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THERMAL DECARBOXYLATION OF ROSE BENGAL DYE

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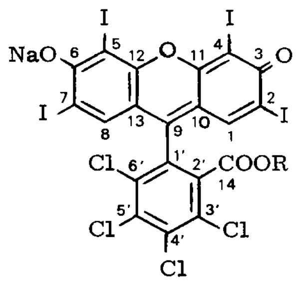
Abstract - The xanthene dye rose bengal undergoes decarboxylation when heated in dimethylformamide or cyclohexanone.

As part of a continuing study on ketone- and dye-based linear polymeric photosensitizers[1], the knowledge of the chemical reactivity of rose bengal (1, R = Na, disodium salt of 3',4',5',6'-tetrachloro-2,4,5,7-tetraiodofluorescein) was needed to provide a solid basis for the preparation and characterization of some linear polymeric sensitizers possessing this particular dye as chromophore. Among other uses, rose bengal finds wide application as a photooxidation sensitizer in solution, on account of its efficiency to photogenerate singlet oxygen[2]. The chemical binding of the dye to cross-linked polystyrene beads[3] has extended its use to work in heterogeneous phase. In spite of the commercial interest, the chemical properties of rose bengal and other members of the xanthene family are scarcely known[4] except for fluorescein, the parent compound. We report here on the easy decarboxylation which occurs when a dimethylformamide or cyclohexanone solution of the dye is heated over 100° (the reaction becomes fast at 130°).

In a work directed to the preparation of some xanthene derivatives, rose bengal was alkylated with several alkyl halides, using acetone as solvent and sodium or potassium carbonate as catalyst. In this way, the methyl (1, $R = CH_3$), benzyl (1, $R = CH_2Ph$) and p-isopropylbenzyl (1, $R = CH_2Ph(p)CH(CH_3)_2$) esters[5] were obtained in good yields, leaving intact the



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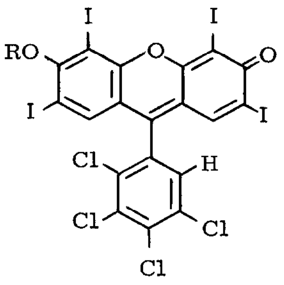

2 : R = Na
3 : $R = CH_3$

phenoxide function of the xanthene group. The last ester was chosen for modelling the chemical binding of rose bengal to linear p-chloromethylpolystyrene. Substitution of cyclohexanone or dimethylformamide for acetone in order to increase the esterification rate (which is very slow at acetone reflux temperature, even when using a great excess of the alkyl chloride), gave a large amount of a new product, 2, together with the expected esters. This compound 2, which is also formed in the absence of the catalyst, resulted from decarboxylation of rose bengal, as shown by its spectroscopic data[6]. Firstly, it displays a visible absorption spectrum very similar to any of the ester spectra. Particularly, it shows an identical pH dependence indicating that lactonization is not possible. On the other hand, its IR spectrum has no absorption in the ν C=O (carboxylic or ester) region. The ^1H NMR spectrum has a singlet signal due to the two equivalent xanthenic protons in positions 1 and 8, and another signal at 7.90 ppm which can be assigned to H-2'. The MS of the acid form shows signals at 928 (3% of the base peak 128, HI), 930, 932 and 934 in relative intensities according with four chlorines. Diazomethane treatment of the acid form of 2 gives a methyl derivative 3 showing ^1H NMR signals (DMSO-d_6) at 7.97, 7.72 and 7.83 ppm, corresponding to protons H-1, H-8 and H-2', respectively. Furthermore, when the ^{13}C NMR spectra of 2 is compared with that of the methyl ester 1, R = CH_3, two significant differences are observed: the C-2' signal of 2 converts to a doublet when the spectrum is run in the coupling mode, and no C-14 carbonyl peak is observed in the decarboxylated dye, as expected. The decarboxylation process undergone by rose bengal must be related to the chlorinated nature of the benzoate ring. Neither fluorescein nor eosin (disodium salt of 2,4,5,7-tetrabromofluorescein) decarboxylate when submitted to the same experimental conditions.

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3. A.P. Schaap, A.L. Thayer, E.C. Blossey and D.C. Neckers, J.Am.Chem. Soc., 97, 3741 (1975).
4. A recent report from J.J.M. Lamberts and D.C. Neckers, J. Am. Chem. Soc., 105, 7465 (1983) describes the preparation of nonpolar derivatives of rose bengal, including the benzyl ester 1, R = CH_2Ph. In that communication a complete bibliographic coverage of the subject can be found.
5. Experimental conditions and analytical data for the whole series of compounds obtained will be published. Data of special concern in relation with the present case are given for the methyl ester derivative 1, R = CH_3. VIS (dioxane/buffer of given pH 1:1) λ_{max} (nm) (log ε): pH 1, 425 (4.11), 505 (4.26); pH 8, 529 (4.53), 5 68 (5.00). ^1H NMR (90 MHz, DMSO-d_6) δ 3.48 (s, CH_3), 7.31 (s, H-1 plus H-8). ^{13}C NMR (300 MHz, DMSO-d_6) δ 53.2 (CH_3), 129.4 (C-2'), 163.7 (C-14). IR (KBr) ν_{max} 1740 cm^{-1} (ester CO).
6. 2: mp 280° d. VIS (dioxane/buffer of given pH 1:1) λ_{max} (nm) (log ε): pH 1, 425 (4.09), 505 (4.30); pH 8, 523 (4.52), 561 (5.02). ^1H NMR (90 MHz, DMSO-d_6) δ 7.38 (s, H-1 plus H-8), 7.90 (s, H-2'). ^{13}C NMR (300 MHz, DMSO-d_6) δ 130.0 (C-2', doublet J_{CH} = 175 Hz in the coupled spectrum).

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