

First Crown Ether Derivative of Benzoxazinone; a New Fluoroionophore for Alkaline Earth Metals Recognition

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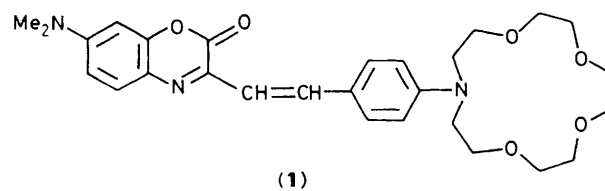
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Alkaline earth cations markedly shift the emission wavelength and enhance the fluorescence intensity of 3-(*p*-13-aza-1,4,7,10-tetraoxacyclopentadecan-13-ylstyryl)-7-dimethylamino-1,4-benzoxazin-2-one.

On account of its high sensitivity, fluorimetry is becoming of increasing importance for chemical trace detection. Recently, the linkage of cation-selective crown ethers with fluorescent dyes¹ has opened a new field of investigation for monitoring low concentrations of alkaline and alkaline earth metals in solution, most of them being of real biological interest.

We have developed a new class of fluorescent dyes, the aminobenzoxazinones,² one of which, 7-dimethylamino-3-(*p*-formylstyryl)-1,4-benzoxazin-2-one (DFSBO), has useful spectral characteristics:^{2b} emission in the red, broad first absorption band, good quantum yield, and very large Stokes shift. The latter feature is particularly important because it

makes fluorescence detection easier. Successful applications of DFSBO or its derivatives as fluorescent probes in molecular and cellular biology are in progress.^{2f}



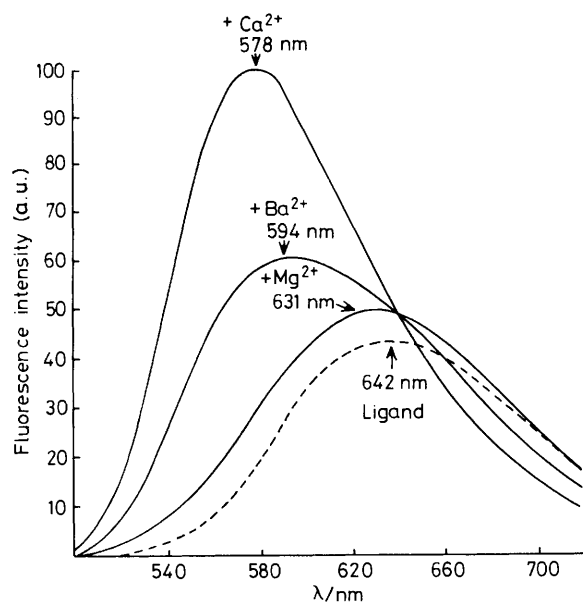


Figure 1. Corrected fluorescence spectra of (1) (1.5×10^{-6} M) in acetonitrile at room temperature before and after addition of 2×10^{-4} M alkaline earth metal perchlorate. Spectra are corrected according to the absorbance of the solutions at the excitation wavelength of 480 nm.

This led us to synthesize a similar molecule linked to a crown ether. Following the procedures described in references 2a and 3, 7-dimethylamino-3-methyl-1,4-benzoxazin-2-one was condensed with *N*-(*p*-formyl)-13-aza-1,4,7,10-tetraoxacyclopentadecane to yield compound (1).†

Figure 1 shows the fluorescence spectrum of (1) in the presence or absence of alkaline earth perchlorates in acetonitrile. The emission band of the ligand undergoes remarkable shifts upon addition of the cations; the wavelength of maximum emission shifts from 642 nm for the free ligand to 578 nm in the presence of 2×10^{-4} M calcium perchlorate.

† Selected data for (1). Satisfactory elemental analysis obtained for $C_{28}H_{35}N_3O_6$. 1H n.m.r. ($CDCl_3$, 200 MHz): δ 3.07 (6H, s, NMe_2), 3.54–3.90 (20H, m, $-CH_2-$), 6.45 (1H, d, $J_{6,8}$ 3 Hz, H-8), 6.60–6.73 (3H, m, H-6 + Ph), 7.44–7.57 (3H, m, H-5 + Ph), 7.24 and 7.89 (2 \times 1H, 2 \times d, J 16 Hz, $-CH=CH-$).

Likewise, a significant enhancement of the fluorescence intensity is observed. The fluorescence quantum yield increases from 0.33 for the free ligand to 0.64 for the calcium complex. Lithium and sodium perchlorates have only a slight effect upon the spectral parameters, whereas the potassium salt hardly induces any detectable change.

In the concentration range 10^{-4} – 2×10^{-2} M, the relative fluorescence intensity is closely correlated with the concentrations of perchlorates. Thus, the data were analysed according to equation (1), where I_{F^0} and I_F are the fluorescence intensities of the free and the complexed ligand, respectively, a and b are constants involving the extinction coefficient and the quantum yield of these two species, and $[M]$ is the concentration of alkaline earth metal. Plotting $I_{F^0}/(I_F - I_{F^0})$ vs. $[M]^{-1}$, the stability constant K_s is given by intercept/slope. $\log_{10} K_s$ values were 4.14 ± 0.08 for the Ca^{2+} salt, and 3.62 ± 0.03 and 2.68 ± 0.02 for Ba^{2+} and Mg^{2+} , respectively, at room temperature.

$$I_{F^0}/(I_F - I_{F^0}) = (1/K_s [M] + 1) a/(b - a) \quad (1)$$

Owing to its sensitive and specific response to alkaline earth cations in the fluorescence spectra, our fluoroionophore appears to be potentially suitable for the photometric ion determination of practical samples.

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