Ultra-Bright NIR-II/SWIR Conjugated Polymer Nanoparticles for Low-Dose, High-Contrast Imaging in Resource-Limited Environments

Far-Forward Portable Life Support & Imaging Devices
MHSRS 2026 - Wednesday, 5 August 2026

Joshua Tropp, Ph.D.
Texas Tech University
Chemistry & Biochemistry
Office ESB2-301C

Disclosure / Conflict of Interest

Dr. Joshua Tropp has no relevant financial relationships with ineligible companies to disclose.

Tropp Research Group - Acknowledgements

TROPP LAB (13)

Robert Posey (organic)
Nikita Gill (inorganic)
Brenda Alfaro (organic)
Nicholas Payne (analytical)
Tahamida Oyshi (analytical)
Paulina Flores (organic)
Wendy Galvan (organic)
Foster Morales (UG – Chem)
Nicholas Portillo (UG – Chem)
Kaleb Jewell (UG – Chem. Eng.)
Sophia German-Kavle (UG – Biochem)
Jacquelyn Tran (UG – Bio)
Nathan Sidor (UG – Biochem)
Helena Garza (UG – Bio)

COLLABORATORS

Prof. Jonathan Rivnay (NU)
Prof. Indrajit Srivastava (TTU)
Dr. Lucas Flagg (NIST)
Prof. Ulrich Bickel (TTU HSC)
Prof. Aristide Gum. (MIT)

PanTEX
Managed and Operated by
Consolidated Nuclear Security, LLC

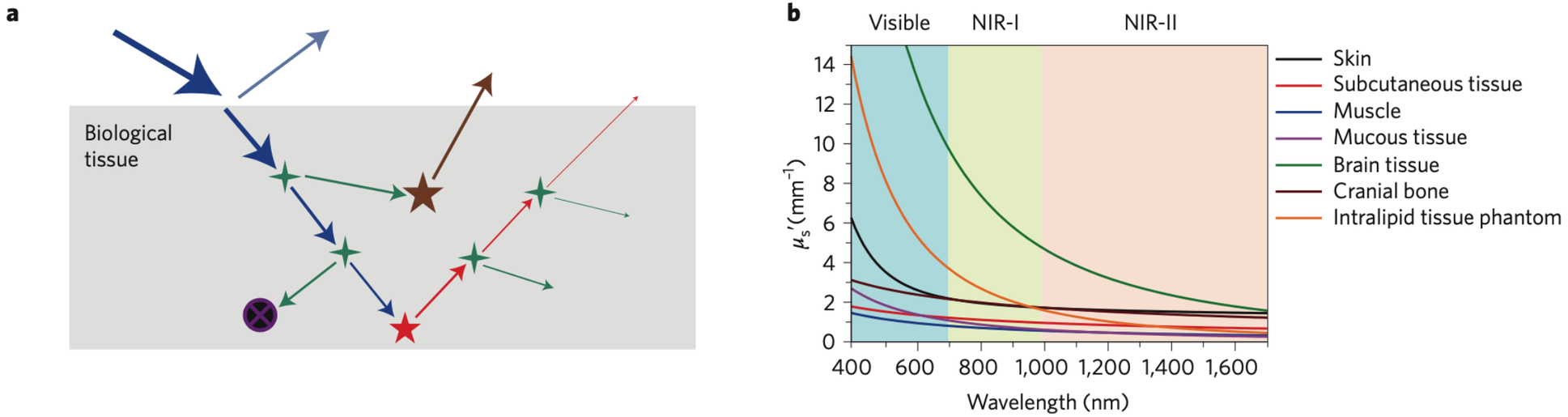
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
UNITED STATES AIR FORCE

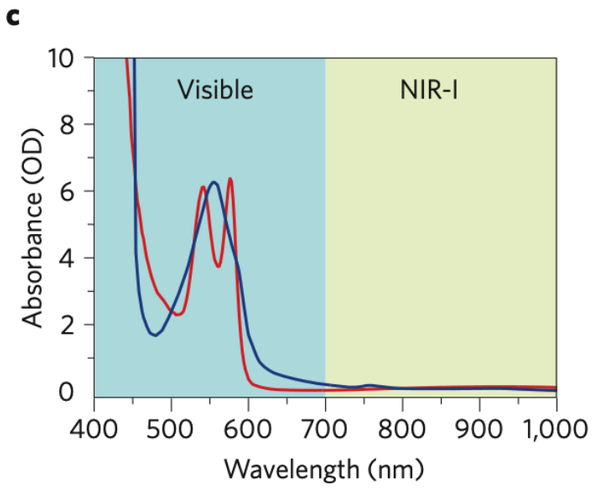
DARPA

THE Welch FOUNDATION

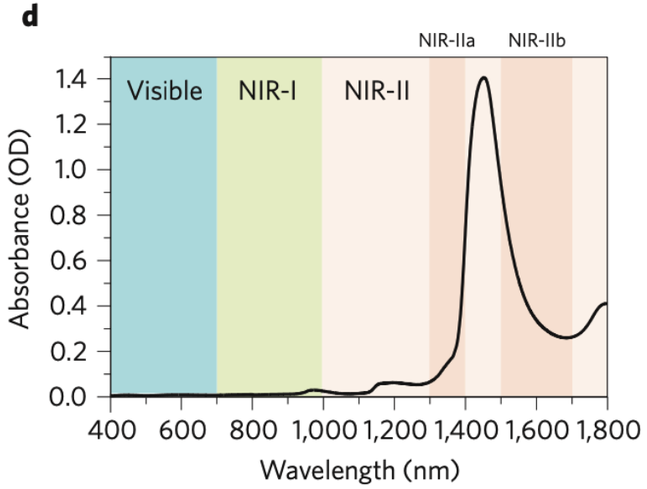
ACS PRF

NIR-II/SWIR Fluorophores for Bioimaging

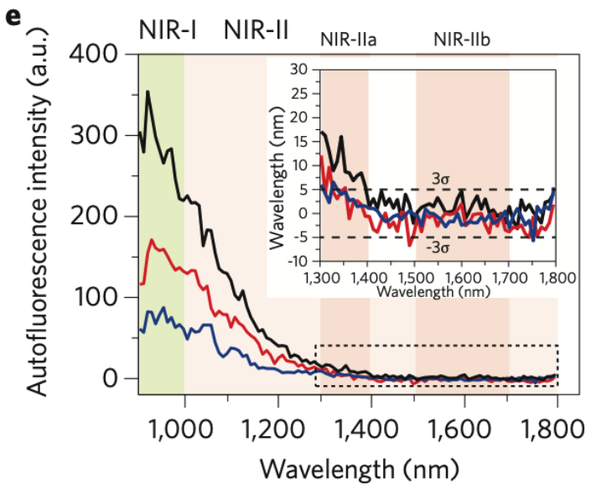




Red: oxyhaemoglobin
Blue: deoxyhaemogolobin

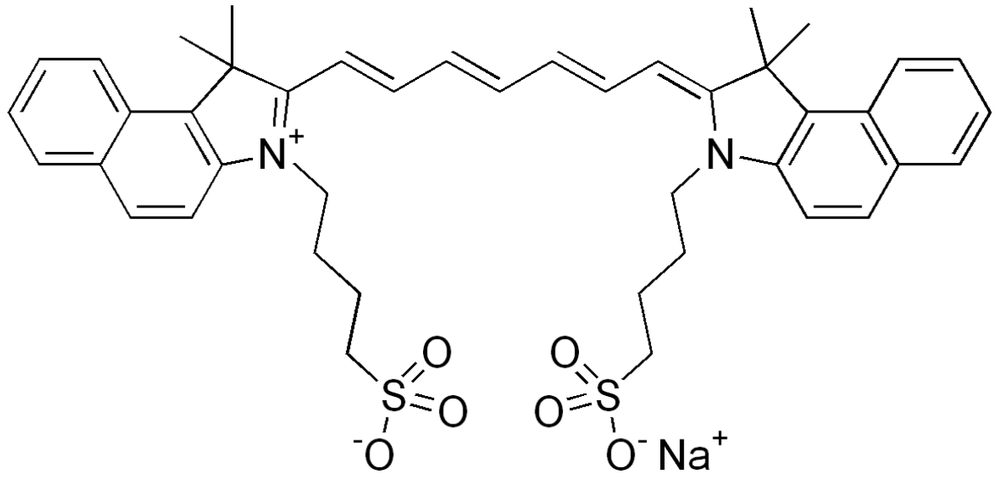


Absorption spectrum of water



Black: liver; Blue: Heart; Red: Spleen

NIR Fluorophores for Bioimaging



Indocyanine Green (ICG)

-Peak abs at 807

-Peak emission at 822 (NIR-I)

-QY = 1 – 9.3%

-Used for tumor imaging among other biomedical applications

-FDA approved in 1950s

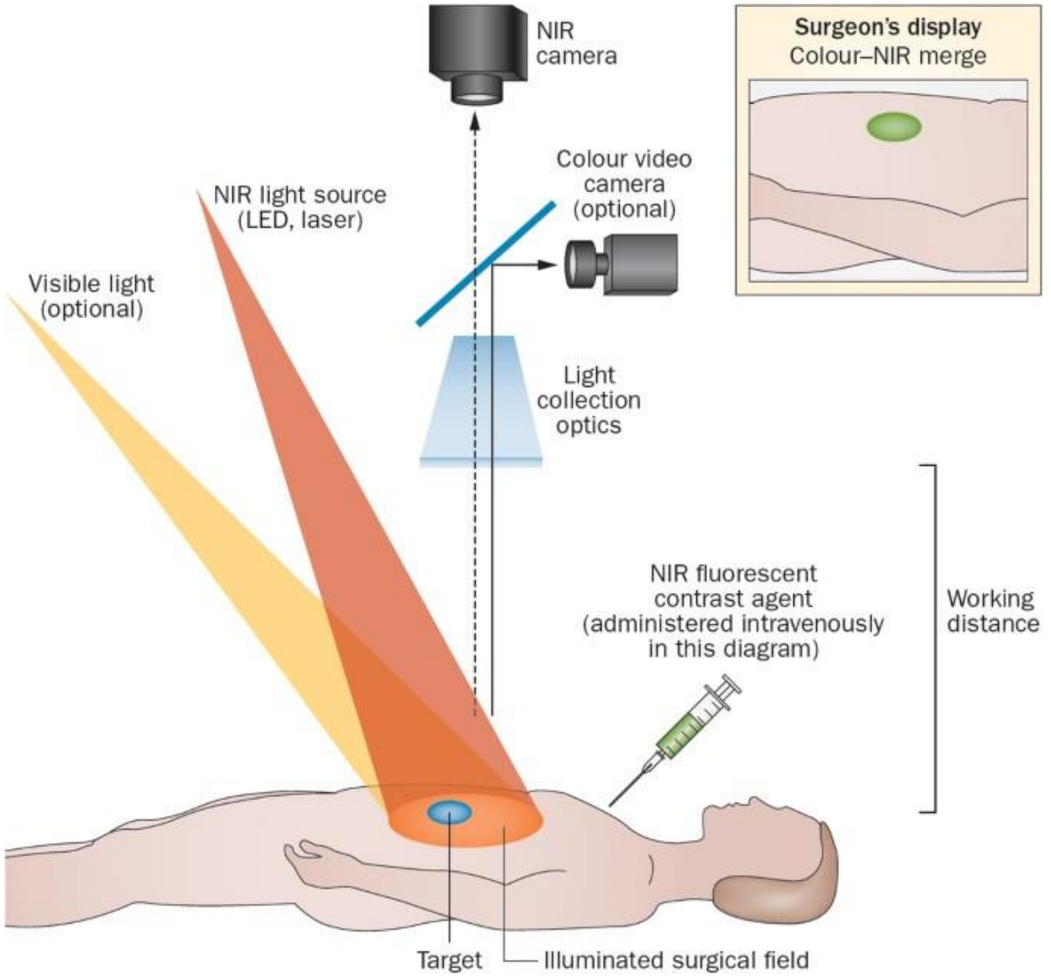
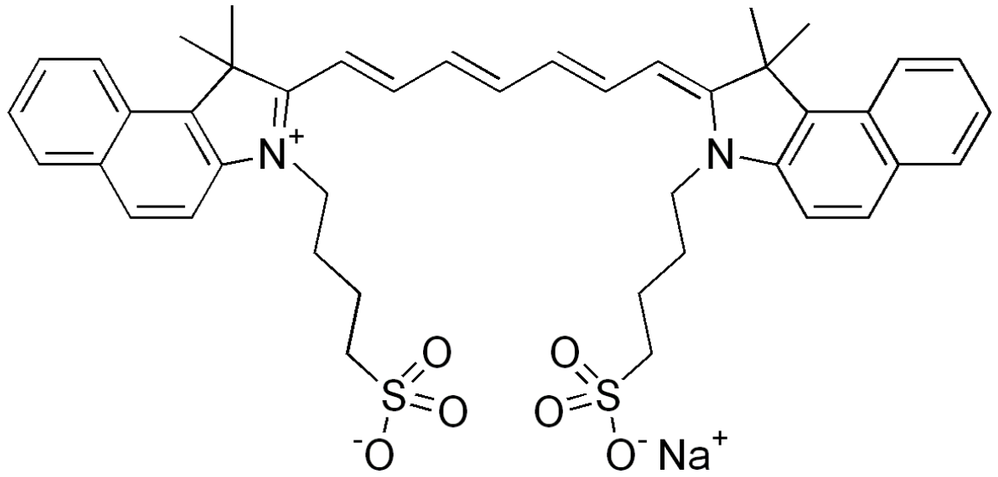


Image Guided Surgery:
Nat. Rev. Clinical Oncology. 2013, 10, 507

Curr. Opin. Chem. Biol. 2003, 7, 626

NIR Fluorophores for Bioimaging



Indocyanine Green (ICG)

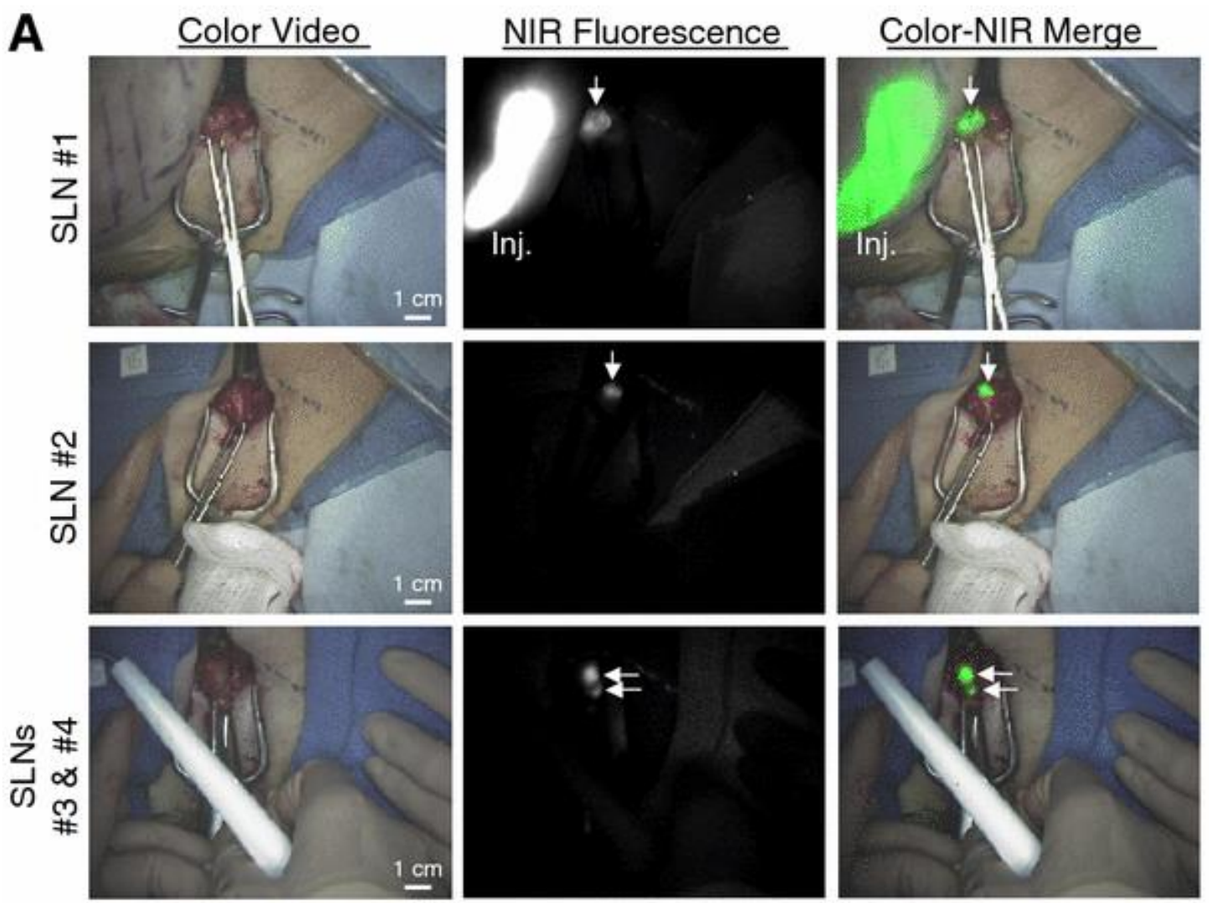
-Peak abs at 807

-Peak emission at 822 (NIR-I)

-QY = 1 – 9.3%

-Used for tumor imaging among other biomedical applications

-FDA approved in 1950s



Sentinel Lymph Node (SNL) Mapping at 800 nm:
Ann. Surg. Oncol. 2009, 16, 2943

Curr. Opin. Chem. Biol. 2003, 7, 626

Potential for Far-Forward Combat Casualty Care (FC3)

Trauma
- *Identification of active vascular injury*
- *Detection of tissue ischemia*

Forward Surgical Care
- *Image-guided debridement*
- *Foreign-body localization*
- *Identification of critical anatomy*

Critical Care
- *Perfusion monitoring*
- *Tissue viability assessment*

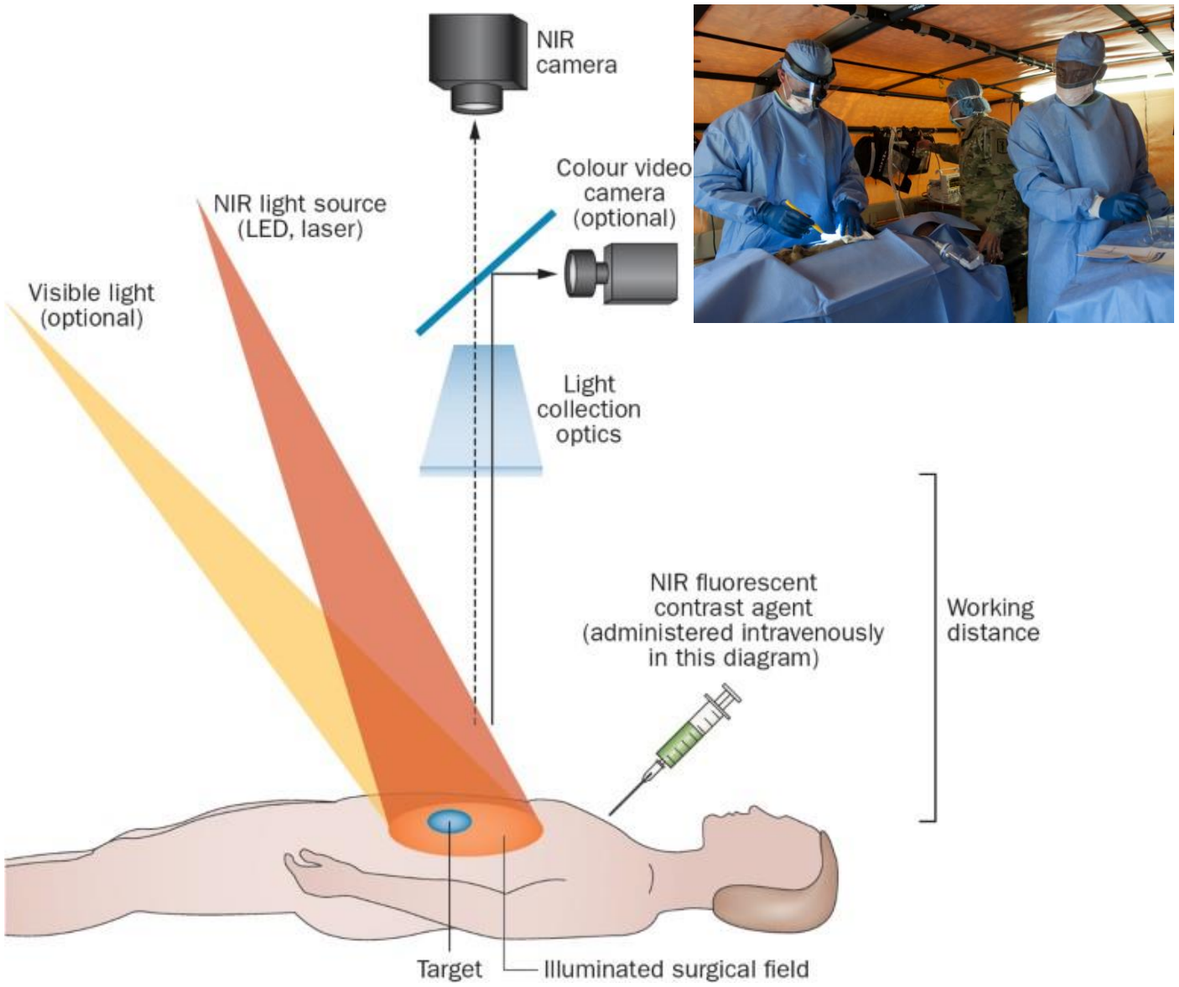


Image Guided Surgery:
Nat. Rev. Clinical Oncology. 2013, 10, 507

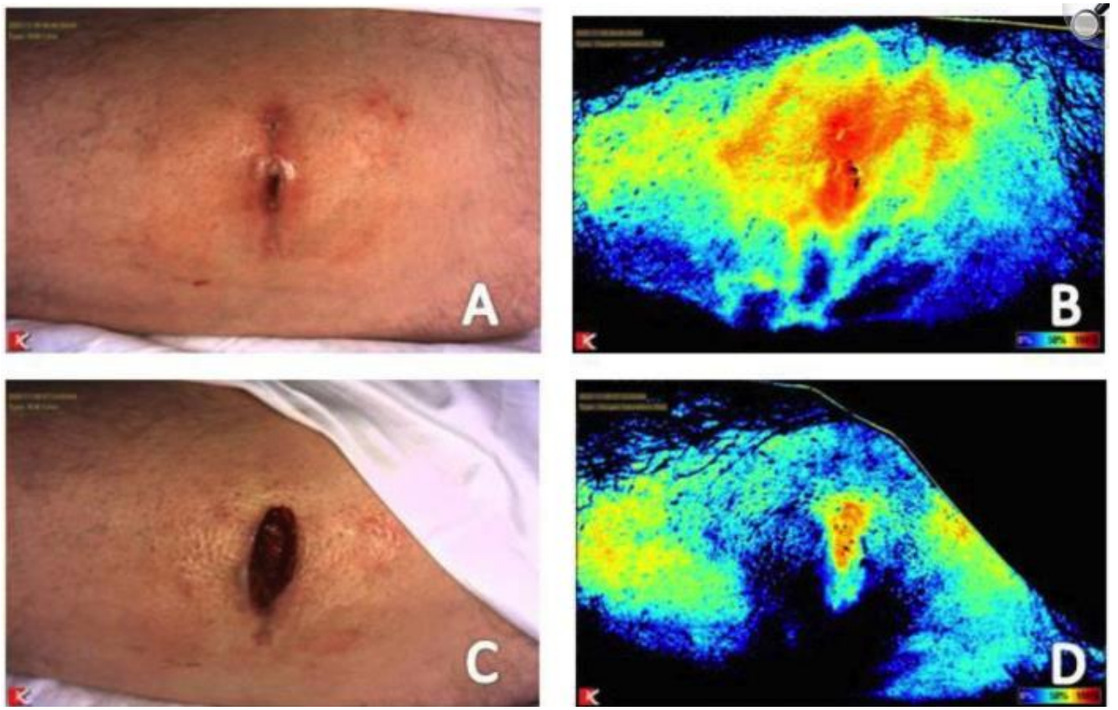
Lightweight and Portable Compared to MRI/CT

Potential for Far-Forward Combat Casualty Care (FC3)

Trauma
- *Identification of active vascular injury*
- *Detection of tissue ischemia*

Forward Surgical Care
- *Image-guided debridement*
- *Foreign-body localization*
- *Identification of critical anatomy*

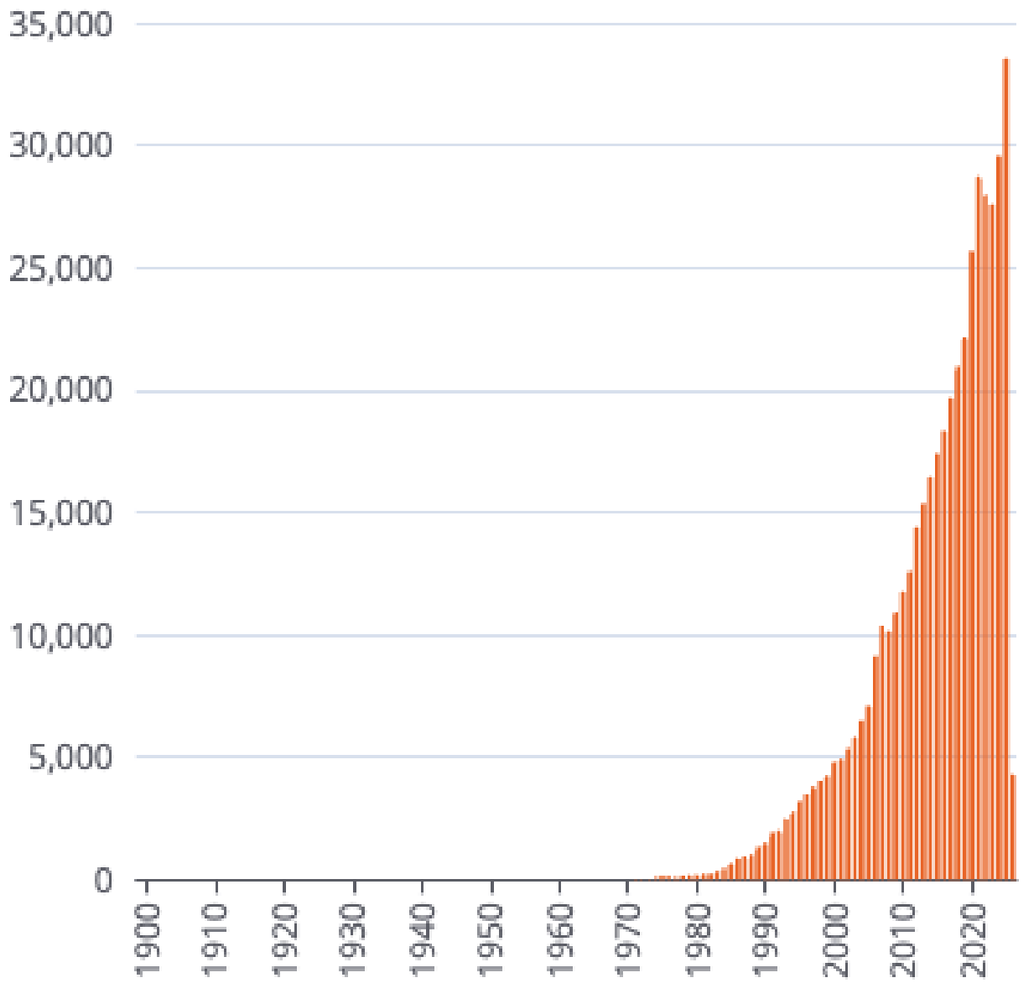
Critical Care
- *Perfusion monitoring*
- *Tissue viability assessment*

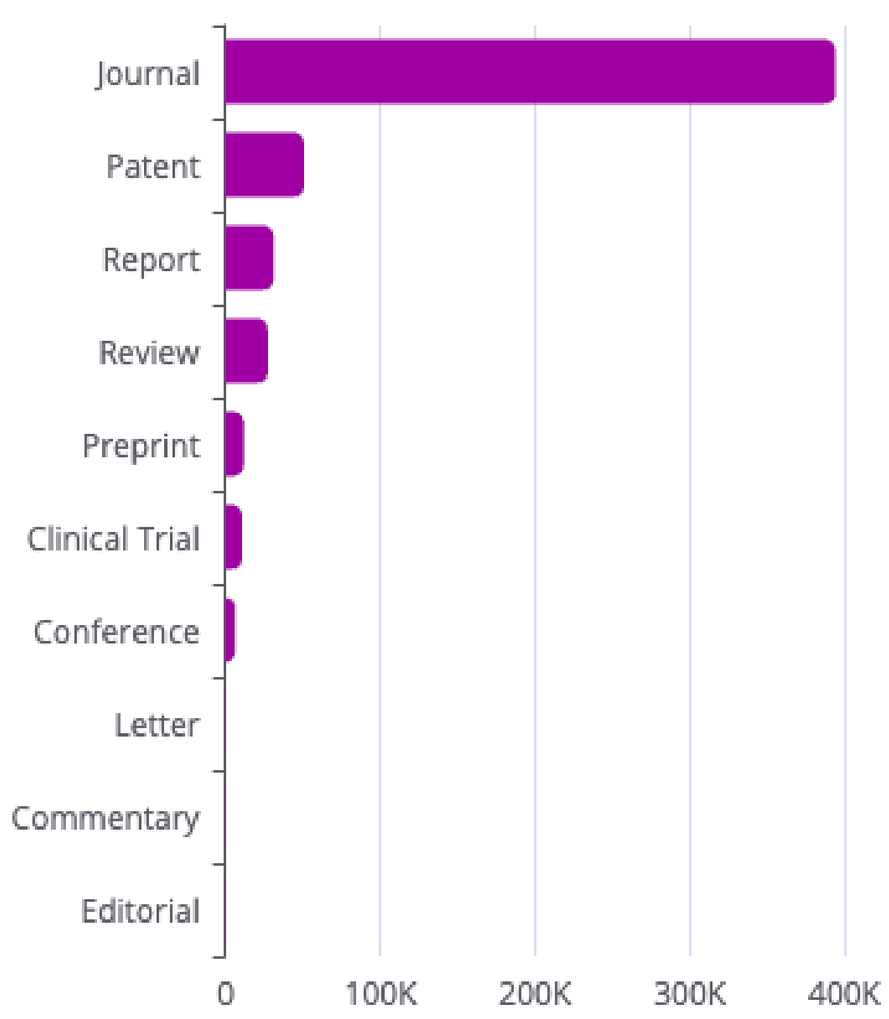


NIR Wound Assessment: *Diagnostics. 2021, 11, 778*

Lightweight and Portable Compared to MRI/CT

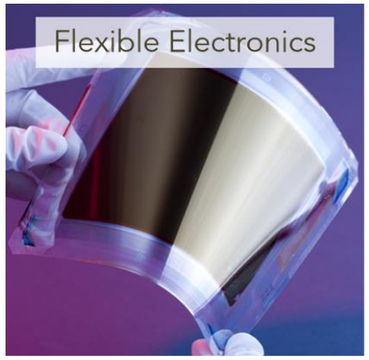
Publications Over Time With Keyword “NIR-II Imaging”

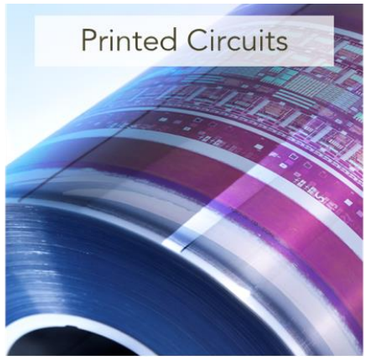


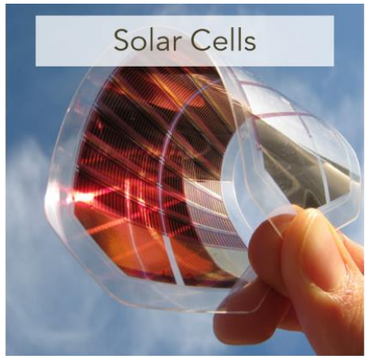


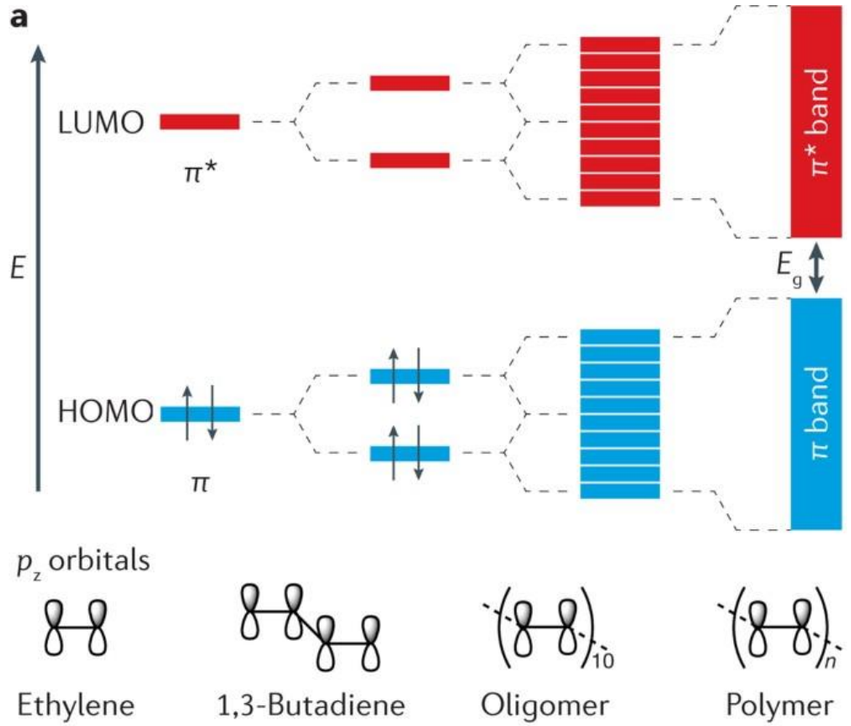
NIR-II Imaging is Growing in Popularity – Materials are Nascent

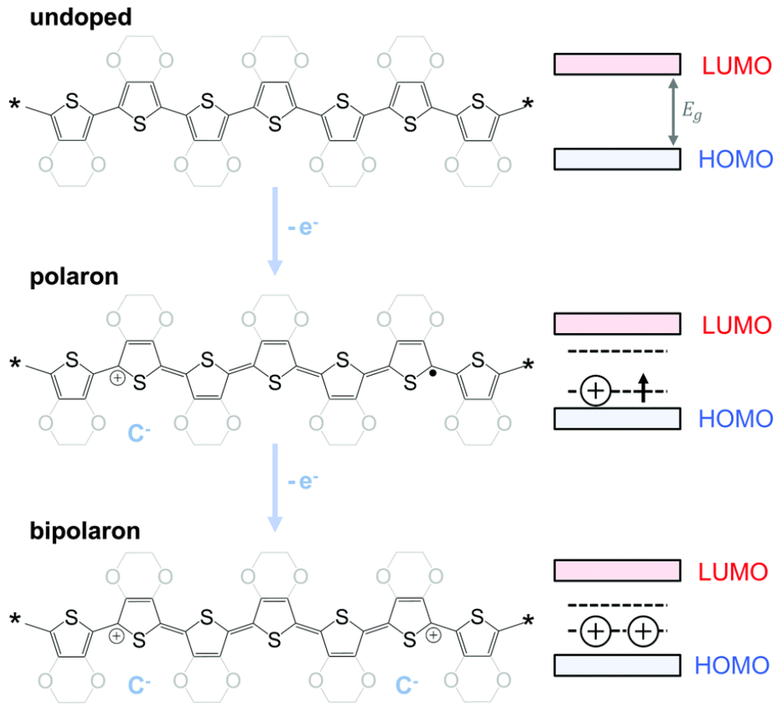
Conjugated Polymers



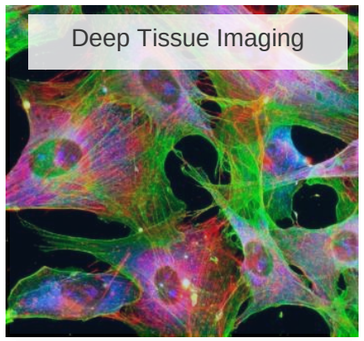


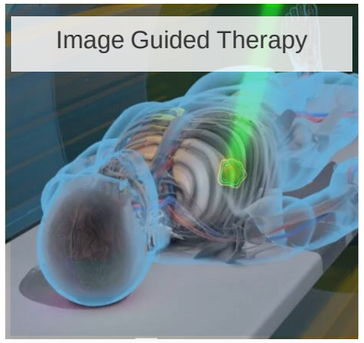


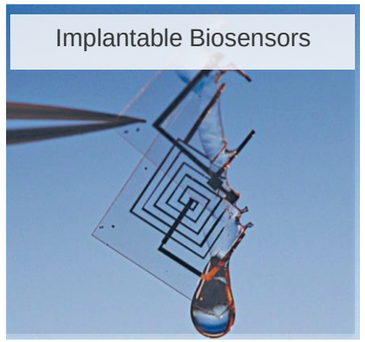


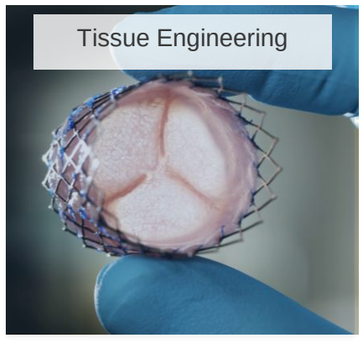


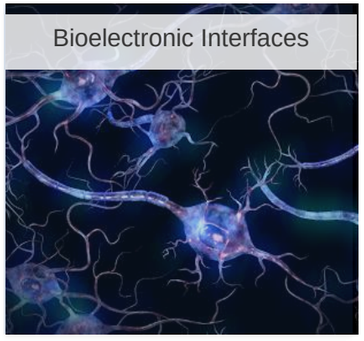
Conjugated Polymers

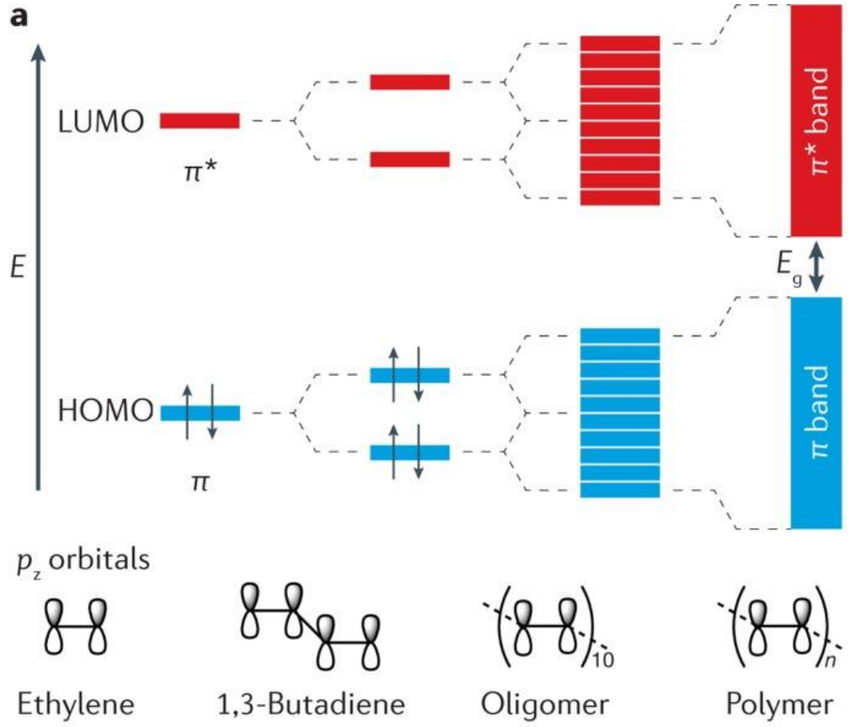


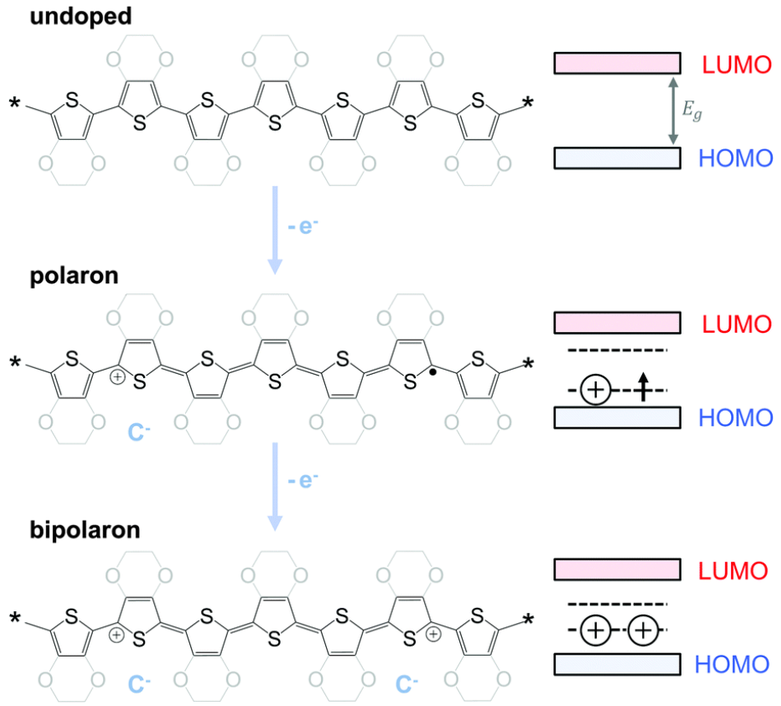




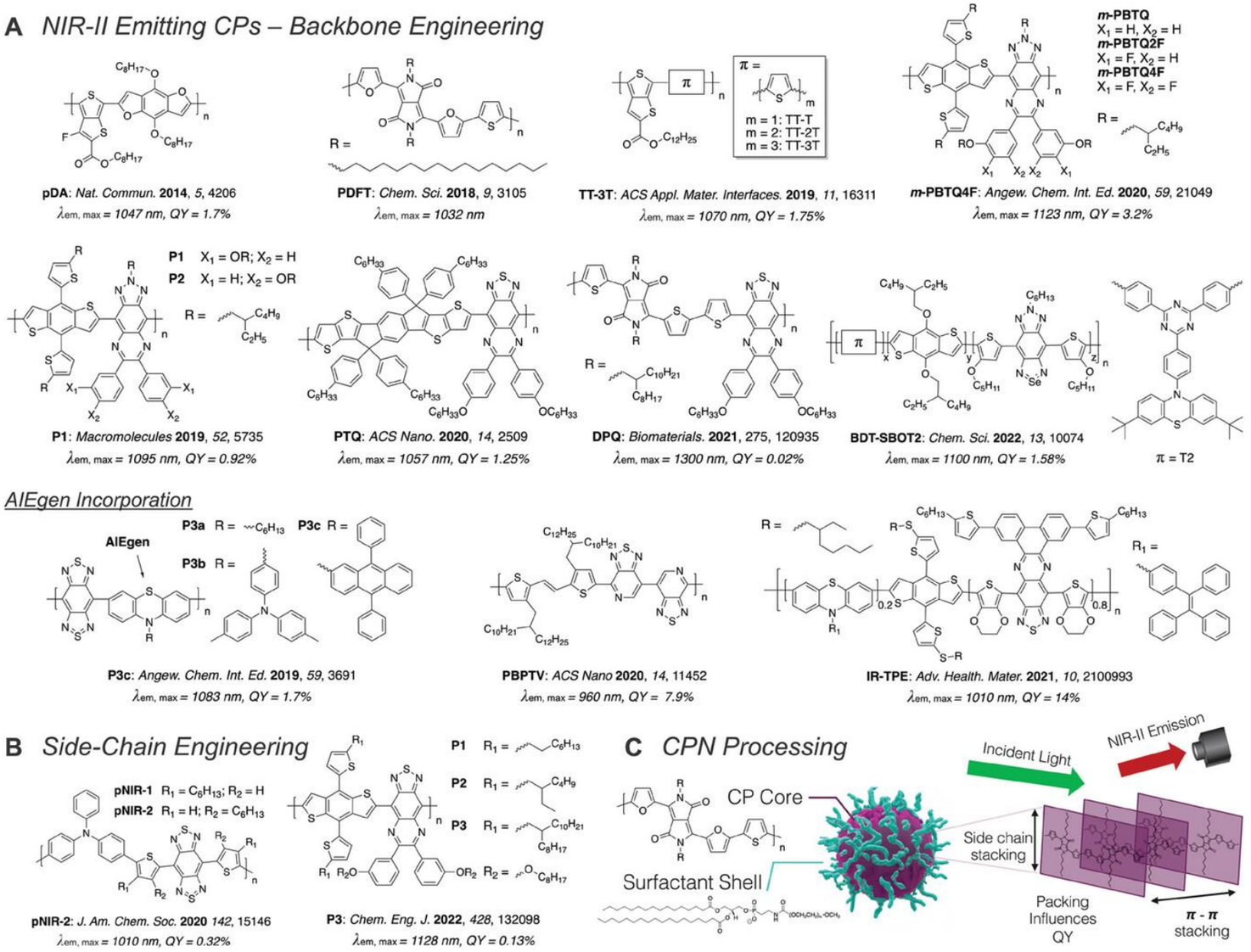




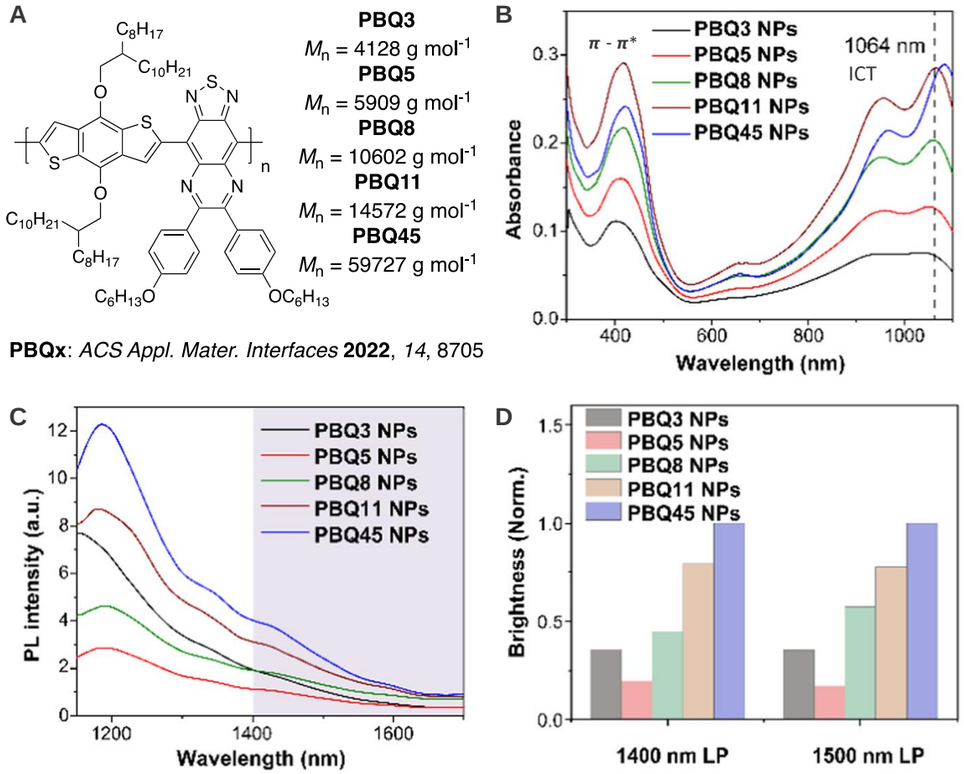




Current State of NIR-II/SWIR Emitting CPs



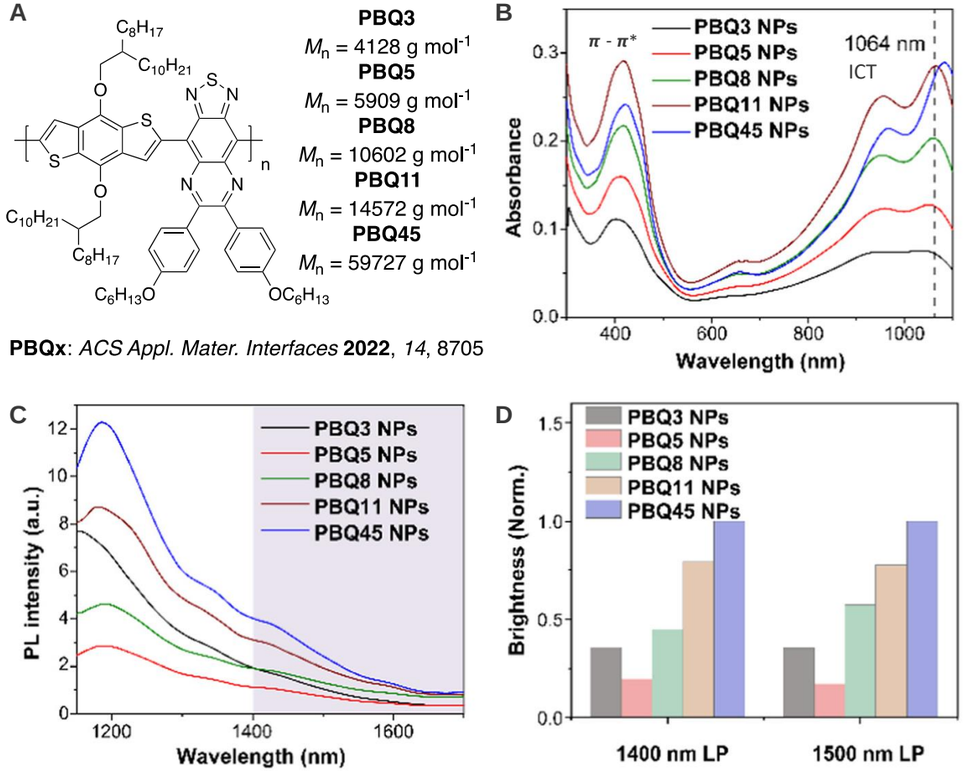
Example: Role of Molecular Weight



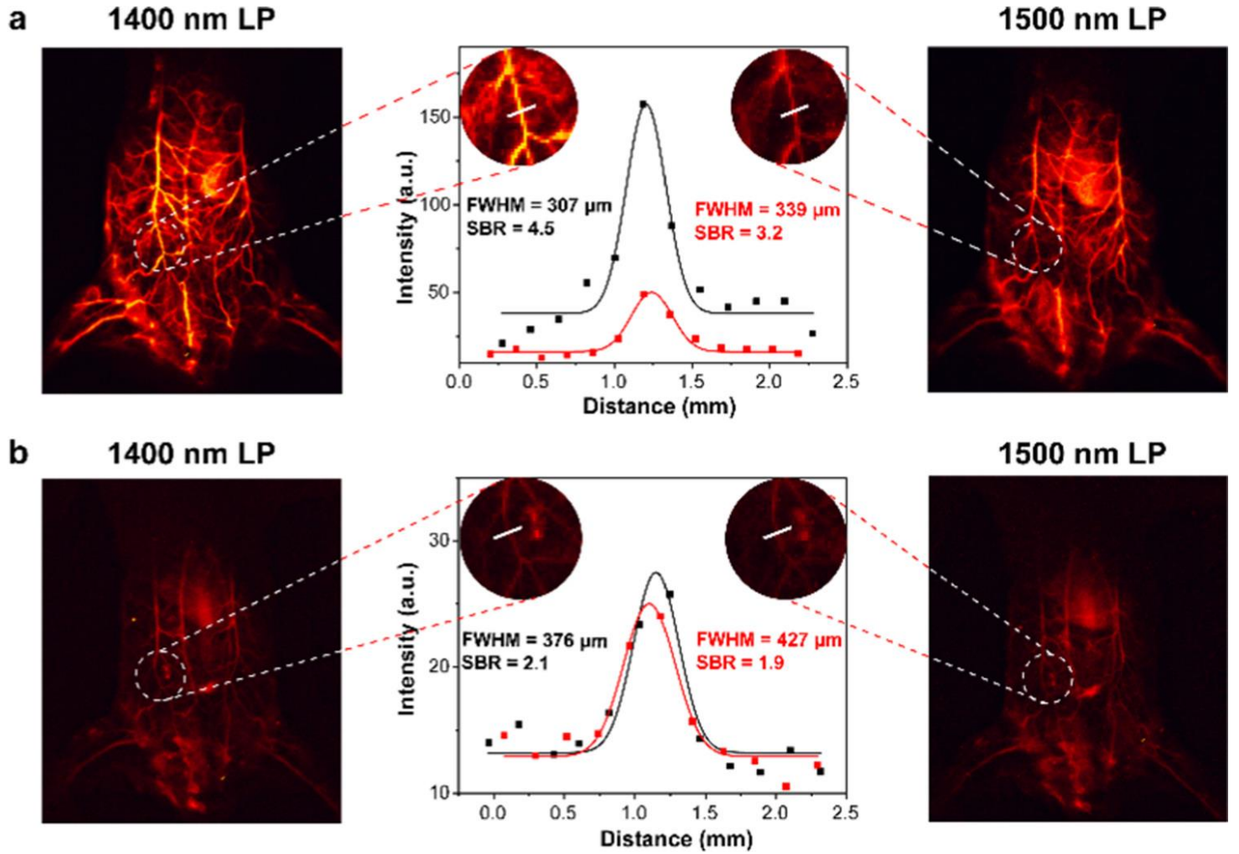
PBQx: *ACS Appl. Mater. Interfaces* **2022**, *14*, 8705

- *Absorptivity increases from 7.2 to 27.5 L /(g cm) with molecular weight*
- *QY decreases from 0.111% to 0.048% with molecular weight*

Structure Property Relationship Example: Role of Molecular Weight



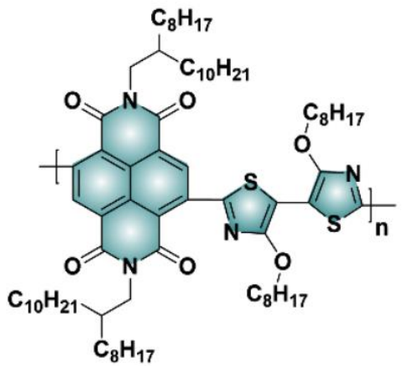
PBQx: *ACS Appl. Mater. Interfaces* **2022**, *14*, 8705



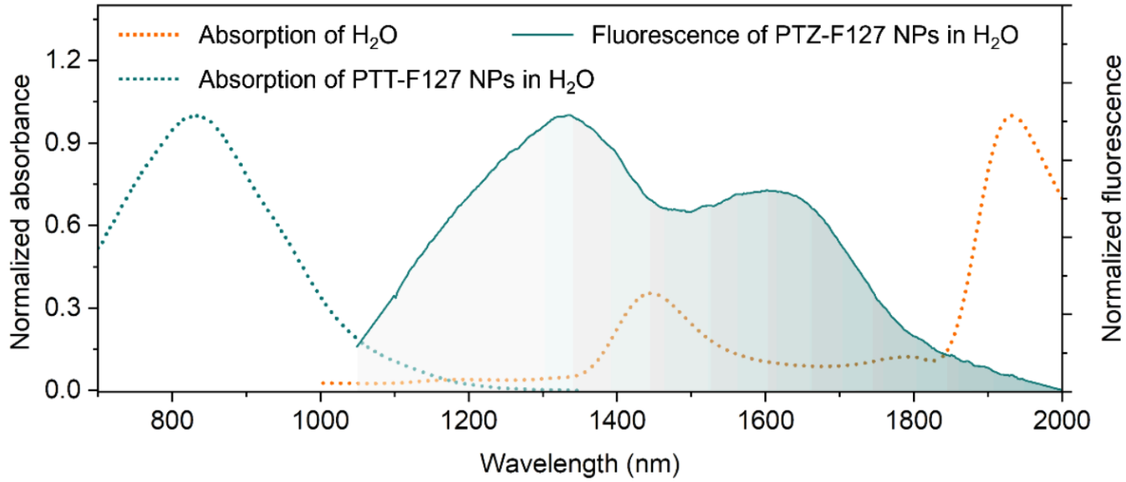
- *Absorptivity increases from 7.2 to 27.5 L /(g cm) with molecular weight*
- *QY decreases from 0.111% to 0.048% with molecular weight*

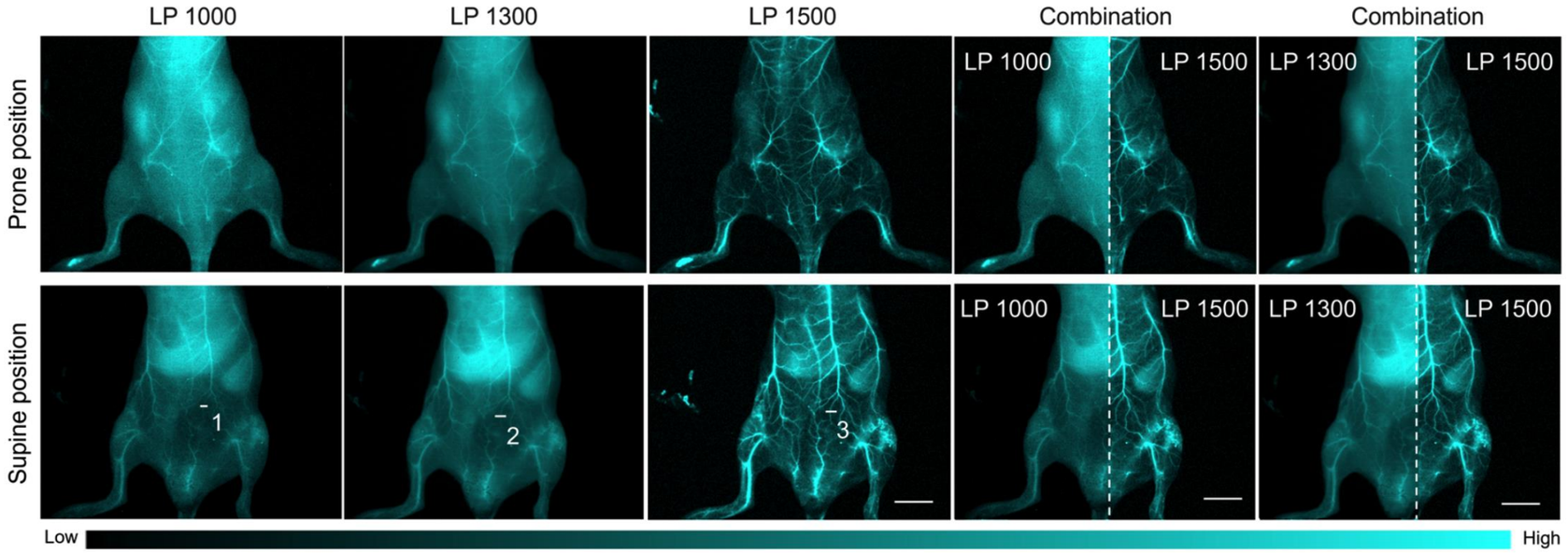
- *Increasing polymer molecular weight improves nanoparticle brightness for in vivo imaging*

Structure Property Relationship Example: Peak Emission Beyond 1300 nm

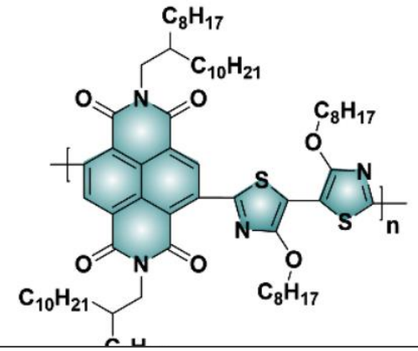


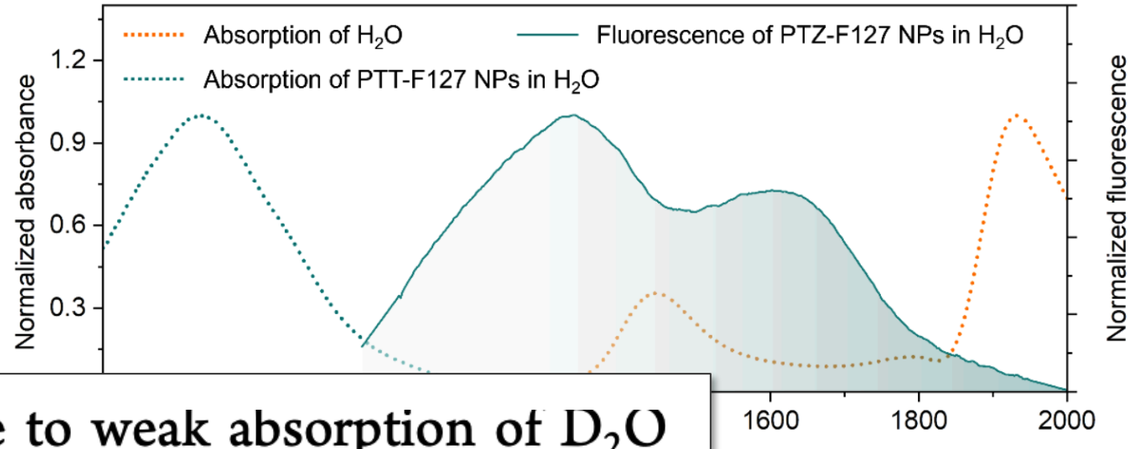
PTZ



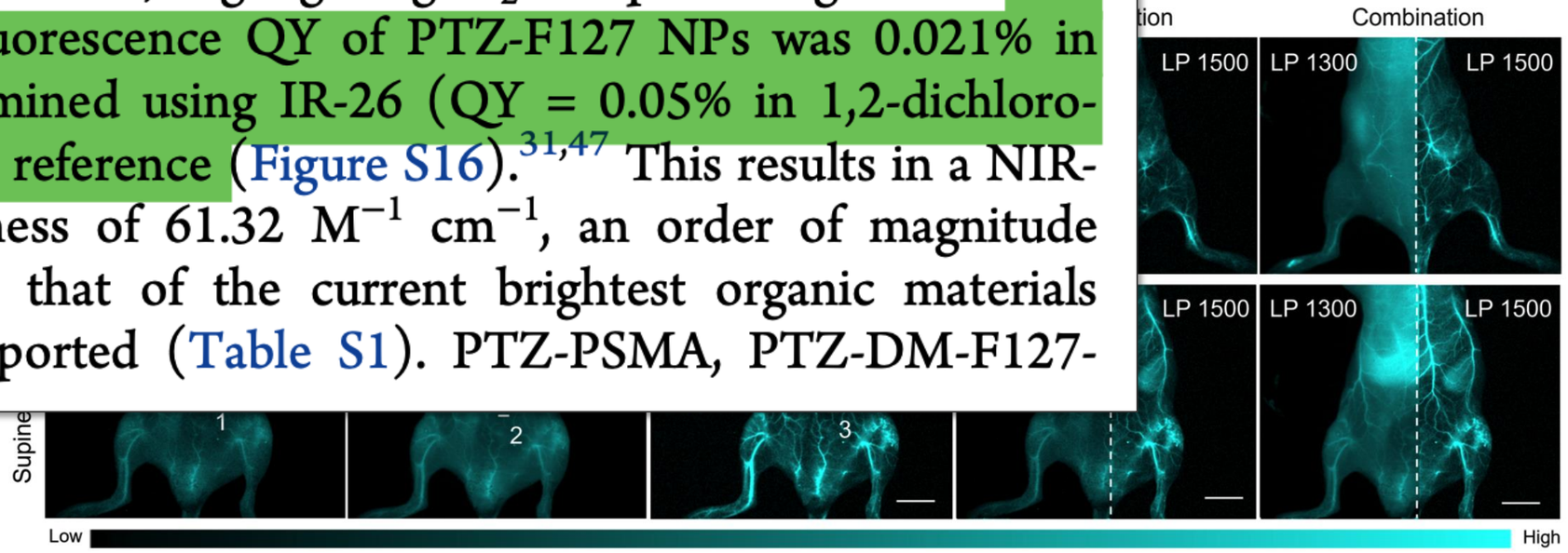


Structure Property Relationship Example: Peak Emission Beyond 1300 nm

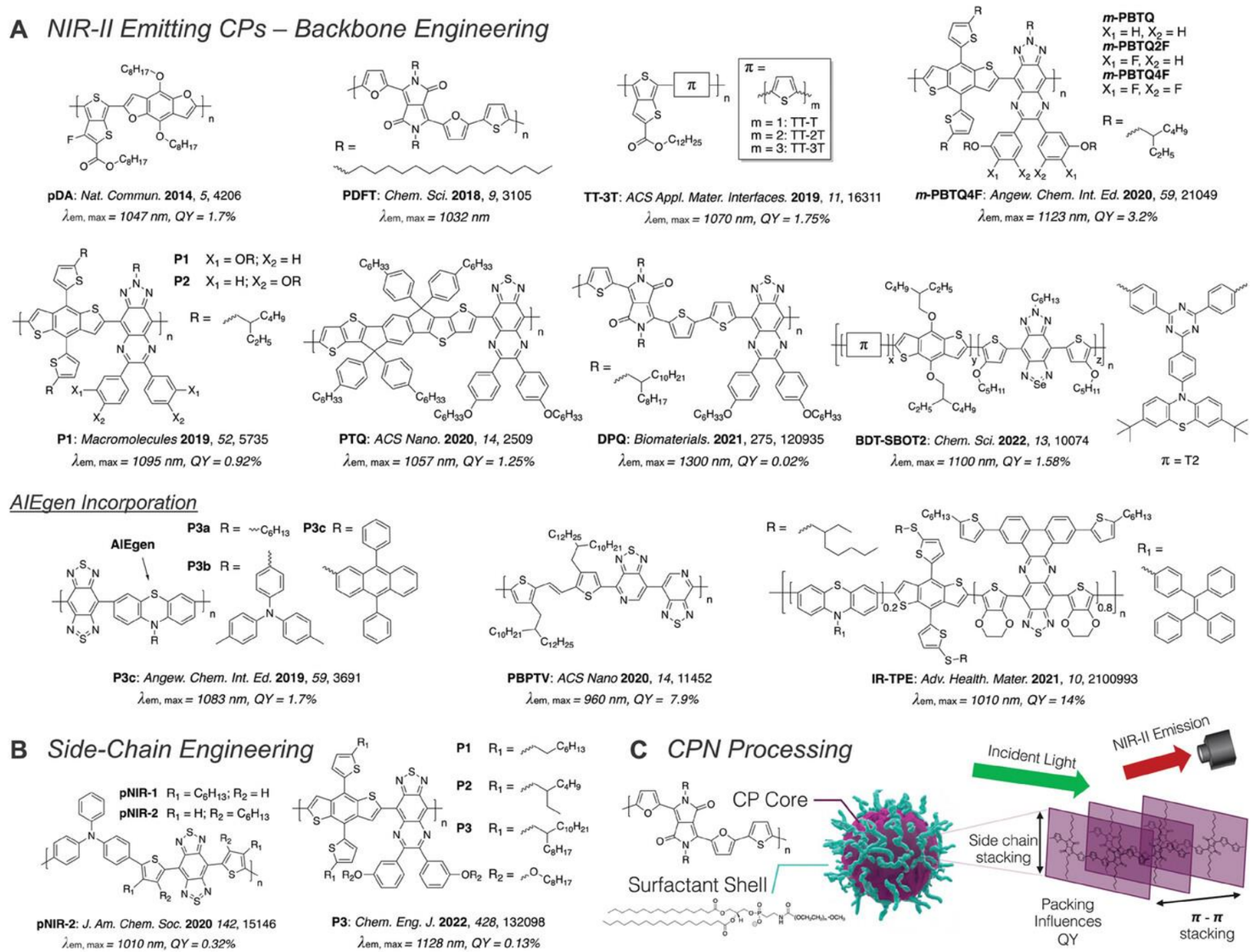


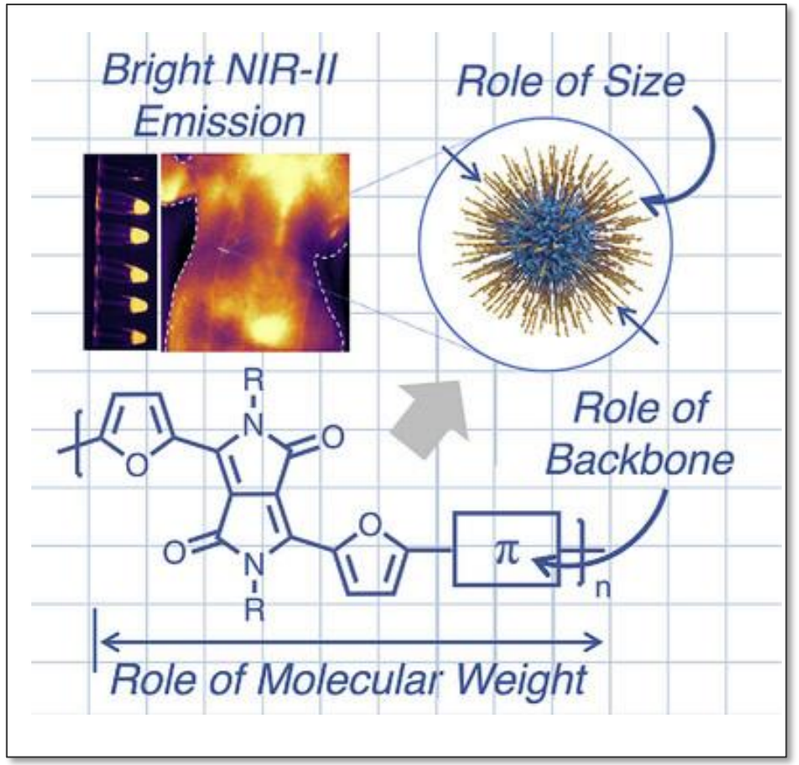


rise at 1600 nm (Figure S15) due to weak absorption of D_2O in 1400–1900 nm, highlighting H_2O's quenching effect. The NIR-IIbc fluorescence QY of PTZ-F127 NPs was 0.021% in H_2O, determined using IR-26 (QY = 0.05% in 1,2-dichloro-ethane) as a reference (Figure S16).[31,47] This results in a NIR-IIbc brightness of 61.32 M^{-1} cm^{-1}, an order of magnitude higher than that of the current brightest organic materials currently reported (Table S1). PTZ-PSMA, PTZ-DM-F127-



Current State of NIR-II/SWIR Emitting CPs

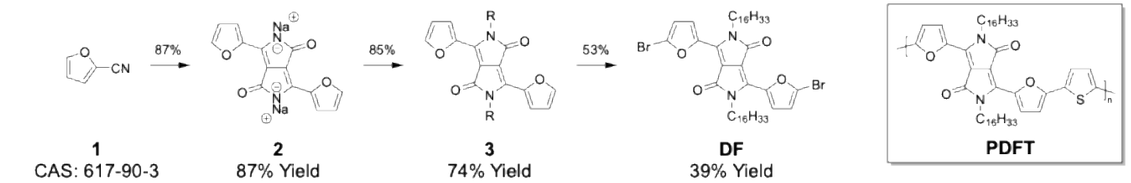




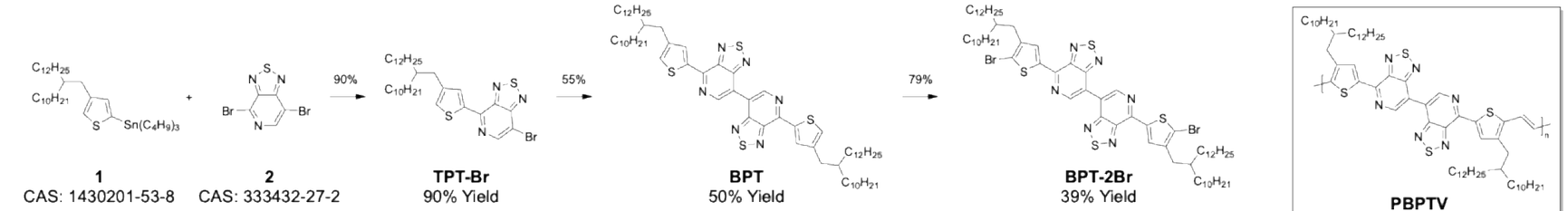
Adv. Opt. Mater. ***2025;***
J. Mater. Chem. B ***2025;***
ACS Nanosci. Au, ***2025****;*
ACS Nano ***2025;***
Small Methods, ***2026***

Gill, N., … Tropp, J., *Adv. Health Mater.* **2024**, *13*, 2401297

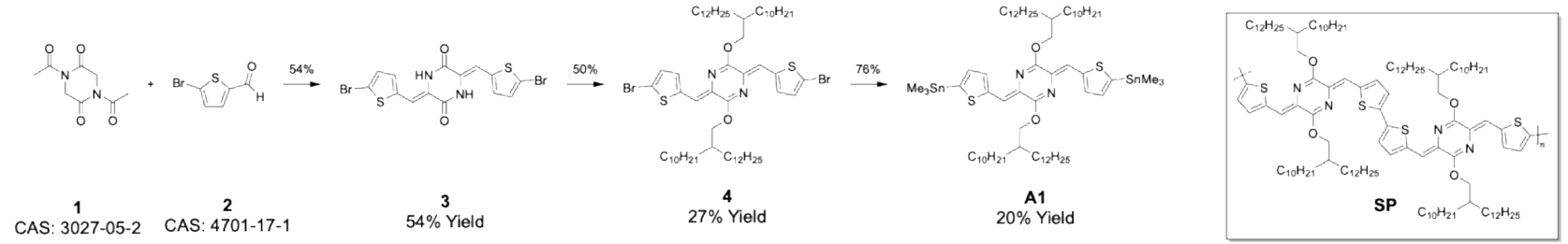
Challenge: Synthetic Complexity, Scalability, and Access



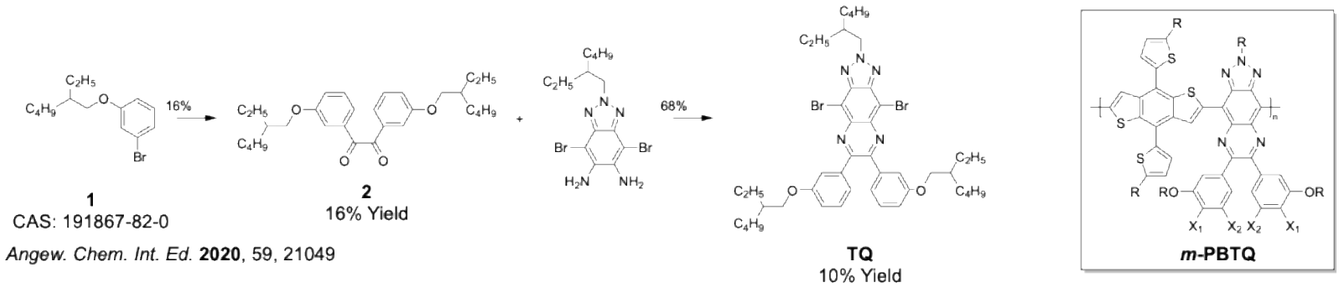
Chem. Sci. **2018**, 9, 3105



J. Am. Chem. Soc. **2017**, 49, 17735

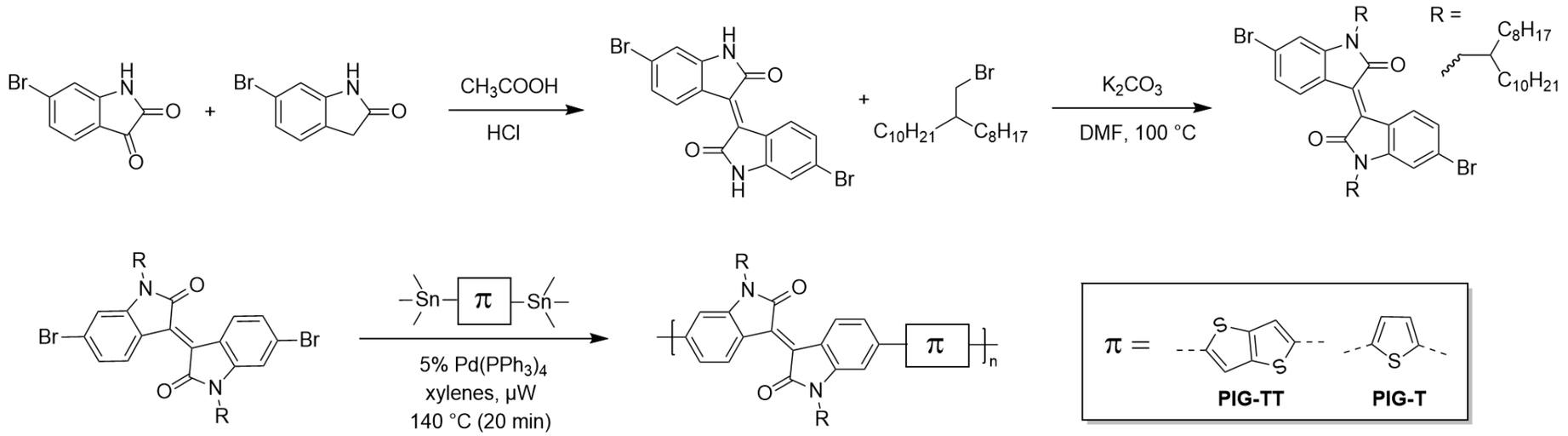


ChemBioChem **2019**, 20, 2793



Angew. Chem. Int. Ed. **2020**, 59, 21049

Polyisoindigo Copolymer Series

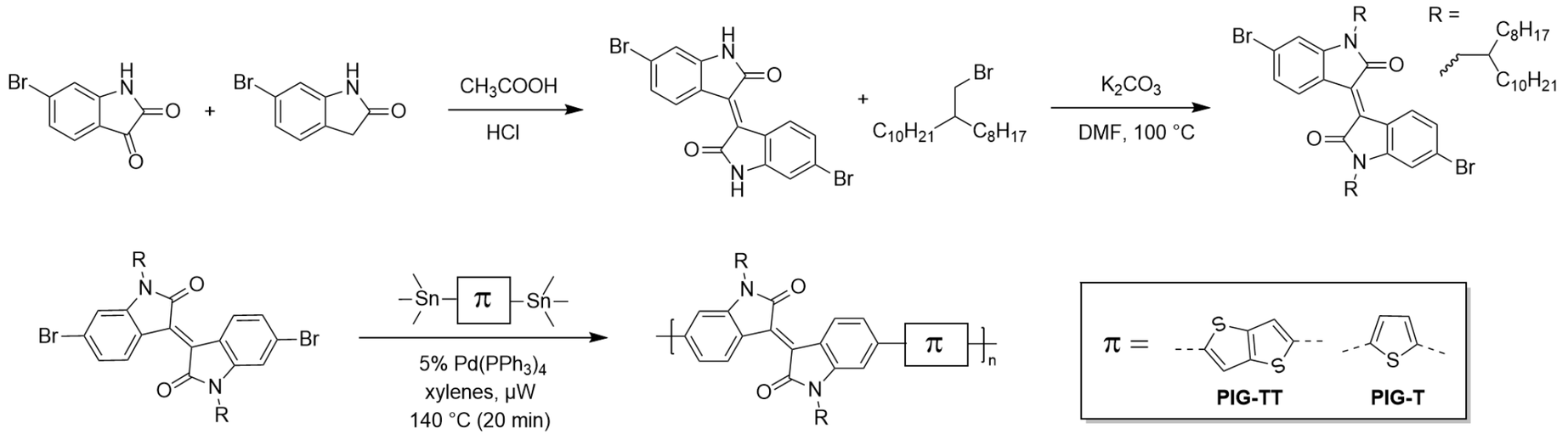


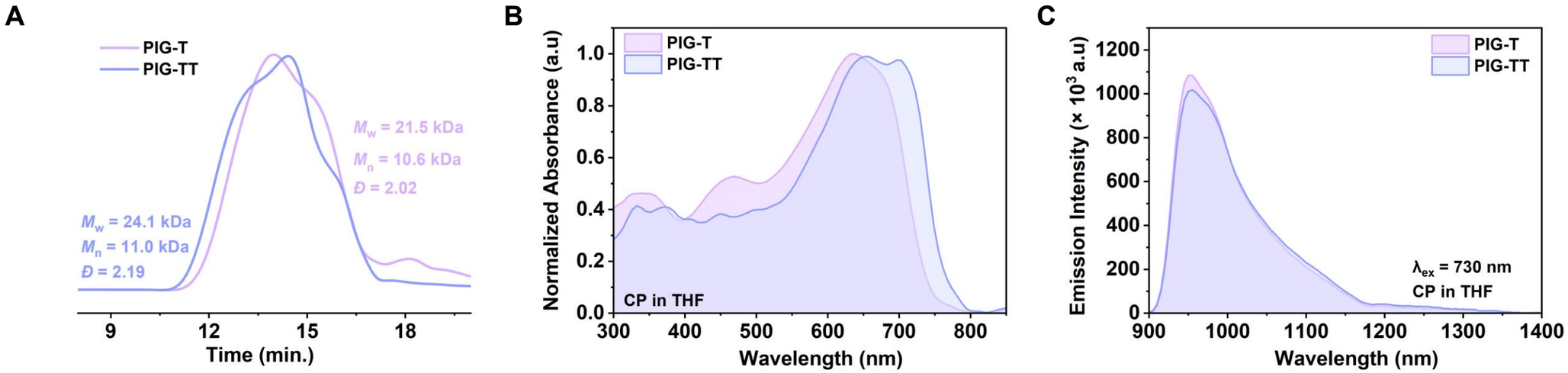
Monomer on > 100g Scale!
>80% Yield

Multigram Polymer Synthesis

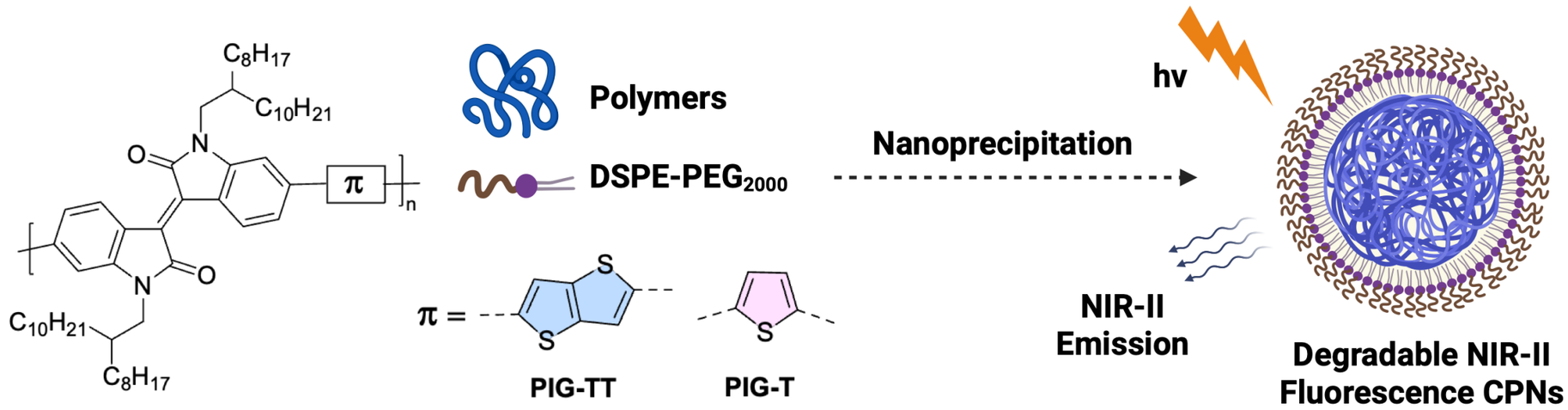
Gill, N., … Tropp, J., *Manuscript in Preparation*

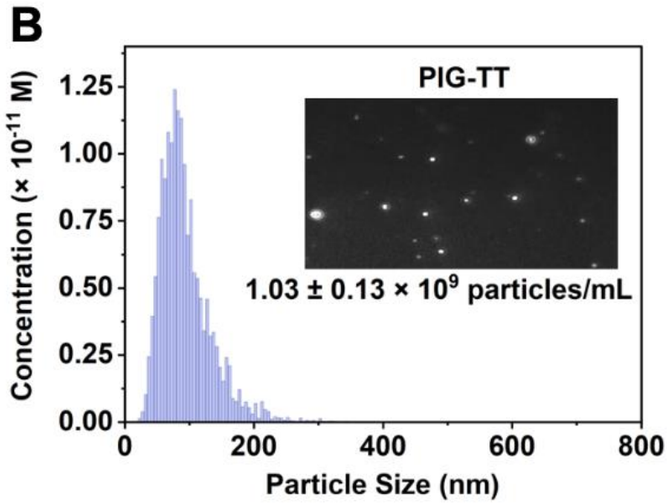
Polyisoindigo Copolymer Series

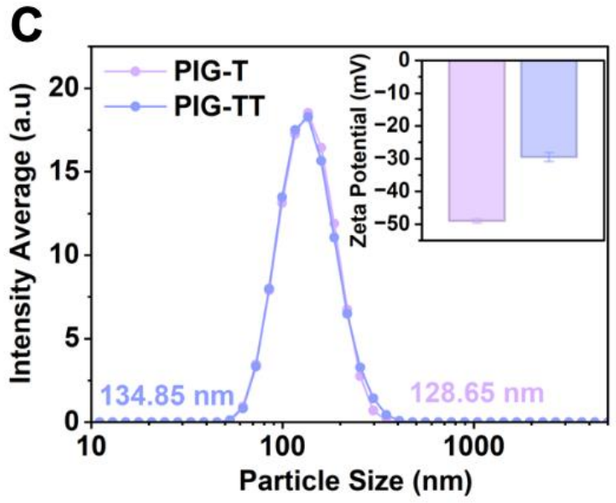


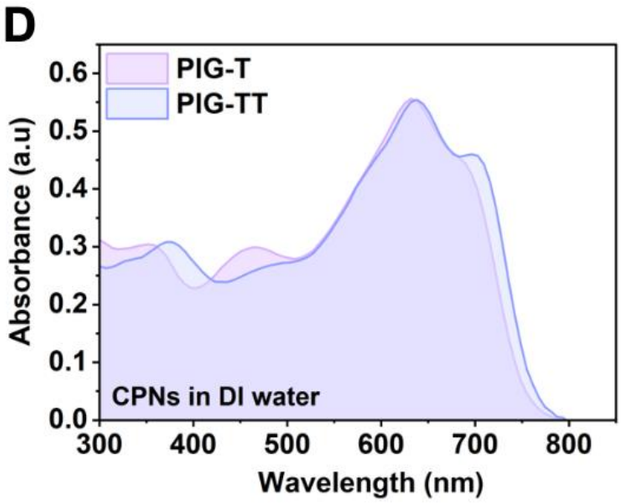


PIG Nanoparticle Series

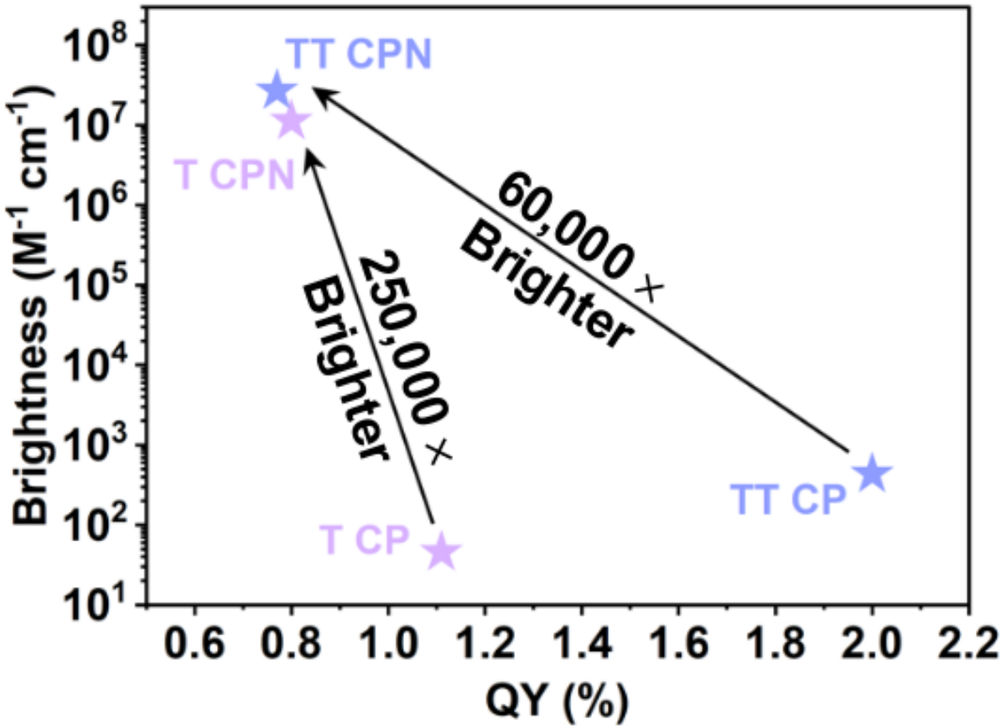


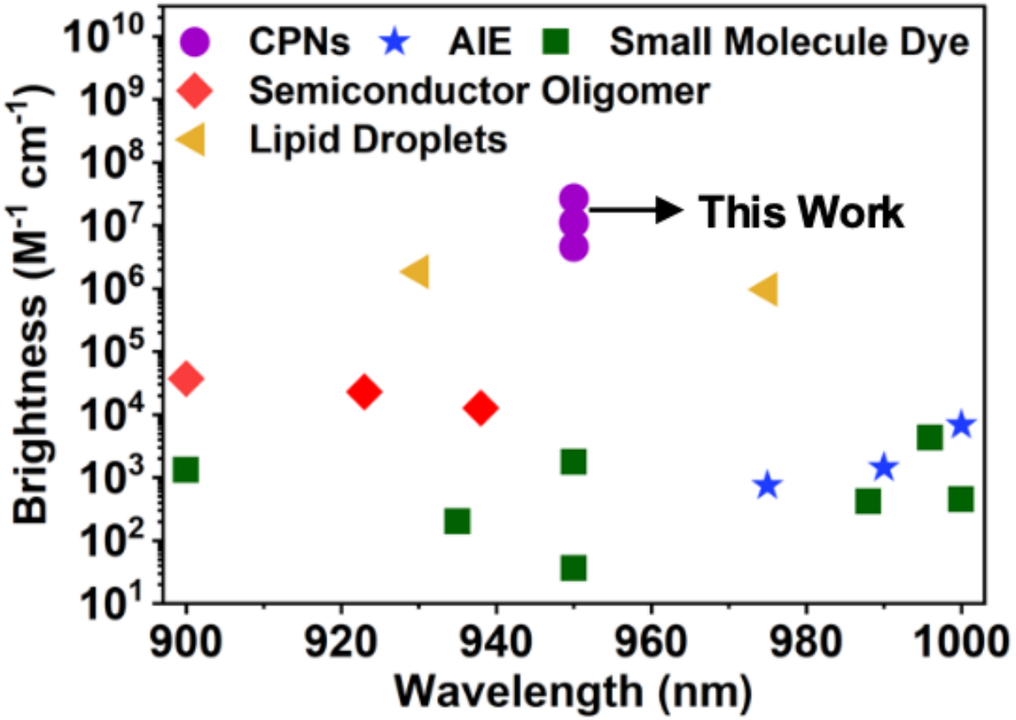






PIG Nanoparticle Series – Brightness Comparison





	M_w (kDa)	$Đ$	$\lambda_{abs,max}$ (nm)	$\lambda_{em,max}$ (nm)	D_h (nm)	ξ (mV)	Φ (%)	ε (M^{-1} cm^{-1})	B (M^{-1} cm^{-1})
PIG-T in THF	21.5	2.02	638	950	-	-	1.11 ± 0.13	4100	46
PIG-TT in THF	24.1	2.19	657	955	-	-	2.00 ± 0.30	21, 500	432
PIG-T CPNs	21.5	2.02	631	950	129.83 ± 2.04	- 49.07 ± 0.68	0.80 ± 0.09	1.4×10^9	$1.12 \pm 0.13 \times 10^7$
PIG-TT CPNs	24.1	2.19	638	950	137.15 ± 0.96	- 29.51 ± 1.37	0.77 ± 0.16	3.5×10^9	$2.70 \pm 0.56 \times 10^7$

Gill, N., … Tropp, J., *Manuscript in Preparation*

PIG Nanoparticle Series – Brightness Comparison

Composition	NPs diameter (nm)	Dye content (wt%)	λ_{abs} (nm)	λ_{em} (nm)	QY (%)	B (M^{-1} cm^{-1})
Molecular organic dyes						
Rhodamine 6G			530	552	90	1.0×10^5
Quantum dots						
QD-585				585	60	$1.8 \times 10^{5\,b}$
QD-605				605	52	$3.0 \times 10^{5\,c}$
QD-705				705	49	$1.0 \times 10^{6\,c}$
Conjugated polymer NPs						
MEH-PPV	15	100	485	590	1	1.2×10^6
PFBT	15	100	450	545	7	5.1×10^5
PFBT	10	100	450	545	30	3×10^6
PFPV	15	100	445	510	8	1.2×10^7
PFBT-DBSOC6 10-COOH	23	50	455	712	15	1.1×10^7
PF-TC6FQ-BODIPY	26	100	495	723	33	1.7×10^7
Pttc-TFQ-BODIPY	28	100	490	724	51	5.1×10^7
PF-TC6FQ	21	100	493	652	47	2.4×10^7
PFDBT5–PFBT	15	80	450	650	56	1.6×10^7
PFGBDP/PFDHTBT–BDP720	31	100	528	721	42	1.8×10^8

- *ε for typical core-only QDs is 10^5 – 10^6 M^{-1} cm^{-1}*
- *ε for typical CPNs is 10^8 – 10^9 M^{-1} cm^{-1}*
- While the QY is higher for QDs, many CPNs are brighter
- Modest improvements in CPN QY can dramatically boost *B*

Klymchenko, S., *Chem. Soc. Rev.* ***2023***, *52, 4525*

PIG Nanoparticle Series – Brightness Comparison

Composition	NPs diameter (nm)	Dye content (wt%)	λ_{abs}	λ_{em}	QY
Molecular organic dyes					
Rhodamine 6G					
Quantum dots					
QD-585					
QD-605					
QD-705					
Conjugated polymer NPs					
MEH-PPV	15	100			
PFBT	15	100			
PFBT	10	100			
PFPV	15	100			
PFBT-DBSOC6 10-COOH	23	50			
PF-TC6FQ-BODIPY	26	100			
Pttc-TFQ-BODIPY	28	100			
PF-TC6FQ	21	100			
PFDBT5–PFBT	15	80			
PFGBDP/PFDHTBT–BDP720	31	100			

Probing the Cytotoxicity of Semiconductor Quantum Dots

Austin M. Derfus, Warren C. W. Chan,† and Sangeeta N. Bhatia*

Department of Bioengineering, University of California at San Diego, La Jolla, California 92093

"Our data further suggest that cytotoxicity correlates with the liberation of free Cd2+ ions due to deterioration of the CdSe lattice."

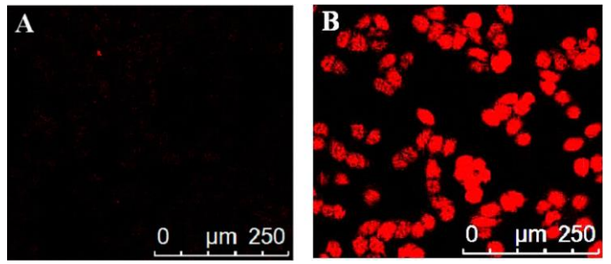
Nano. Lett. ***2004****, 4, 11*

ACS APPLIED MATERIALS & INTERFACES — Research Article — www.acsami.org

Highly Enhanced Fluorescence of CdSeTe Quantum Dots Coated with Polyanilines via In-Situ Polymerization and Cell Imaging Application

Jingjing Xue, Xinyi Chen, Shanglin Liu, Fenfen Zheng, Li He, Lingling Li,* and Jun-Jie Zhu*

State Key Laboratory of Analytical Chemistry for Life Science, Collaborative Innovation of Chemistry for Life Science, School of Chemistry and Chemical Engineering, Nanjing University, Nanjing 210093, China



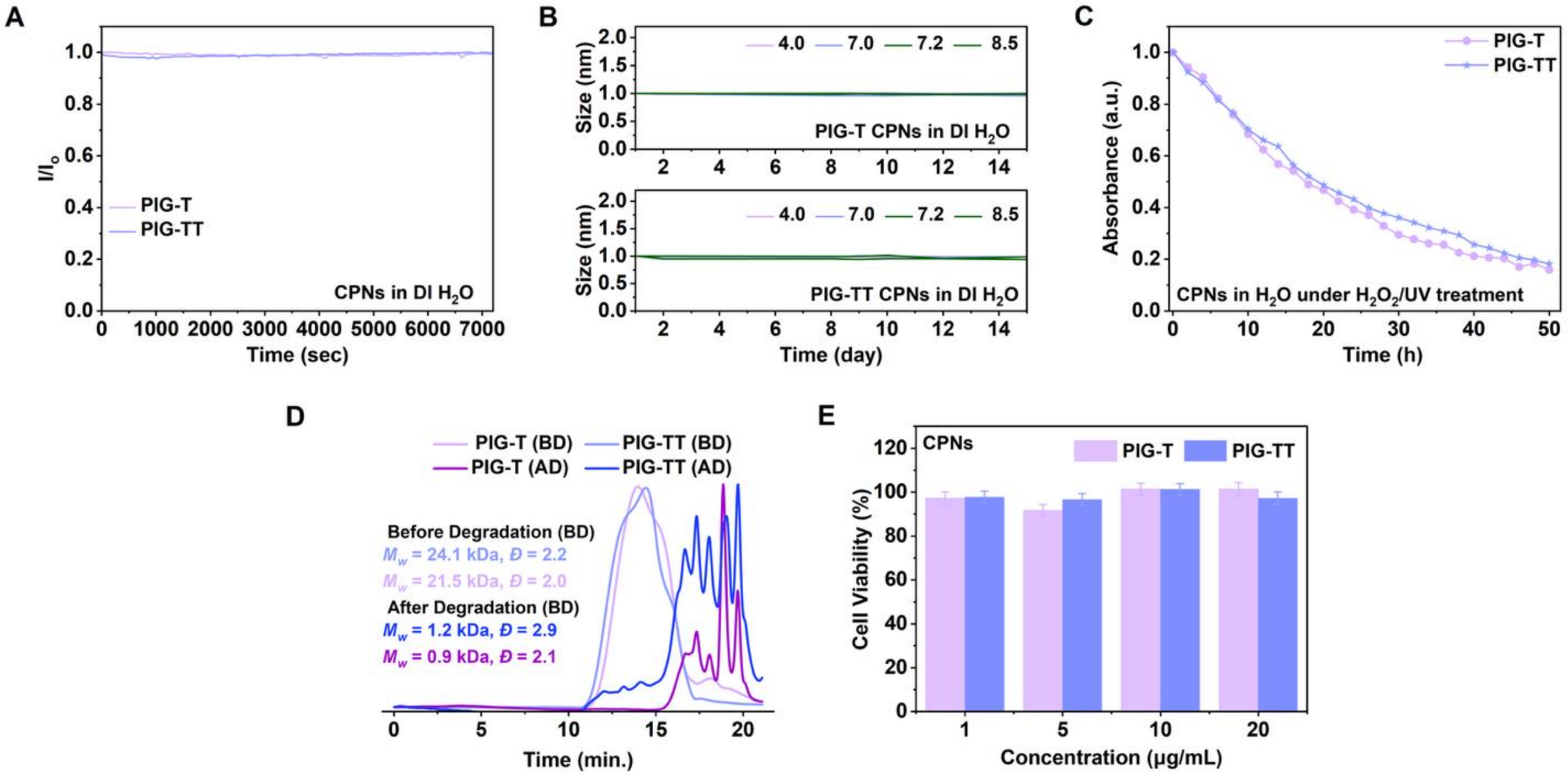
FI images of HeLa cells cultured with (A) CdSeTe QDs and (B) PANI coated QDs.

Recent Update: *Biophys. Rev.* ***2020****, 12, 703*

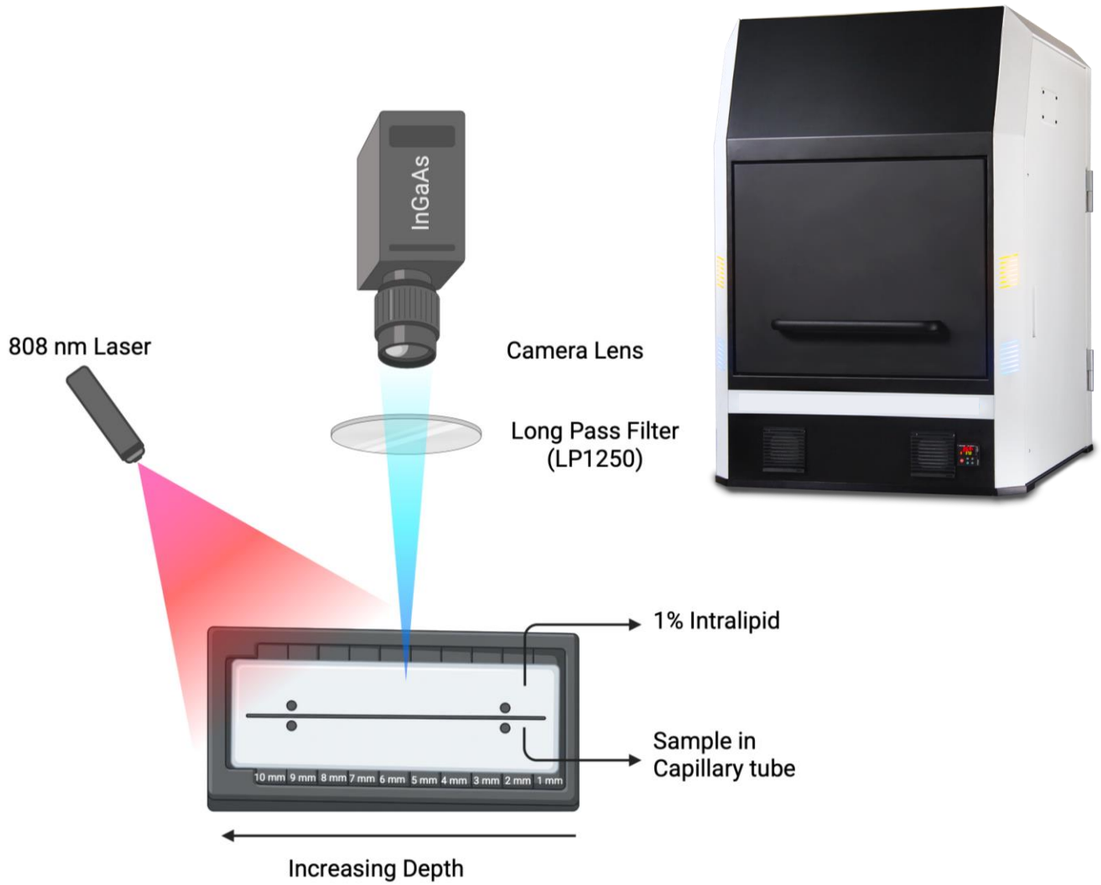
- *ε for typical core-only QDs is 10^5 – 10*
- *ε for typical CPNs is 10^8 – 10^9 M^{-1} cm*
- While the QY is higher for QDs, many CPNs are brighter
- Modest improvements in CPN QY can dramatically boost *B*

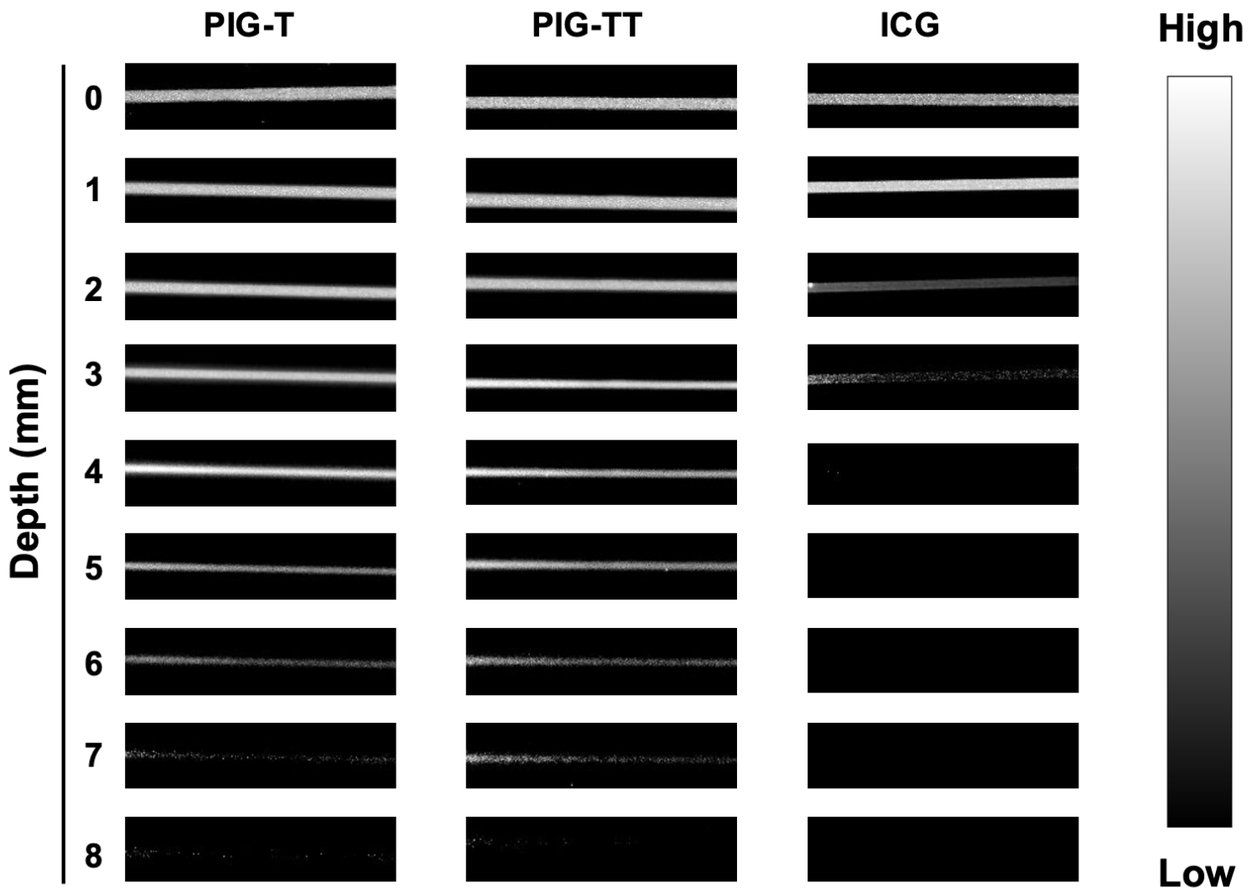
Klymchenko, S., *Chem. Soc. Rev.* ***2023****, 52, 4525*

PIG Nanoparticle Series – Degradability and Stability

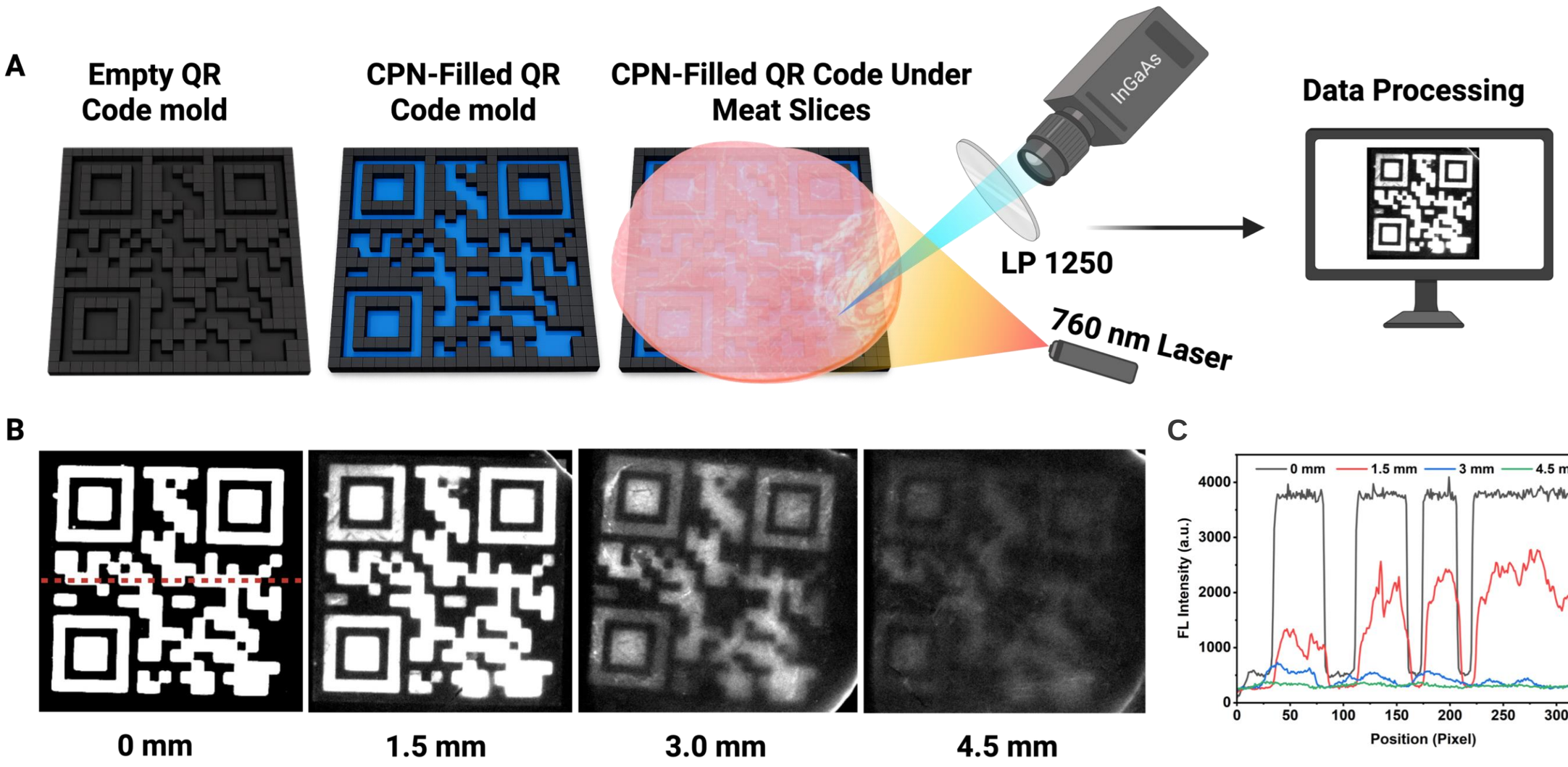



PIG Nanoparticle Series – Penetration Depth

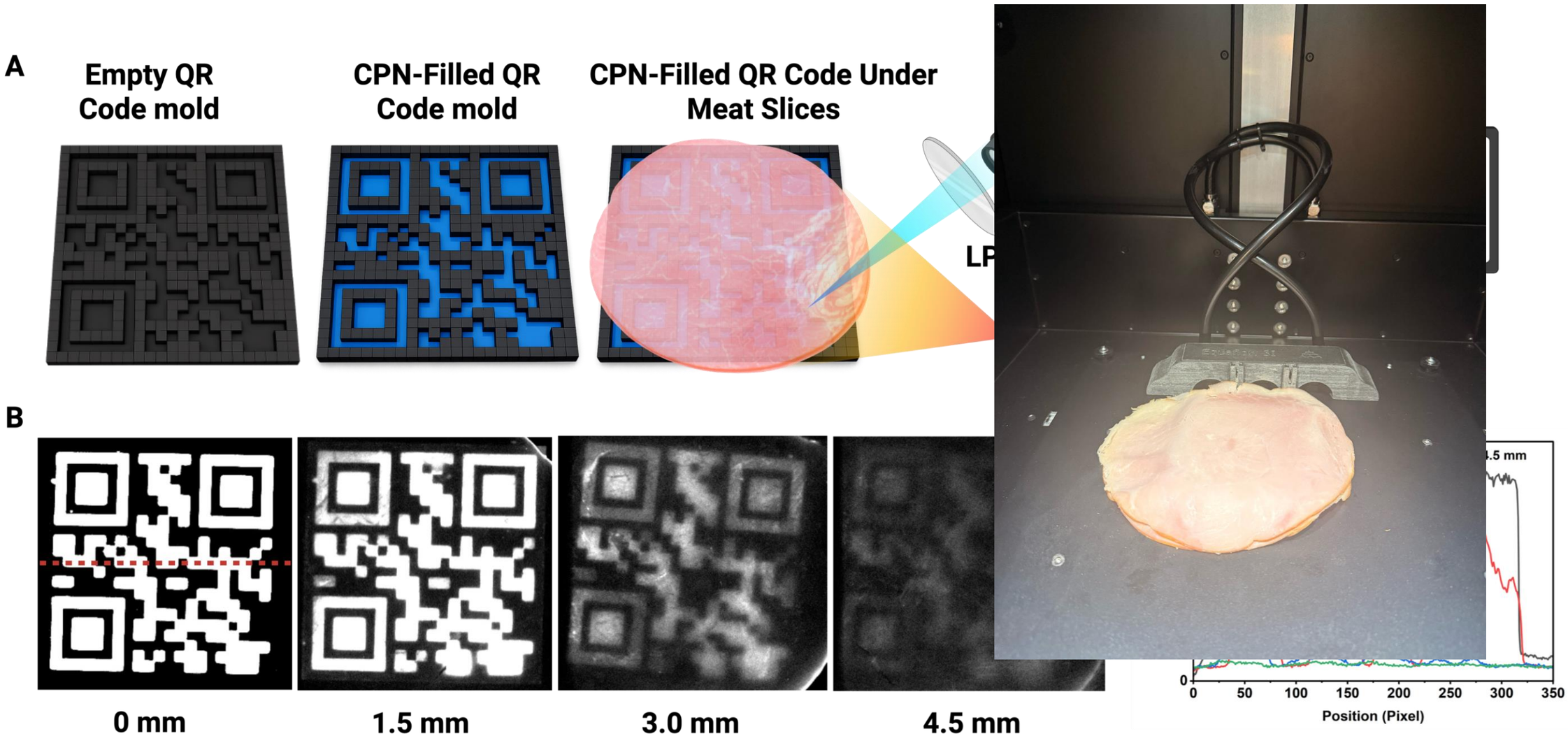




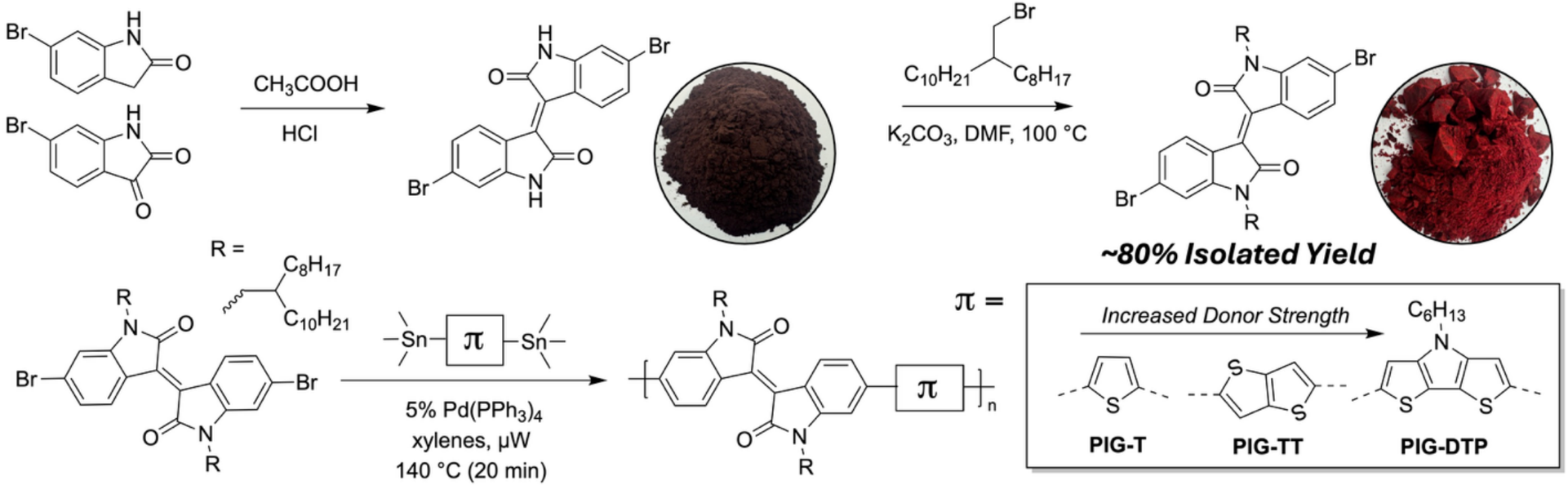
PIG Nanoparticle Series – Subcutaneous Information

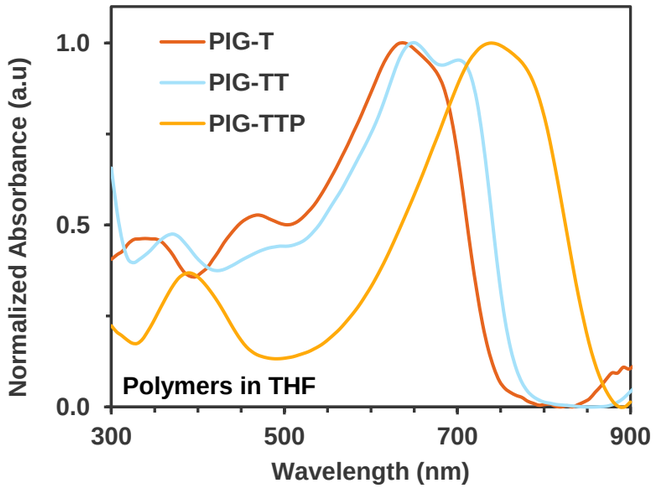


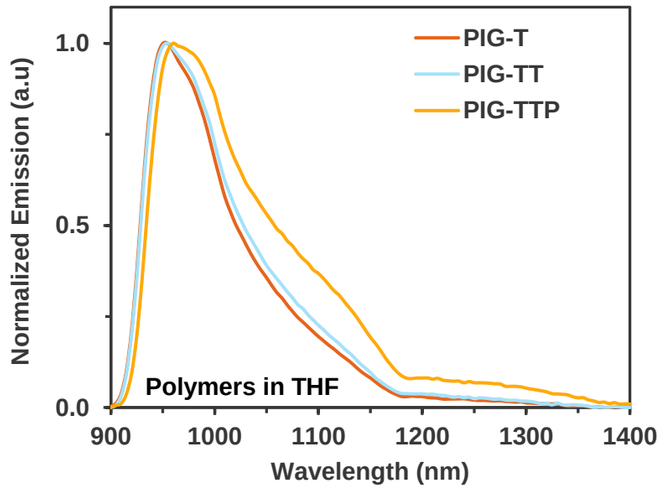
PIG Nanoparticle Series – Subcutaneous Information

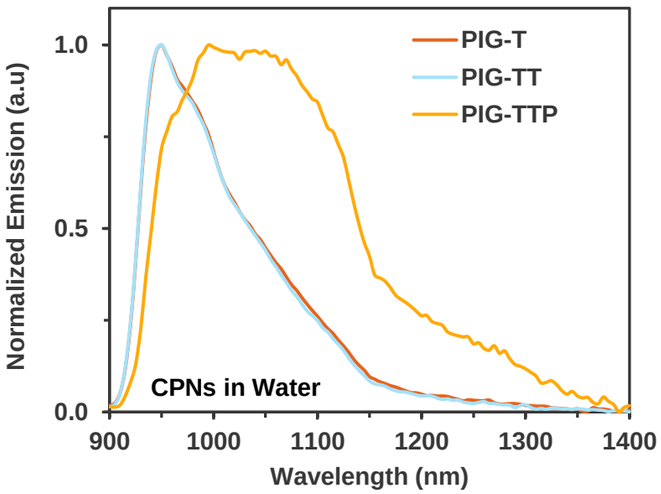


What is Next? Let's Shift it to the Right…



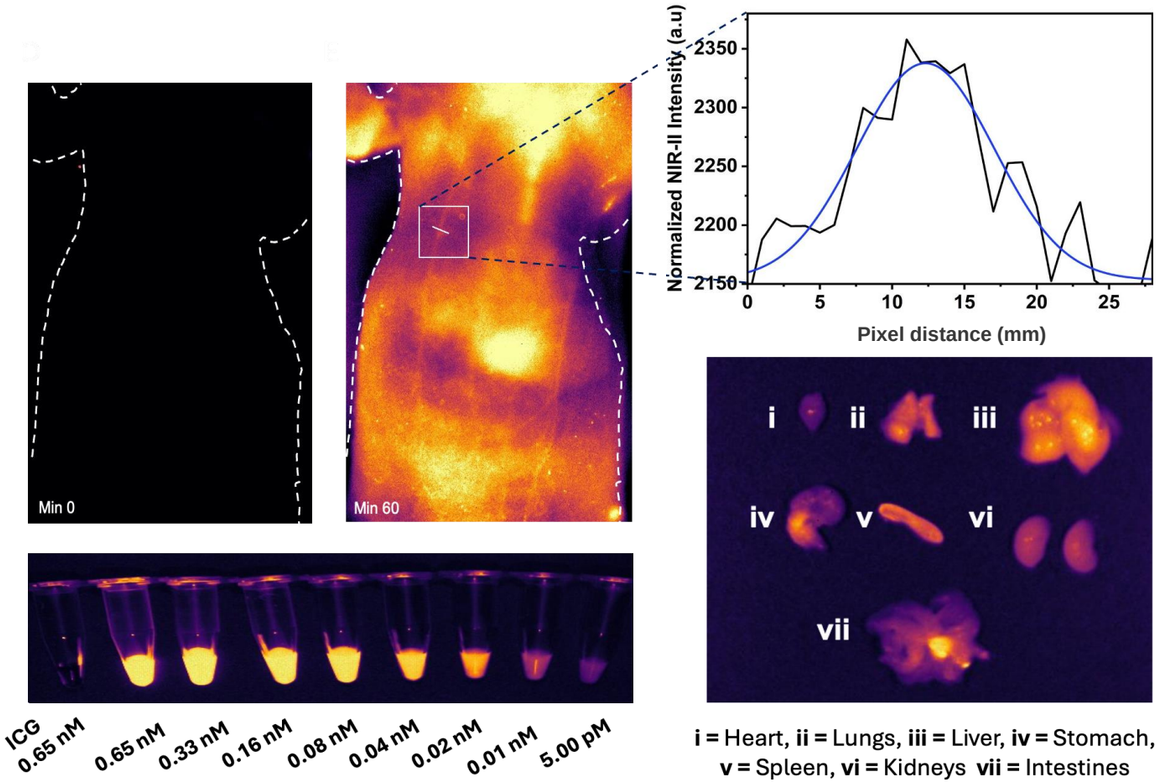


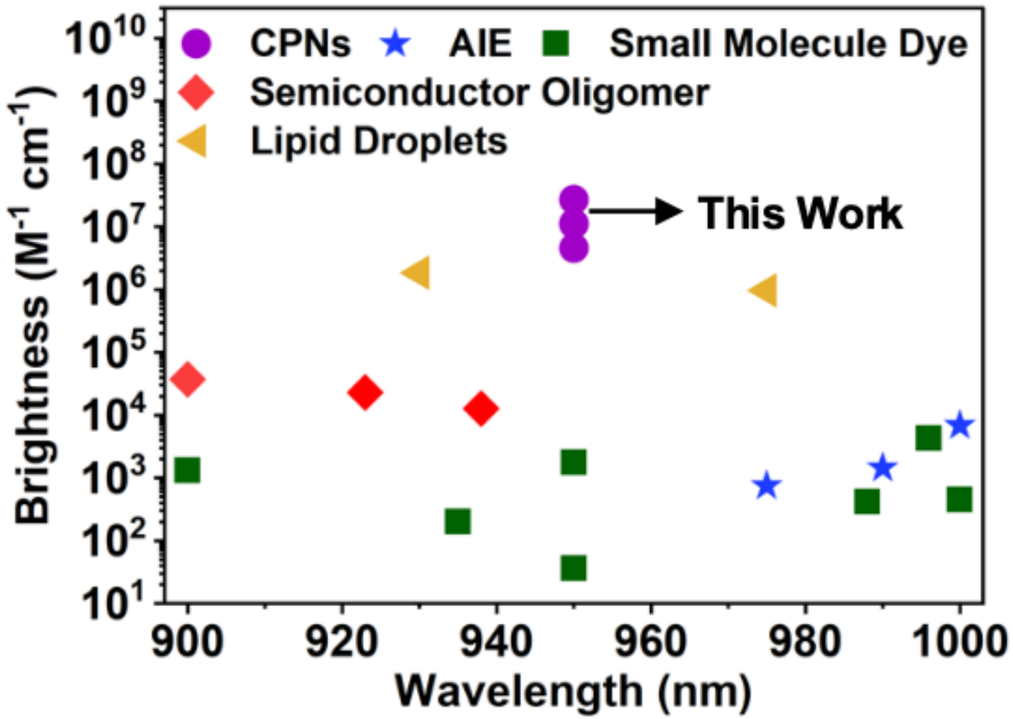




Gill, N., … Tropp, J., *Manuscript in Preparation*

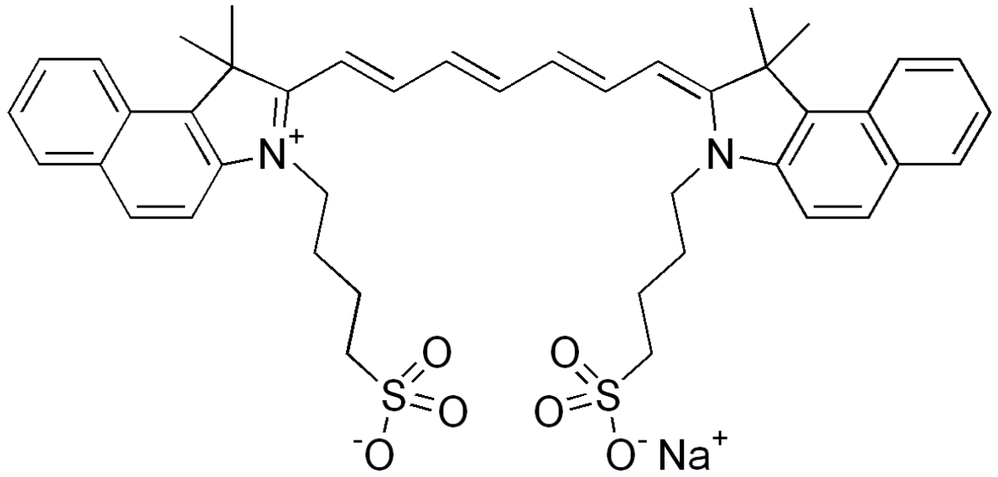
Conclusions and Outlook





- *PIG Copolymers feature brilliant emission in the NIR-II/SWIR.*
- *Organic NIR-II fluorophores are approaching brightness levels that could enable portable fluorescence-guided imaging systems for future austere surgical environments.*

A Scalable Alternative to ICG for Far Forward Portable Imaging



Indocyanine Green (ICG)

-Peak abs at 807

-Peak emission at 822 (NIR-I)

-QY = 1 – 9.3%

-Used for tumor imaging among other biomedical applications

-FDA approved in 1950s

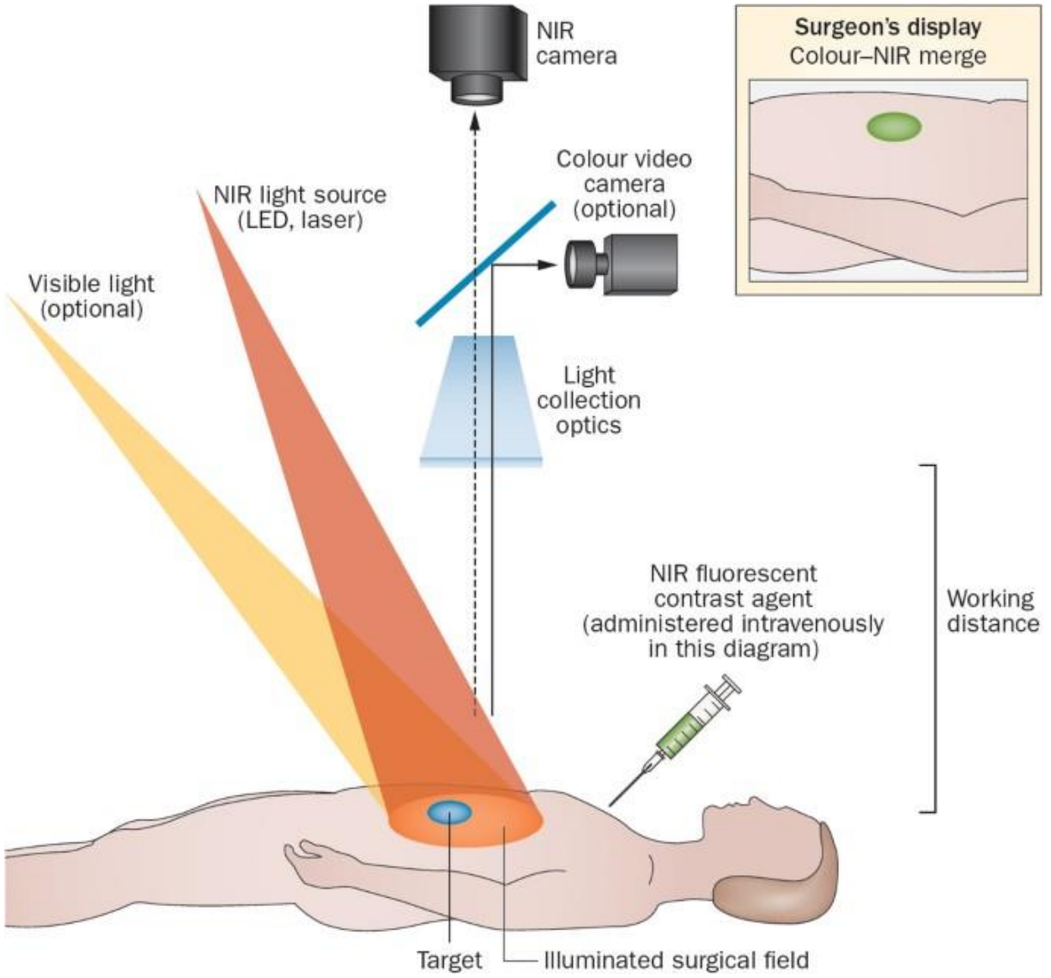


Image Guided Surgery:
Nat. Rev. Clinical Oncology. 2013, 10, 507

Curr. Opin. Chem. Biol. 2003, 7, 626