

Lifetime Studies of Buckminster Fullerene C₆₀ in the Region 370 nm to 421 nm Using THF (Oxolane)

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Abstract

Lifetime studies of C₆₀/Oxolane (THF) were studied in the 370 nm to 421 nm region. The average lifetime of the triplet state has been found to be 3.388956 seconds. The Chi squared probability was 0.9969191. Optical switching effect and photonic devices are suggested as applications.

Keywords: Lifetime studies; Oxolane; triplet state; Chi squared probability; Optical switching; Photonic devices

Introduction

Due to its unique opto-electronic property of C₆₀ and its reverse saturable absorption phenomena found by Guiliano and Hess [1], C60 makes a suitable candidate for optical switching purposes. Several studies have been done on photoexcitation of C60 in liquid solutions and in thin films. Here, in this paper, we found that C60/THF (oxolane) combination in the liquid form were subjected to photon interaction using a laser as a probe tuned in the 370 nm to 421 nm region using a visible region laser and analyzed using a Horiba Jobin Yvon Fluorolog fluorescence spectrometer that does a steady-state measurement of fluorescence and produces an averaged picture of a substance: its absorption and resultant emission of light in the UV, visible, and IR region of the spectrum [2]. By introducing time discrimination, much more information is revealed. The motion, size, environment, intermolecular distances, and many other molecular parameters can be deduced from the behavior of a material's fluorescence as a function of time (Figure 1).

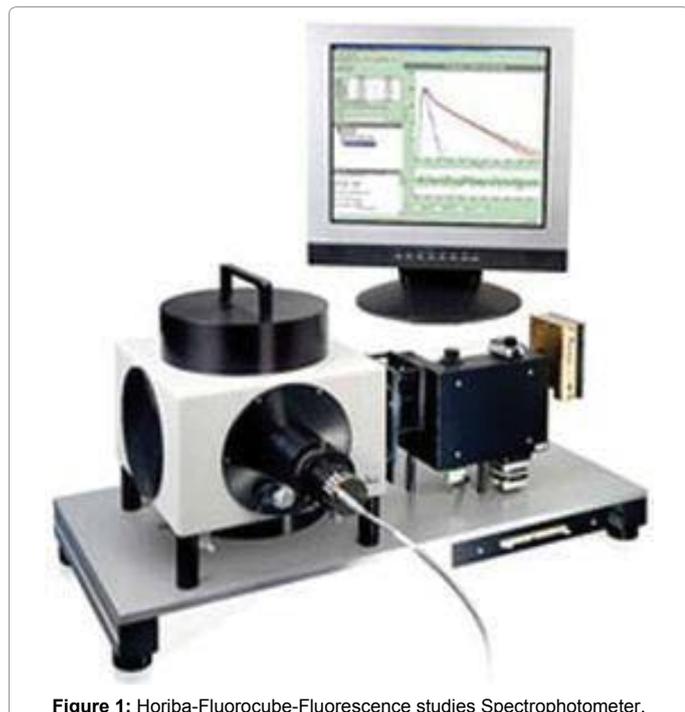


Figure 1: Horiba-Fluorocube-Fluorescence studies Spectrophotometer.

Experiment Details

We had purchased a 99.99% pure research grade sample of C₆₀ nano particles and the sample of 10 mg were dissolved in Oxolane (THF) suitably so that the sample dissolved in it thoroughly [3]. The sample so prepared was introduced into the Fluorolog, fluorescence-lifetime studies, spectrometer. The total time duration of the sample analysis was 88.18 seconds. A pulsed diode laser was used as a probe for excitation of the C60/THF matrix solution, and the time-resolved lifetime studies revealed three different lifetimes as shown in Figure 2 above. The peak photon counting was fixed at 10004. The background on the 'prompt' was kept at 44. The time calibration was fixed at

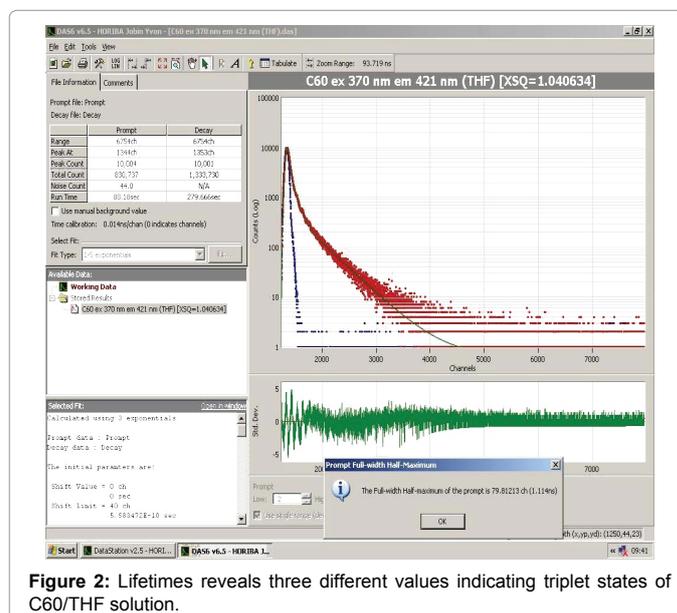


Figure 2: Lifetimes reveals three different values indicating triplet states of C60/THF solution.

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Prompt data- prompt	T1Estimate	T2Estimate	T3 Estimate	A	B1	B2	B3		
Shift value =0; Channel 0 seconds.	56.35059	112.7012	225.4023	Free	Free	Free			
Shift limit 40 Ch; 5.583472 E-10 sec. Decay data-Decay									
Prompt and decay - Low								1250	1.74483 5E-08 sec.
Fitted parameters	High :7964 Channels; Shift:-4.912201; Ch:-8.856785E-11 sec.; S.Deviation-7.531715E-13 sec.								
T1 - 9056264	Ch- 1.264135E-09 sec.; S.Deviation-1.414566E-11 sec.								
T2-12.62675	Ch.-1.767528E-10sec; S. Deviation- 3.275742E-12 sec.								
T3-427.121	Ch.5.962046E-09 ; S. Deviation- 2.253981E-11 sec.								
Prompt and decay-High	800 1.11725 4 3E-07 sec.								
Background on prompt	44								
Time Calibration: 1.39586 8E-11 sec./Ch.					6.431247 E-03; [35.26 Rel. Ampl.] [0.09 Alpha] S.Deviation-1.924897 E-05.	6.089931 E-02; [46.55 Rel.Ampl.] [0.90 Alpha]; S.Deviation-1.204013 E-04.	7.032348 E- 04;[18.18 Rel. Ampl.] [0.01 Alpha]; S.Deviat ion-2.203793 E-06.		

Table 1: Lifetime measurements for C60 in Oxolane.

1.395868 E-11 seconds/channel. The estimated values of T_1 and T_2 and T_3 were 78.65798 E-9 sec (T_1) for the channel 56.3509, 1.57316E-9 sec, (T_2) for the channel 112.7012 and 3.136316E-9 sec (T_3) for the channel 225.4023 respectively. Initially the decay rates were set free, namely, A, B_1 , B_2 , and B_3 was set free. Compared with this 'estimate, the three lifetimes observed were 1.264135 E-9 sec (T_1), 17.6258E-9 sec (T_2), and 5.962046E-9 sec (T_3) respectively. The corresponding channels for which the lifetimes were 'observed' were, 90.56264(T_1), 12.62675(T_2), and 427.121 (T_3), respectively. The total numbers of channels studied were 7964 in this period [4-9]. The 'red' color line shows the decay of the curve plotted on the logarithmic scale. The decay rates of the species present in the sample was 6.134217 E-3 (B_1), 6.083199 E-2(B_2), and 7.032348 E-4(B_3) respectively. The Chi squared test yielded 1.040634 for the fitted parameters having 6707 degrees of freedom. The Chi squared probability was observed as 0.9969191 and the Durbin-Watson parameter was 1.404432. The residuals and the standard deviations for all the lifetimes and the decay rates were also tabulated as shown in Table 1 above. Three exponentials were calculated and all the values recorded and tabulated [10]. Since the data were within the acceptable parameters, it is predicted that the above sample had showed three lifetimes predominantly. Thus the C60/Oxolane combination can be used for optical switching and photonic device purposes (Table 1).

Results and Discussion

The fluorescence lifetime studies for the fullerene molecule were carried out in duration of 88.18 seconds. A pulsed laser was used to study the time-resolved lifetime studies of the fullerene molecule mixed with THF(Oxolane) solution in the 370 nm to 421 nm region and it was found that revealed three lifetimes for the 1344th channel. The total number of channel studied were 7964 in this period. The estimated values of T_1 and T_2 and T_3 were 78.65798 E-9 sec (T_1) for the channel 56.3509, 1.57316E-9 sec, (T_2) for the channel 112.7012 and 3.136316E-9 sec (T_3) for the channel 225.4023 respectively. The corresponding channels for which the lifetimes were 'observed' were, 90.56264(T_1), 12.62675(T_2), and 427.121 (T_3), respectively. The Chi squared probability was observed as 0.9969191 and the Durbin-Watson parameter was 1.404432. It is predicted that the above sample had showed three lifetimes predominantly.

Conclusion

The fullerene molecule in a matrix with THF oxolane exhibits three lifetimes in the region 370 nm to 421 nm region.

The C60/Oxolane matrix can be used for optical switching and photonic device purposes.

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