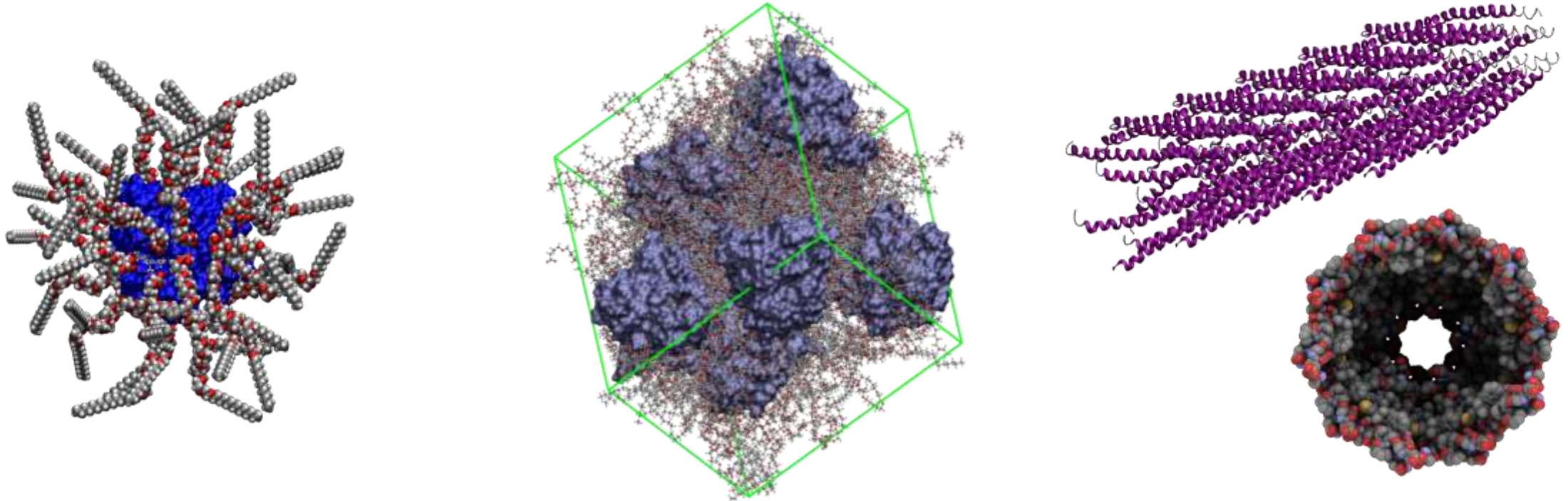


# Solvent-free Liquid Proteins: Enhancing Proteins Through Surface Engineering



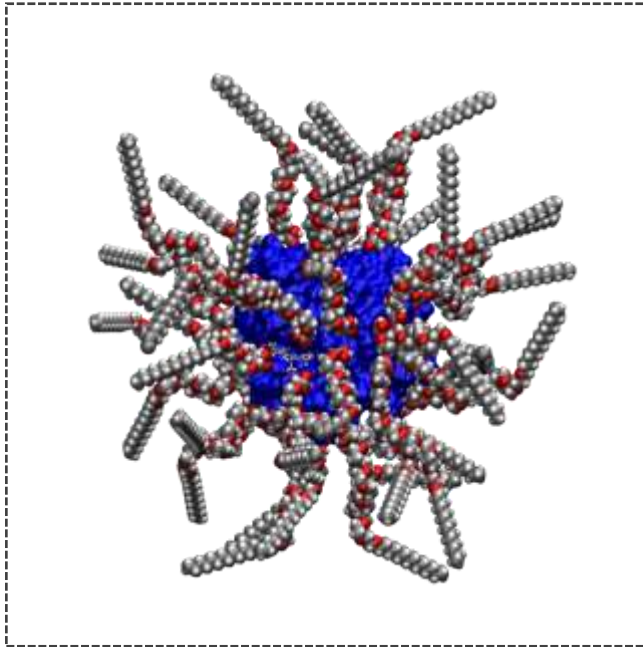
**Dr. Alex P. S. Brogan**  
Department of Chemistry  
 @apsbrogan

**KING'S**  
*College*  
**LONDON**

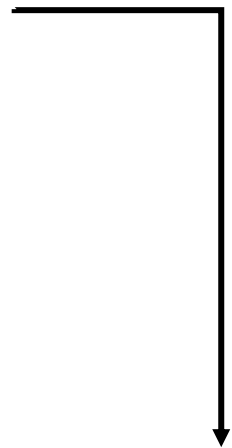
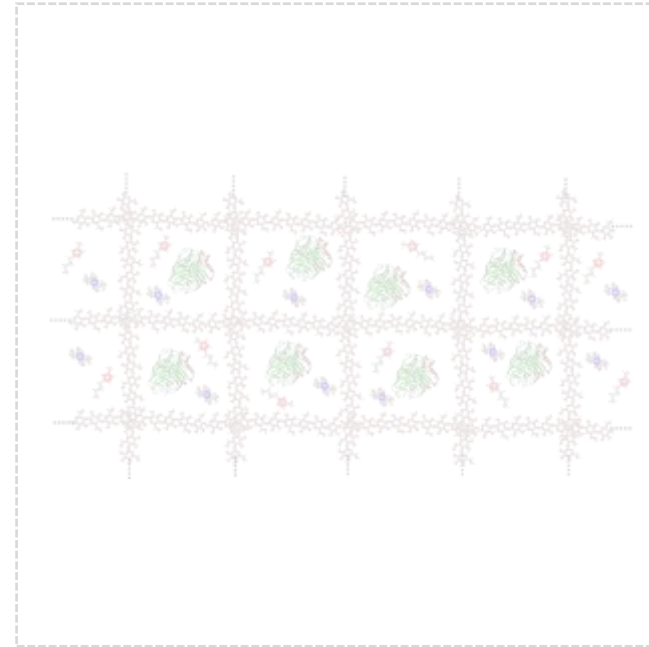
22<sup>nd</sup> August 2021  
*ACS Fall 2021*

[alexbrogan.co.uk/acs2021](http://alexbrogan.co.uk/acs2021)

## Solvent-free Liquid Proteins



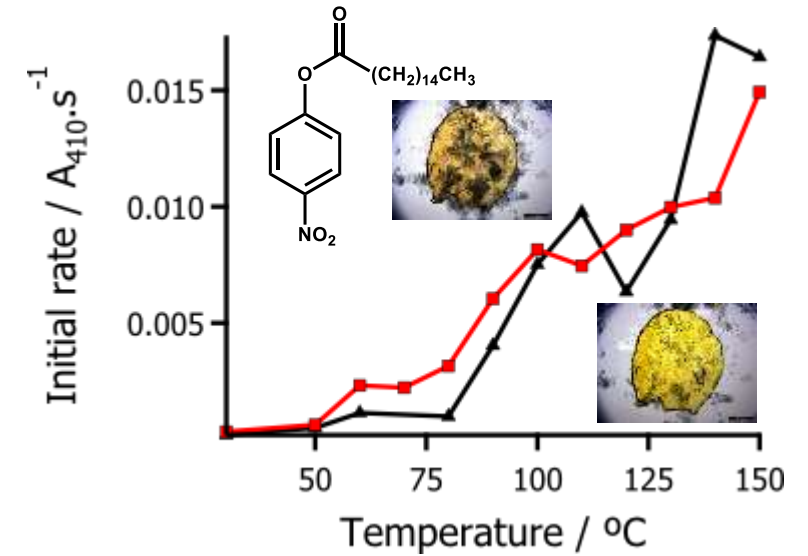
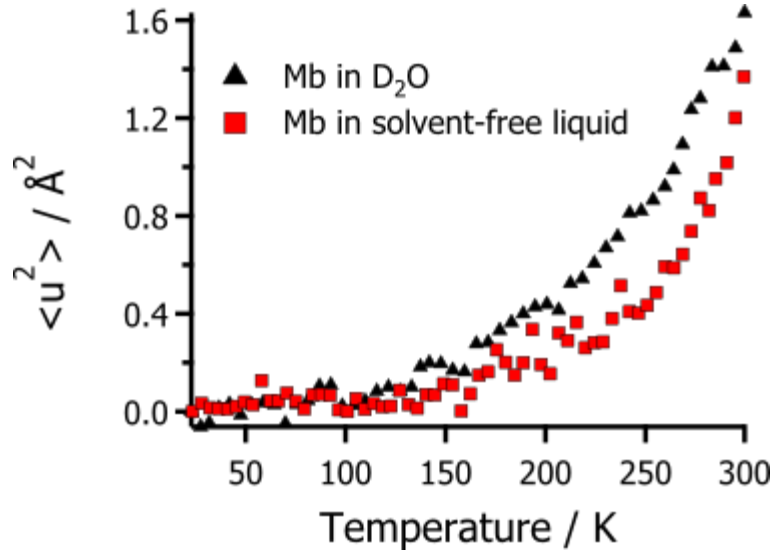
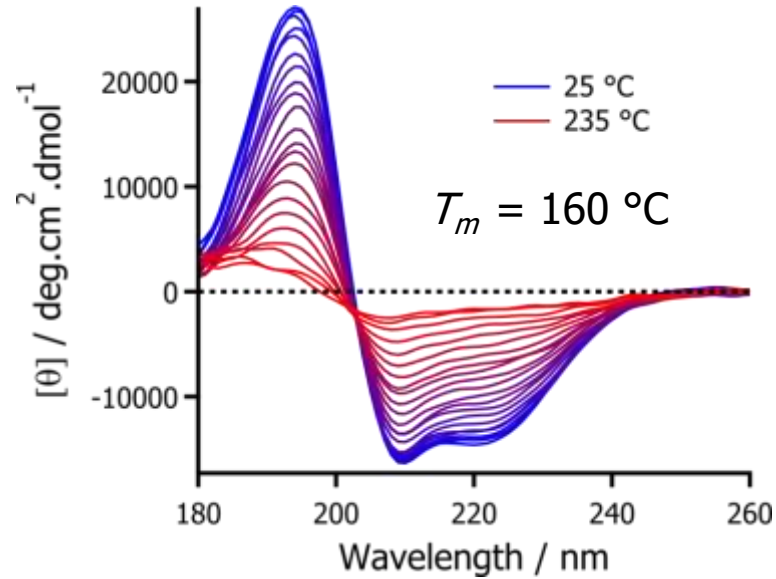
## Ionogels



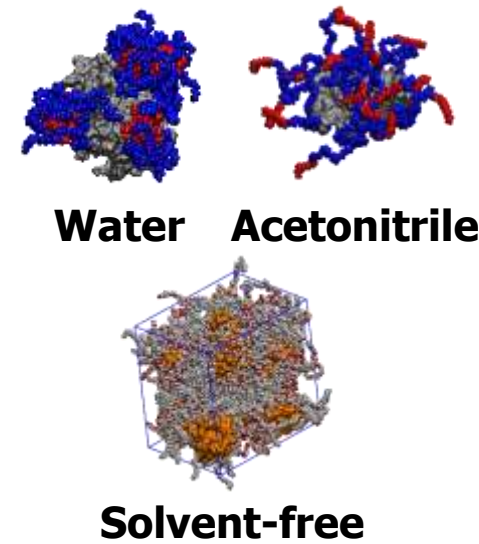
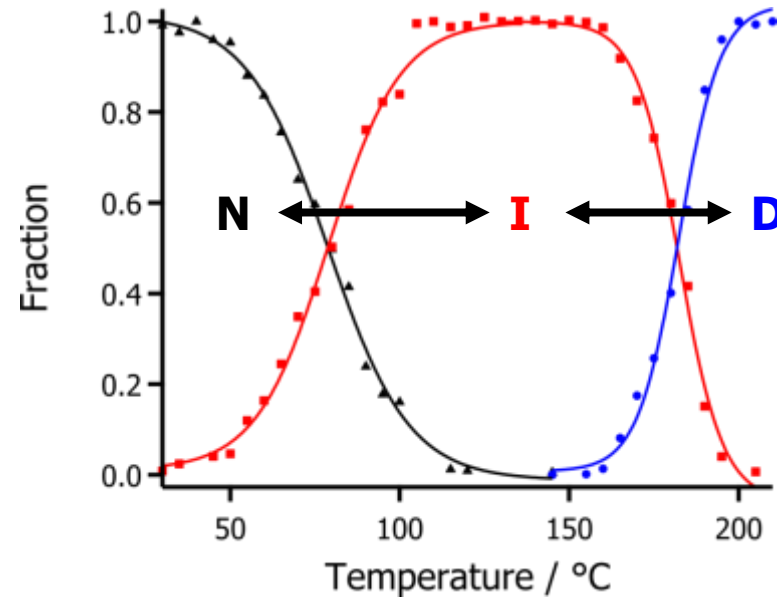
**Thermal stability and protection from aggregation**

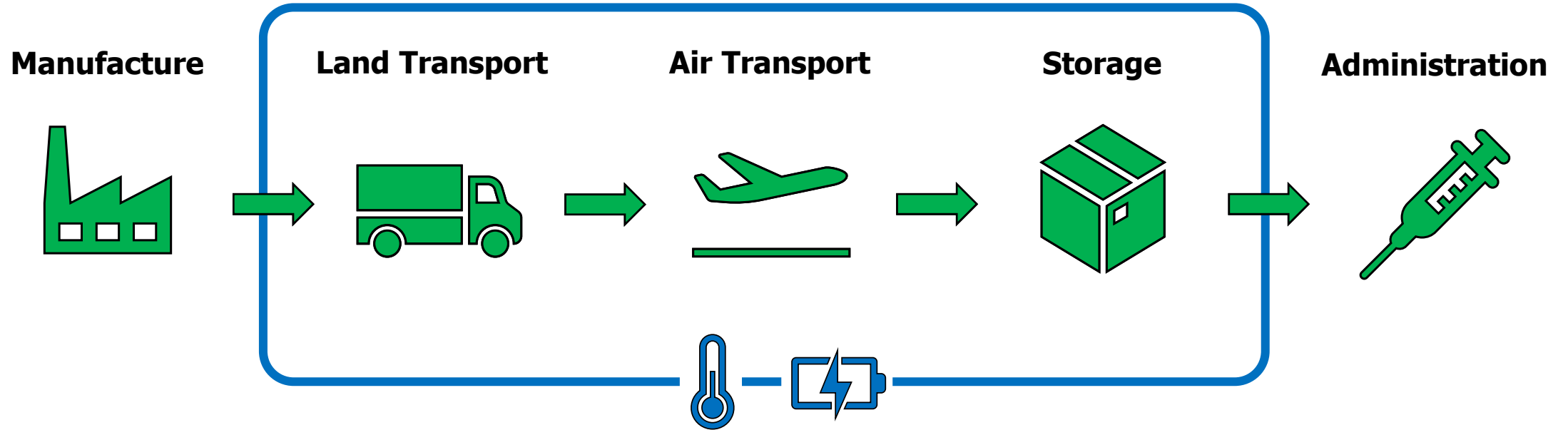


# Solvent-free Liquid Proteins



- Retained structure and hyperthermophilic-like stability.
- Protein dynamics retained within organic corona.
- Enhanced enzyme activity in absence of water.
- Protection against aggregation.





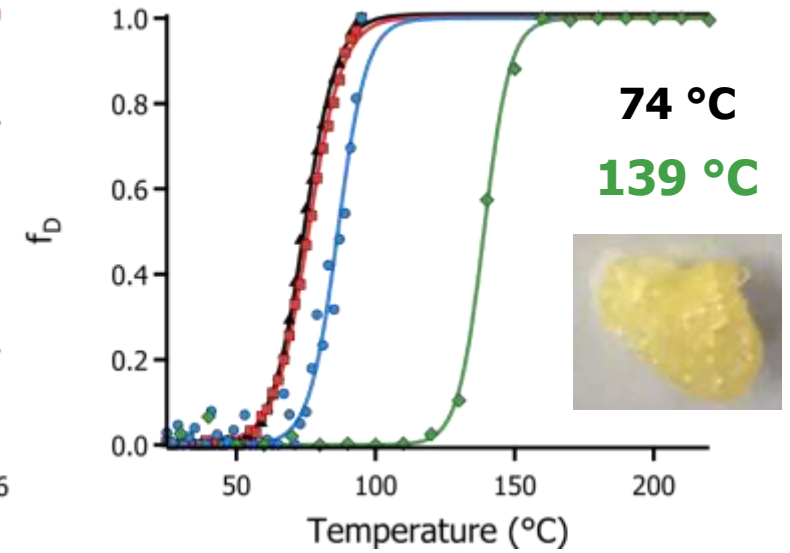
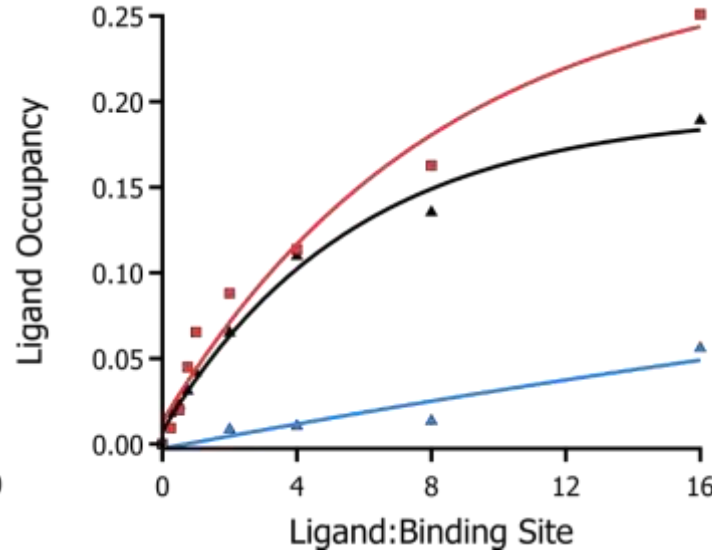
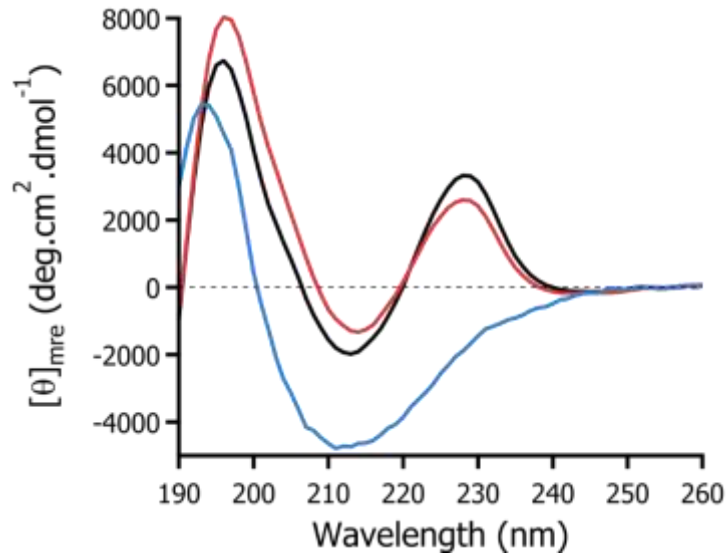
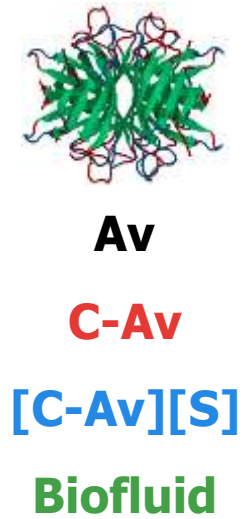
## The Challenge

Protein based therapeutics aggregate at high temperatures.

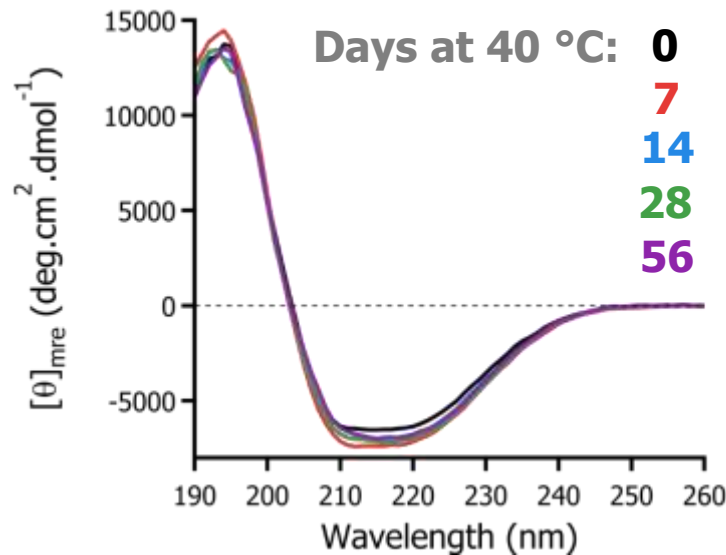
Accidental freezing can cause aluminium (adjuvants) to aggregate.

Cold chain can account for up to 80% of the cost of vaccinations.

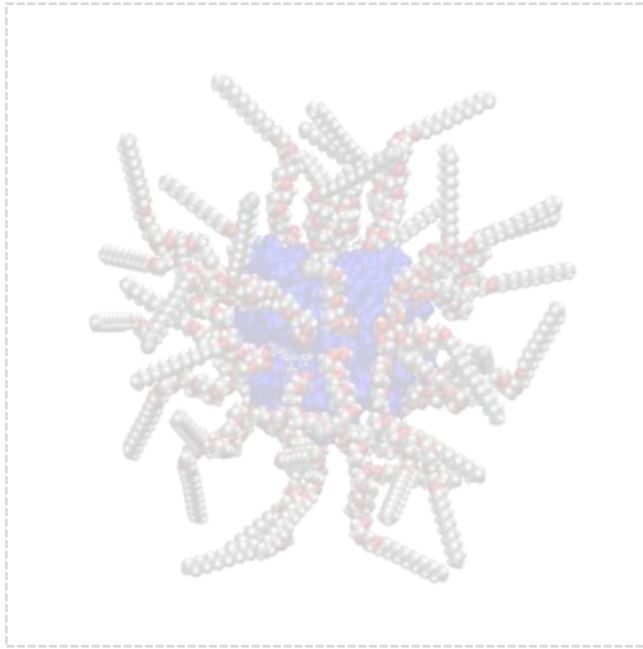
# Solvent-free Liquid Avidin



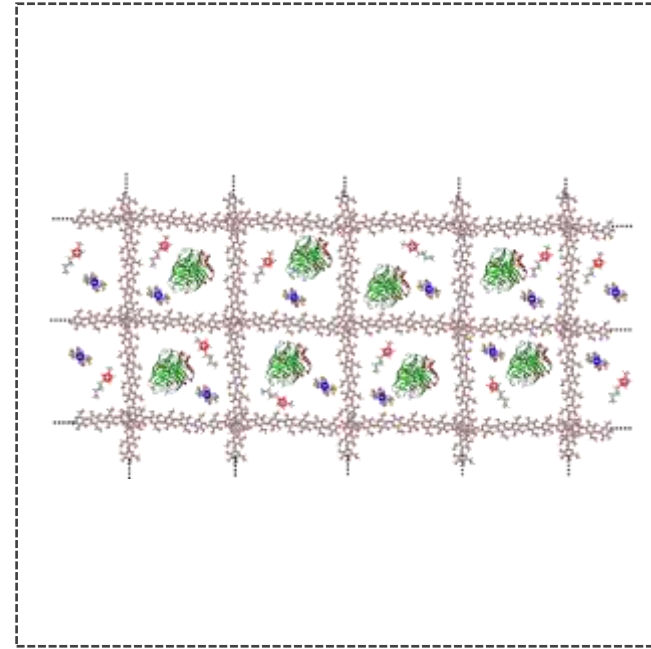
- Surface functionalization of avidin causes some changes in structure.
- Reduced Biotin-PEG-FITC binding.
- Increased thermal stability.
- Stable for 160 days at 25 °C.



Solvent-free Liquid  
Proteins



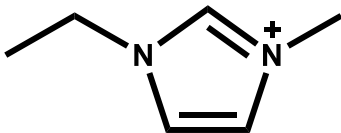
**Ionogels**



**New soft materials for biointerfacing**

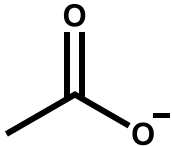
# Ionic Liquids in Materials Design

Cation

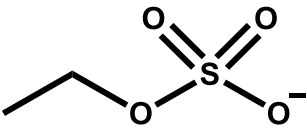


[emim]<sup>+</sup>

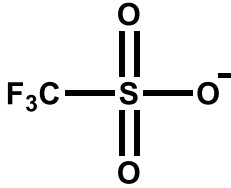
Anions



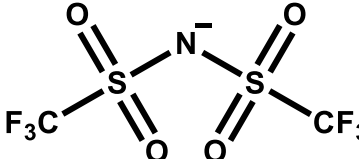
[OAc]<sup>-</sup>



[EtSO<sub>4</sub>]<sup>-</sup>



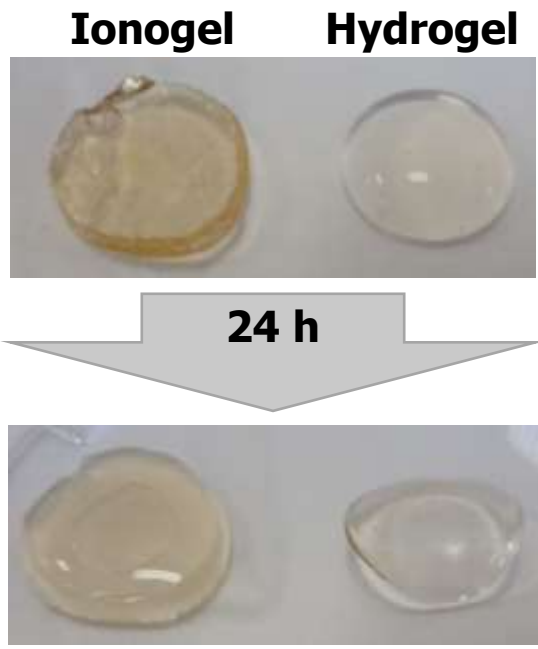
[OTf]<sup>-</sup>



[NTf<sub>2</sub>]<sup>-</sup>

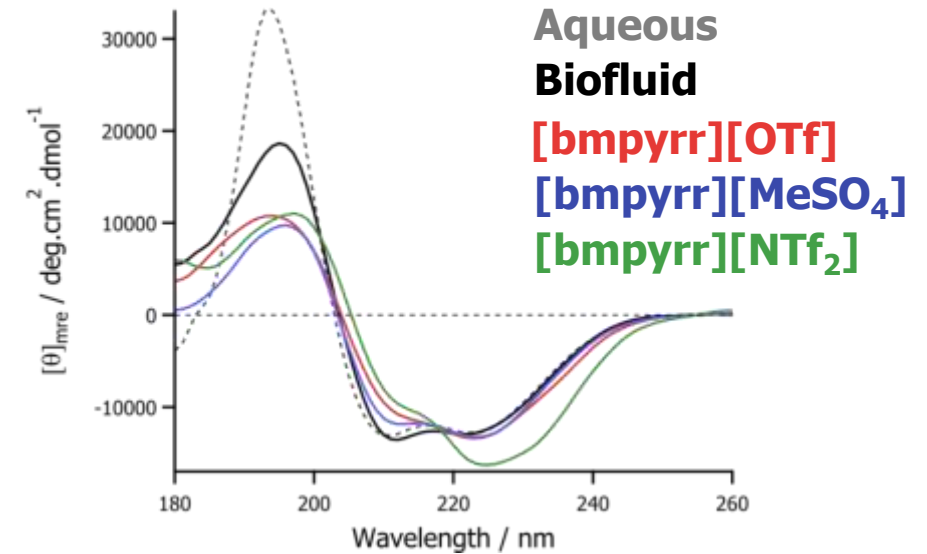
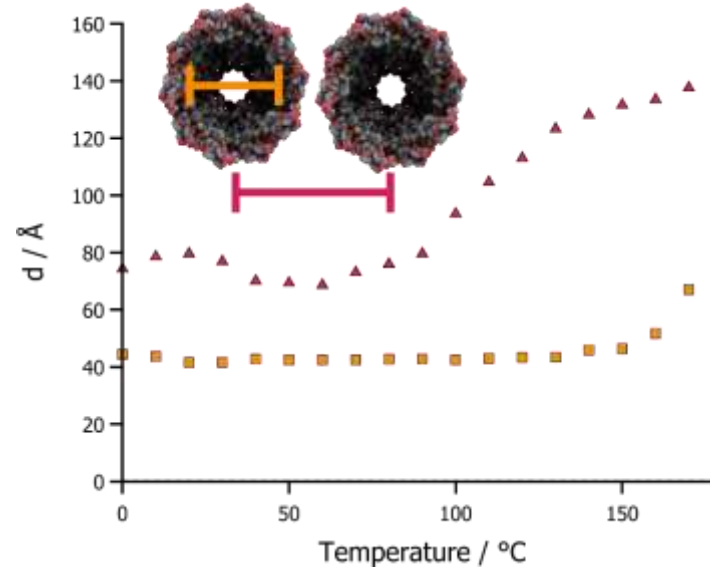
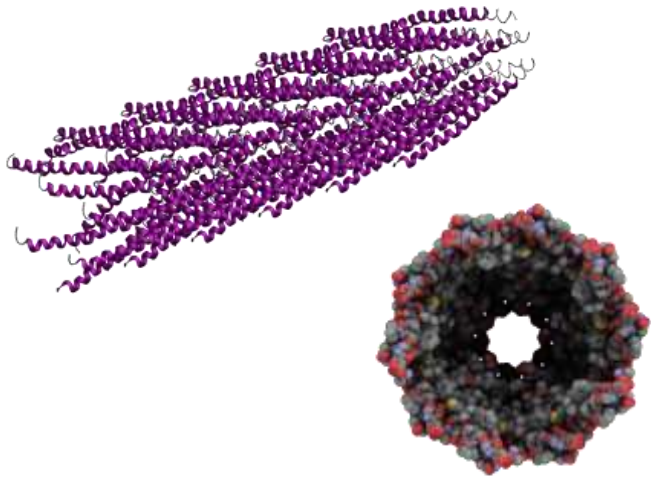


- Ionic liquids are organic solvents with highly tuneable properties.
  - Can solubilize and process otherwise recalcitrant polymers.
  - High thermal stability, broad electrochemical window, and negligible vapour pressure.
- **Relatively untapped potential in soft material design.**

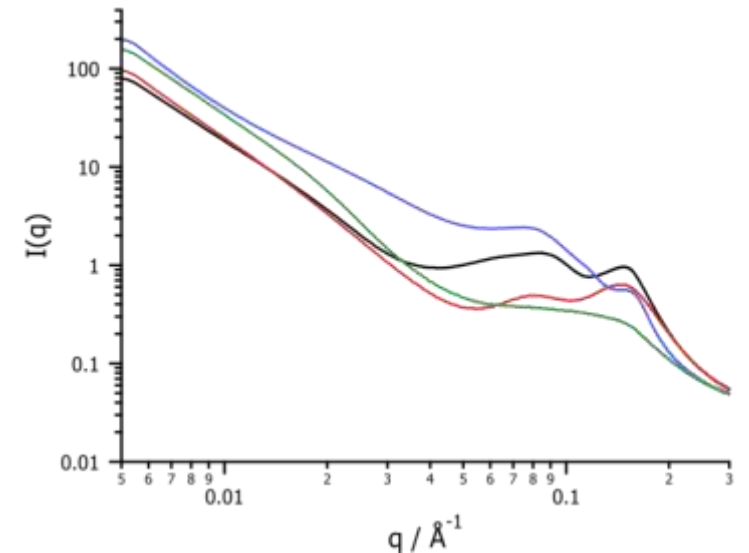




# Filamentous Viruses as Functional Scaffolds for Ionogels

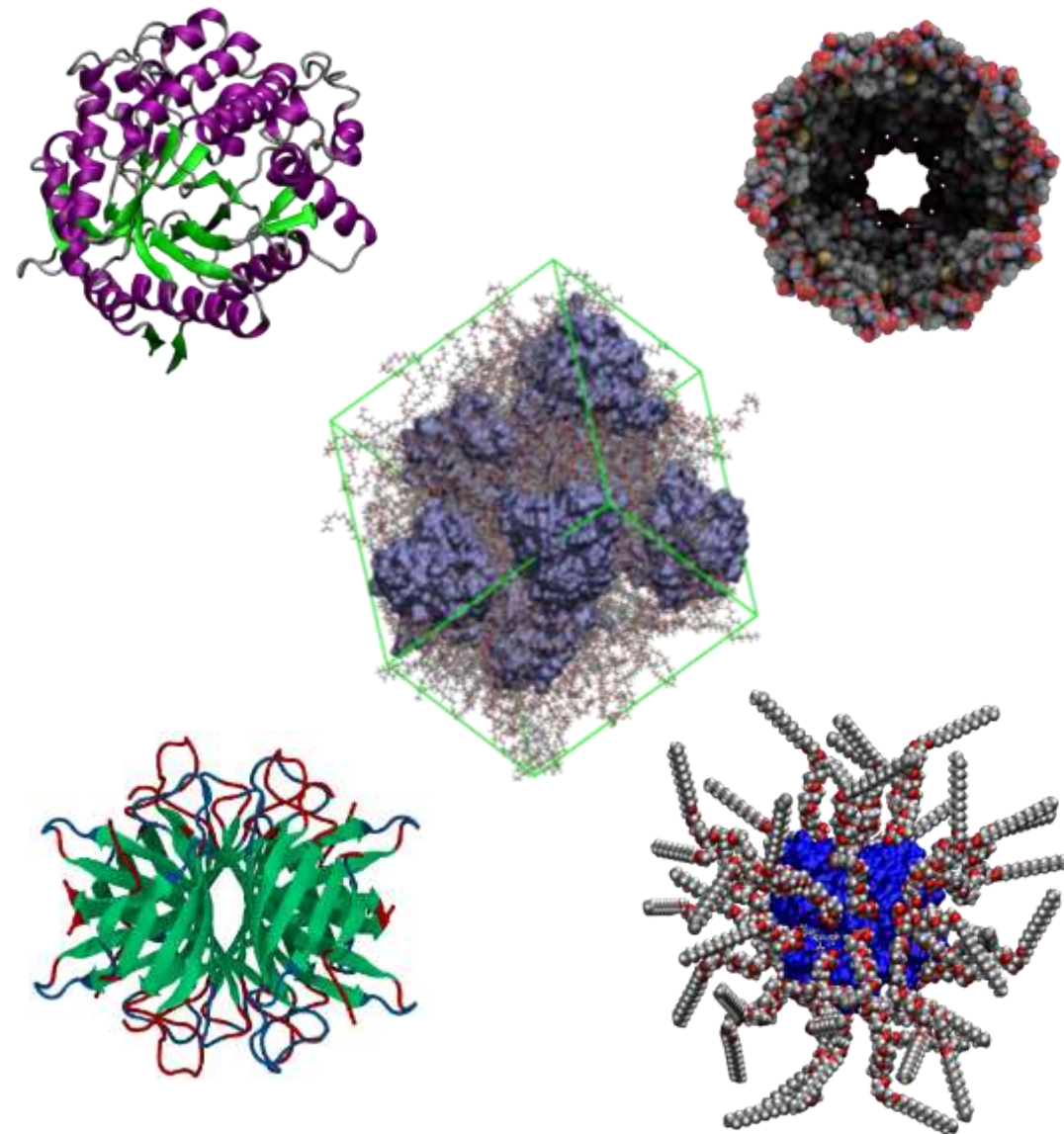


- M13 filamentous bacteriophage – 10 x 900 nm
- Global architecture of M13 maintained up to 150 °C in solvent-free biofluid.
- Structure maintained in ionic liquids.
- Ionogels with phage incorporated can be made.



# Conclusions

- Robust synthesis for chemically modified proteins and enzymes.
- Good compatibility with ionic liquids.
- Protein structure highly conserved – in the absence of water.
- Thermal stability improves as compared to aqueous system.
- Enzyme activity enhanced in anhydrous conditions.
- Significant increase in long term stability of therapeutic biomolecules.
- Proteins as designable structural motifs for non-aqueous soft biomaterials.



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