Chiral Luminescent Materials for Theranostics

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Chiral nanostructures, constituted of both organic and inorganic materials, have exhibited considerable promise in various applications such as asymmetric catalysis, chiral optics, molecular recognition, data encryption, and the enantiospecific separation of chiral compounds. When a chiral nanostructure possesses fluorescence, it may exhibit circularly polarized luminescence (CPL). CPL-active materials are predominantly discussed in the realms of asymmetric photosynthesis, optical spintronics, optoelectronic devices, and chiral sensing. Regarding hierarchical assemblies and CPL, induction can occur either by employing a chiral fluorescent monomer in the self-assembly process or by inducing CPL in an achiral monomer through its interaction with a chiral assembly.

In the upcoming presentation, my focus will be on the fabrication of circularly polarized luminescence (CPL) active materials, utilizing nanoscale particles as the fundamental building blocks. Our success lies in creating fiber-like structures that demonstrate CPL activity, comprised of achiral nanoscale particles such as carbon dots and atomically precise clusters. In our initial investigation, we detail the assembly of luminescent achiral carbon dots into fibrous structures that exhibit CPL. This achievement was made possible through chiral induction utilizing limonene, a chiral solvent.[1] In the next study, we achieved the chiral assemblage of atomically precise achiral gold nanoclusters into a fibrillary assemblies using a two-step process – (i) complexation reaction using zinc ions, followed by (ii) directional hydrogen bonding using a polymer – tween 20. The resultant assembly featured CPL, despite being composed of all achiral units.[2] Our research contributes to unraveling the intricate chiroptical properties inherent in assemblies composed of nanoscale particles. This understanding represents a crucial milestone in the development of chiroptical materials with advanced applications, highlighting the significance of our work in this field.

In the next segment of the presentation, I would like to discuss about the monitoring of cholinesterase enzyme activity in blood plasma using near infrared fluorescent single-walled carbon nanotubes (SWCNTs) as probes.[3] NIR fluorescent probes offer a substantial advantage in the context of probing biological systems due to the inherent transparency of biological samples, including blood, plasma, and tissue, within this wavelength range. An intriguing approach involves leveraging SWCNTs, which boast several advantageous features, including remarkable photostable fluorescence emission in the NIR spectrum, biocompatibility, and facile surface functionalization. In our pursuit, we have strategically modified the SWCNTs with the substrate of cholinesterase enzymes. This modification enabled the real-time monitoring of cholinesterase activity within complex biological fluids, such as blood plasma.

References:

1. **S. Basu**, N. Amdursky, The Role of Surface Groups in Dictating the Chiral-Solvent-Induced Assembly of Carbon Dots into Structures Exhibiting Circularly Polarized Luminescence. *Small* **2023**, 19, 2205880. https://doi.org/10.1002/smll.202205880
2. **S. Basu**[*], (**corresponding author**) M. P. Bakulić, Ž. S. Maršić, V. Bonačić-Koutecký N. Amdursky, Excitation-Dependent Fluorescence with Excitation-Selective Circularly Polarized Luminescence from Hierarchically Organized Atomic Nanoclusters. *ACS Nano* **2023**, 17, 16644–16655. https://doi.org/10.1021/acsnano.3c02846.
3. **S. Basu**, A. Hendler-Neumark, G. Bisker, Rationally Designed Functionalization of Single-Walled Carbon Nanotubes for Real-Time Monitoring of Cholinesterase Activity and Inhibition in Plasma. *Small* **2024**, 2309481. https://doi.org/10.1002/smll.202309481.