Design, Synthesis, and Property Tuning of Spin-Coated Chiral Polymer Films for Advanced Photonic Applications

CIC 2025 Conference

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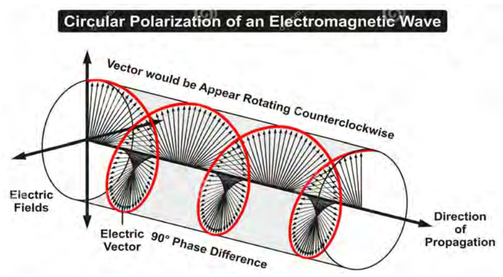
Introduction : Chirality in nature

Chirality is a fundamental symmetry property that is present in all natural and life sciences, from small molecules to spiral galaxies.

Just as molecules light can feature LH or RH circular polarization



Multiscale Chiro-optic Material Development

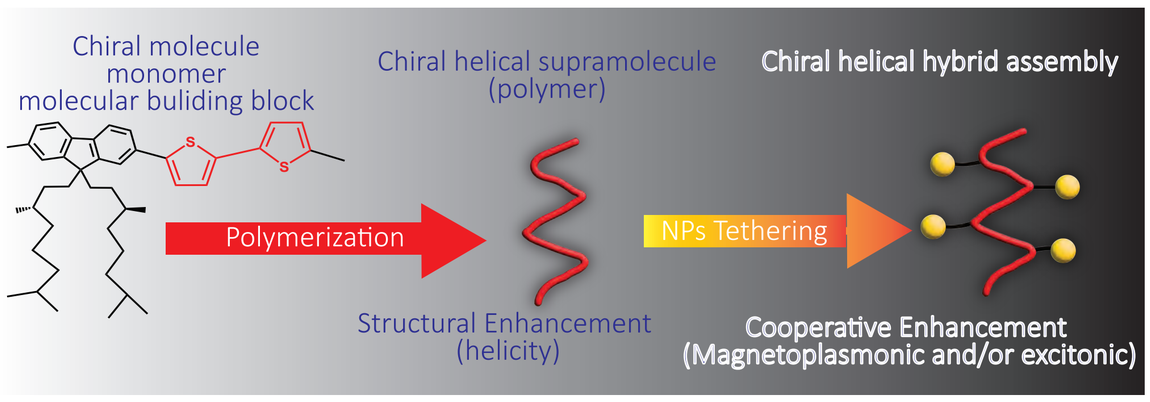
Designing chiroptical materials:

Chiro- and Magneto-optics in a chiral nanocomposite

$$n_{R,L}(\omega, I) = \sqrt{\varepsilon'\mu'} \pm \kappa \pm \kappa^{B} + (n_2 \pm \kappa_2)I$$

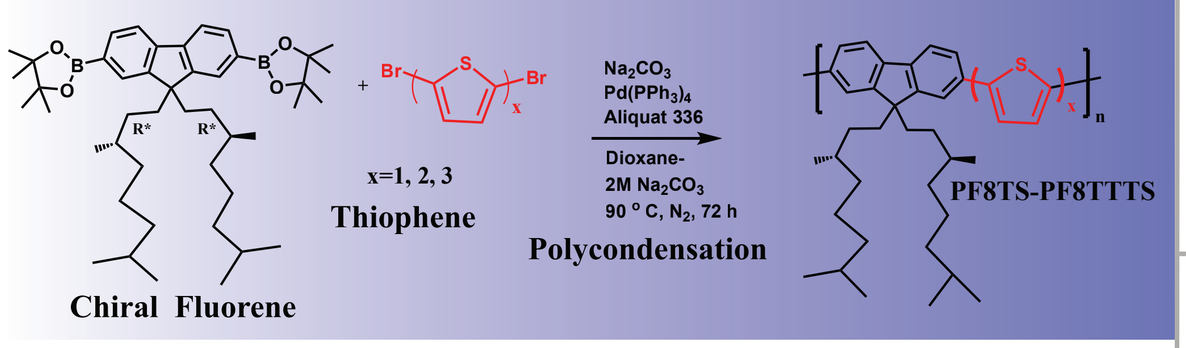
$$\Delta n^{B} = 2\kappa^{B} = VB\frac{\lambda}{\pi}$$

$n_{R,L}$- Refractive index
ω'- angular momentum
ε'- dielectric permittivity
μ'- magnetic permittivity
κ - chirality parameter
κ^{B}- chirality parameter due to magneto-optic effect
n_2- nonlinear refractive index
κ_2- nonlinear chirality parameter
I - intensity of light

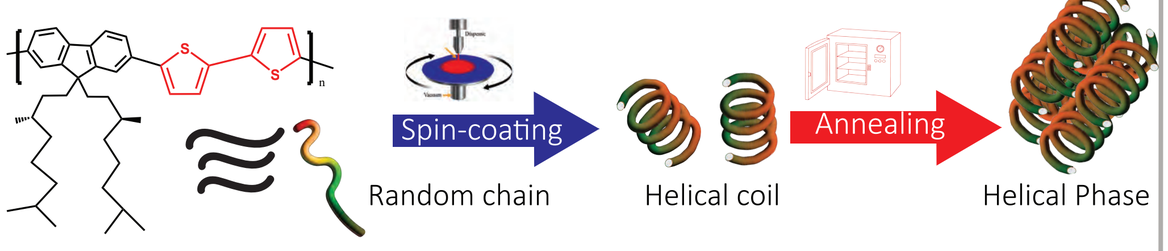


Results: Synthesis of chiral polymers

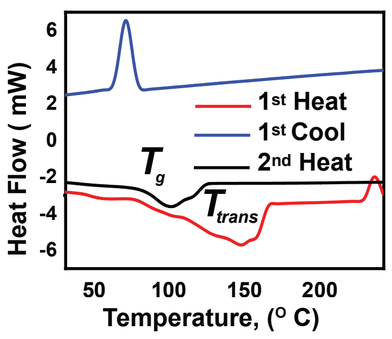
Scheme of synthesis of Fluorene –thiophene copolymer



Supramolecular reorganization to helical phase

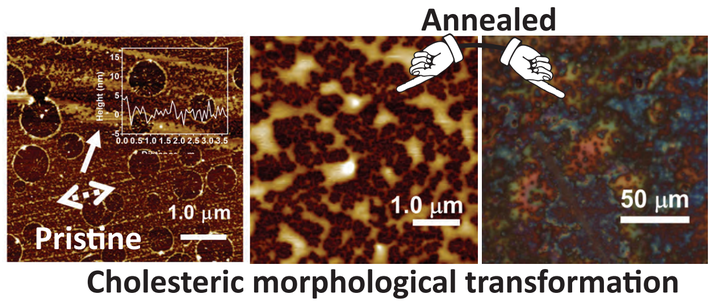


DSC: Heat transition



AFM images

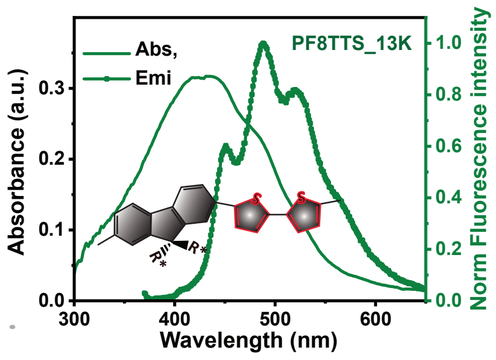
POM images



Cholesteric morphological transformation indicates long range order chirality on annealing

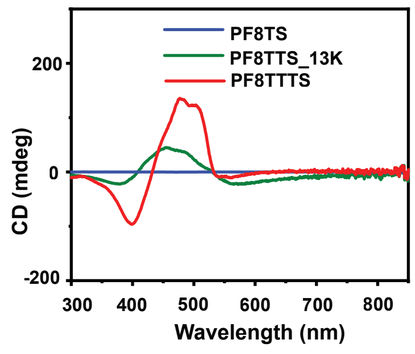
Thin film Chiro-optical characterization

UV-Vis response



Pristine film studies

Ellipticity response pre-annealing

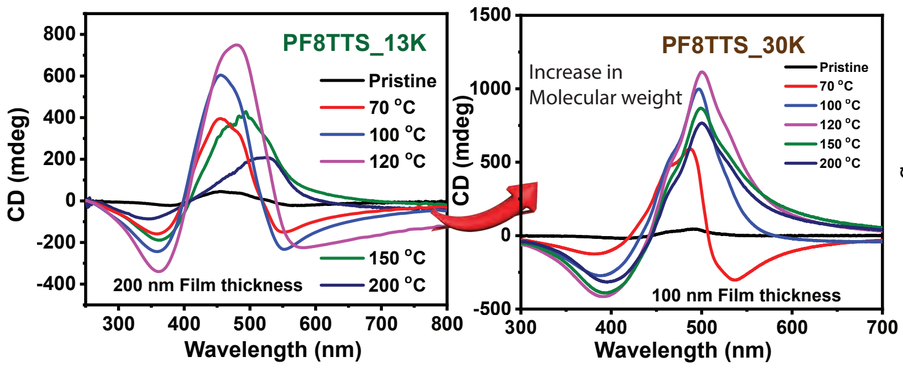


Red shift in the CD response with increase in thiophene units

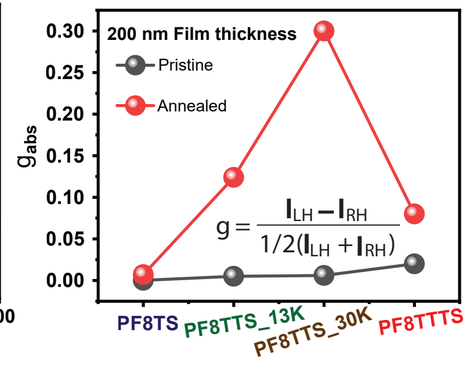
Thin film Chiro-optical characterization

Effect of annealing

Ellipticity response post-annealing

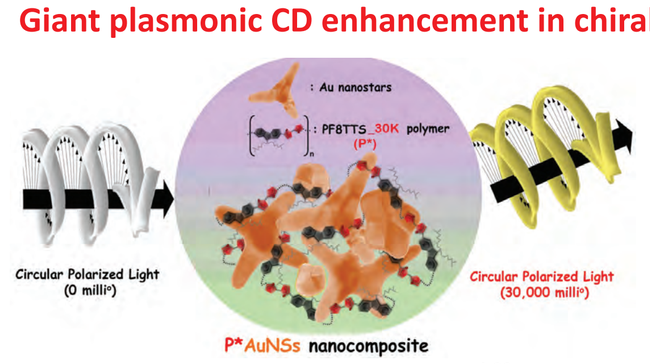


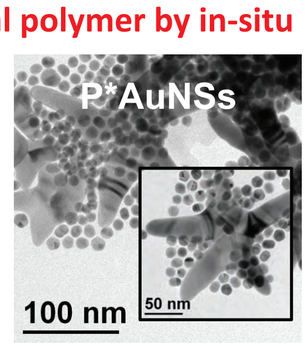
Dissymmetry



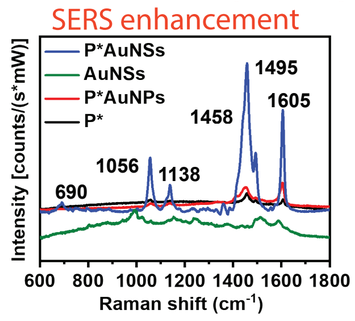
The PF8TTS_30K and 13K film showed highest Ellipticity response

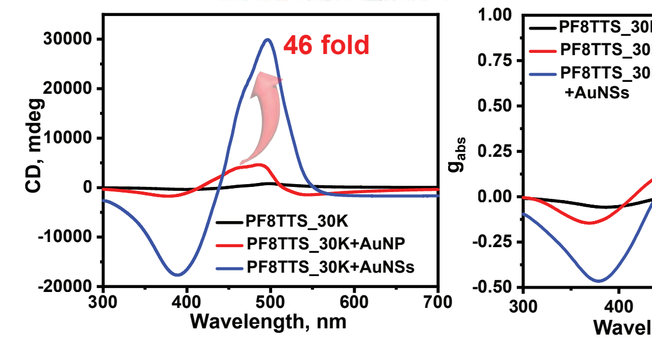
Giant plasmonic CD enhancement in chiral polymer by in-situ Gold Nanostars (AuNSs)

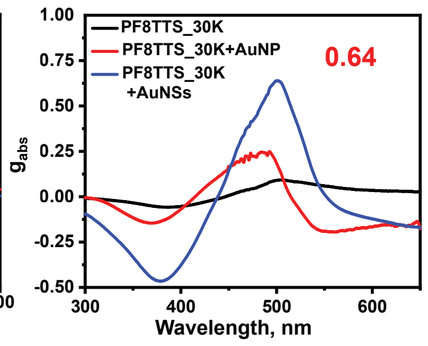




SERS enhancement







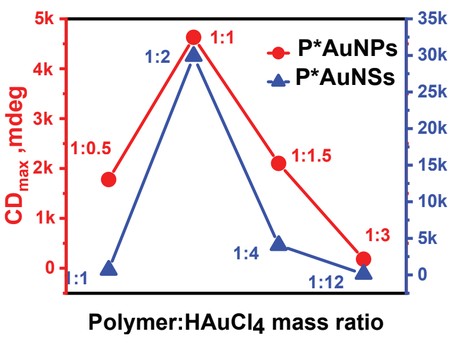


Table comparing the enhancement in the ellipticity and highest dissymmetry ratios from literature

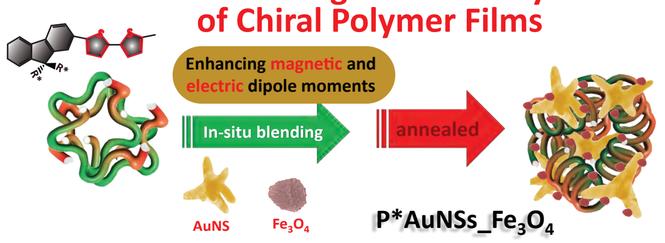
Material	g abs	CD enhancement
Our work	0.64	46 fold
PFBT/ CdTe /ZnS	--	31
PFBT/(10nm) AuNPs	0.02	42

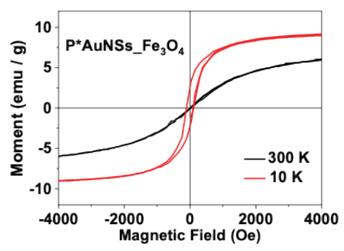
By embedding PF8TTS with gold nanostars (NSs) in an in-situ fashion, we observed an enhancement in the chiroptical signal.

SERS enhancement in P*AuNSs more prominent; shows the proximity of the polymer to the AuNSs

The presence of XPS satellite peaks in the sulfur reflect the change in the binding energy due to the close interaction of the polymer with the AuNCs

Unprecedented Magneto-Optics in Plasmonic–Magnetic Nanohybrids of Chiral Polymer Films





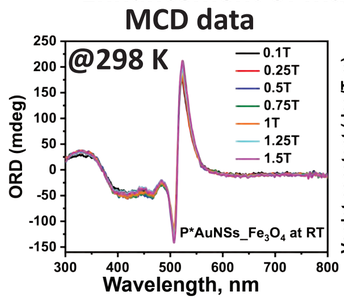
Verdet constant calculated using:

$$\theta = VBl$$

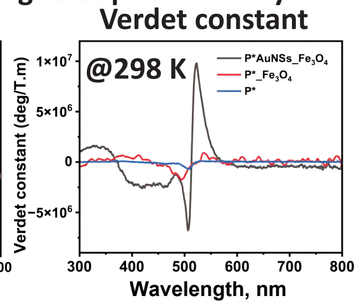
θ – Optical rotation,
B – Magnetic field,
l – thickness of the film

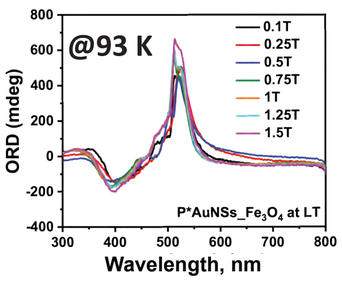
Enhancement of magnetooptical activity

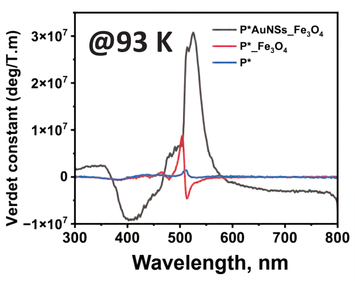
MCD data



Verdet constant

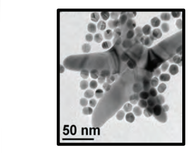


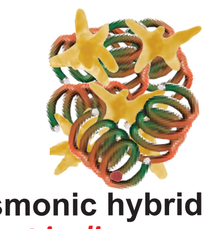




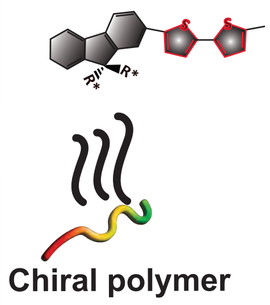
The nanocomposites displayed a 28-fold enhanced Verdet constant at 93 K relative to the pure polymer system.

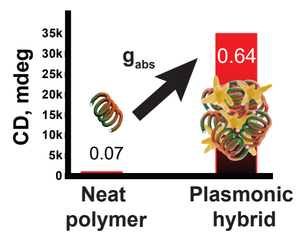
Conclusion



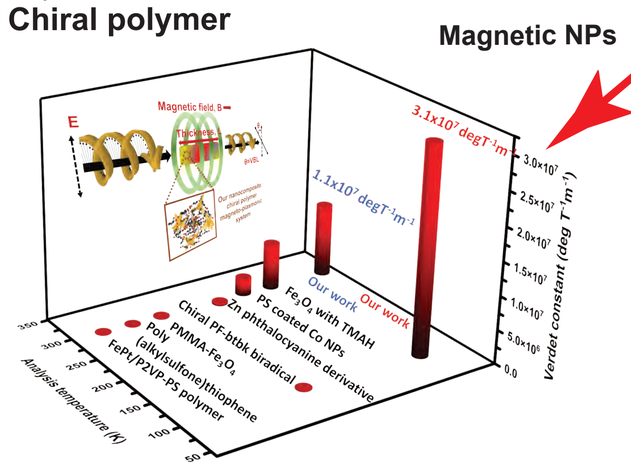


Enhancement in dissymmetry





Magnetic NPs



References

1.) Abraham S. R. *et. al.*, *Adv. Optical Mater.* **2024**, 2400914

2.) Abraham S. R. *et. al.*, *Small.* **2025**, 2409752

3.) Joseph, J. P. et. al., *J. Phys. Chem. Lett.* **2022**, 13, 9085–9095.

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Acknowledgments

SUNY RF The Research Foundation for The State University of New York