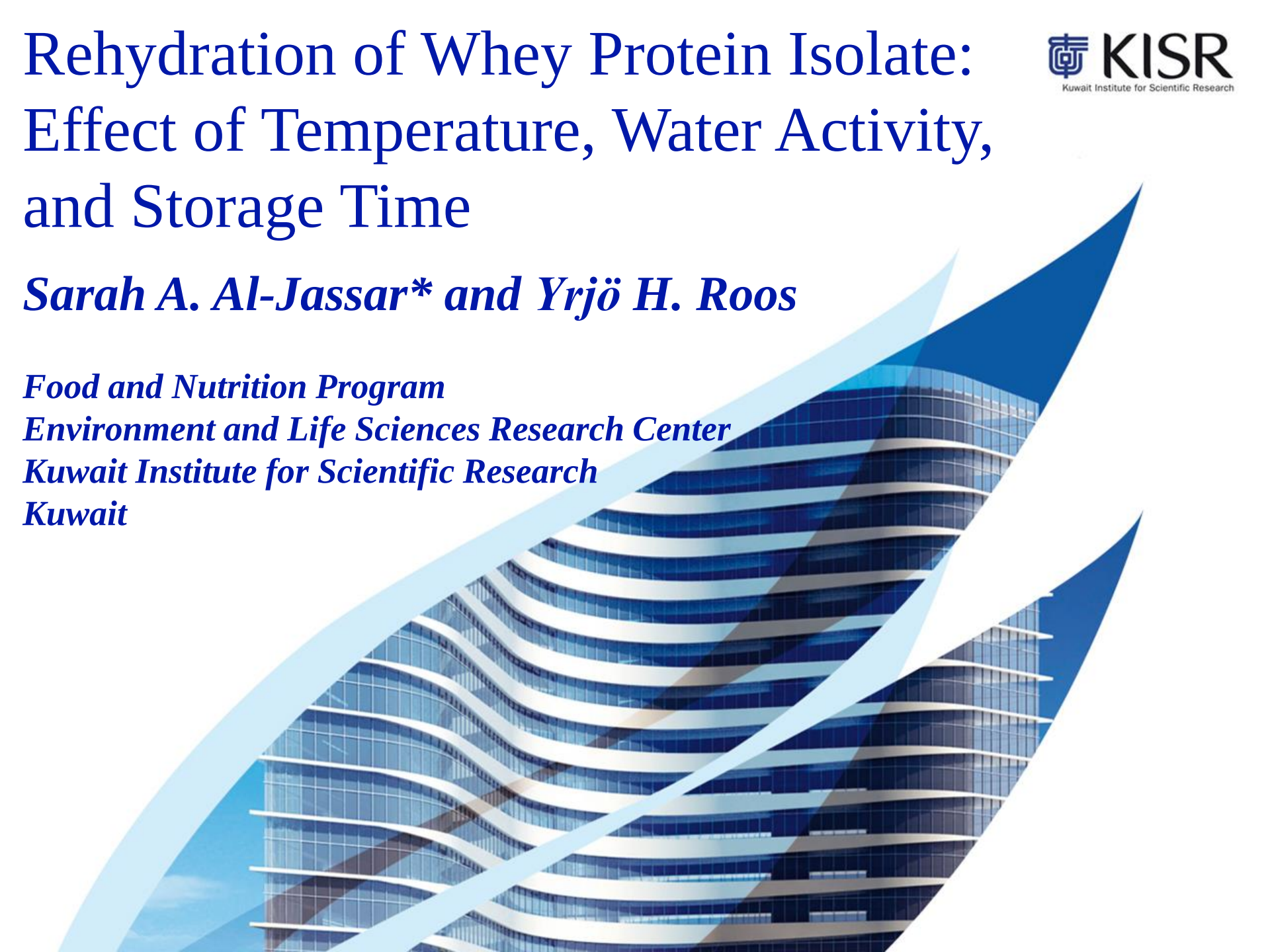
Rehydration of Whey Protein Isolate: Effect of Temperature, Water Activity, and Storage Time

Sarah A. Al-Jassar* and Yrjö H. Roos

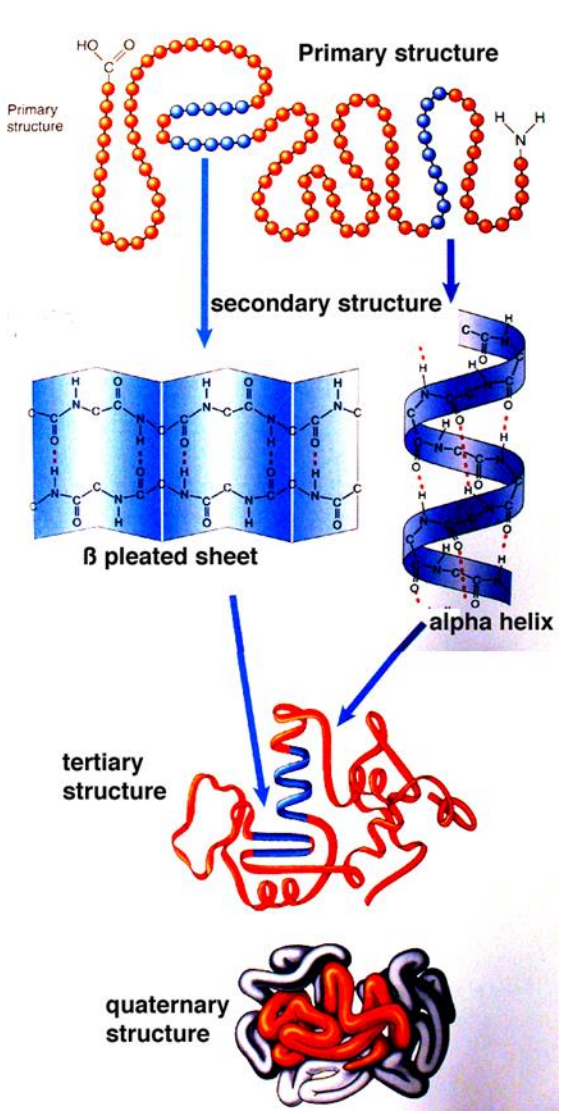
Food and Nutrition Program
Environment and Life Sciences Research Center
Kuwait Institute for Scientific Research
Kuwait



Contents

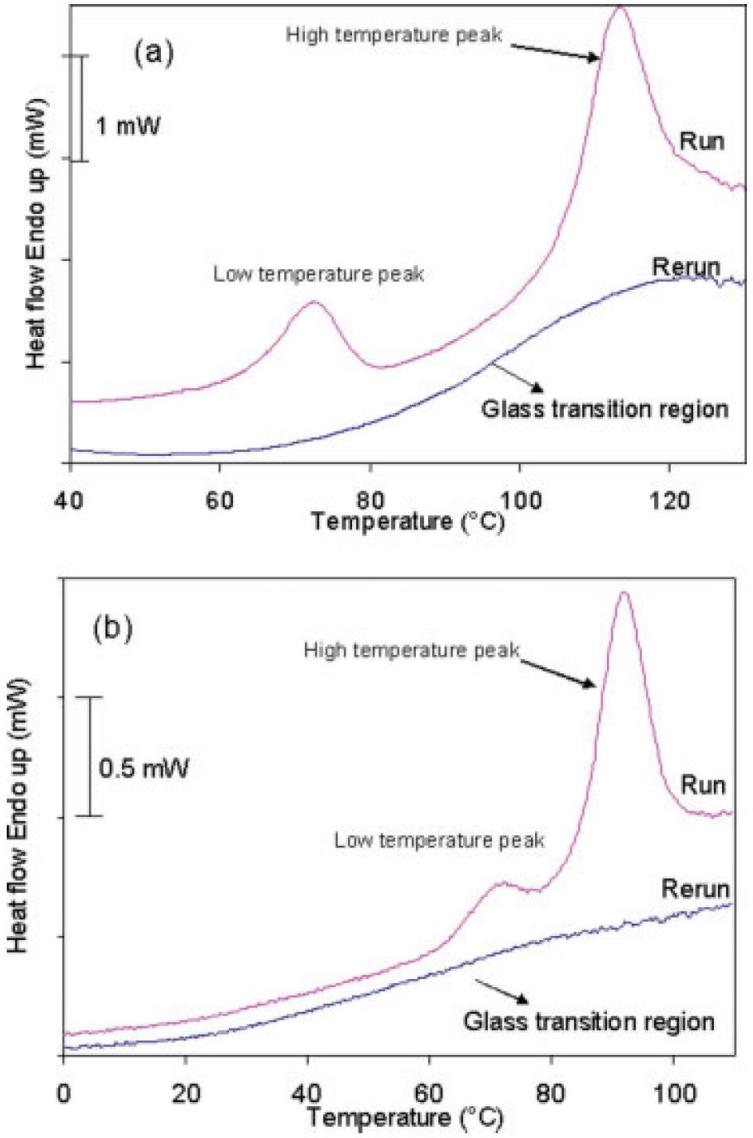
- Background
  - Thermal properties and water sorption
- Experimental Design
  - Sample preparation
  - Differential Scanning Calorimetry
  - Water activity
  - FTIR Spectroscopy
  - Viscosity
- Results and Discussions
- Conclusions

Background



- Hydration properties of whey protein powders are poorly understood
- Conformational changes occur at ambient conditions during storage
- Such structural changes may increase the hydrophilic area resulting in a decrease water activity of WPI
- Various physco-chemical properties are dependent on temperature and water content

Thermal Properties of Proteins



- Biological polymers often show a low temperature endotherm that appears below glass transition
- Farahnaky et al. (2005) interpreted such endotherm in bovine serum albumin as enthalpy relaxation
- Potes and Roos (2015) explained such time-dependent endotherm as hydration/dehydration of protein.

Farahnaky et al. (2005), Biopolymers 78, 69–77.

Objectives

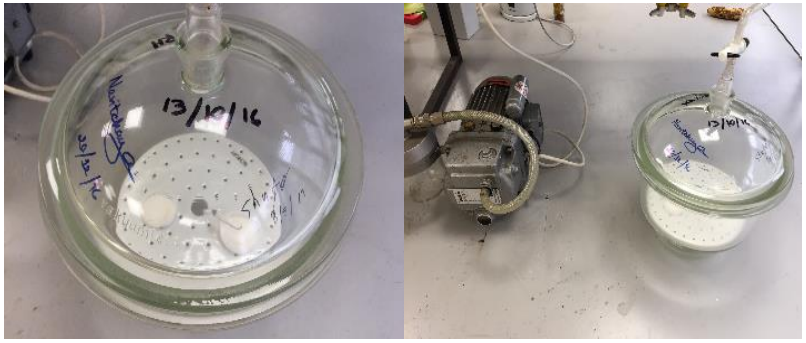
- To understand the hydrodynamics of water-protein behavior on the reversible endothermic transition
- To understand the effect of storage time and temperature on WPI conformational structure

Whey protein isolate (WPI)

Experimental

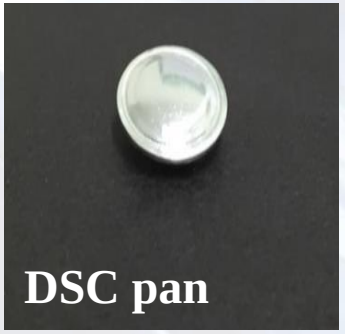
WPI powder with various a_w was prepared using saturated salt solutions in humidified vacuum sealed desiccators at RT

Vacuum Desiccator



Differential Scanning Calorimetry (DSC)

WPI samples with different a_w
Heat-scanning: -20°C - 50°C, 5°C/min with 2 cycles.
Repeated after storing at RT for 7d.

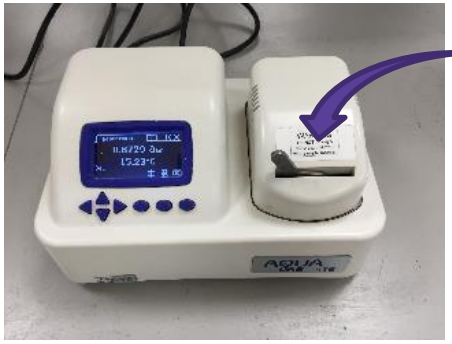


DSC pan

Experimental

Water Activity Measurement

WPI samples with various a_w.
Temperature range 20°C-50°C at 5°C intervals for 3 cycles of heating-cooling.
Repeat after storing for 7d &14 d at RT

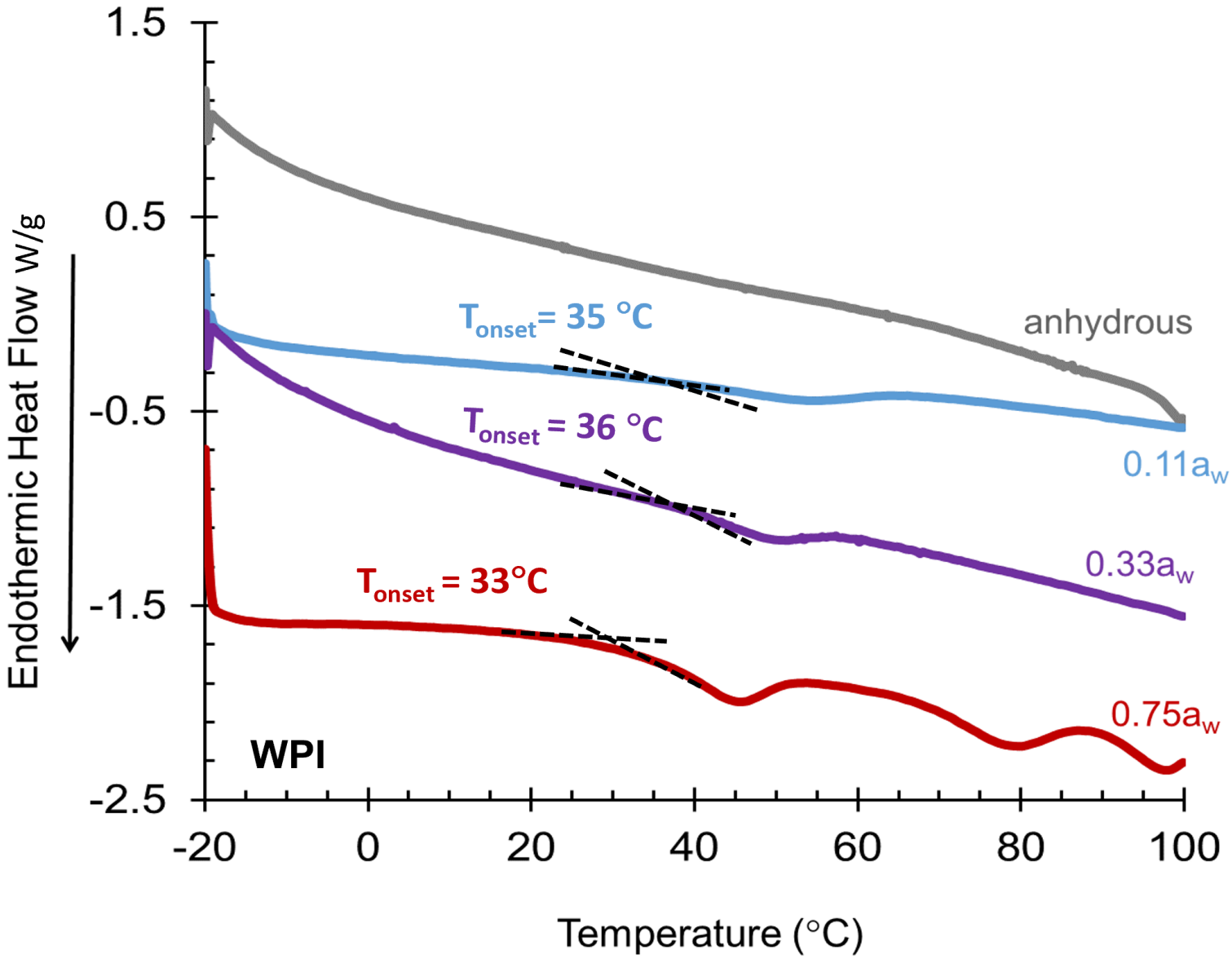


Apparent Viscosity

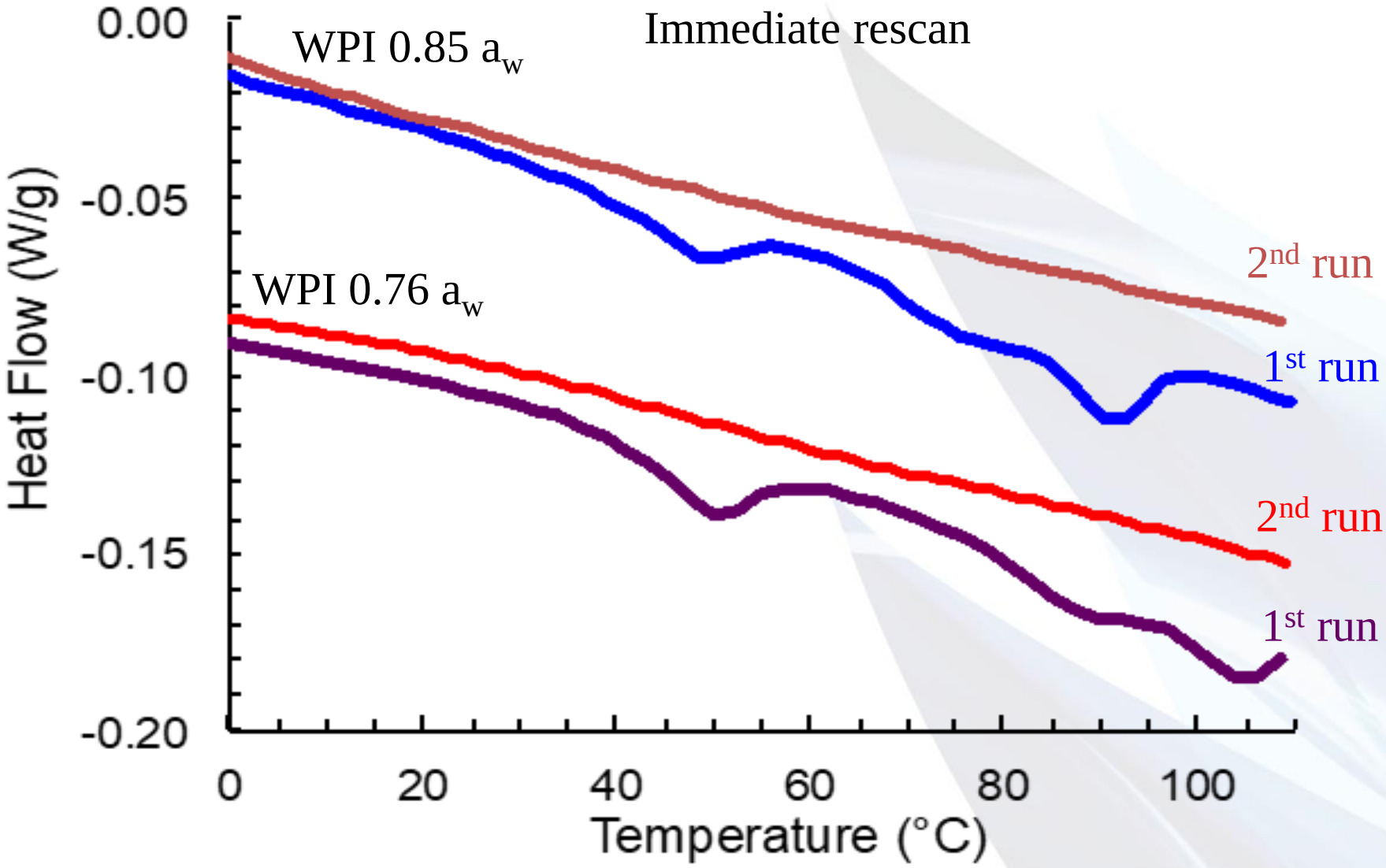
Sample: WPI powder dispersed in water (5% - 40%, w/w), mixed for 1 h at 5°C -50°C.
Shear rate: 250 s^{-1}

Results and Discussions

Thermal analysis (DSC)



Thermal analysis (DSC)

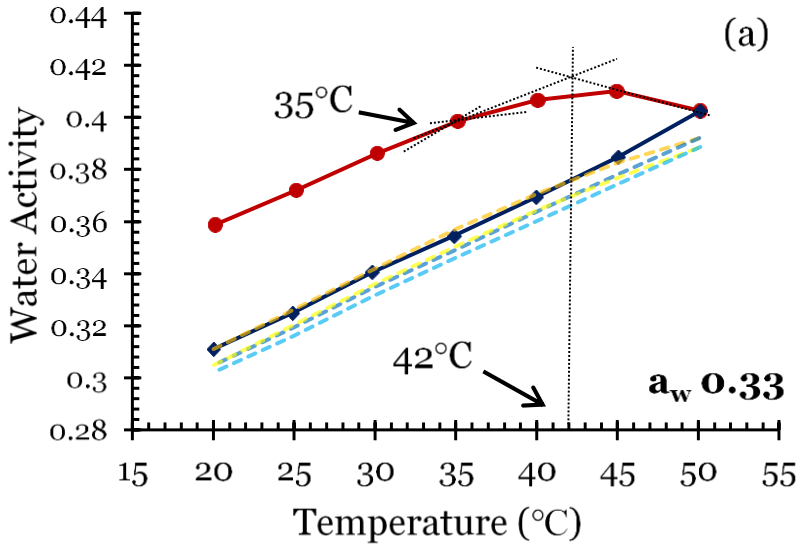


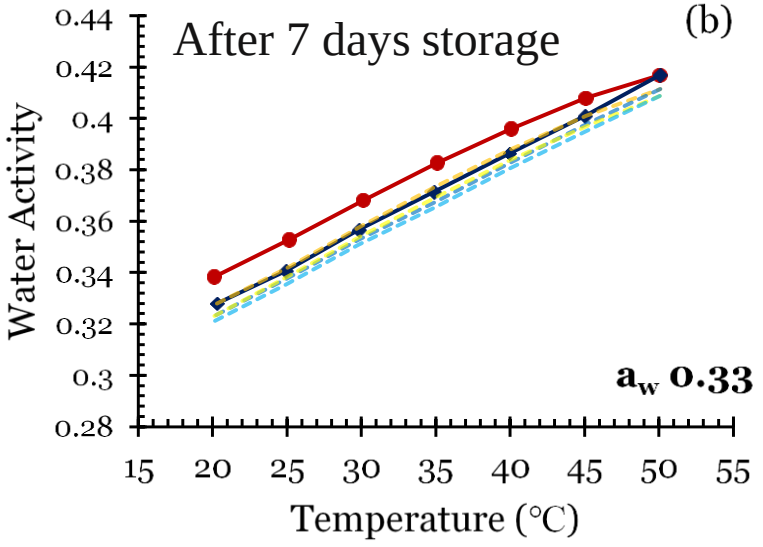
Thermal analysis (DSC)

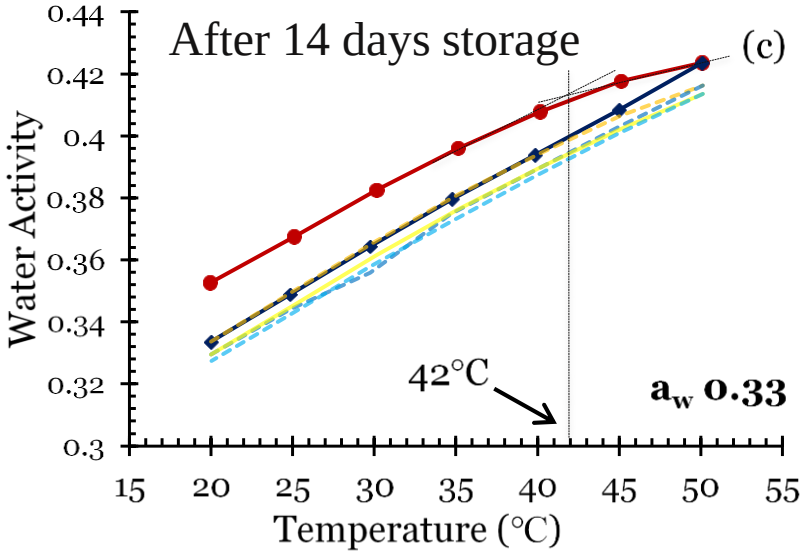
WPI scanned up to 50 °C, and again after 7 days storage

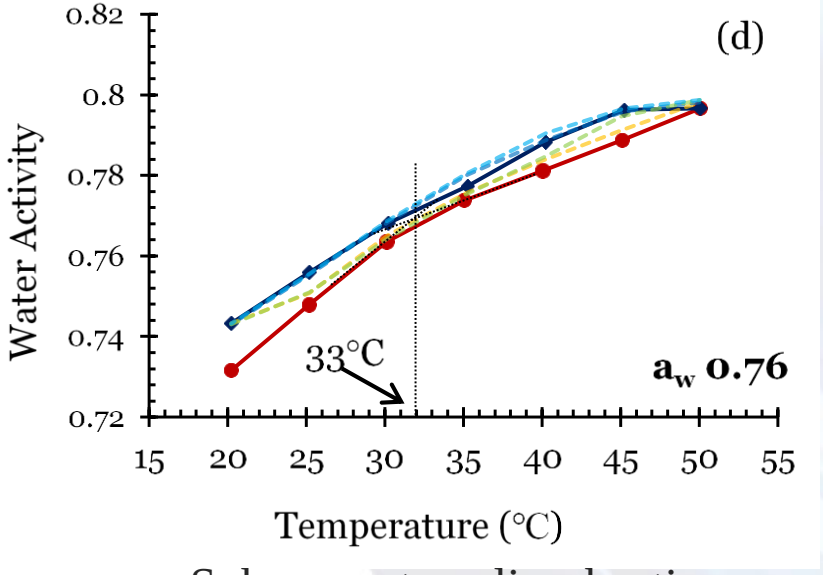
	First Scan				Rescan after stored for 7 Days			
	1st heating		2nd heating		1st heating		2nd heating	
RH%	T_{onset} (°C)	T_{endo} (°C)	T_{onset} (°C)	T_{endo} (°C)	T_{onset} (°C)	T_{endo} (°C)	T_{onset} (°C)	T_{endo} (°C)
11	23	30	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-
33	-	-	-	-	-	-	-	-
44	29	40	-	-	-	-	-	-
54	32	41	-	-	34	45	-	-
65	28	39	-	-	32	44	-	-
76	30	41	-	-	32	43	-	-
85	28	39	-	-	30	42	-	-

Water Activity Measurement of WPI



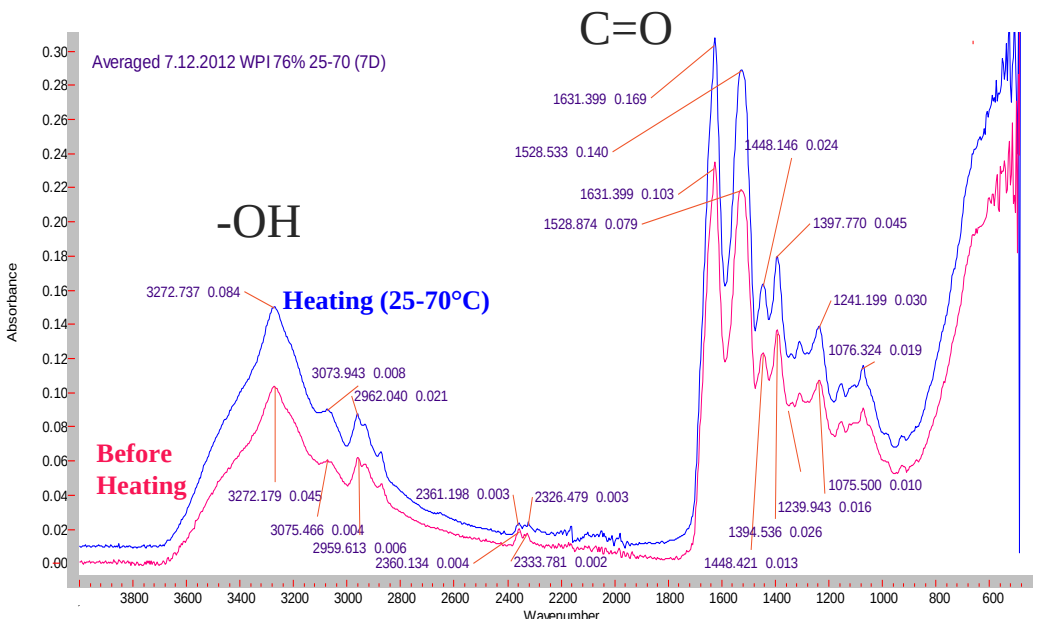


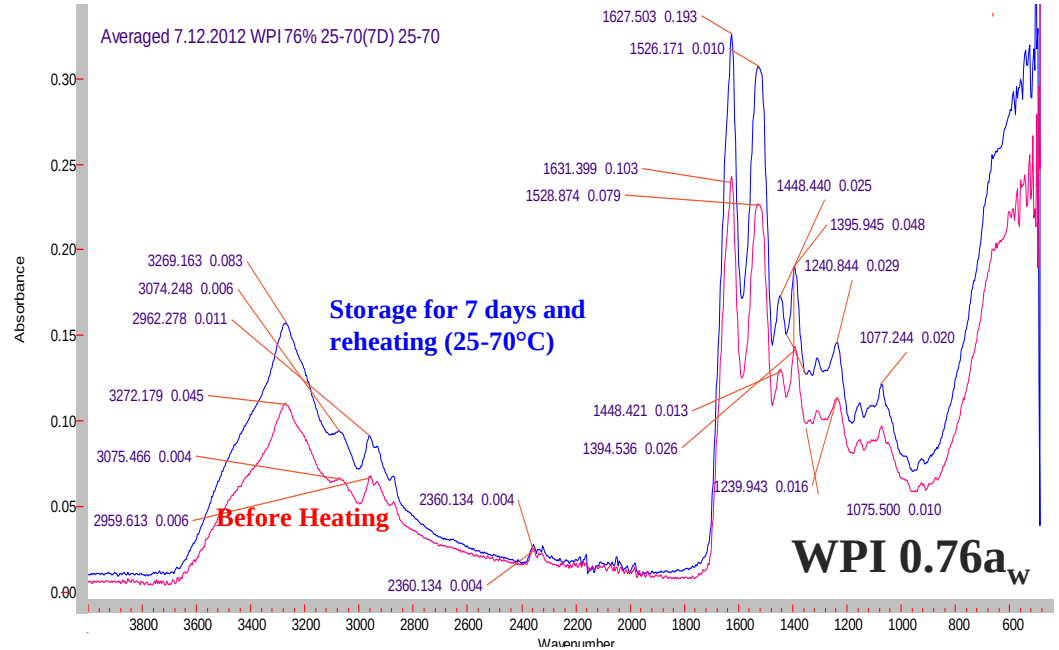




Heating Cooling Subsequent cooling-heating

FTIR Spectroscopy



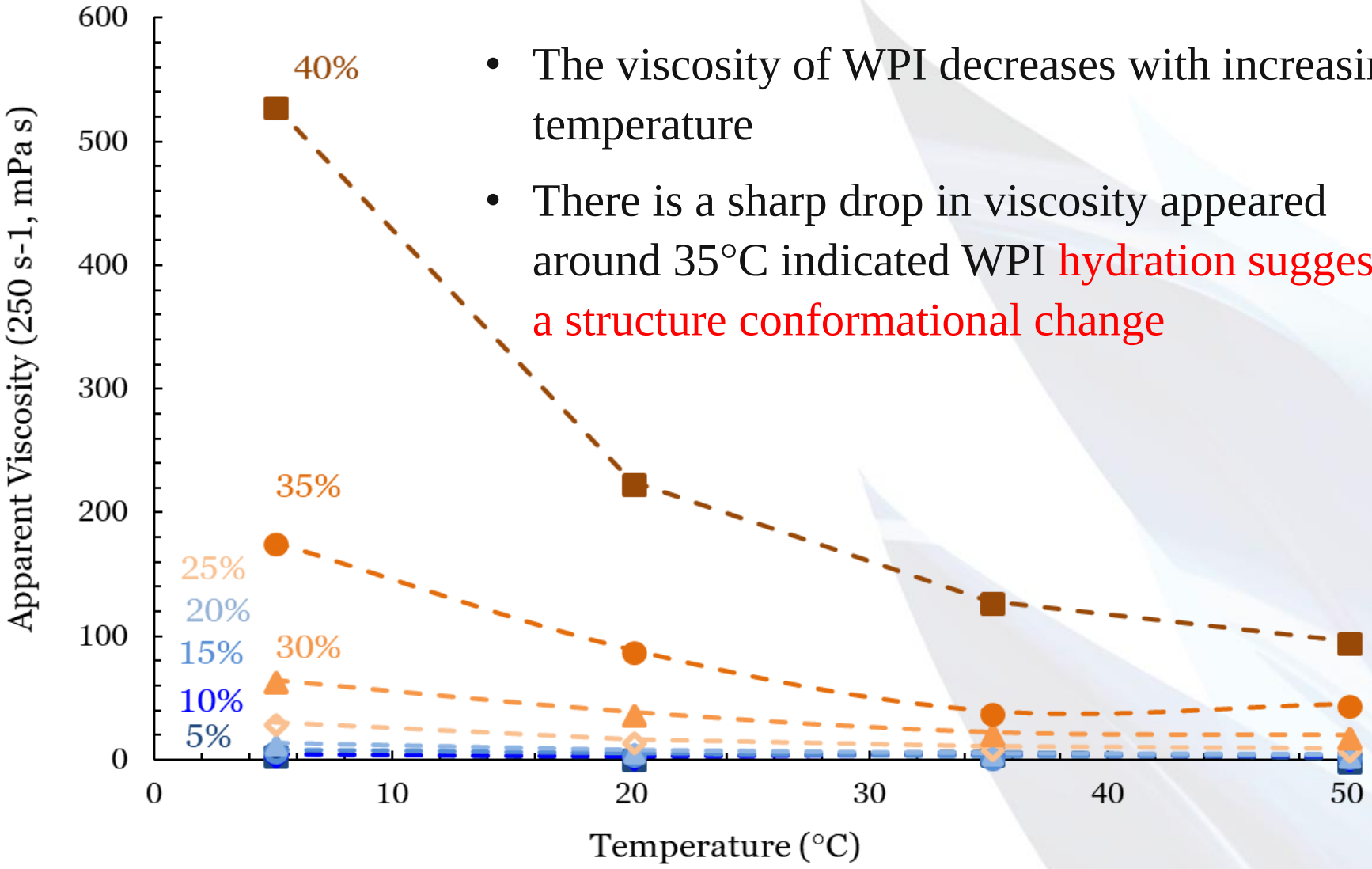


- FTIR spectra are similar before and after heating followed by 7 days of storage
- Reheating up to 70°C shifts FTIR absorbance peaks at several wavelengths
- Largest shifts found for –OH groups at 2500 to 3300 nm^{-1}

Apparent Viscosity (WPI Dispersion)

Apparent Viscosity of WPI aqueous dispersions at a fix shear rate $250s^{-1}$ as a function of temperature

- The viscosity of WPI decreases with increasing temperature
- There is a sharp drop in viscosity appeared around 35°C indicated WPI hydration suggesting a structure conformational change



Conclusion

- A water content and time-dependent reversible endotherm occurs in WPI within 30°C - 40°C
- Heating WPI from 25°C - 50°C results in increased protein hydration according to a consequent decrease and hysteresis of a_w during re-cooling
- FTIR data show that the time-dependent endotherm is related to changes in hydrogen bonding (hydration/dehydration)
- Viscosity decreases significantly at ~ 35°C as a function of WPI concentration and temperature

Acknowledgment:

UCC

University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Contact info:
Sarah A. Al-Jassar
E-mail: sjassar@kisr.edu.kw