PASSIVE Q-SWITCHED PULSE DURATION USING DIFFERENT SOLVENTS

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ABSTRACT
Using nickel dye (BDN-1) as solid Q-Switched films for Nd:YAG laser, environment effect on the Q-Switched pulse duration have been investigated Chloroform(18e⁻), benzene (12e⁻), dichloroethane (12e⁻), acetone (8e⁻), and dioxane (8e⁻) which possess different number of anti-bond electrons have been used with PMMA and BDN-1 solvent each at 4% dye concentration. The measured pulse duration were (28.60, 29.60, 36.75, 71.47 and 77.20ns) respectively, while the free-running pulse duration of Nd:YAG laser is about 100μs. The greatest pulse duration reduction has been observed using chloroform, which is referred as the most active solvent with respect to other solvents in use. The electronically active classification of these solvents has been performed depending on three hypothesis to calculate the number of anti-bond electrons the solvent molecules.

INTRODUCTION
The spectroscopy of atomic and molecular system is normally affected by the existence of the surrounding molecules, of the solvent, which can produce significant changes in their photophysical properties. The vibrational structure of the absorption and fluorescence spectra is influenced by interactions of the guest molecules with the host environments. If the molecular spectra exhibit vibrational structure in the vapor phase, this structure is normally broader and
more diffuse in solution compared with gases. The change of environment may modify the vibrational spacing, the shape of the Franck-Condon envelope. The loss of vibrational structure of BDN due to specific host-guest interaction envelop is due to the environmental modification of the molecular potential energy surface [1].

Since no fluorescence of BDN-1 is observed in 1,2-dichloroethane, it follows from the relatively long recovery time the inter-system crossing rate from the lowest excited singlet to the triplet state must determine the recovery time of the dye and hence the pulse duration. This is achieved by solution of BDN-1 in electronically active solvents [2]. It had been suggested that electronically active solvents cause lifetime shortening through reversible electron transfer [2]. Measurements of the ground state recovery times of nickel dyes in a variety of solvents had been carried out in order to times of nickel dyes in a variety of solvents had been carried out in order to elucidated the reasons for the strong solvent dependance of the lifetime [3].

EXPERIMENTAL

Liquid BDN-1 [4] mixed with many solvents at different concentrations have been prepared. Specific amount of PMMA has been added to each solution in glass vessels. The aforementioned containers were sealed well for a long period to insure both, the complete salvation of the polymer and the homogenous dispersion of the dye through the plastic solution. The viscous mixtures have been casted in circular glass dishes containing a small amount of chloroform which acts as a catalytic agent for solidifying the viscous mixture homogenously. As the chloroform is used as BDN-1 mixer, no excess chloroform is used in the glass dish. An evacuated oven has been used to complete the film preparation. The system layout which has been
utilized to generate, detect, and record Q-Switched pulse. It consists of Q-Switched Nd$^{3+}$-YAG laser attenuator and detection system. The pulses have been detected by a silicon diffused pin photodiode supplied by EG&G Company. Attenuators working at 1060 nm have been mounts in front of the photodiode to reduce the incident energy and to operate the detector far from the saturation limit. Fast oscilloscope model PM3350 (frequency 10 MHz) supplied by Philips Company was used to record the pulses.

RESULTS AND DISCUSSION

Many solvents of PMMA such as chloroform, benzene, chloroethane, acetone, and dioxane have been investigated. In this research study the solvents were mixed with BDN-1. A4%BDN-1 concentration (volume % ratio) in chloroform, benzene, dichloroethane, acetone, and dioxane has been used for preparing dye foil films. The Q-Switched laser pulse durations of Nd:YAG laser using the prepared dye foil films are shown in table (1). They are optically arranged in the laser resonator as shown in fig(1).

Three hypothesis are suggested to determine the number of anti-bond electrons that can transfer from the solvent molecule to the excited BDN-1 molecules. Solvent molecule with larger number of anti-bond electrons is of larger ability of anti-bond electron transfer and therefore the solvent is more electronically active. These hypothesis are:

a- The solvent molecules with many anti-bond electrons are electronically more active in comparison to those having less anti-bond electrons.

b- If molecules of two different solvents have the same number of anti-bond electrons, the most electronically active solvent is that whose anti-bond electrons are at high order outer orbital, i.e. with electrons of less binding energy.
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c- A solvent molecule of double-bonds (π-bonds) has greater ability of anti-bonds electron transfer than that of a single bond solvents.

As a result, chloroform is the most electronically active solvent compared with those listed in table 2 and so the shortest Q-Switched pulse duration for Nd:YAG laser has been obtained using chloroform as a solvent for PMMA and as a mixer to BDN-1. The five solvents in table(2) are listed according to their chemical activity which is compatible with the pulse duration sequence in table(1).

Table (1): solvent of PMMA, Mixer with BDN-1 and Pulse duration

<table>
<thead>
<tr>
<th>Solvent of PMMA</th>
<th>Mixer with BDN-1</th>
<th>Pulse duration (ns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>Chloroform</td>
<td>28.6 ± 0.735</td>
</tr>
<tr>
<td>Benzene</td>
<td>Benzene</td>
<td>29.64 ± 0.00</td>
</tr>
<tr>
<td>Dichloroethane</td>
<td>Dichloroethane</td>
<td>36.75 ± 1.33</td>
</tr>
<tr>
<td>Acetone</td>
<td>Acetone</td>
<td>71.47 ± 1.95</td>
</tr>
<tr>
<td>Dioxane</td>
<td>Dioxane</td>
<td>77.2 ± 5.9</td>
</tr>
<tr>
<td>Solvent</td>
<td>Bonding Structure</td>
<td>*</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Chloroform</td>
<td></td>
<td>Cl, Cl, Cl, Cl</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Third</td>
</tr>
<tr>
<td>Benzene</td>
<td>H</td>
<td>C = C</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>second</td>
</tr>
<tr>
<td>Dichloroethane</td>
<td>Cl - C - C - Cl</td>
<td>Cl, Cl</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>3s² 3p²</td>
</tr>
<tr>
<td>Acetone</td>
<td>H - O - H</td>
<td>O = C</td>
</tr>
<tr>
<td></td>
<td>H - C - C - H</td>
<td>Second</td>
</tr>
<tr>
<td>Dioxane</td>
<td>H - C - O - H</td>
<td>O, O</td>
</tr>
<tr>
<td></td>
<td>H - C - C - H</td>
<td>Second</td>
</tr>
</tbody>
</table>

Atoms having anti-bond electrons, outer orbital.

** number of anti-bond electrons.
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1. Active medium Nd:YAG rod.
2. Partial reflected mirror (output coupler).
3. Retrareflected prism (totally reflected element).
4. Flashlamp (pumping source).
5. Flashlamp power supply and triggering system.
7. Reflector.
8. Attenuators.
10. D.C. power supply.
11. Storage Oscilloscope.
14. ED-500 Joule meter.

Fig. (1) Dye foil film Test System.
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REFERENCES
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امد نبضة تحويل عامل النوعية السلبي باستخدام مذيبات مختلفة

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الخلاصة

باستخدام صيغة النيكل (BDN-1) كرفائق صلبة تعمل كمفتاح عامل النوعية للبيزز
النيكل فقد تمت دراسة تأثير المحيط على امد النبضة. استخدمت المحاليل التالية والحاوية
على اعداد مختلفة من الكترونات غير المناصرة الكتروفتروم (8 الكترون)، البنزين (12 الكترون).
الدياكلوروتان (12 الكترون)، الاستون (8 الكترون)، دايكسمين (8 الكترون) مع لدائن من نوع
PMMA وصيغة النيكل وتركيز حجمي 4% لكل منهم.

بينت النتائج ان امد النبضة كان 28.60 - 29.60 - 36.75 - 71.20
نانو ثانية على التوالي. في حين كان امد نبضة التشغيل الحر للبيزز البالغ حوالي
100 مايكروثانية. ان اعتماد نقصان في زمن النبضة كان عند استخدام الكتروفتروم وهذا
اعزي سبب ذلك إلى الفعالية الإلكترونية العالية لهذا المحالل مقارنة مع المحاليل
الخري. رتب الفعالية الإلكترونية لهذه المحاليل على اساس ثلاث فرضيات لحساب عدد
الإلكترونات غير المناصرة في جزيئات المحالل المستخدم.