

### Optical Chemical & Biosensors

- Circulating Tumor Cell Detection
- Platelet Activation Monitoring
- miRNA Detection

Functionalized graphene oxide (GO) Polymer-GO  
Thermoresponsive polymer  
Circulating Tumor Cell

Chem. Sci. 2016  
Adv. Mater. 2016

### Application of Polydiacetylene Sensors

Temperature sensor (polyNIPAM) Glucose sensor (boronic acid)  
DNA sensor Reversible sensor  
Peptide sensor Antibody-antigen sensor  
Virus sensor Blue Color Non-fluorescent

+ Target

Peptide receptor Antigen  
Virus Red Color Fluorescent

#### Developed Sensors

- Nerve Agents
- Antibiotics
- Melamine
- Proteins
- Hg<sup>2+</sup>
- Influenza Virus
- Prostate Specific Antigen
- K<sup>+</sup>
- DNA
- Immunofluorescence labeling

target color change

conjugated p-orbital twisted p-orbital

0 (Increased response)

### Self-signaling and Signal-amplifying Optical Sensors

**K<sup>+</sup> Sensor** JACS 2008, 130, 5010.

0.01 0.05 0.1 0.25 0.5 1.0 × 10<sup>-3</sup> mol

**Nerve gas sensor**  
Adv. Func. Mater. 2010 and 2012.

**Antidote**  
(2-PAM)

HCl HF H3PO4 DCP DFP Control

**Melamine sensor**  
Chem Comm 2010, 47, 358.

Blue Phase Red Phase

Cyanuric acid Melamine

Repulsion (Intra) and Aggregation (Inter)

#### Developed Sensors

- Nerve Agents
- Bacteria & Influenza Virus A
- Antibiotics
- Melamine
- Prostate Specific Antigen
- DNA
- Mercury
- Potassium
- Water

### Novel Emissive Materials by Design

#### Understanding the Intermolecular Phenomena

- Halogen Bonding
- Crystallography and Photophysics
- Emission Intensity v.s. Crystal Packing

#### Fundamentals:

- Materials Chemistry
- Molecular Photophysics
- Device Physics

#### Applications:

- Solid-state Lighting
- Light Emitting Diodes
- Photovoltaics
- Polarized Emission Devices

#### Color Tuning & Conducting Property

- Electron Density of the Core Unit
- Extended Conjugation
- Conducting Property

Argon Air "On"

Intravitreal Injection Retinal Vein Occlusion Site

Nature Chemistry 2011, 3, 205.  
J. Am. Chem. Soc. 2013, 135, 6325.  
Angew. Chem. Inter. Ed. 2014, 53, 11177.

Chem. Mater. 2014, 26, 6644.  
Nature Communications 2015, 6, 8947.  
Angew. Chem. Inter. Ed. 2017, 56, 16207.

### Lyotropic Liquid Crystalline CP Design for Directed Conjugated Polymer Alignment

**CP1**

1. Concentration-induced Chain Planarization
2. Non-interdigitating Large Side Chain
3. Out-of-plane Tetrahedral Carbon Linker

Shear field

Solvent evaporation causes chain planarization and CP assembly

Shear field aligns CP

substrate

Enabled LC-like mobility & directed alignment

Suppressed

- Strong  $\pi$ - $\pi$  aggregation
- Side chain interdigitation

1 Concentration induced chain planarization  
2 Bulky side chain attached on a Tetrahedral carbon

PL intensity (a.u.) Wavelength (nm)

mobility (cm<sup>2</sup>/Vs) Aligned direction to S-D electrode

0° to polarizer 45° 90° 135°

125 mg/ml 250 mg/ml

Nature Materials 2013, 12, 659.

### High Thermal Conductivity in Amorphous Polymers

#### Polymer Blend System

Molecular complex Small  $\Delta T_g$  Small  $\Delta(\text{DOF})$ : small  $\Delta c_p$

Glass transition

Molecular dispersion Large  $\Delta T_g$  Large  $\Delta(\text{DOF})$ : large  $\Delta c_p$

c.  $\kappa$  (W m<sup>-1</sup> K<sup>-1</sup>)  $\phi_{\text{PAA}}$  PAP-PAA

Nature Materials 2015, 14, 295.

#### Polyelectrolyte System

Coiled and entangled polyelectrolyte chains Low  $\kappa$

Extended or swollen polyelectrolyte chains High  $\kappa$

High pH Low pH

PAA PVP

Science Advances 2017, 3, 1700342.

#### 1. Through Interpolymer Bonding

a. Penetration of polymer A within the gyration radius of polymer B

Heterogeneous distribution of thermal connections

Homogeneous distribution of thermal connections

b. PAP-PAA: Strong H-bond, Short and light linker, High density of H-bond moieties,  $MW_{\text{PAA}}/MW_{\text{PAP}} \gg 1$

PAP-PVA: Weak H-bond via short linker

PAP-PVPh: Heavy and large linker, Moderate H-bond

#### 2. Electrostatically Induced Random Chain Extension

- Coiled ionized polyelectrolyte chains with bends and kinks

- Poor chain packing with voids and entanglements

- Van der Waals interchain interactions and H-bonds

Chain morphology: Extended and stiffened ionized polyelectrolyte chains

Chain packing: Compact chain packing

Inter-chain interactions: Ionic bonding, van der Waals interactions and H-bonds

Low  $\kappa$  High  $\kappa$

Substrate