

Investigation of spectral properties of Laser dye doped Silica gel Based Solid State Dye Laser Materials

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Abstract :

SSDL materials were synthesized by trapping of stable laser dye in to Solid Silica host matrix , they may be polymer , inorganic-organic hybrids , ceramics .These materials have many excellent properties as compare to liquid dye laser system . SSDL materials are broadly tunable at wide range , can be manufactured at low cost .Sol-Gel method was used for synthesis of these materials and Nile Blue laser dye is used for doping . Ethanol is used as solvent for dye After preparation of these materials spectroscopic characterization was done by UV-VIS Spectrophotometer and Photoluminescence spectrophotometer. Along these two studies XRD testing was also done to find out the nature of these prepared solid state dye laser materials

Keywords : SSDL , Laser dye , sol -gel ,Nile blue A Perchlorate

INTRODUCTION:

Solid state dye laser materials have come in much more spotlight in last years as more advantageous wide wavelength laser sources due to reason of accessibility ,wide tunability and economical range[1]. Liquid dye laser also show properties like these materials but liquid dye laser have many disadvantages such as toxicity , high in cost , requires a bulky liquid circulating equipment and it was not user friendly and these disadvantages of liquid dye laser generates the need of more advance system for lasing operation of lasers[2,3] . First time in 1967 Soffer & Mcfarland report about the stimulated emission of dye molecule from solid matrix rather than liquid solutions of dye . After that a much more efforts have been done for the trapping of laser dye in different types of solid matrix and many host matrix prepared for trapping were xerogel ,silica gel , polymers ,silica- polymers hybrids[4] . Silica gel based materials have synthesized by sol- gel method and polymers based dye laser materials have been synthesized by slow polymerization method or via cold press or hot press method [5] . Solid state dye laser materials have many application in medical field , in astronomy , in telecommunication and they are also widely used in

industrial application they are also used as a range finder[6,7] . Materials synthesized by sol -gel method show high porosity and show a very good optical homogeneity . They are very flexible in starting phase and can easily transformed into shape of glassware in which the solution is poured . Sol - Gel process occur via two step reactions in first step hydrolysis reactions occur while in second step poly- condensation reactions occur[8,9,10].

Silica gel based solid state dye laser materials are the best sources for continuous emission of laser radiations . During the starting phase of solid state dye laser materials many problems were faced by scientist because of lack of stable and efficient laser dyes[11] . The dye present in market at that time have problem of degradation of dye molecule at the time of doping and that affect the laser action and the results expected from those materials were not that much satisfactory but after many efforts new and efficient laser dyes were evolved which show good lasing efficiencies which are free from degradation problem[12] .

Nile Blue A Perchlorate is one of the best fluorescent laser dye from benzo[a]phenoxazine family which is highly fluorescent and photostable laser dye .It is

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soluble in acetone ,Ethanol ,Methanol .Laser action of laser dye depends upon in which matrix it is doped[13]. In our present study laser dye was doped in silica gel matrix and five type of solid state dye laser materials have been synthesized via five different concentration of dye solution was added to stock solution .One concentration is undoped and other four concentrations are 0.97×10^{-6} , 1.94×10^{-6} , 2.91×10^{-6} and 3.88×10^{-6} mol/L . Prepared sample were characterised by UV-VIS,PL for there study of there photophysical properties and XRD was also done to study the nature of these synthesized materials .

EXPERIMENTAL Studies

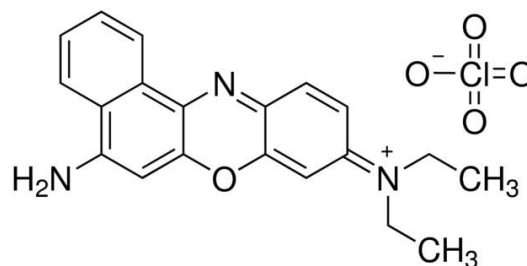
Chemical used :

Nile Blue A Perchlorate is the laser dye which is used for doping in silica gel based solid state dye laser materials . The Empirical formula of dye is Nile blue $C_{20}H_{20}ClN_3O_5$ & the molecular weight of dye is 471.87 . The chemical structure of laser dye is shown in figure 1 . The chemicals that were used for synthesis work of silica based materials TEOS (Sigma Aldrich) , Acetonitrile (AR Grade ,CDH) , Ethylene Glycol (AR Grade , Fischer Scientific) , N ,N Dimethyl Formamide (AR Grade , Fisher Scientific) , Ethanol (AR Grade , Fischer scientific) , Hydrochloric acid (AR Grade , RANKEM)

Method used for sample fabrication

Silica gel based dye laser materials have been synthesized by using below methods

TEOS and DMF were taken in M ratio of 0.070: 0.40(v/v) , Water 5 ml (v/v), Ethanol 25 ml (v/v) ,Ethylene Glycol 15 ml (v/v) Acetonitrile 12ml (v/v) all these chemicals were poured into beaker and placed on magnetic stirrer for 60 minutes at a temperature of 35 degree . after 60 mints HCL was added to solution and a dye solution 10^{-6} M solution is formed with Ethanol . After that prepared solution of TEOS and dye solution with different concentration is doped in TEOS solution . Mixture is allowed to settle down and after that mixture was poured into glassware and place the glassware in oven at $70^{\circ}C$ for 40 h , after 40 h reaction mixture starts converting in to gel and coming in shape of glassware . temperature was again increased to $90^{\circ}C$ for next 72 hours for final finish and to attain good mechanical strength.



Structure of Nile Blue A Perchlorate Laser Dye

FIGURE 1

RESULTS AND DISCUSSIONS

UV -VIS STUDY

The absorption spectra of five different synthesized silica gel based materials in comparative view of all these series is given in fig 2

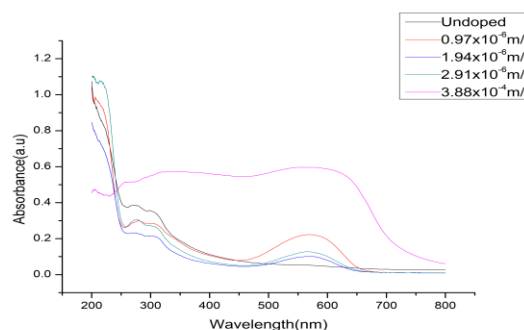


Figure 2

Absorption spectra of undoped and doped silica based dye laser materials

Results which we have obtained from different samples we concluded it as that with the increase in dye concentration affect the intensity of absorbance band and the peaks get broad and very clearly visible and noticeable. Region of absorbance wavelength also increases . Undoped material show peak 280 nm and 301nm .The three absorption band appear at 574 ,571, 568 nm wavelength but at 3.88×10^{-4} concentration it show peak at 591nm which is highest from other samples. As the concentration of dye varies in synthesised materials the slight shifting is seen .Except one concentration of materials all materials show absorbance at high intensities . Material with 3.88×10^{-4} M/l concentration show a different type of spectrum form other may be its due some loss of dye time during aging and drying process of silica gel based solid state dye laser materials . these spectral properties of these synthesized silica gel materials confirms that solid state silica gel based dye laser

materials have good optical properties they show good absorbance in UV-VIS region and they are best optical laser materials .

Photoluminescence (PL) study

The fluorescence emission spectra of undoped and Nile Blue a perchlorate dye doped 0.96×10^{-6} , 1.94×10^{-6} , 2.91×10^{-6} and 3.88×10^{-6} mol/L silica based materials are down in fig.3 and fig 4

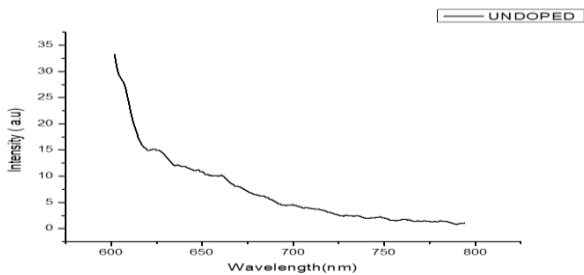


Fig 3

PL spectra of undoped silica based dye laser materials

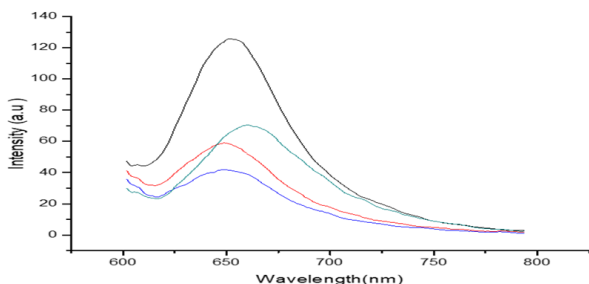


Fig 4

PL spectra of dye doped silica based dye laser materials

It been observed that as concentration of dye varies in the silica based samples from 0.97×10^{-6} to 3.88×10^{-6} mol/L, the emission peaks appears at wavelength 663, 654, 650, and 648 nm respectively in visible region with blue shift It is clear that as concentration of dye increases, the stoke's shift increase. The photophysical properties of Nile Blue a perchlorate doped silica based materials suggest the tunable behavior of the prepared materials which may be beneficial in the fabrication of tunable dye lasers

XRD STUDIES

The X-ray diffraction patterns of Nile Blue a perchlorate doped silica based material are shown in Fig 4

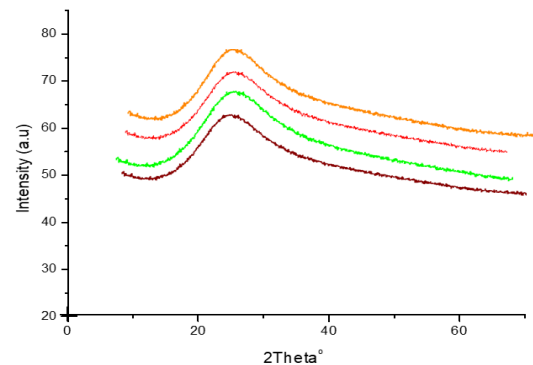


Figure 5

XRD Spectra Of Dye Doped Silica Based dye laser Materials

The concentration of dopant varies as 0.97×10^{-6} , 1.94×10^{-6} , 2.91×10^{-6} and 3.88×10^{-6} Mol/L. The X ray diffraction pattern provides significant information in relation to the nature and structure of the sample. The X-ray diffraction pattern depend on the synthesis route, solvent & ionized state and many other factors that are related to prepared samples . It has been observed that the diffraction peaks are broad, which is a typical feature of the amorphous nature and in other words we can say that the samples are amorphous in nature because no sharp peak has been observed m X ray diffraction patterns

CONCLUSION

In this present work , Nile Blue A Perchlorate doped silica gel based dye laser materials have synthesized and characterized by UV- spectrophotometer , Photoluminescence spectrophotometer and XRD .From UV Studies we have found that visible band is going on increasing with increasing concentration of dye the maximum absorbance we observe at 591nm for higher dye concentrations. From XRD the nature of synthesized materials has found the materials are of amorphous nature and from our PL study we get maximum band at 663 from we can easily say that the stock's shift is occurring due to formation of loosely bound dimmers in prepared samples with the variation of dye concentration . The study of these three factors tell about the advantages of dye in solid state matrix. By doping of laser dye in solid matrix the properties of laser

materials get enhanced or we can say that these investigations are very helpful in exploring the new ways for the development of more advanced silica gel based solid state dye laser materials .

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