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Synthesis and Characterization of a Cationic BODIPY-Conjugated Polymer as a Fluorescent Probe for Bacterial Sensing

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INTRODUCTION

The accurate detection of microorganisms is essential to optimize antimicrobial therapy [1]. The use of fluorescent probes has emerged as a promising strategy for the rapid identification of bacteria, as it enables the direct, sensitive, and real-time visualization of microbial cells [2].

BODIPY derivatives has been proposed as fluorophores [3]. In this work, the synthesis of a hybrid fluorophore based on the conjugation of BODIPY with PEI (BDP–PEI), a polycationic aliphatic polymer due to the presence of amine groups, which can enhance interactions with bacterial envelopes, along with its spectroscopic characterization and its interaction with Gram-positive bacteria (Staphylococcus aureus) using fluorescence microscopy.

RESULTS & DISCUSSION

The synthetic procedure of the BDP started by mixing pentafluorobenzaldehyde and 2,4-dimethylpyrrole in DCM, catalyzed by the addition of TFA (**Figure 1**). The mixture was stirred overnight followed by the addition of DDQ as the oxidant. After 4 h, TEA together with $BF_3{\cdot}OEt_2$ was added to close the dipyrromethene ring, obtaining the BDP in 47% yield.

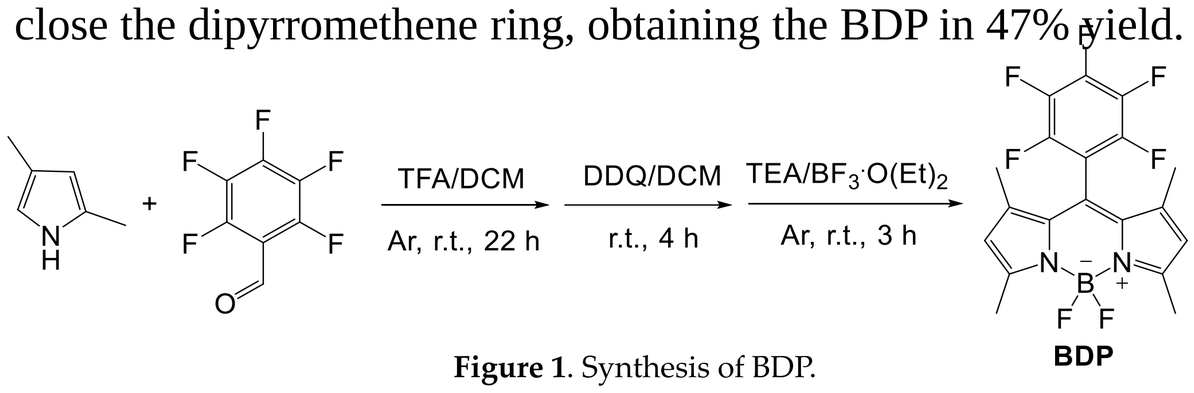

Figure 1. Synthesis of BDP.

The conjugation of BDP to PEI (**Figure 2**) was carried out in DMF by stirring at room temperature for 72 h. TLC analysis showed complete consumption of the starting BDP, with the resulting conjugate (BDP-PEI) remaining at the origin of the chromatographic plate. The solvent product was evaporated, and the resulting solid was washed several time with hexanes.

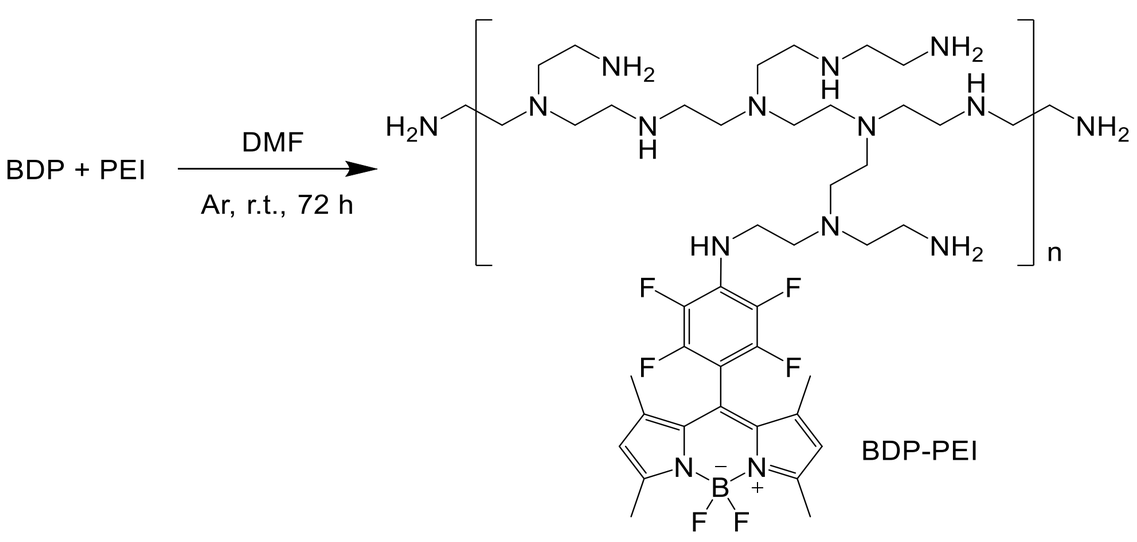

Figure 2. Synthesis of BDP-PEI conjugate.

The UV−visible absorption spectra of BDP and BDP-PEI in DMF are shown in **Figure 3A**. This absorbance was attributed to the 0−0 vibrational band of the $S_0 \rightarrow S_1$ transition. The fluorescence emission spectra displayed a band at 515 nm, corresponding to the 0–0 vibrational band of the $S_1 \rightarrow S_0$ electronic transition. From these data, a Φ_F of 0.18 was determined for BDP-PEI (**Figure 3B**).

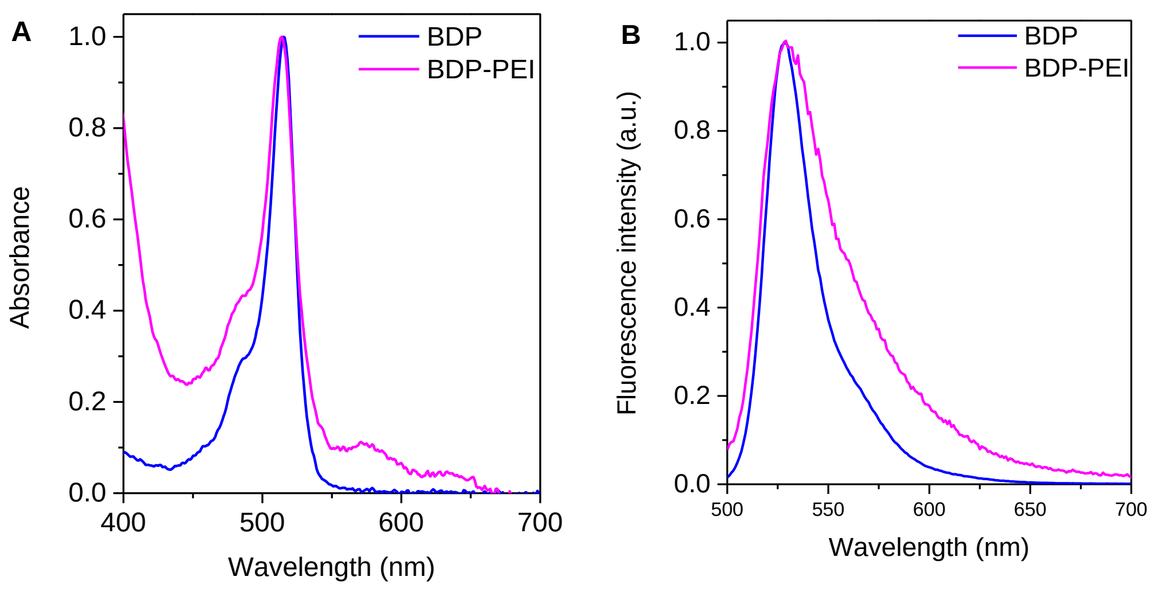

Figure 3. (A) Absorption and (B) fluorescence emission spectra of BDP and BDP-PEI (l_{exc} = 483 nm) in DMF.

To investigate the cellular imaging of *S. aureus*, fluorescence microscopy was employed to assess the uptake of BDP-PEI by bacterial cells (**Figure 4**).

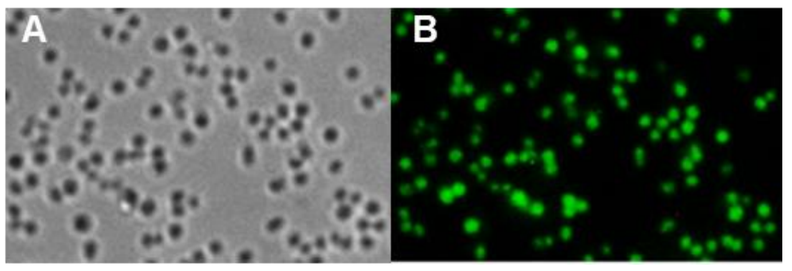

Figure 4. Microscopy images of *S. aureus* cells attached to a glass surface treated with 1.0 mM BDP-PEI for 10 min in the dark; cells under (A) bright field and (B) blue fluorescence channel.

CONCLUSION

The conjugate retained the characteristic absorption band at 505 nm and exhibited fluorescence emission at 515 nm, with a quantum yield of 0.18, confirming its suitability as a fluorophore. Fluorescence microscopy studies demonstrated the ability of BDP-PEI to associate with S. aureus cells, producing strong green emission that enabled clear visualization of individual bacteria. These findings indicate that BDP-PEI combines favorable spectroscopic properties with effective microbial labeling, highlighting its potential application as a diagnostic tool for pathogen sensing and monitoring.

REFERENCES

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3. Durantini *et* al. *Eur. J. Med. Chem.* **2018**, *144*, 651−661.