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Solvent Surface Tension Effect on Passive Liquid Q-switch Pulse Duration

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Abstract

Nickel dye, Bis-(4-Dimethylaminodithobenzil)-Nickel (BDN-I) was used as liquid Q-switch for Nd: YAG laser. Solvent surface tension effect on the Q-switched pulse duration was investigated. Carbon tetra chloride (CCl_4), Chloroform ($CHCl_3$), and dioxin ($C_4H_8O_2$) were used as solvents to BDN-I at molar concentration of 59.52 M/l. The measured Q-switched pulse duration was 60± 2.33, 71± 1.95, and 84± 1.32 nsec respectively. The greatest pulse duration reduction was achieved by using CCl_4 which is of the lowest surface tension with respect to other solvents. The study related that to the low ability of electron transfer from this solvent to the dye molecules.

Key words: Physics, Laser, Passive Q-switching, liquid dyes

1.Introduction

Giant laser pulse may be generated by means of Q-switching. Fast optical shutters can be made by using the electro-optic effect or the acousto-optic effect in some solid-state crystals. These active Q-switching systems are effective and have been widely used in many of the industrial applications because they operate reliably over an extended period of time and can be triggered at any moment within the pumping cycle. However, the overall laser system is rather complicated. Compared to active Q-switching, passive Q-switching with a saturable absorber is economical and simple because it requires less optical elements inside the laser cavity and no outside driving circuitry. Passive Q-switching is a better choice for those applications where compactness of the laser is prime requirement [1,2].

One can shortly express Q-switching as a sudden altering of the losses of laser cavity, as a consequence of the close relationship between resonators looses and resonator quality factor (Q) [3]. The Q-switching technique is based on closing for the optical cavity until the population inversion is built up far above threshold.

Many dyes were used as slow saturable absorbers which were suitable for passive Q-switching and mode-locking of many laser systems [4]. BDN-I had been prepared in 1964 by Muller-Westerhoff at Munich University [5], it was prepared in Iraq in 1997 [6]; it is recommended as a laser Q-switch primarily because of its exceptional chemical, thermal, and photo stability compared with the other dyes[7].

Many parameters effect the reduction of the Q-switched pulses, one of them is the environmental effect; many solvent are used to dissolve dyes. These solvents are of different physical properties, like surface tension. Surface tension is defined as the force perpendicularly affects the line of 1 cm length of liquid surface (it is of dyne/cm unit); Eotvos had measured the surface tension in 1886 [8].

2. Experimental

The different solvents have been mixed with the same concentration of liquid BDN-I dye consequently, the motivation for using these solvents because these solvents were of a different electronic activity.

The first mixture (BDN-I&CCl_4) used as a passive Q- switch with Nd-YAG laser to investigate the output laser pulse duration. Also another experimental testes for the second mixture (BDN-I&$CHCl_3$) and the third (BDN-I&$C_4H_8O_2$) have been performed under the same conditions for solvent temperature and the concentration of BDN-I dye.

The system which was utilized to generate, detect, and record free running and Q-switched pulses, shows in Fig.(1).

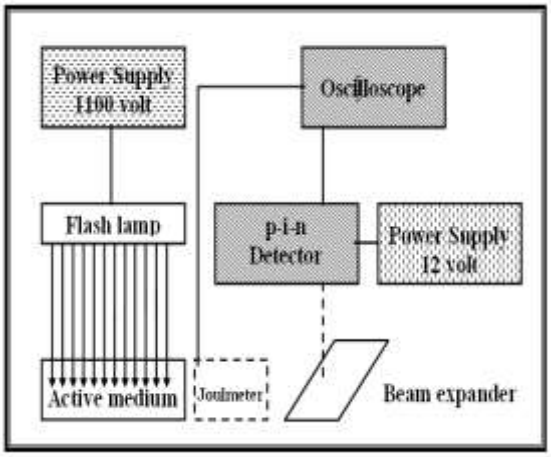

Fig. (1): The experimental setup for generation, detection laser pulses.

3. Results and Discussion

Table (1), shows the obtained results while using the BDN-I concentration of 59.52 M/l in carbon tetra chloride, chloroform, and dioxin.

Table (1): The pulse duration as a function of surface tension for different solvents with 59.52 M/l BDN-I dye.

Molar Concentration (M1)	Solvent	Surface tension (dyne/cm) [9,10]	Pulse duration (nsec)
59.52	CCl_4	26.70 at 20 C^0	60 ± 2.33
59.52	$CHCl_3$	27.16 at 20 C^0	71 ± 1.95
59.52	$C_4H_8O_2$	34.40 at 20 C^0	84 ± 1.32

The passively Q-switched pulse duration of the Nd:YAG laser was 60 ± 2.33 nsec while using carbon tetra chloride as a solvent to BDN-I at 59.52 M/l molar concentration. While it was 71 ± 1.95 nsec concerning chloroform as a solvent at the same BDN-I molar concentration, and it was 84 ± 1.32 nsec concerning dioxin solvent.

The surface tension of carbon tetra chloride is of lowest value compared with those of the other two solvents. This means that the bonds between carbon tetra chloride molecules are weaker than those of the other solvent molecules. The surface tension is associated with the posses of electrons in the molecule groups of high electro negativity. If the electron density is higher, the surface tension will be higher, so the tension between the molecules is higher also. Consequently, the ability of electron transfer from the solvent molecules to the excited BDN-I molecules, is high, i.e., high electronically active solvent.

Finally, the solvent with lowest surface tension is of lowest Q-switched pulse duration.

References

[1]-Yen-Kuang, Kuo, Horng-Min Chen, and Chia-Ching Lin., (2000) " A theoretical study of the Cr:$BeAl_2$ O_4 Laser passively Q-switched with Cr: YSO Solid state saturable absorber" , Chinse Journal of physics , 38, (3-I),(9443).

[2]- Iftitan M. azzouz and Adel EL-Nozahy, (2006). "Numerical study of Cr^{4+}:YAG passivily Q-switching Nd:$GdVo_4$ laser ", Ejupt, J.Solids, 29, (1),(215).

[3]-Patel F.D., Beach R.J, (2001), "New formalism for the analysis of passively Q-switched laser system", IEEE. J. Quan. Elect. , 37, (707-714).

[4]-Penzkofer , (1988), "Passive Q-switching and mode-locking for the generation of nanosecond to femto second pulses", J. Applied Phys.,B 46,(43), (43-60).

[5]-Muller-Westerhoff U.T. , (1964), M.Sc. Thesis Munich University, Germany.

الخلاصـــــة

أستخدمت صبغة النيكل السائلة (BDN-I) كمفتاح لتحويل عامل النوعية مع ليزر النيوديميوم–ياك (Nd:YAG) ,حيث درس عمليا تأثير الشد السطحي (داين /سم) لمحاليل مختلفة اذيبت فيها هذه الصبغة على أمد نبضة التحويل السلبي لعامل النوعية .أستخدمت المركبات رابع كلوريد الكاربون (CCl_4)، الكلوروفورم($CHCl_3$)، والدايئوكسين ($C_4H_8O_2$) كمحاليل مذيبة للصبغة (BDN-I) عند تركيز مولاري مقداره 59.52 مول/لتر.

أظهرت النتائج بعد أذابة الصبغة واستخدامها كمفتاح تحويل عامل النوعية أن هناك تأثيرا ملموسا لقيمة الشد السطحي لتلك المحاليل على أمد النبضة, حيث كانت قيم امد النبضة هي (60 ± 2.33) ، (71 ± 1.95)، (84 ± 1.32) نانوثانية على التوالي لكل من المركبات أعلاه, وأن أقل قيمة لأمد النبضة هي عند التعامل مع محلول رابع كلوريد الكاربون الذي يتميز باقل قيمة للشد السطحي من قيمة تلك المحاليل المستخدمة في هذا العمل. وتفسر هذه الدراسة ذلك الى الامكانية الضعيفة للانتقال الألكتروني من جزيئات هذا المحلول الى جزيئات الصبغة.