Diaminoterephthalate Fluorescence Dyes – Versatile Tools for Life Sciences and Materials Science

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The 2,5-diaminoterephthalate structural motif is a powerful chromophore with remarkable fluorescence properties. Containing two carboxylate and two amino functions it defines a colored molecular scaffold which allows for orthogonal functionalization with different functional units. Therefore, different applications in Life Sciences and Materials Science could be addressed.

1. Synthetic Strategy

Diaminoterephthalates (DATs) are bright and colorful dyes which exhibit powerful fluorescence properties. These compounds are readily accessed by conversion of succinyl succinates **1** with primary amines under oxidative conditions (Figure 1). Actually, the chromophore defines a molecular scaffold, which can be orthogonally equipped with different functional units at the ester and amino groups. Thus, tailored functional materials can be prepared for addressing different applications in Life Sciences and Materials Science (Figure 1).[1]

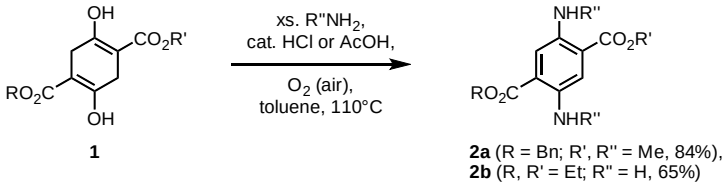

Figure 1. Synthesis of diaminoterephthalates **2**.

2. Turn-On Probes for Thiols

As an example for a DAT scaffold difunctionalized at the carboxylate moieties compound **3a** with alkyne and maleimide moiety was prepared by sequential deprotections and amidations from parent compound **2a** (four steps, Figure 2). The cyclooctyne ring of **3a** is susceptible for copper-free "Click" reactions. Compound **3a** was used as a molecular probe for the cross-linking of proteins.[2] Figure 4 (right) shows the absorption and emission spectra of compounds **3a** and **3b**. Conjugated addition of a thiol "turns on" the fluorescence of this dye: Whereas compound **3a** shows almost no emission (red graph, quantum yield Φ = 2%), compound **3b** gives luminescence at 560 nm (blue graph, Φ = 41%) when irradiated at its absorbance band (415 nm). The mechanism of this "turn-on" process was investigated with computational methods: It is the π*-orbital of the maleimide C=C-bond which defines the LUMO of compound **3a** and prevents relaxation by emission.[3]

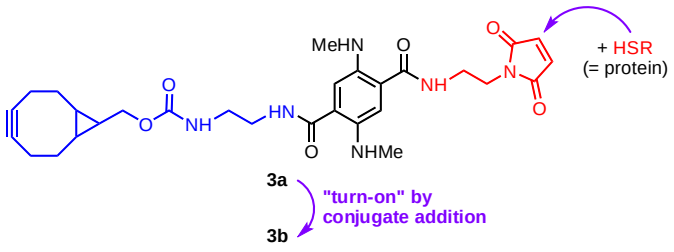

Figure 2. Difunctionalized diaminoterephthalate **3a** and "turn-on" reaction with thiol; for spectral data see Figure 4 (right).

3. Functionalization at Nitrogen

Starting from compound **2b**, the two amino functions were alkylated by reductive amination with side chains carrying either amino (orthogonally protected as Boc or Alloc) or carboxylate functions (orthogonally protected as *t*Bu or allyl ester; compounds **4a**–**4c** in Figure 3).[4] After sequential deprotections, functional units were introduced by amidation reactions. As an example, compound **4a** was used to couple the chromophore to retinoic acid (blue) and fullerene C_{60} (red) in order to obtain the triad **5** for studying photoinduced electron transfer processes.

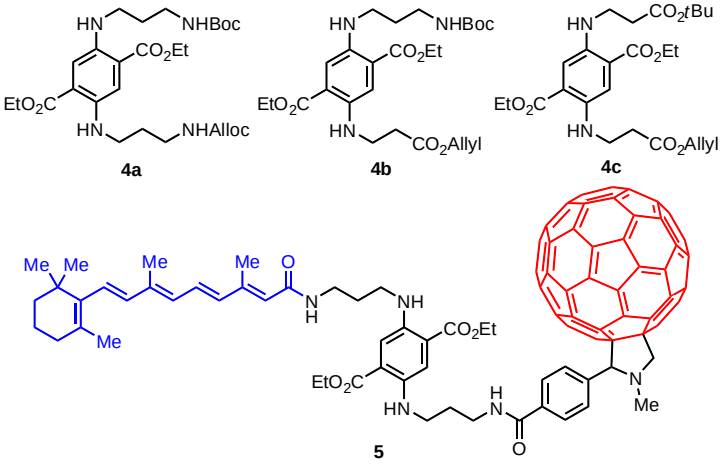

Figure 3. Orthogonally protected DAT building blocks **4a**–**4c** for the introduction of functional units at the amino residues; model triad **5** was prepared from compound **4a**.

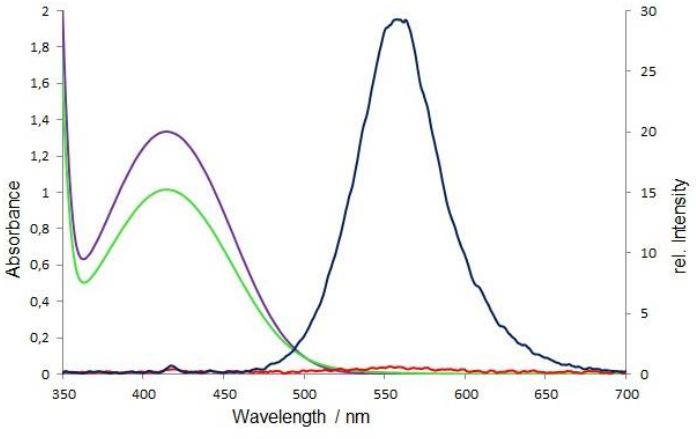

Figure 4. Spectra of compounds **3a** and **3b** (structures see Figure 2) in CH_2Cl_2. Color code: Compound **3a**, abs. violet, em. red; compound **3b**: abs. green, em. blue (λ_{ex} = 415 nm).

[1] Review: J. Christoffers, *Eur. J. Org. Chem.* **2018**, 2366–2377.
[2] M. Wallisch, S. Sulmann, K.-W. Koch, J. Christoffers, *Chem. Eur. J.* **2017**, *23*, 6535–6543.
[3] N. Wache, A. Scholten, T. Klüner, K.-W. Koch, J. Christoffers, *Eur. J. Org. Chem.* **2012**, 5712–5722.
[4] L. Buschbeck, J. Christoffers, *J. Org. Chem.* **2018**, *83*, 4002–4014.