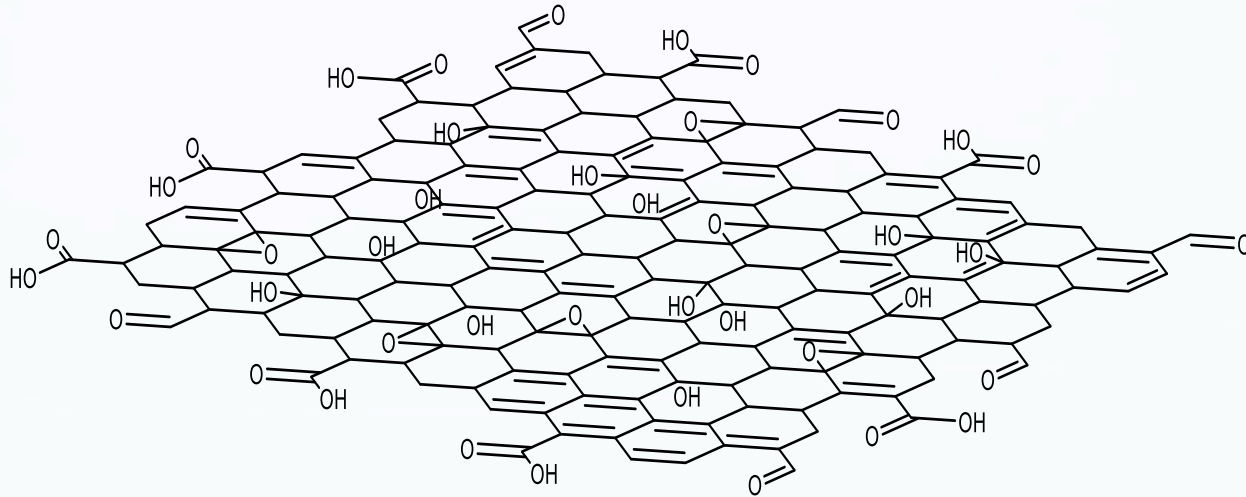


Ice Nucleation using Graphene Oxide

Background

- Ice nuclei increase the temperature at which water freezes
- Exact properties of an ice nuclei are unknown but some are considered more important than others
 - Hydrophobicity
 - Structure
- Aim is to synthesize a molecule that can show the desirable properties of an ice nuclei
- Applications: Atmospheric science, cryopreservation, cryomedicine, cryosurgery, freeze-drying of pharmaceuticals, and food science

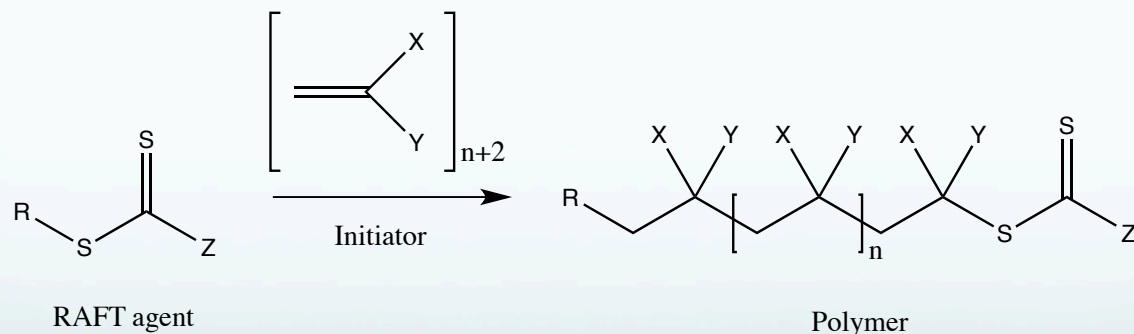
Why Graphene Oxide?



- Crystallographic match
- Large surface area
- Shown to have slight nucleating potential alone
- Able to functionalize

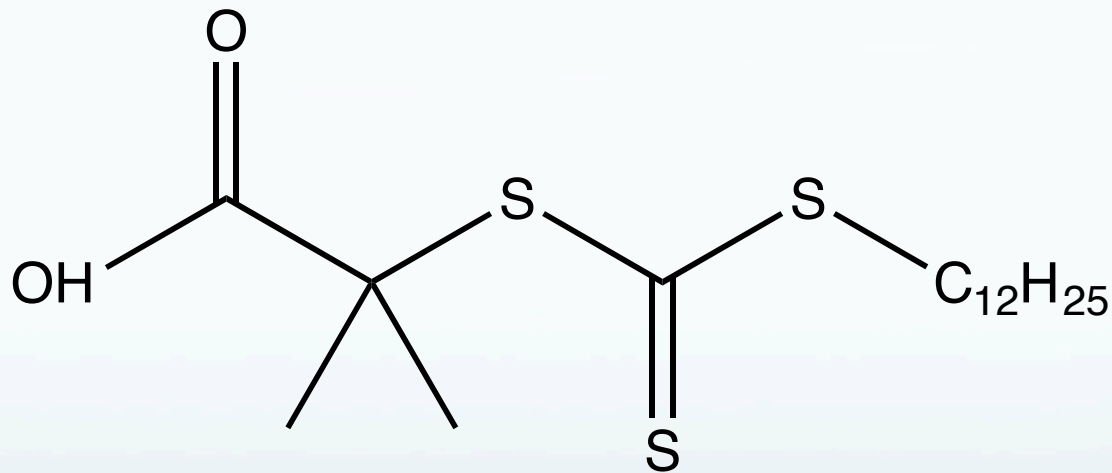
Grafting to Graphene Oxide

- Ring opening of epoxides on surface by reactive thiols
- Polymers can be synthesized with a thiol end group using RAFT

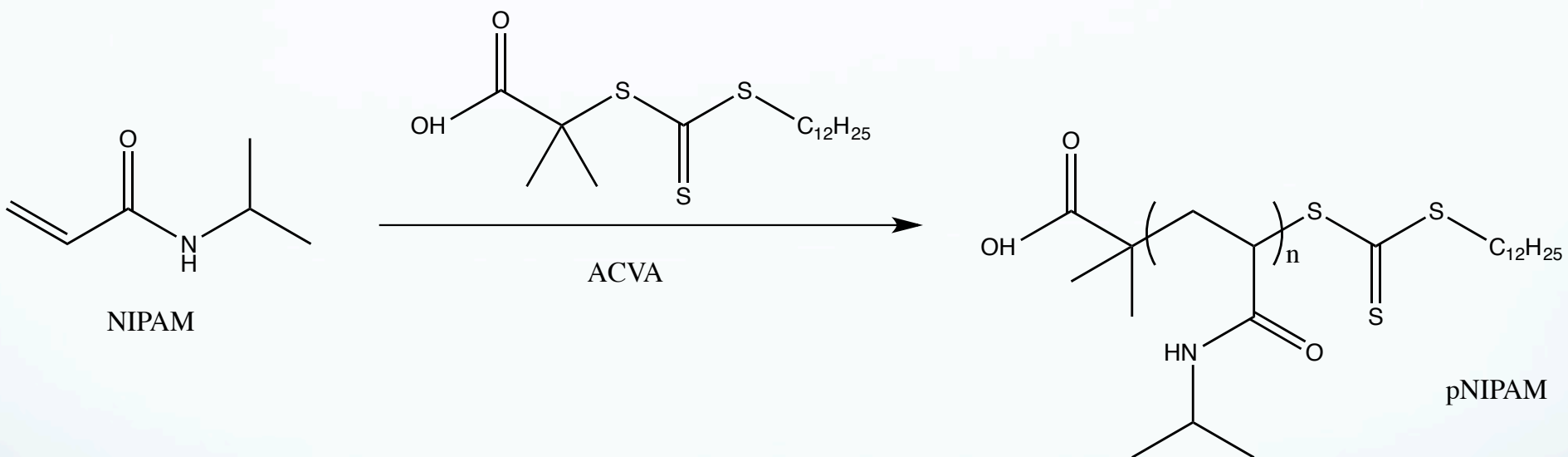


Polymer Synthesis

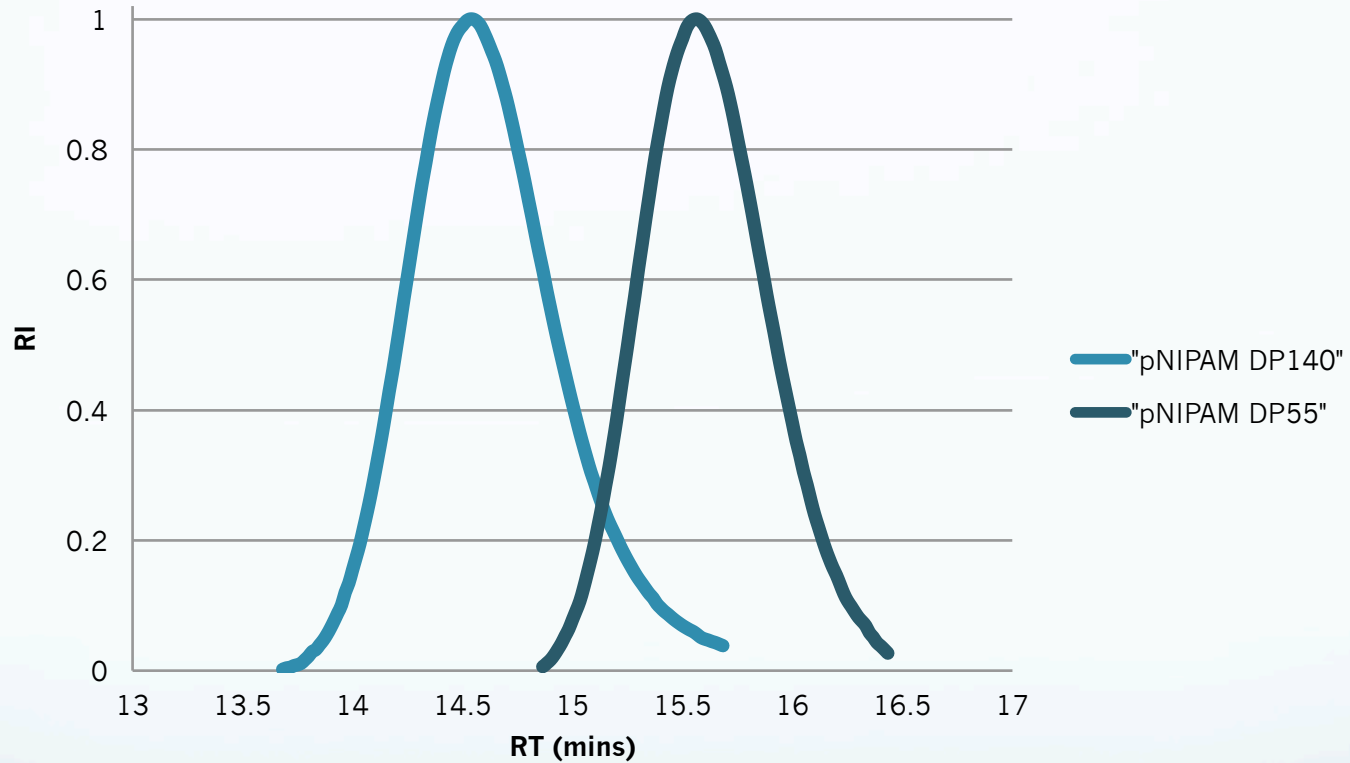
- First, synthesized RAFT Agent, 2-(dodecylthiocarbonothioylthio)-2-methylpropanoic acid (DMP)



- Used the RAFT agent to synthesize pNIPAM

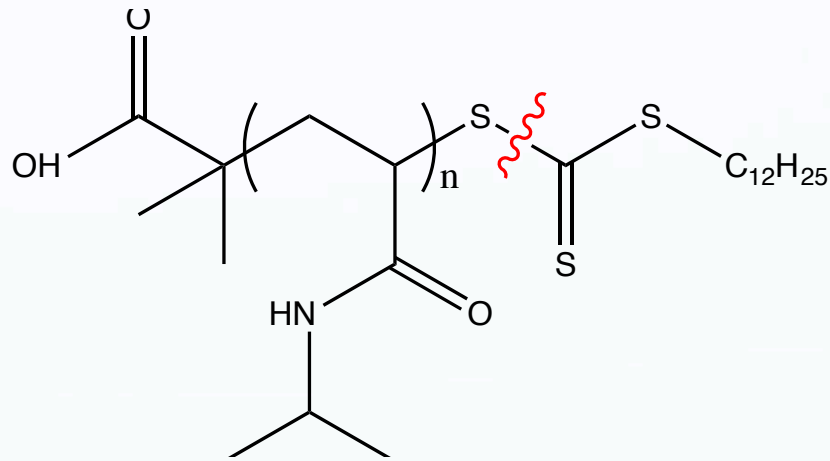


GPC Data



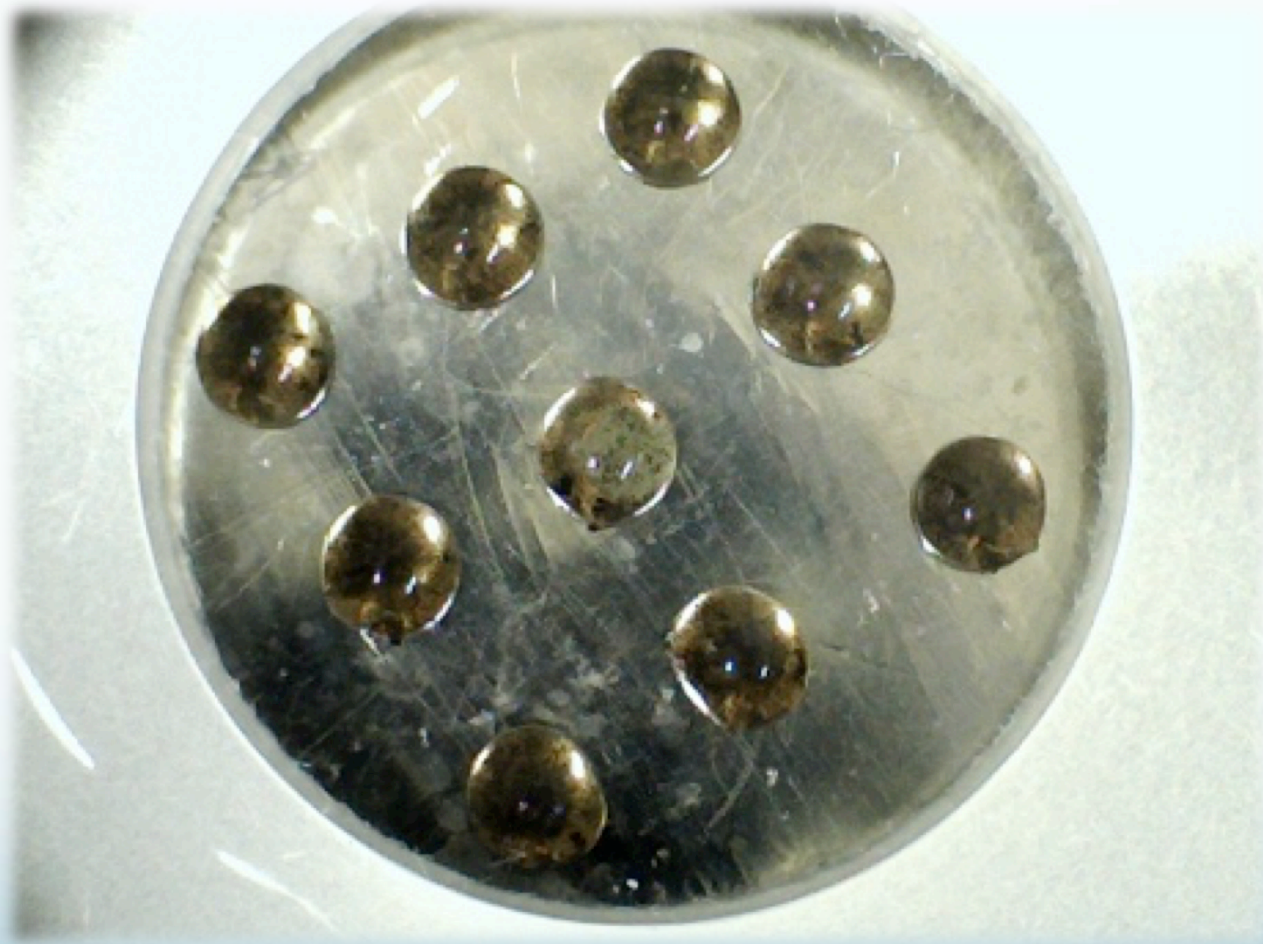
Polymer	Mp	Mn	Mw	Mz	Mz+1	Mv	PD
pNIPAM DP140	17781	15673	17361	18967	20497	18736	1.107701142
pNIPAM DP55	6823	6202	6699	7188	7660	7117	1.08013544

Grafting samples to Graphene Oxide



- Cleave at the terminal thiol, then reactive thiol can attack at the epoxide groups on the surface.
- Cysteine and Dodecanethiol were also grafted to GO, initially as controls

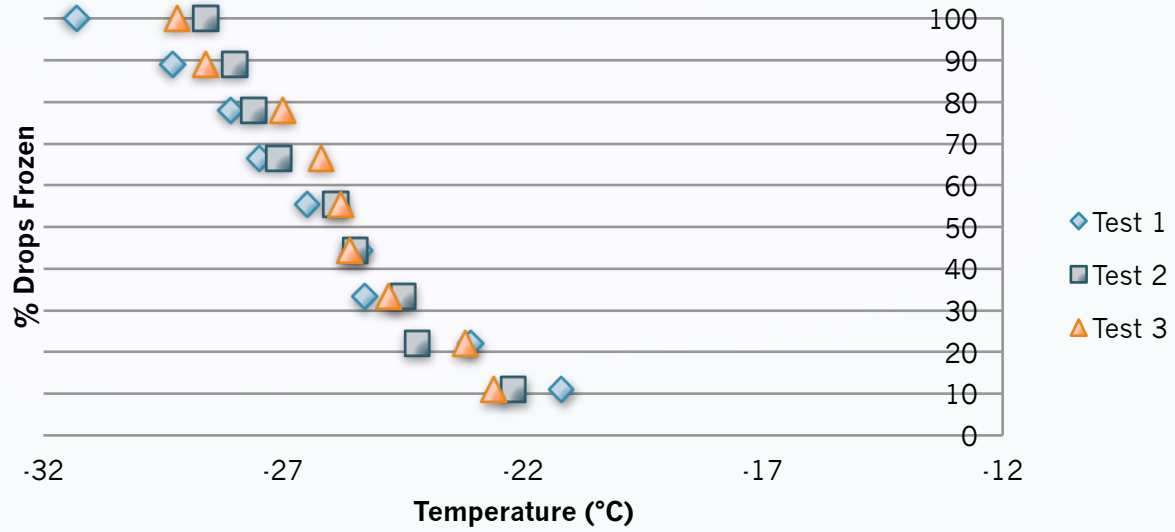
Ice Nucleation Assay



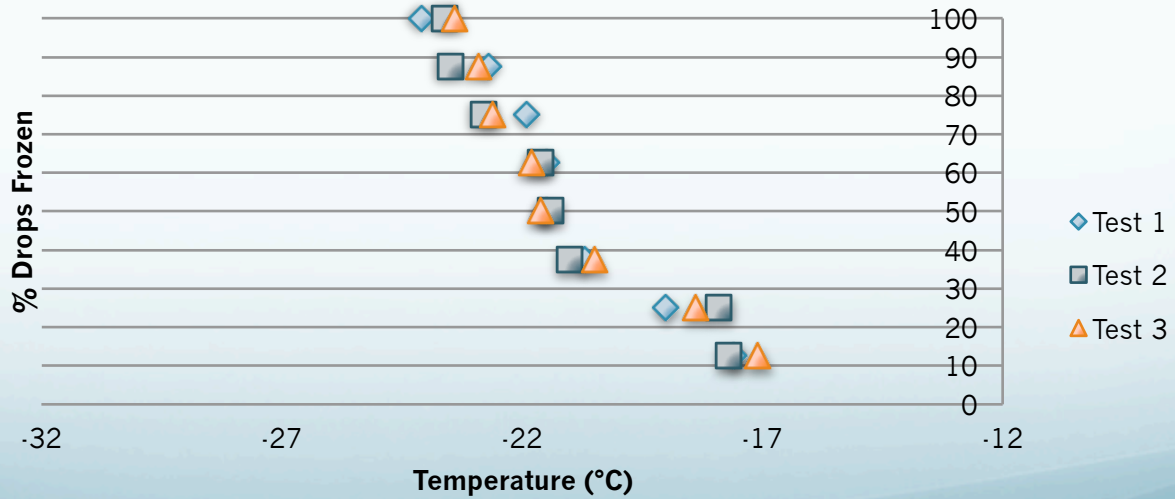
Ice Nucleation Assay



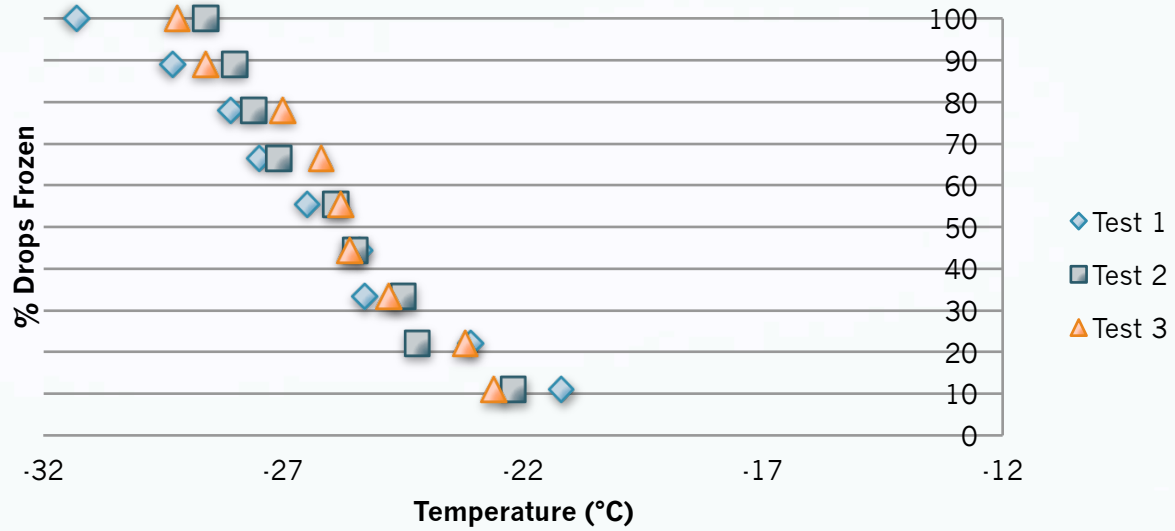
Milli Q Water



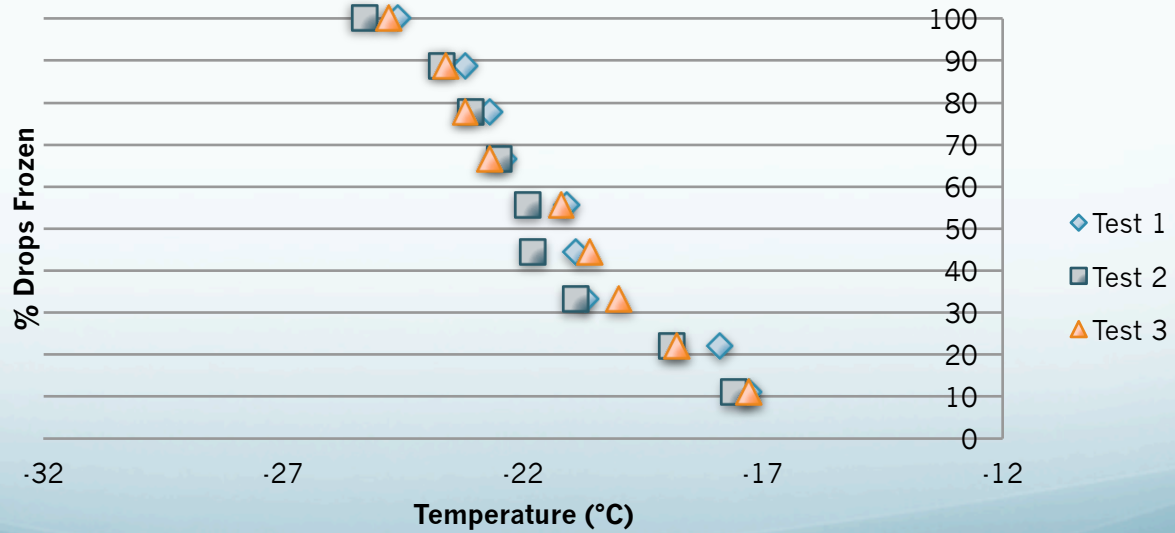
Tap Water



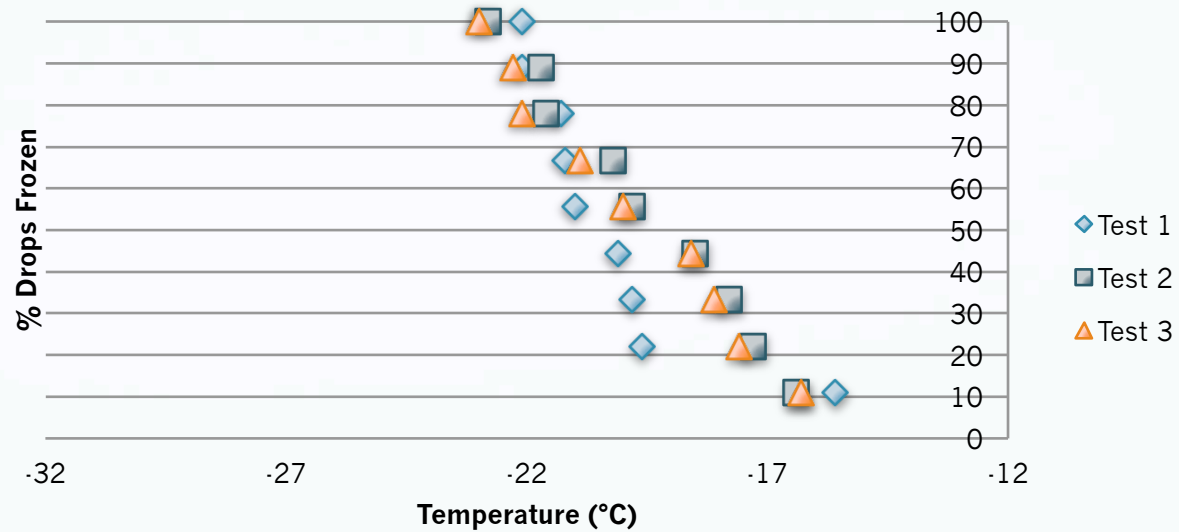
Milli Q Water



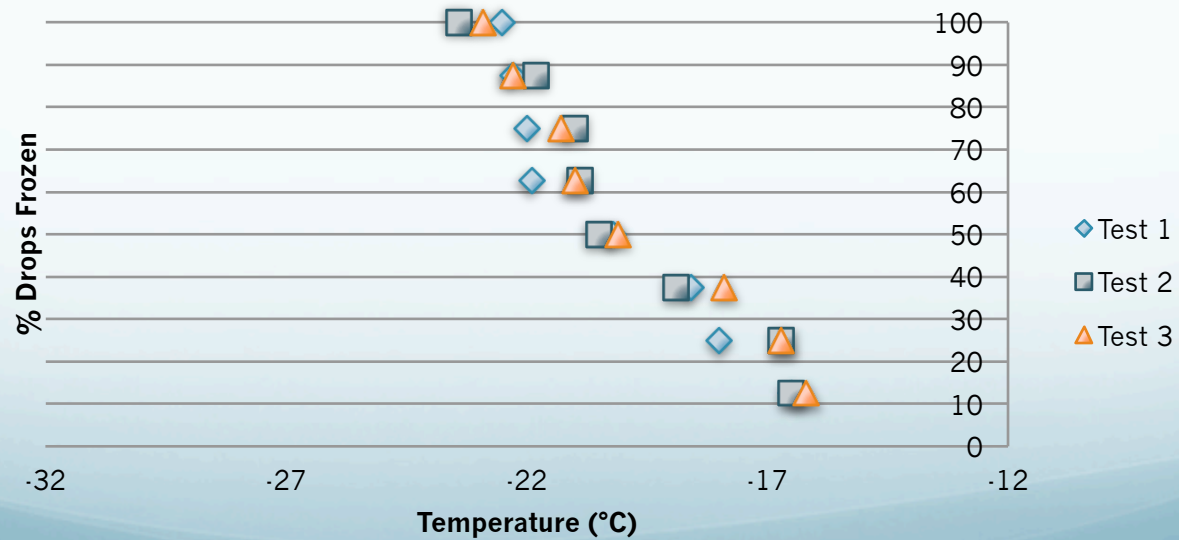
GO (2.5mg/ml)



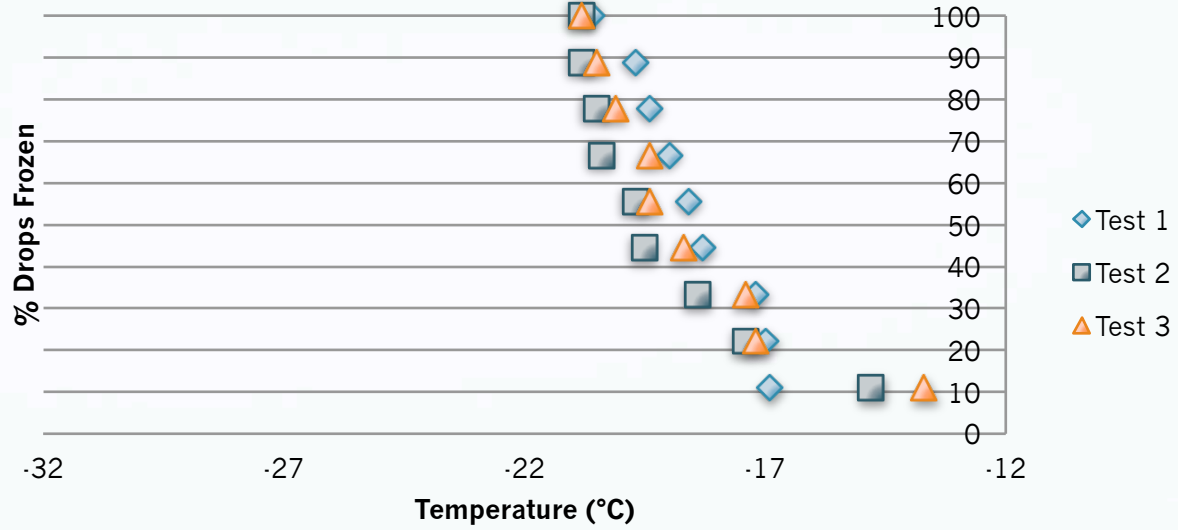
GO-pNIPAM 140 (2.5mg/ml)



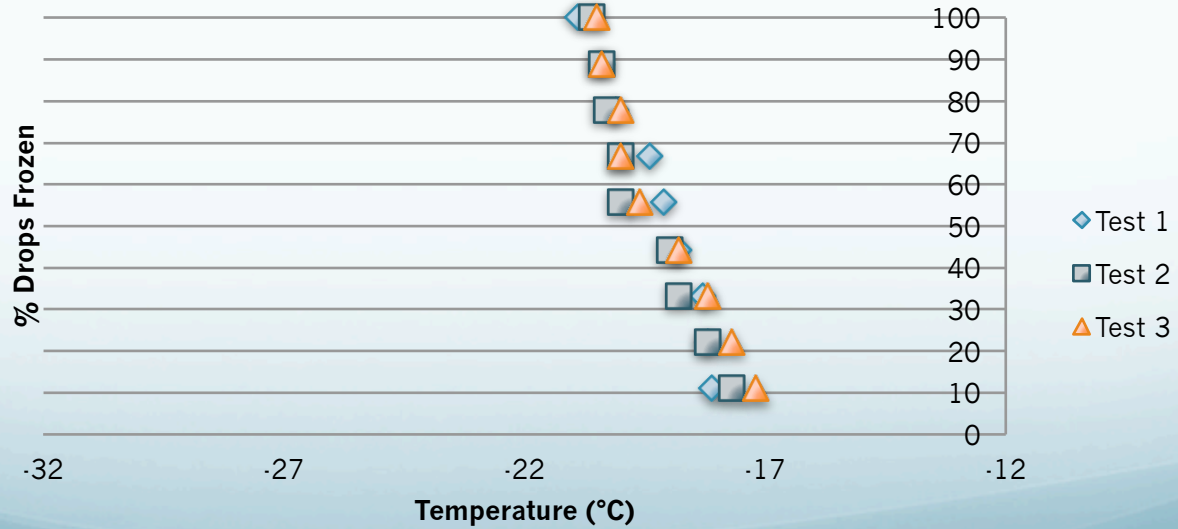
GO-pNIPAM 55 (2.5mg/ml)



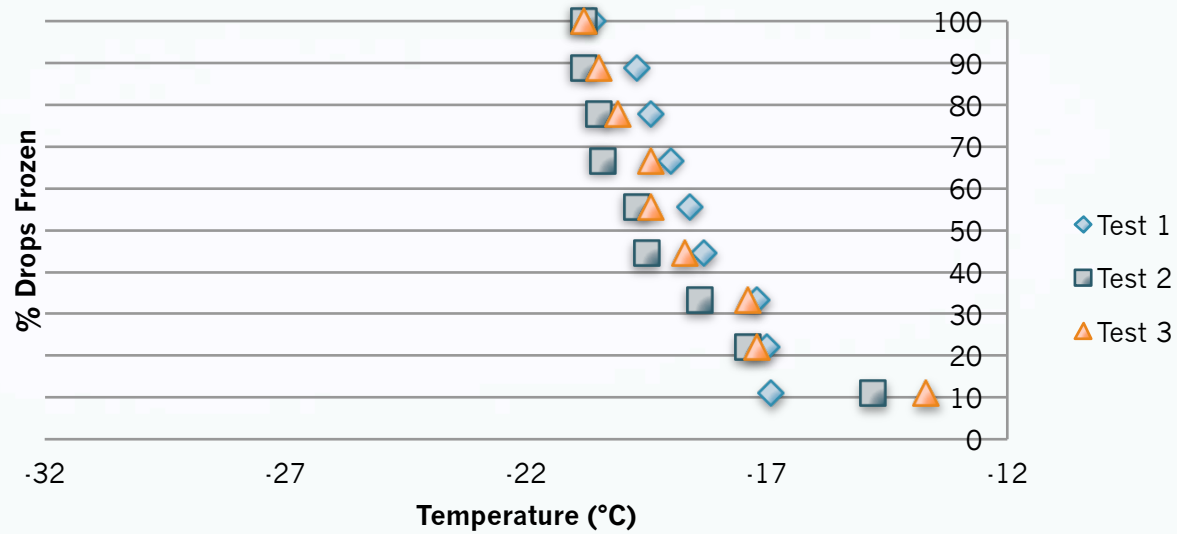
GO-DDT (2.5mg/ml)



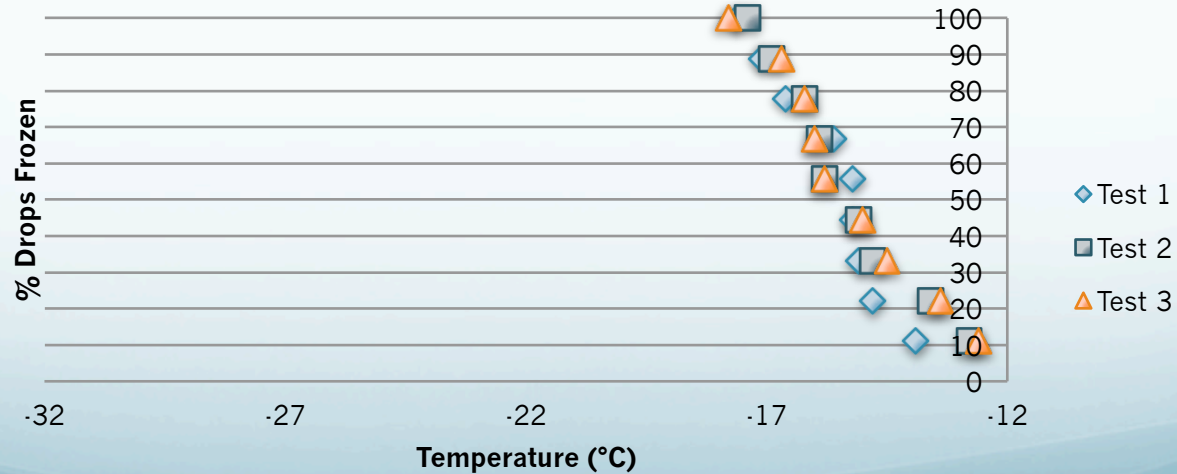
GO-Cysteine (2.5mg/ml)



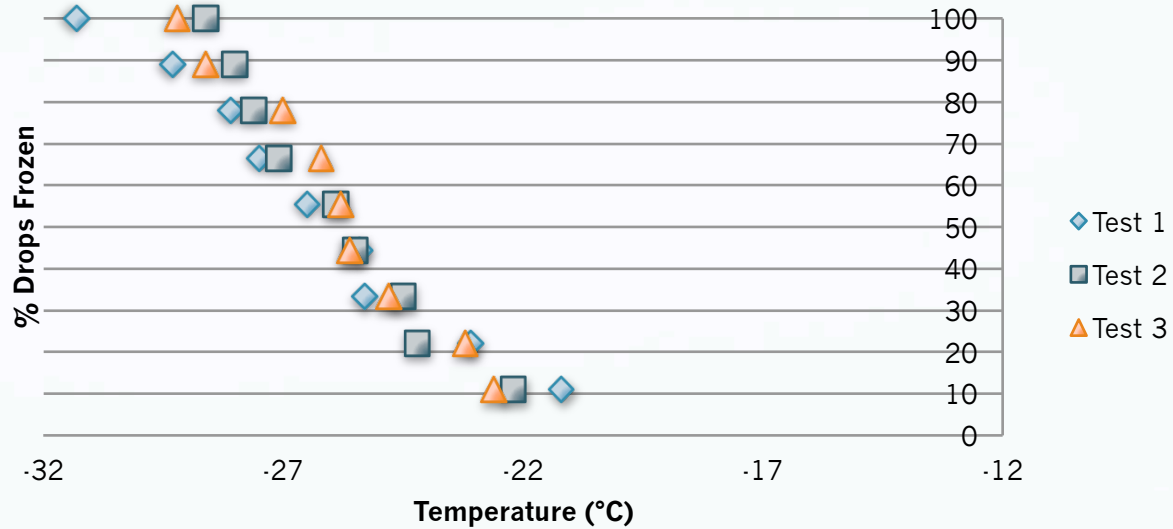
GO-DDT (DMF Solvent) (2.5mg/ml)



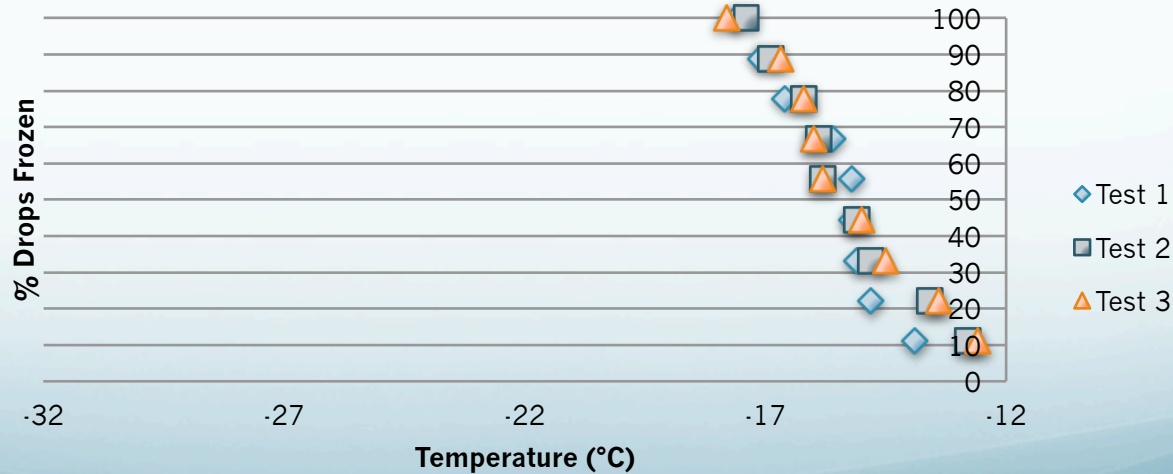
GO-DDT (Acetonitrile solvent) (2.5mg/ml)



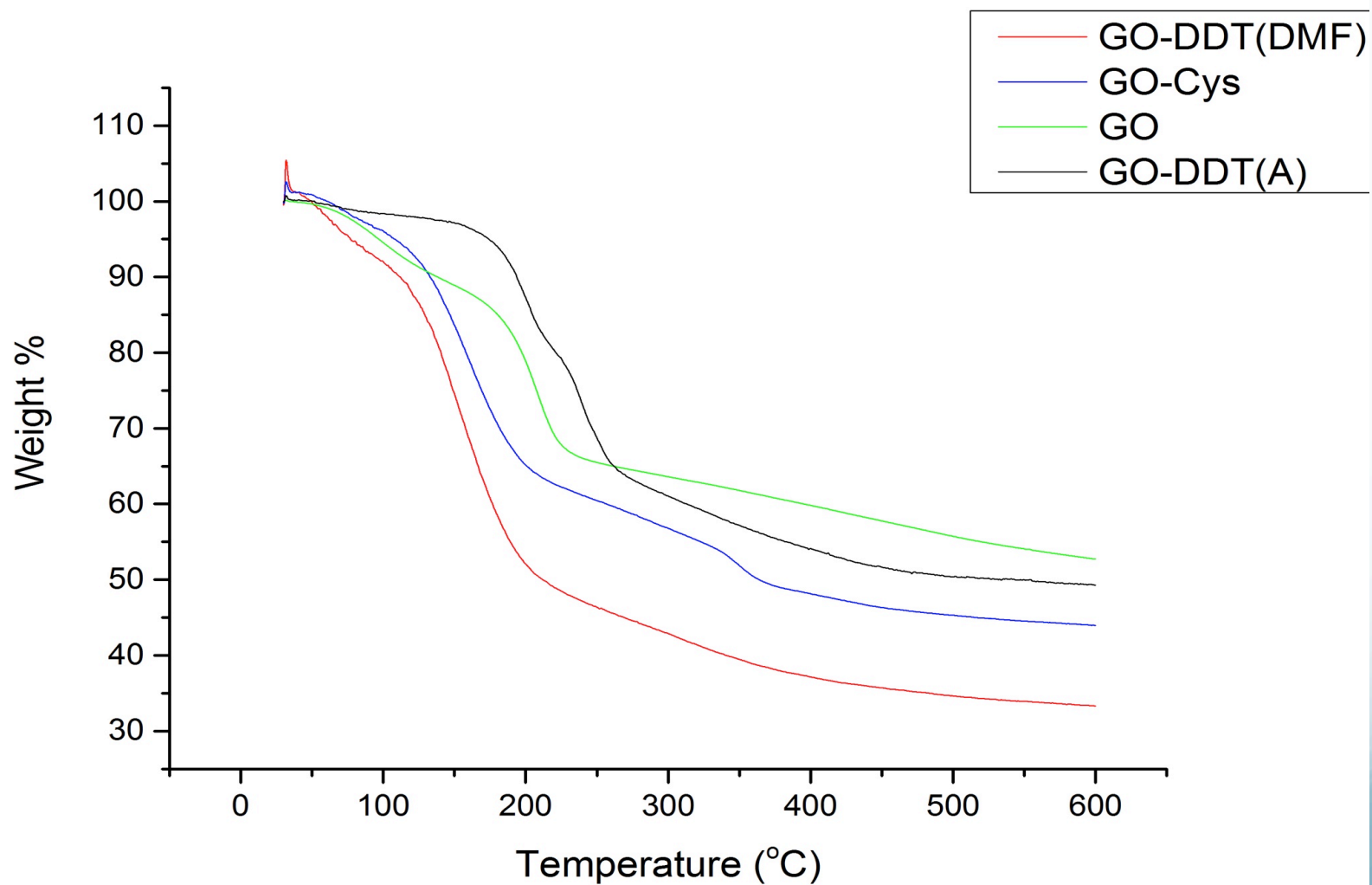
Milli Q Water

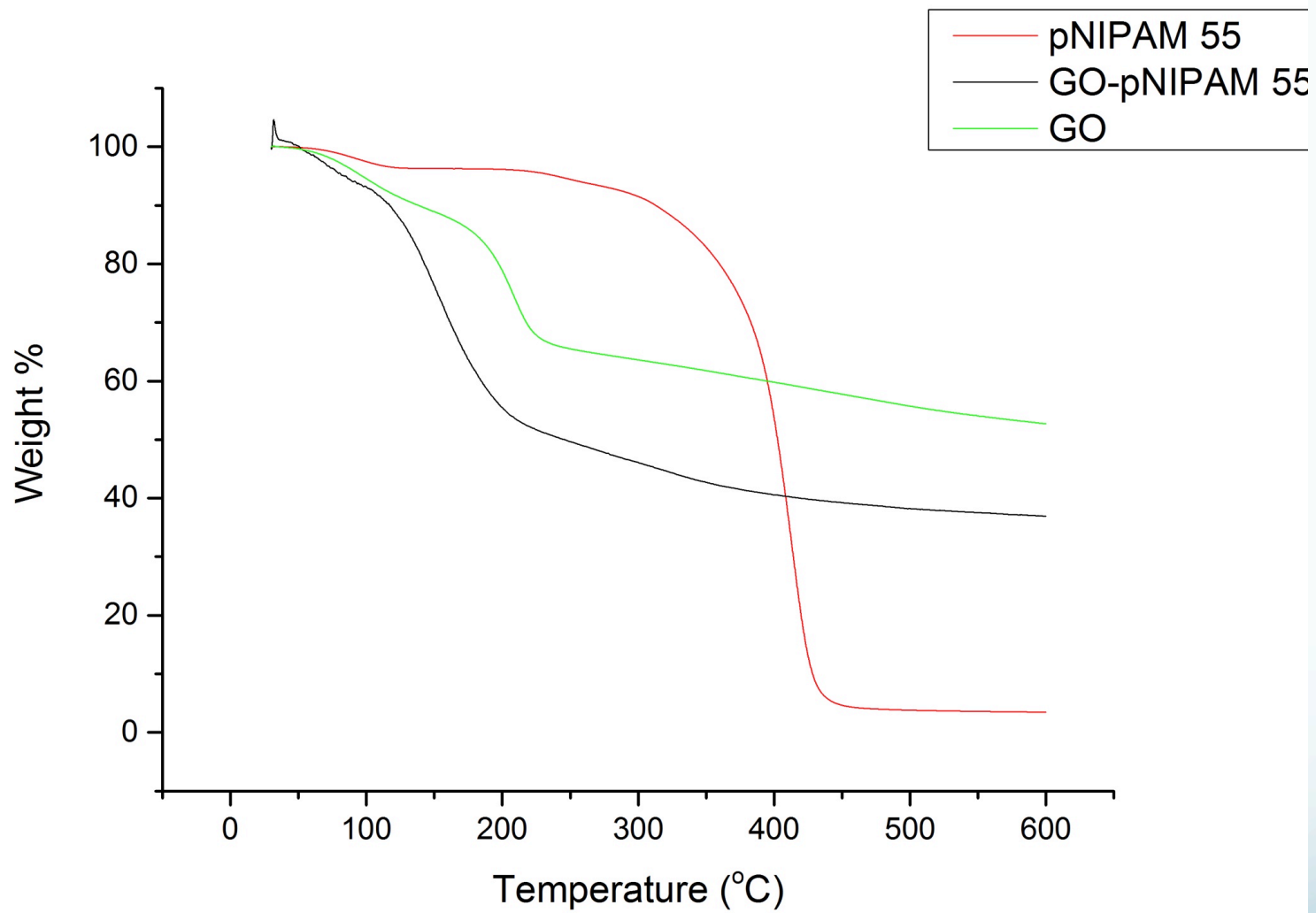


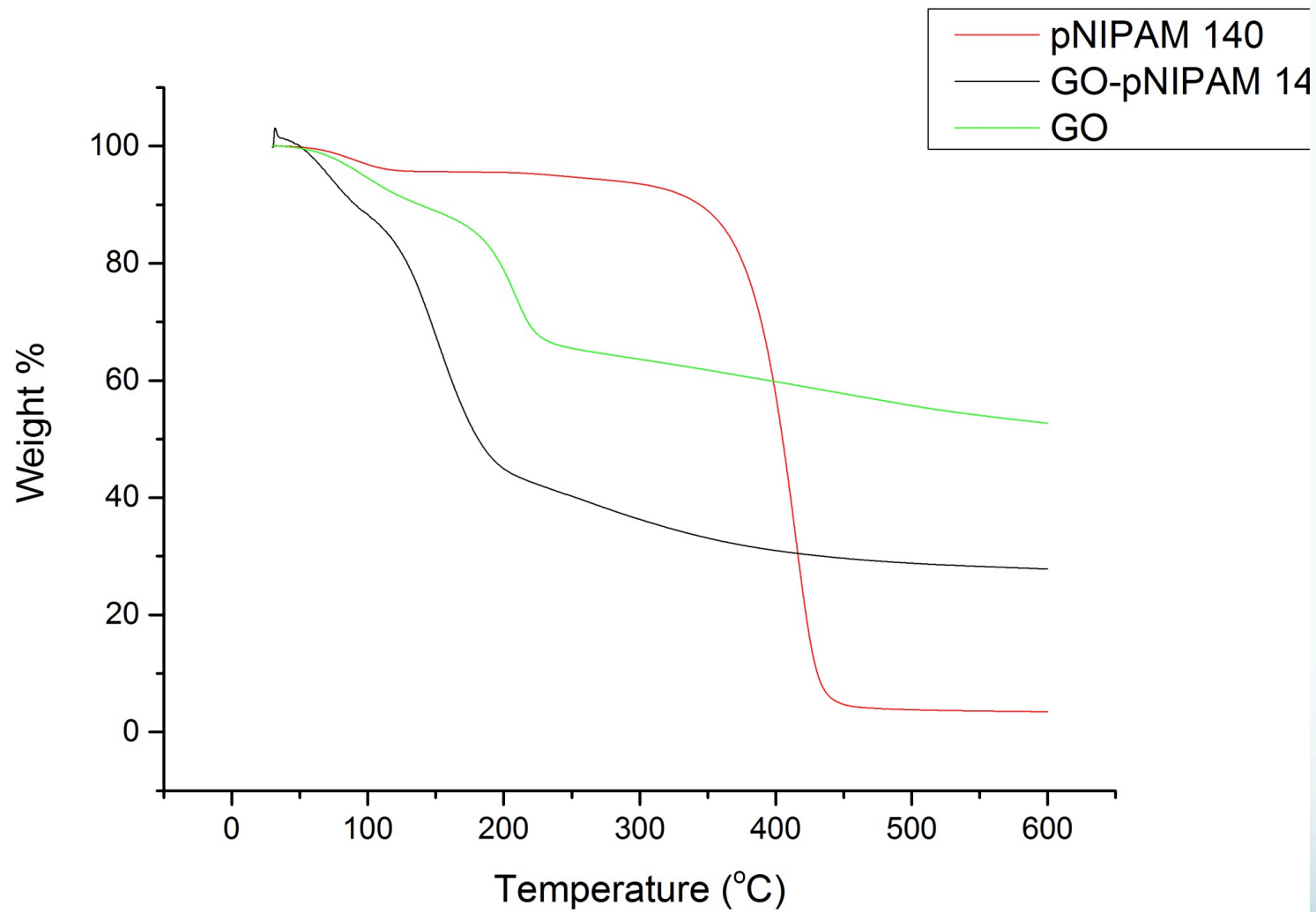
GO-DDT (Acetonitrile solvent) (2.5mg/ml)

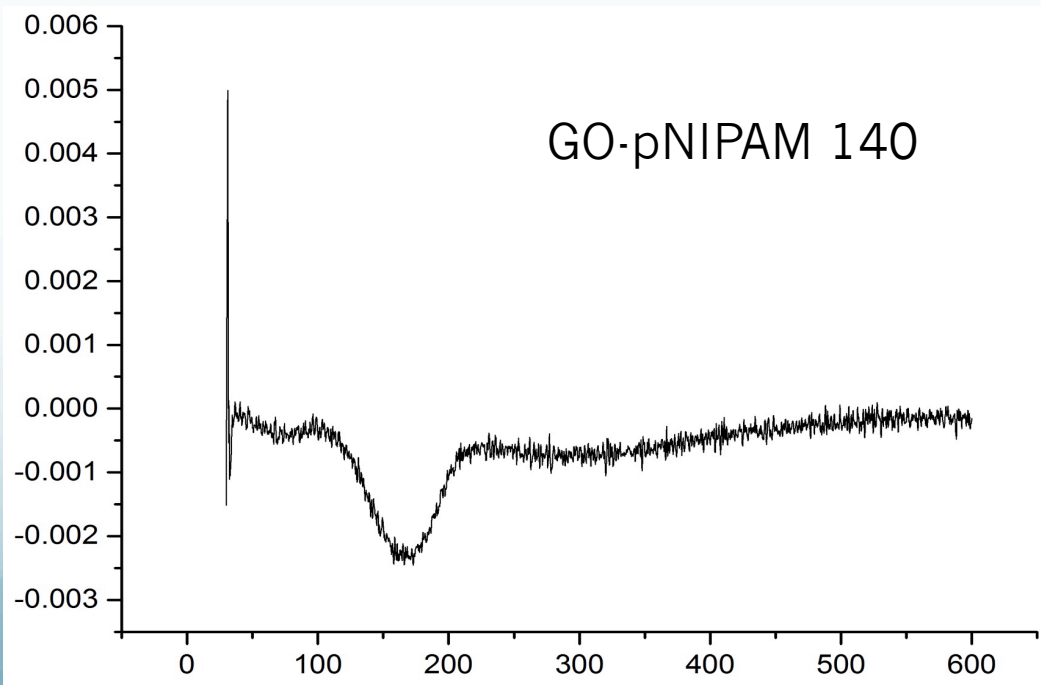
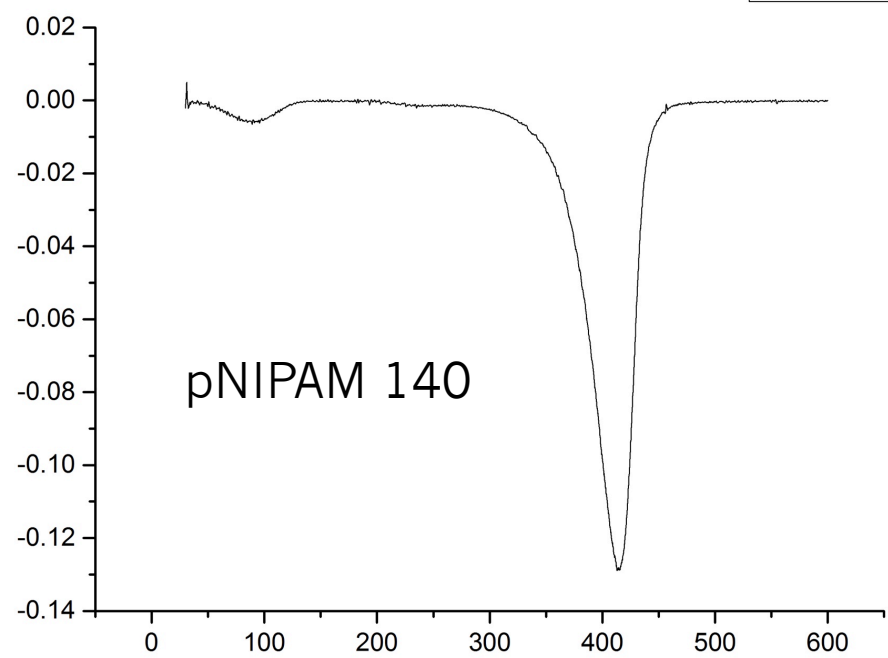
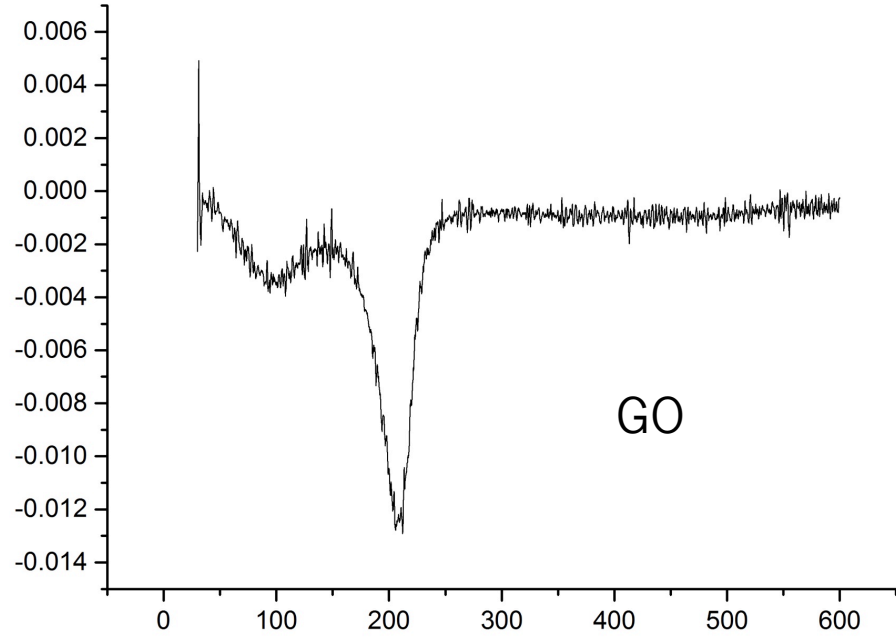


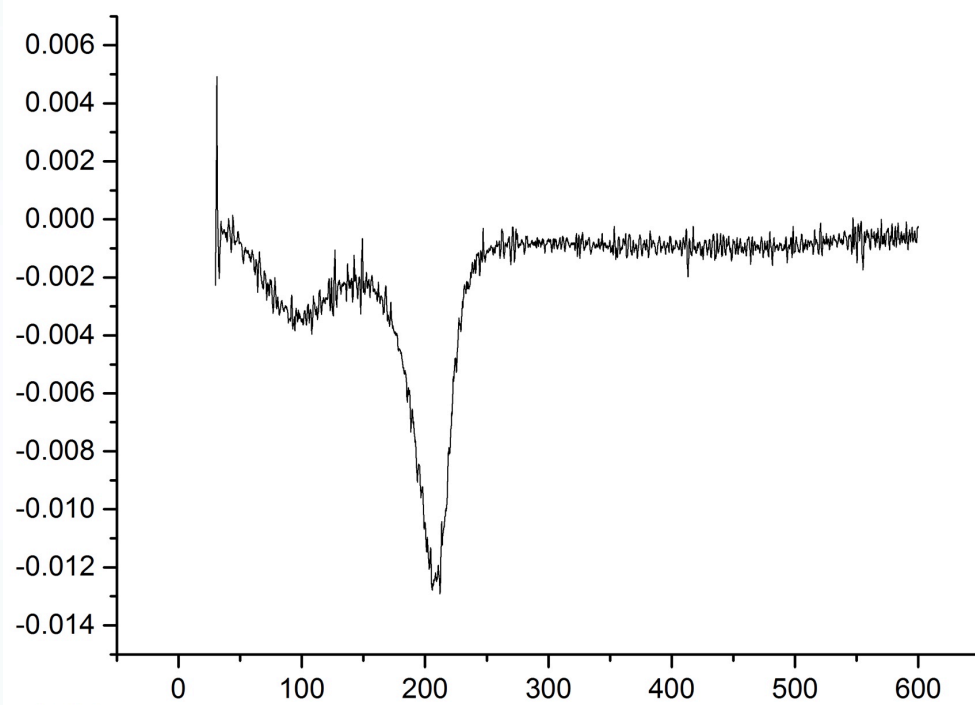
TGA Data



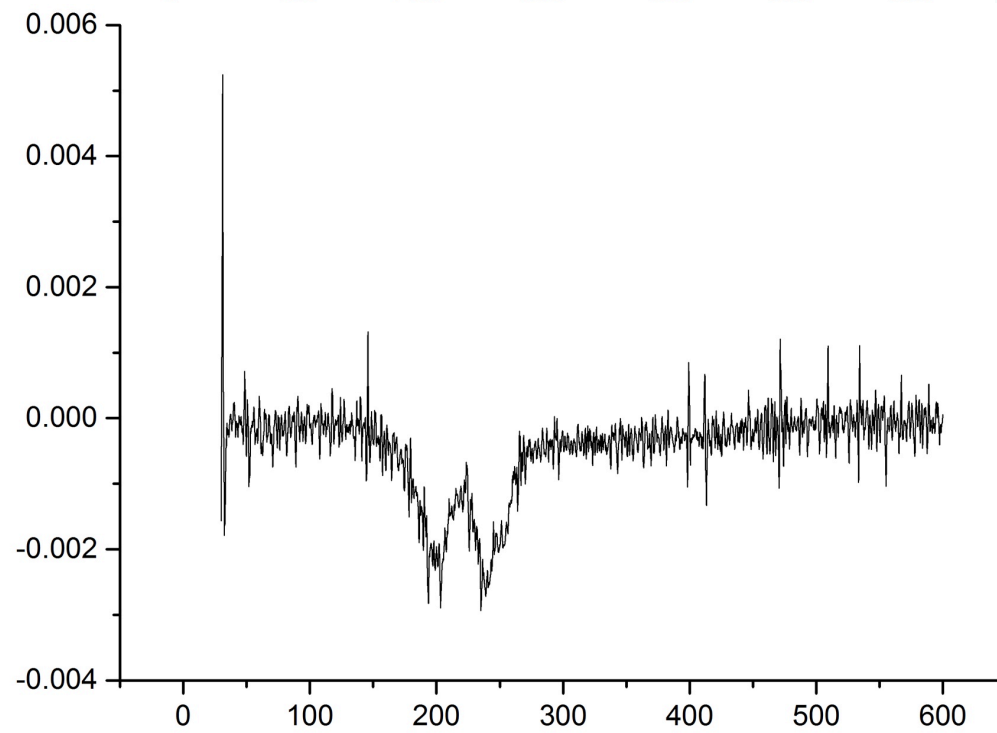








GO



GO-DDT(A)

Future Work

- Look at the properties of Dodecanethiol which may indicate good ice nuclei (hydrophobicity, chain length)
- Grafting hexanethiol and octadecanethiol to graphene oxide
- Find away to do the nucleation assays at a higher concentration

Acknowledgements

- Gibson Group
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- Davies Group