

PHOTO-OXIDATION IN THE SYNTHESIS OF ^{17}O AND ^{18}O LABELLED COMPOUNDS: SYNTHESIS OF XANTHONE- $^{18}\text{O}_1$

Henry J. Pownall

Department of Biochemistry, Baylor College of Medicine,
Houston, Texas 77025, U.S.A.

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SUMMARY

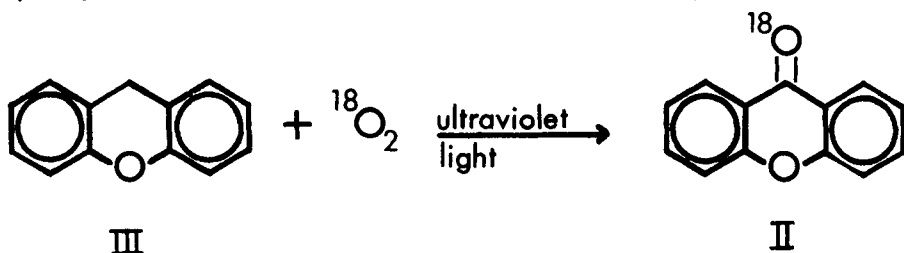
It is shown that the photo-oxidation of aromatic molecules containing an active methylene group can be used to introduce isotopic oxygen. Photo-oxidation of xanthene results in the formation of xanthone with the oxygen label appearing in the product at the carbonyl group. In this way, 100% enrichment can be realized. A brief discussion of other systems to which this method may be extended is also given.

INTRODUCTION

It is frequently informative for the molecular spectroscopist to use isotopes in assigning molecular vibrations which are observed in the electronic, Raman and infrared spectra of complex ions, radicals and molecules [1,2]. In particular, substitution of the heavier ^{17}O and ^{18}O for ^{16}O in carbonyl compounds should produce a decrease in the carbonyl frequency of these spectra. Also, because of its nuclear spin, ^{17}O can be introduced for experiments in both nmr [3] and endor [4].

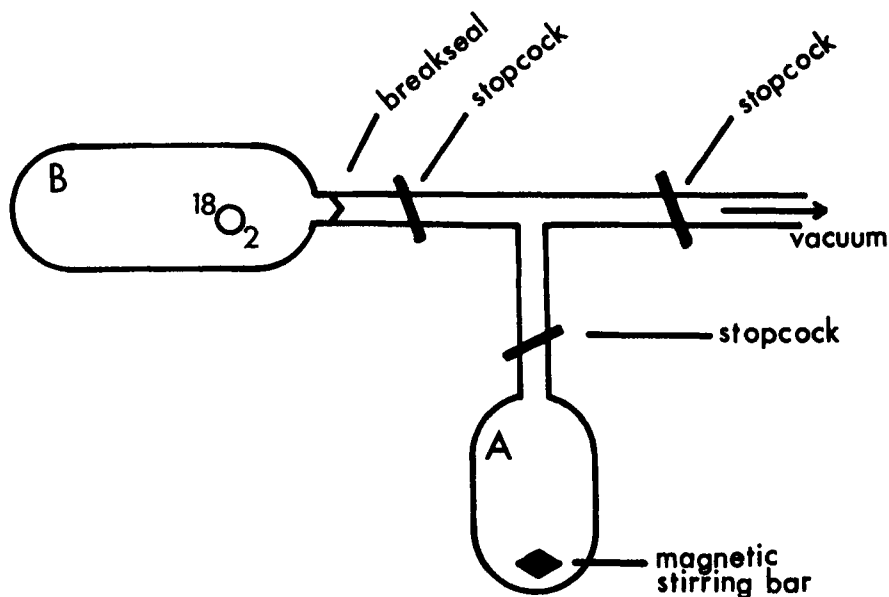
In earlier work on the phosphorescence spectroscopy of xanthone (I) we were faced with the problem of assigning the vibrational progression in its emission

spectrum in polar aprotic solvents to either the carbonyl stretch frequency or to a ring mode. Both of these would be expected to appear between 1600 cm^{-1} and 1700 cm^{-1} in the Raman or infrared spectra. Therefore the 1620 cm^{-1} vibration in the phosphorescence spectrum could not be unambiguously assigned to either of these vibrational modes. Examination of the infrared spectrum of xanthone shows that this region of the spectrum is particularly congested having several bands overlapped [5]. In order to resolve this dilemma we have synthesized xanthone- $^{18}\text{O}_1$ (II) by the photo-oxidation of xanthene (III) according to the scheme,



EXPERIMENTAL

A 50 ml quartz bulb, A (cf. Figure 1) containing 0.1 g of III (Aldrich, recrystallized from ethanol to remove the xanthone impurity) in 25 ml of 3-methylpentane (Phillips, distilled and chromatographed on alumina) was degassed by passing nitrogen through the solution for 15 min. followed by degassing by the freeze-pump-thaw method. The system was completely evacuated while maintaining the solution of III at 77°K by means of a liquid nitrogen bath. Then, ca. 50 ml of $^{18}\text{O}_2$ (Miles-Yeda, 99.9 %) was introduced from B by means of a valve-break-seal arrangement. The solution was saturated with $^{18}\text{O}_2$ at ca. 380 torr by the vigorous agitation of a magnetic stirring bar for 15 min. The valves to A and B were closed and A was removed to a photolysis chamber. Here the solution was irradiated for one hour with a focused, heat-filtered 1500 w xenon lamp (Oriol) at a distance of 50 cm. The resulting mixture of II and unreacted III was taken to dryness by



rotary evaporation and redissolved in 2 ml of 1:1 benzene and pentane which was applied to a 1 x 30 cm silicic acid column. The effluent was monitored by measuring the absorbance of II and III at 338 nm and 292 nm respectively. The excess III eluted first and was followed by pure II. Total isolated II was 10 mg. All operations were performed in subdued light using Pyrex containers which filter out the ultraviolet light which might cause photo-oxidation by air.

RESULTS AND DISCUSSION

The mass spectrum of xanthone- $^{18}\text{O}_1$ recorded on an LKB 9000 GC/MS exhibits a parent ion peak corresponding to its molecular weight of 198. Relative intensities of the 198 and 196 mass peaks indicate that the isotopic purity of the xanthone- $^{18}\text{O}_1$ is 95% before column chromatography

and 80% thereafter. If the higher isotopic purity is required, purification should be carried out under a nitrogen atmosphere. Its infrared spectrum in methylene chloride (Beckman Accu-Lab-4) contains a band at 1637^{-1} which does not appear in the spectrum of the unlabeled compound. We have assigned this frequency to the totally symmetric carbonyl stretching vibration. The corresponding vibration in unlabeled xanthone appears at 1665 cm^{-1} [5]. A lower frequency for this vibration in xanthone- $^{18}\text{O}_1$ is predicted from the increase in its reduced mass [6]. The ultraviolet spectrum of I and II are identical.

A survey of the photochemical literature reveals that photo-oxidation can also be used to convert thioketones [7] and olefins [8] to ketones, olefins to quinones [8,9], haloalkanes to carboxylic acids [10] and aldehydes [11,12]. This list should not be considered as exhaustive, but rather as an indication of the general applicability of this method to a variety of syntheses which require a high enrichment of isotopic oxygen.

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