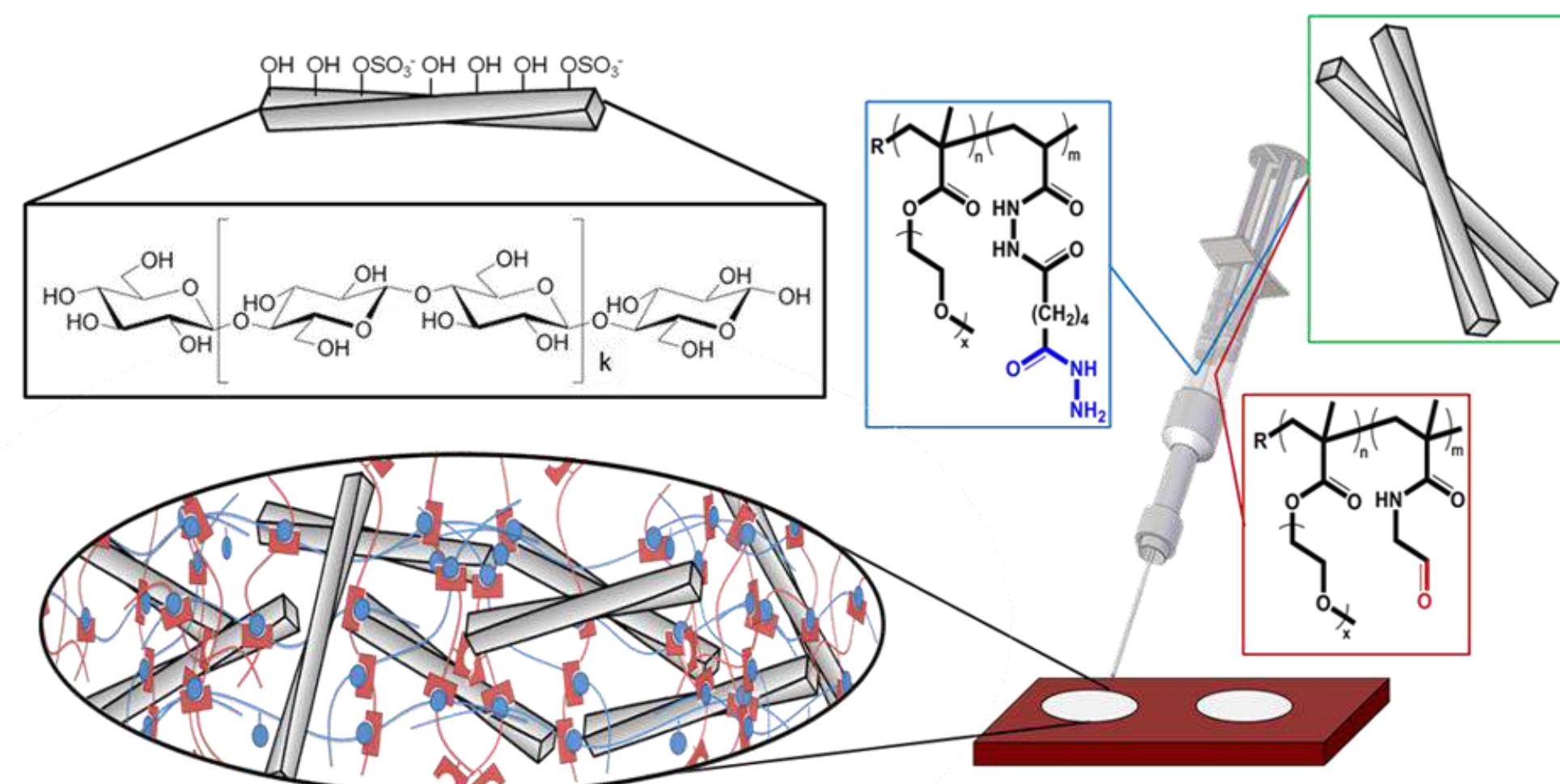




Introduction

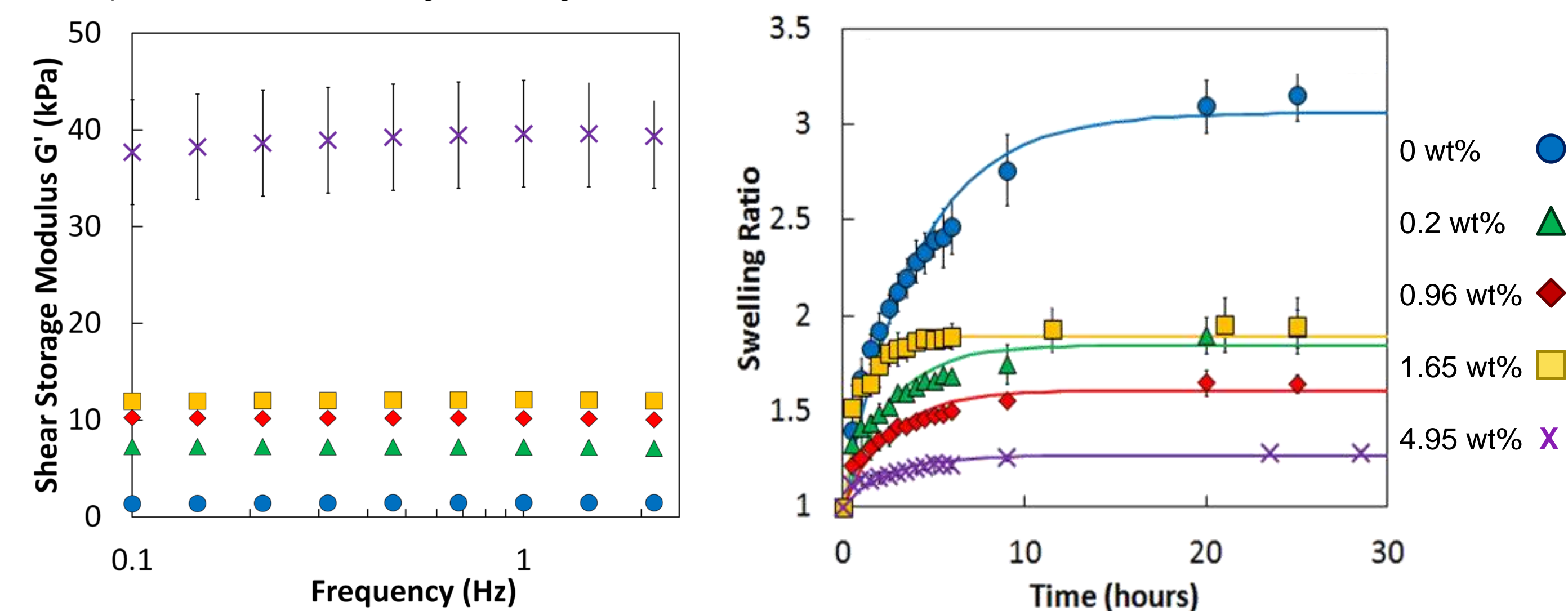
The poly (oligo ethylene glycol methacrylate) (POEGMA) family of hydrogels has recently gained significant research attention in the fields of drug delivery and tissue engineering due to the thermoresponsiveness, low protein adsorption, and low cytotoxicity of POEGMA polymers. By incorporating reactive aldehyde and hydrazide groups into POEGMA precursor polymers, our lab has demonstrated the use of POEGMA as an injectable "smart" material platform that may be further modified with other functional monomers or proteins for a wide variety of applications. However, these highly tunable hydrogels display a relatively isotropic network structure, which may limit potential applications as many natural tissues (e.g. muscle, cartilage, cornea) exhibit hierarchical directionality.



- Can we incorporate cellulose nanocrystals (CNCs) and exploit their diamagnetic anisotropy in order to create aligned composite hydrogels *in situ*?

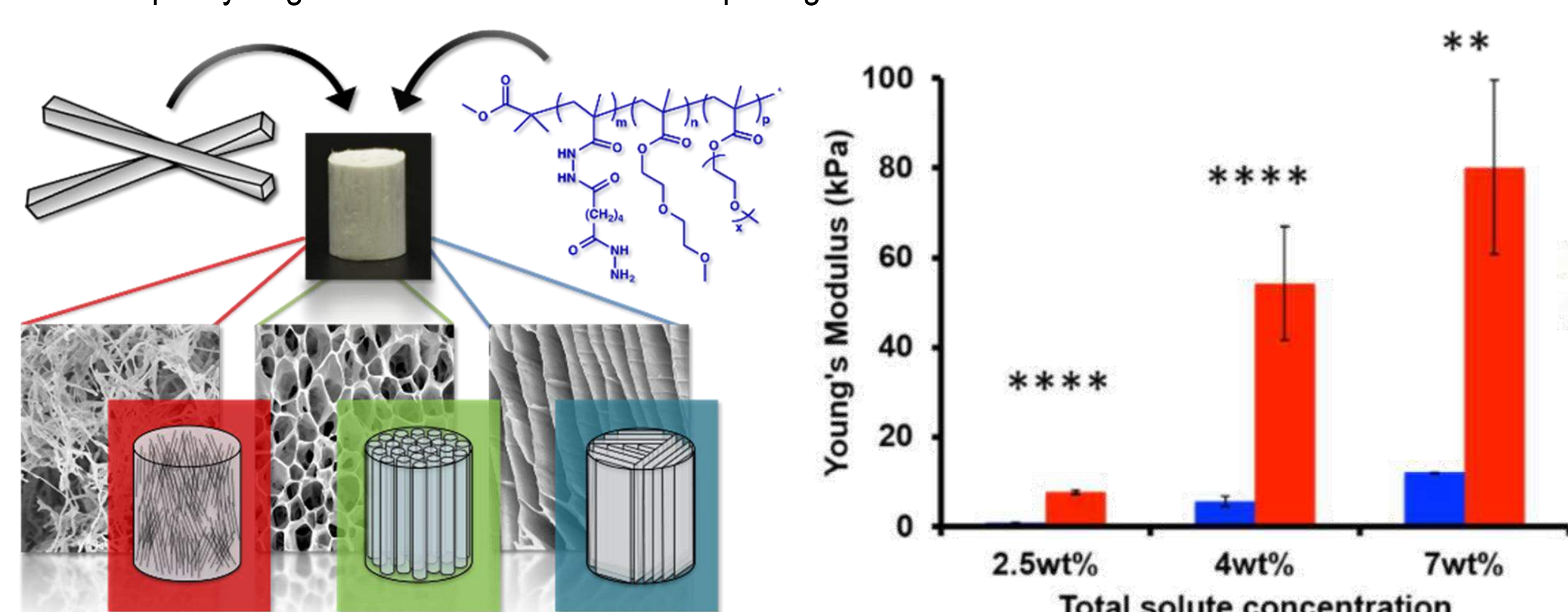
Building on Our Previous Work

- Through the addition of CNCs we have shown that a drastic enhancement in hydrogel mechanical properties, coupled with a decrease in gel swelling can be achieved



K.J. De France, K.J.W. Chan, E.D. Cranston, and T. Hoare, *Biomacromolecules*, **2016**, 17, 649

- Freeze casting covalently cross-linked aldehyde functionalized CNCs and hydrazide functionalized POEGMA gives anisotropic hydrogels with tunable network morphologies



M. Chau, K.J. De France, B. Kopera, V.R. Machado, S. Rosenfeldt, L. Reyes, K.J.W. Chan, S. Forster, E.D. Cranston, T. Hoare, and E. Kumacheva, *Chemistry of Materials*, **2016**, DOI: 10.1021/acs.chemmater.6b00792

Sustainable



Composites

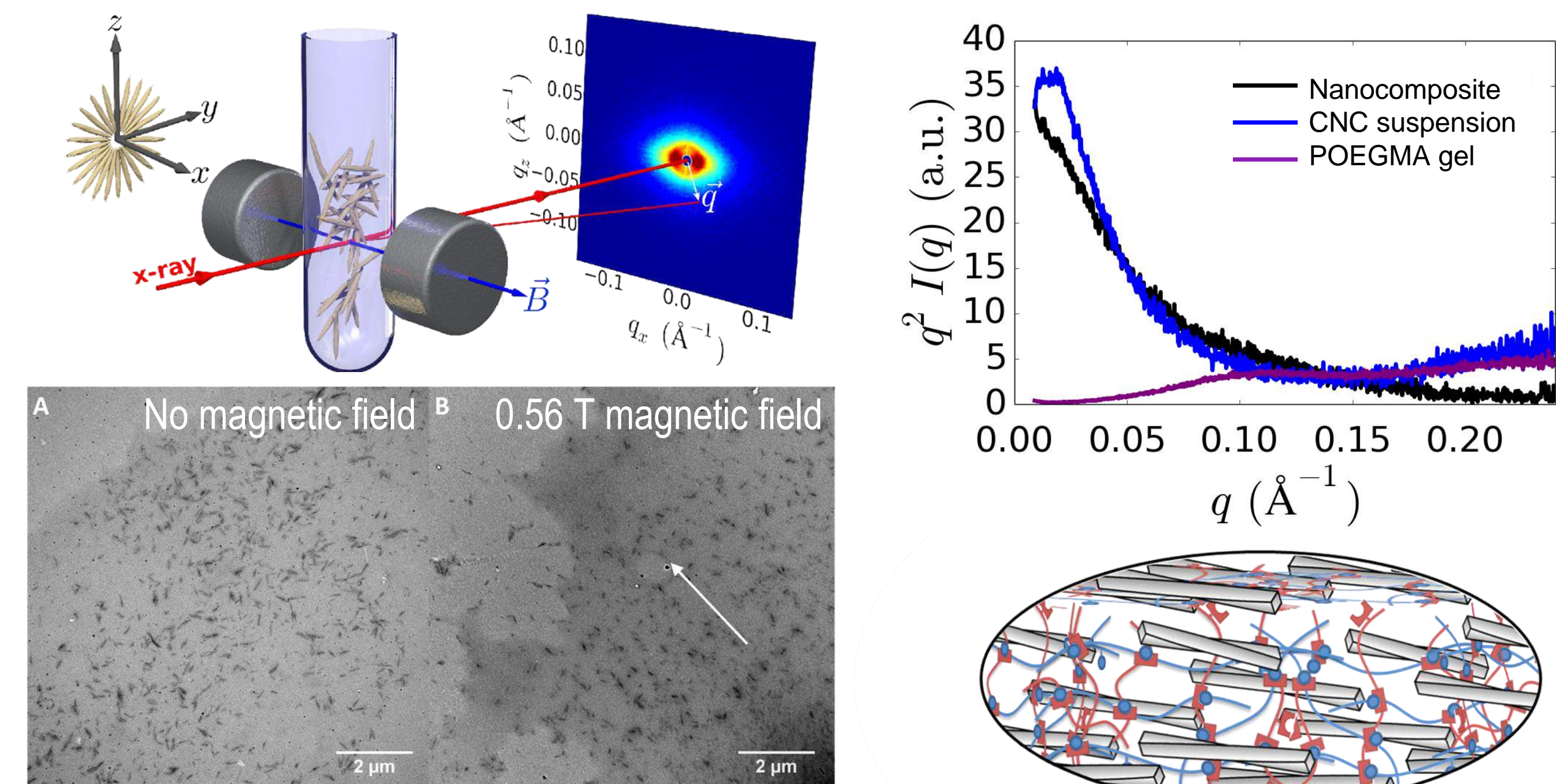


THE HOARE LAB

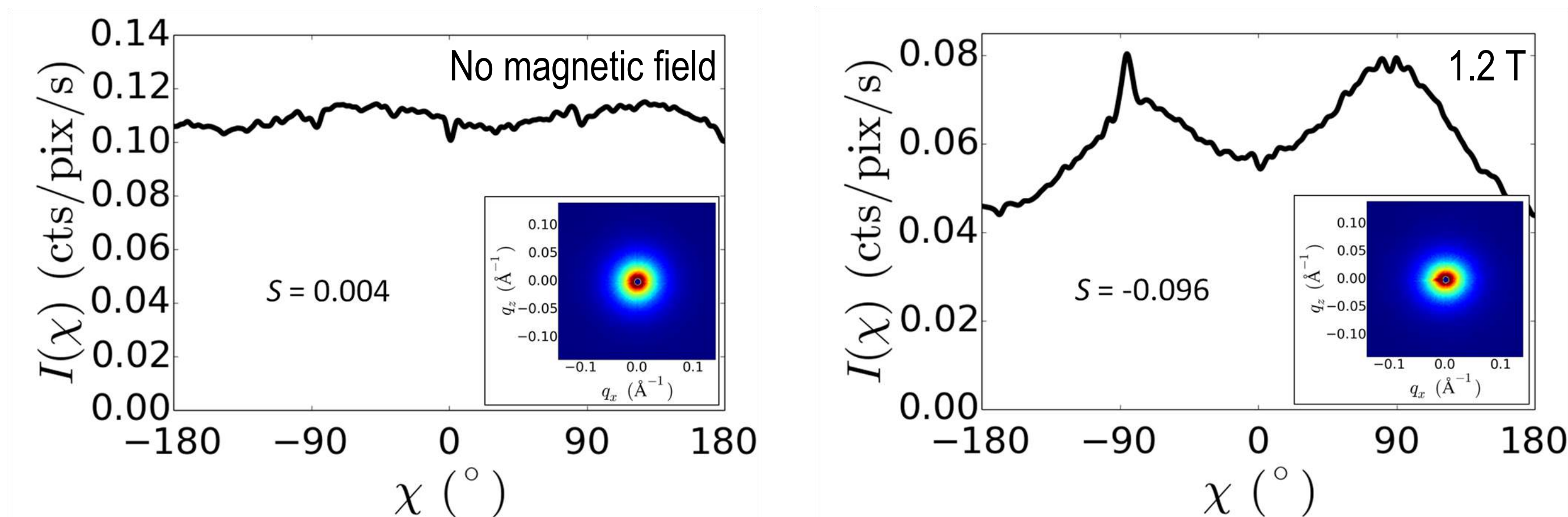
Laboratory for Engineered Smart Materials

Hydrogel Anisotropy

EXPERIMENTAL SETUP & NETWORK CHARACTERIZATION: TEM AND SAXS

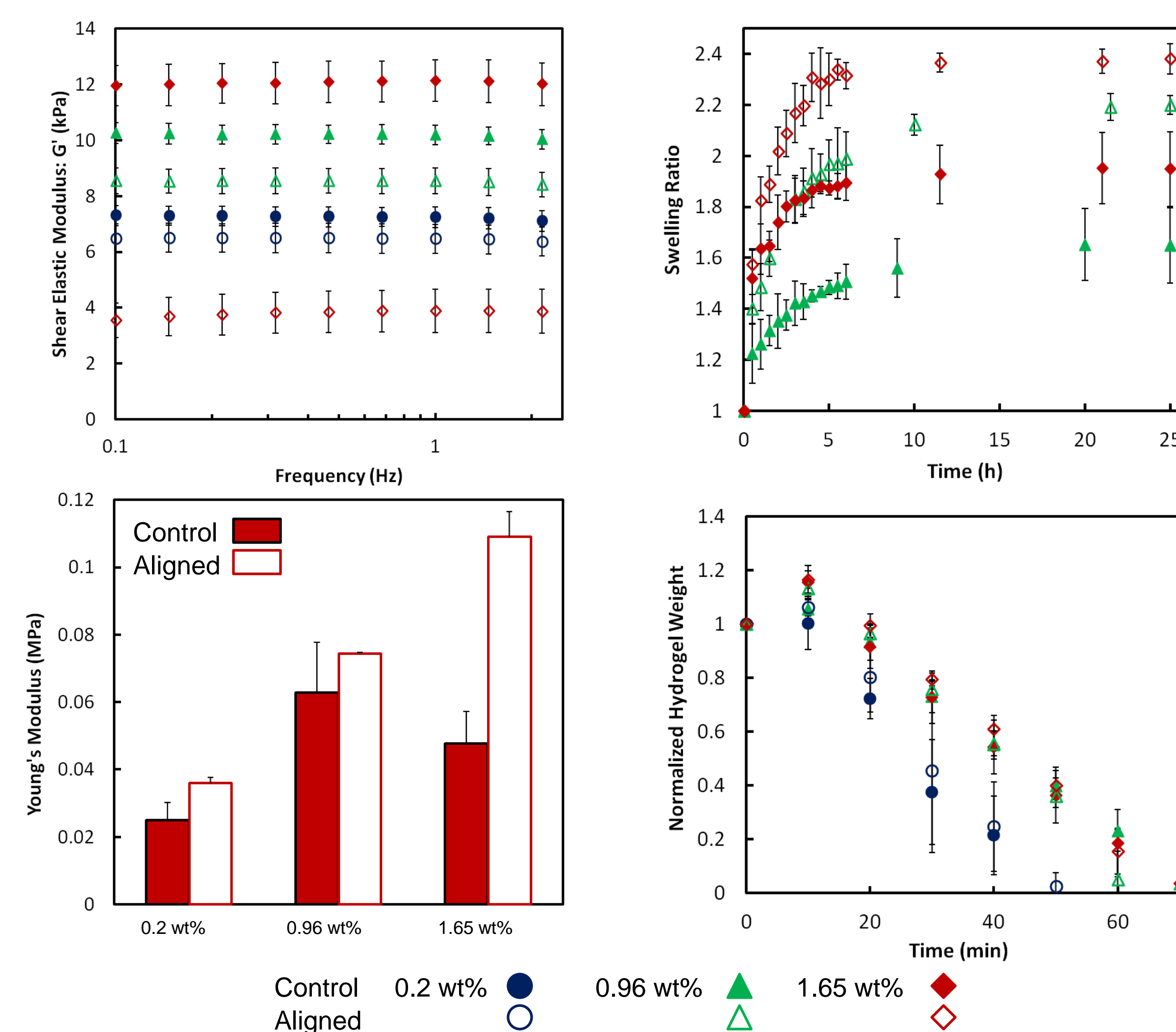


- 1.65 wt% nanocomposite hydrogels organize, forming a combined phase of CNCs and POEGMA
- Cryo-TEM images suggest CNCs can order within nanocomposite hydrogels



- SAXS reveals alignment of CNCs with an increase in absolute value of order parameter S

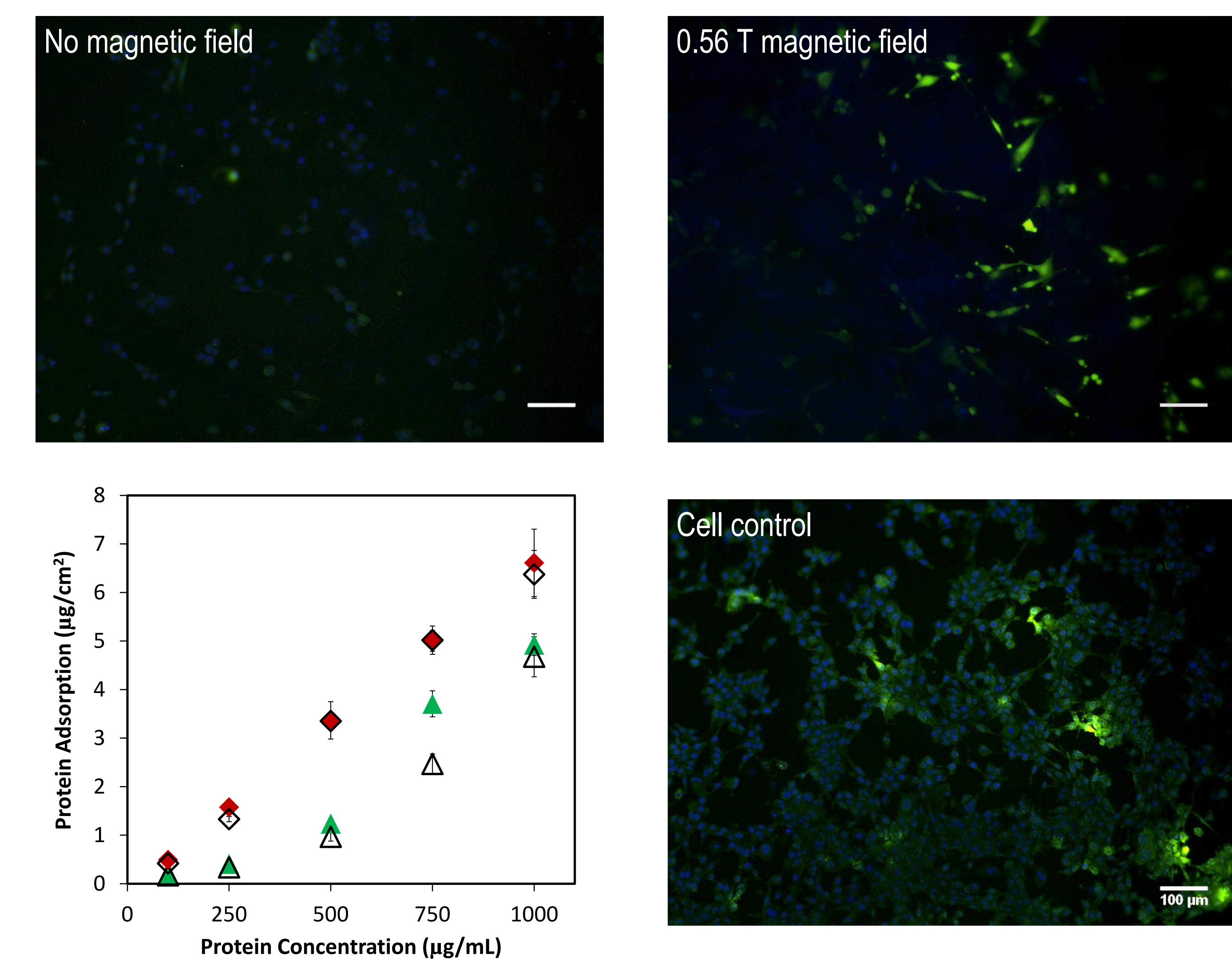
PHYSICAL PROPERTIES: MECHANICS, SWELLING, & DEGRADATION



- Hydrogels exposed to 0.56 T magnetic field show decreased storage modulus, increased compressive modulus and increased swelling versus controls due to CNC alignment

Biological Implications

C2C12 MOUSE MYOBLAST ADHESION & BSA ADSORPTION



- Preliminary C2C12 adhesion studies show an increase in cell elongation when cells are plated on aligned hydrogels versus controls
- BSA (♦) and fibrinogen (▲) adsorption are unaffected by magnetic alignment (unfilled) of nanocomposite hydrogels

Conclusions

- A 0.56 T magnetic field successfully reorients CNCs *in situ* within POEGMA hydrogels in the time frame of gelation (< 15 minutes) as demonstrated through TEM and SAXS
- A decrease in the storage modulus parallel to the aligned CNC planes and an increase in compressive modulus perpendicular to the aligned CNC planes is demonstrated upon reorientation
- Hydrogel swelling is increased following magnetic alignment while degradation is unaffected
- Preliminary cell adhesion studies show increased cell elongation and directionality on aligned CNC hydrogels
- Protein adsorption is unaffected by magnetic field, suggesting nano-topography (CNC alignment) directs cell growth
- The facile *in situ* alignment of CNCs to create anisotropic nanocomposite hydrogels is promising for developing injectable and highly tailorable high performance scaffolds for select tissue engineering applications

Acknowledgements and References

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