Study of optical properties & fabrication route of silica gel based solid statedye laser materials doped with Oxazine 170 Perchlorate

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ABSTRACT. The synthesis and spectral properties of laser dye doped solid state materials have been reported in this paper . Silica gel based materials that are doped with different concentration of dye synthesized . Porous silica gel based materials have been synthesized by using sol -gel method .TEOS is used as precursor for synthesis work .Many other chemicals are also used in standard concentration for crack free synthesis for these materials . oxazine 170 perchlorate laser dye is used for doping process. Ethanol is used as a solvent for making different concentration of dye solution .The spectral properties of these synthesized silica based SSDL materials were studied with UV Spectrophotometer and their other characteristics are studied by XRD and SEM. From UV Study we have find out the absorbance patterns . Shifting in peaks of absorption spectra has been observed from the data with increase of dye concentration in silica matrix . From XRD studies we have find out about the nature of materials and From SEM we have find the variations in size of particles present in dye doped silica gel particles present in synthesized materials .

Keywords : Silica -Gel , Sol -gel method , Oxazine 170 Perchlorate , Spectral properties

1.INTRODUCTION.

Solid state dye laser materials are most commonly used laser materials because they have excellent optical transparency , resistivity and also they are tunable at broad range[1]. They have good mechanical strength & good optical homogeneity .Solid state dyelaser materials have many applications in optics , underwater sensing , medical field ,local area communication networks and in industries[2] . SSDL based materials have many technical advantages and the biggest advantage of these materials are non-toxic, fireproof , economical range and user friendly and this feature made them strong contenders in markets[3] . Many different types of materials have been synthesized in past years but the most commonly used SSDL materials are based silica , PMMA and silica PMMA hybrid materials[4,5] .In this paper we have synthesized silica gel based SSDL materials via sol- gel method and this process occur at low temperature which save energy & reduce the rate of evaporation losses that occur in reaction mixture and the main thing about this process is that we can be synthesized a new crystalline phase from new non – crystalline solids . Silica gel networks are formed with hydrolysis and condensation reactions[6] . Silica gel based solid state dye laser materials are the most advanced class of optical materials with great deal of future perspective[7] . SSDL materials are high performance optical laser materials Soffer and McFarland and Peterson and Snavely in 1967 report about the stimulated emission from solid state matrix doped with organic dyes ,but that time problem was faced because of quality of laser dyes present in market , only very few laser dyes show complete miscibility in solution and because of less solubility they have low lasing efficiencies due to which photodegradation occur in dye molecules and this alter spectral

properties of solid dye laser materials [8,9] .After many years of trails and researches a few new laser dyes are synthesized which show high performance inSSDL materials .

Some new methods were also implemented for trapping of laser dye in solid matrix and after spectral studies of these synthesized solid state dye laser materials it is proved that yes these are advanced and beneficial optical materials[10,11] . silica gel based dye laser materials gave a platform for the innovation of active elements for laser technology . Oxazine 170 Perchlorate is one of that high performance dye for Oxazine family which is highly fluorescent and photostable organic dye. The absorption spectra of this dye depend upon the in which matrix dye is doped . In our present study one concentration is undoped silica gel materials and other four concentrations are 0.98×10^{-6}, 1.96×10^{-6}, 3.92×10^{-6} , 5.88×10^{-6} mol/l Prepared samples were characterized by using spectroscopic testing'ssuch as UV Spectrophotometer ,XRD AND SEM .

2.EXPERIMENTAL SECTION.

Chemical used :

Oxazine 170 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 $C_{21}H_{22}ClN_3O_5$ & 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^{-3} 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 70^0C for 40 h , after 40 h reaction mixture starts converting in to gel and coming in shape of glassware . temperature was again increased to 90^0 c for next 72 hours for final finish and to attain good mechanical strength.

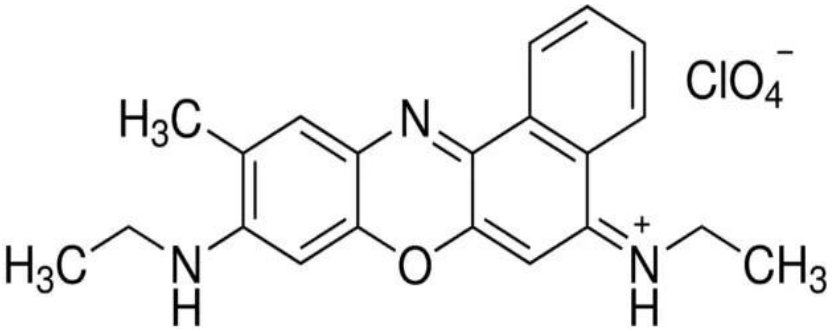


Figure 1

Chemical structure of Oxazine 170 Perchlorate

3.RESULTS AND DISCUSSION.

3.1 UV – VIS STUDY

The absorption spectra of five different synthesized silica gel based materials is shown in figs 2,3,4,5,6 and a comparative view of all these series is also given in graph in fig 7 and from the data 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 .

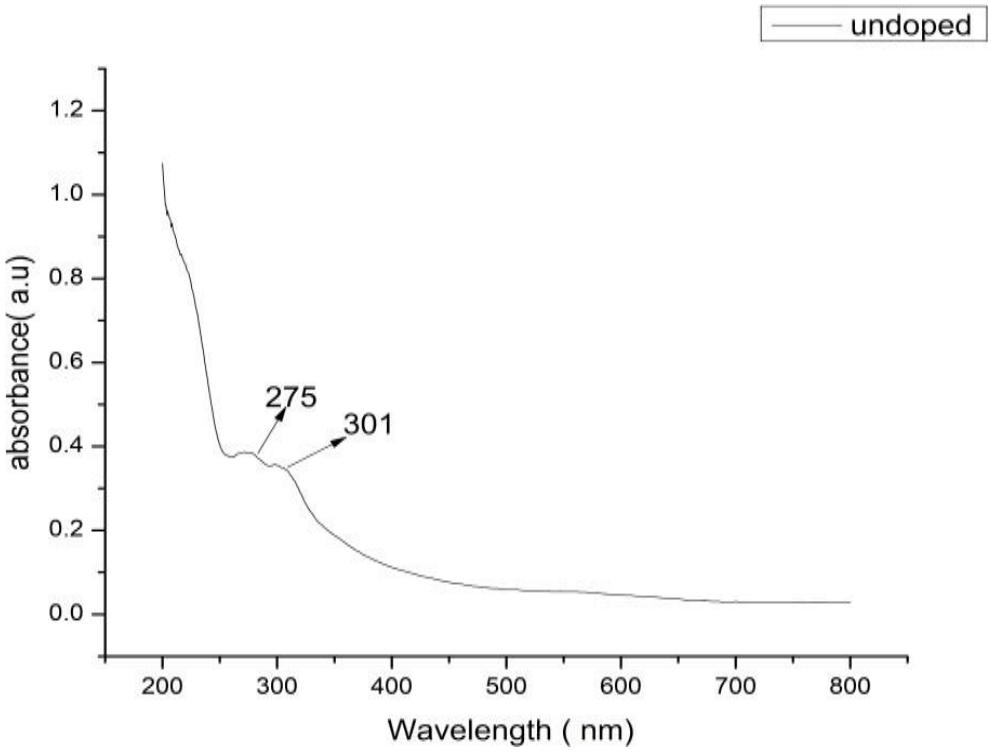
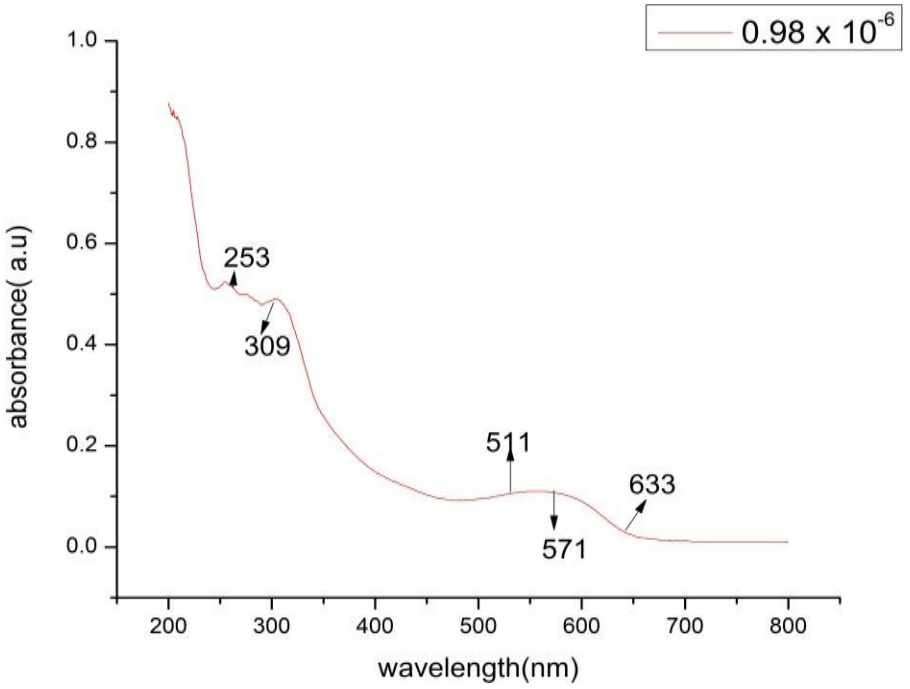


Figure 2



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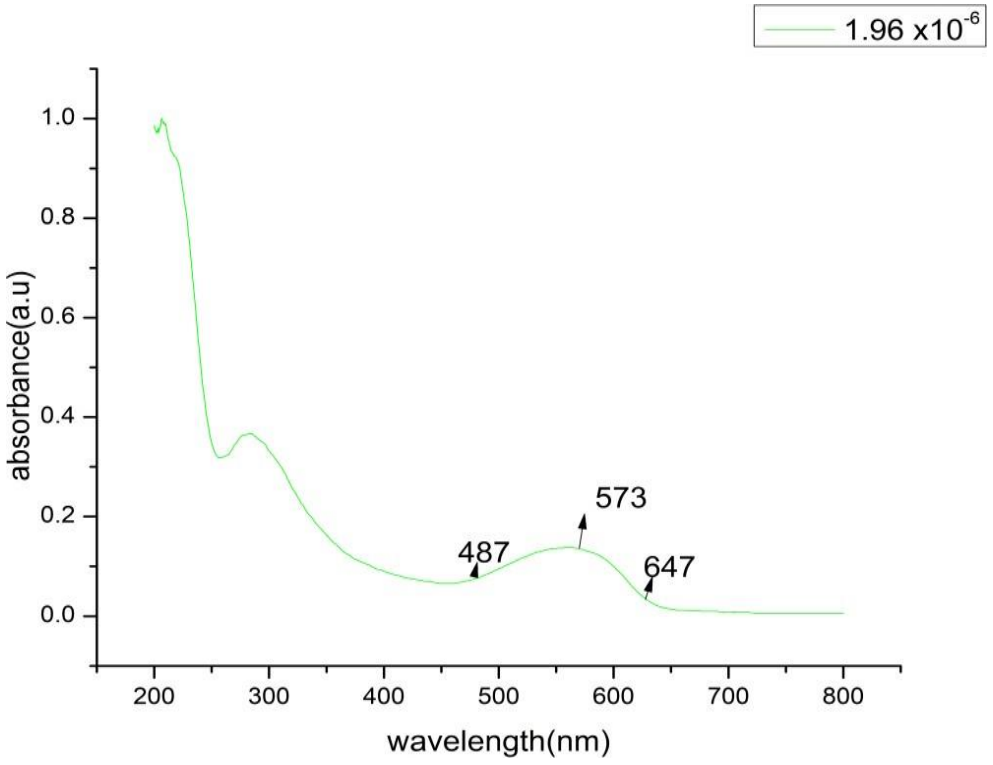

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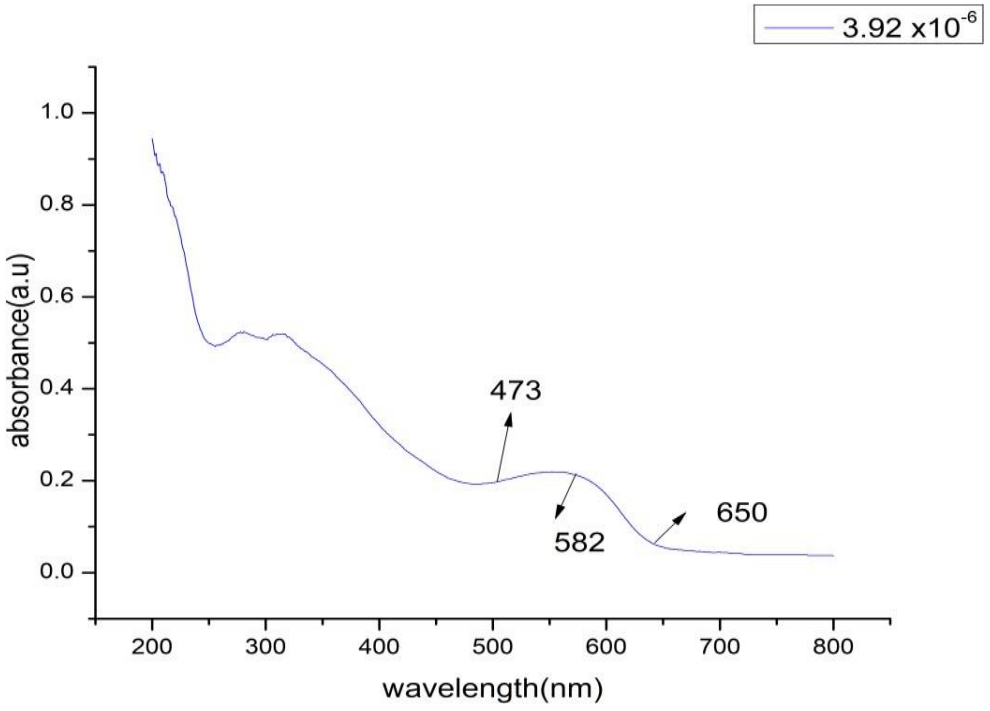

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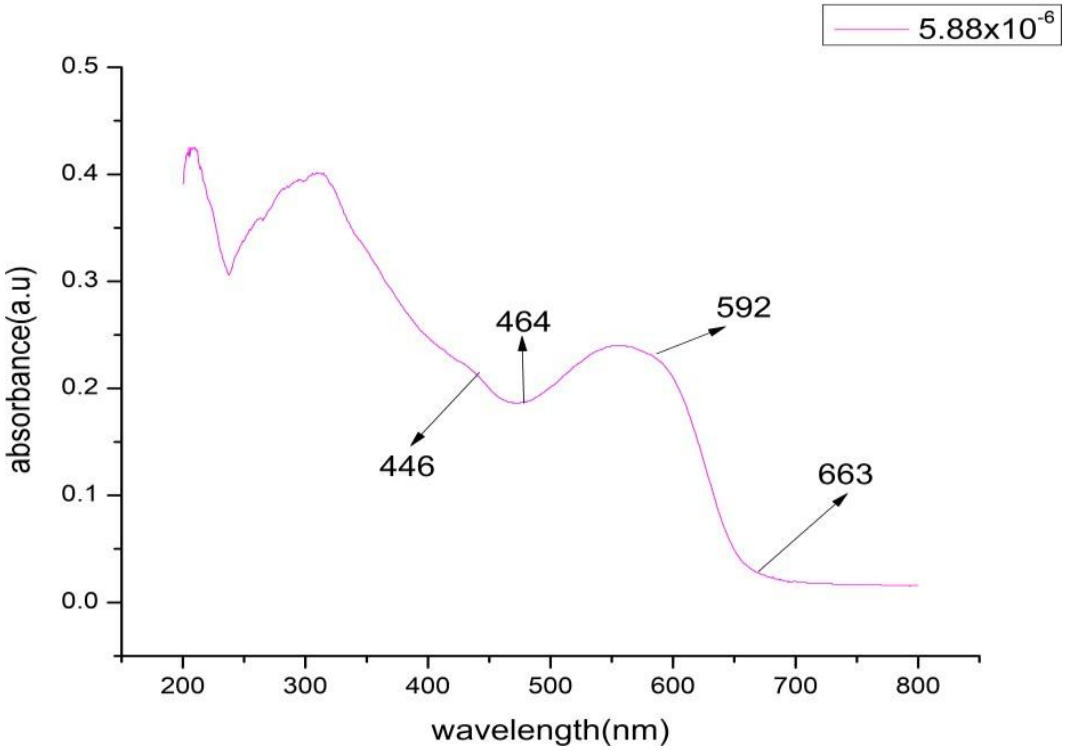

Figure 6

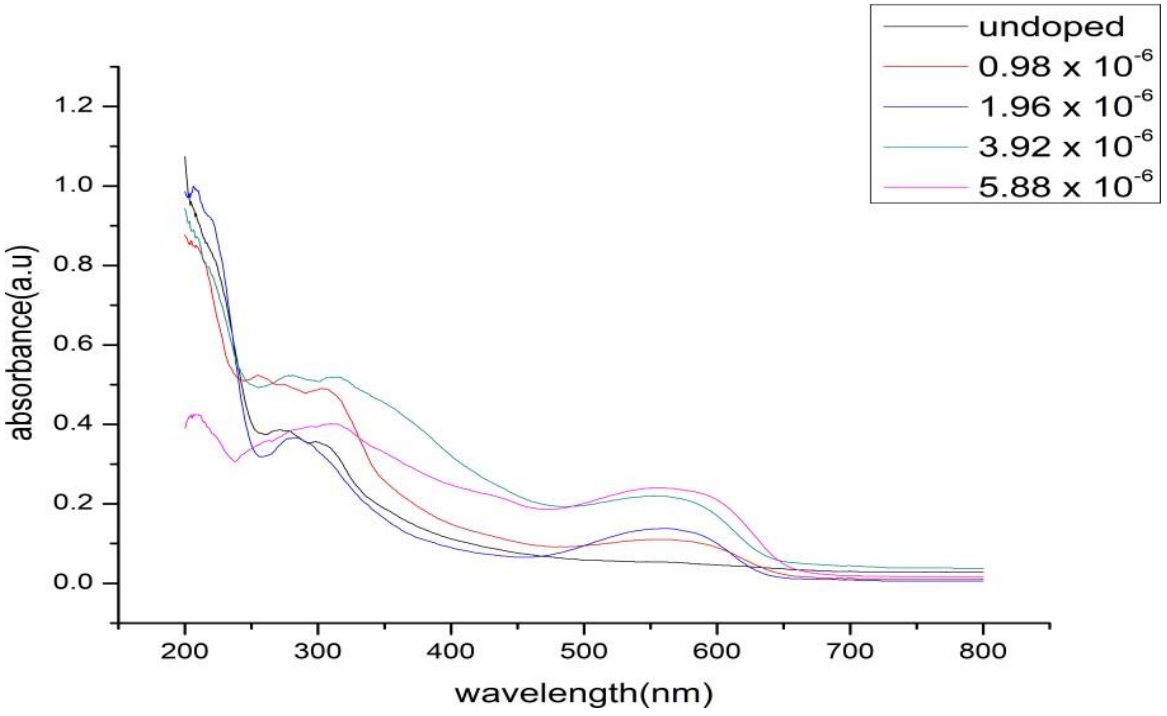

Figure 7

Overall spectrum of undoped and doped materials with different concentration of dye peaks observed from all five series are depicted below :

1.Undoped material with out doping gives peak at 275 nm another at 301 nm at intensity 0.39

2.Doped material with 0.98 $\times 10^{-6}$ mol/l concentration of dye gives peak at 511nm ,571nm and 620 nm at 0.1 intensity .

3. Doped material with 1.96 $\times 10^{-6}$ mol/l concentration of dye shows peak at 487 nm ,573 nm andpeak at 647 nm at 0.15 intensity .

4. Doped material with 3.92×10^{-6}mol/l concentration shows peak at 473nm ,582 nm, 650nm at 0.2 intensity .The peak observed from this concentration are clear and wide also as compare to above series .

5. Doped material 5.88×10^{-6}mol/l concentration show peak at 446 nm , 464 nm , 592 nm and 663 nm at 0.19 intensity but the height of peak at 640 nm is near by the 0.25 intensity. As from data its very clear that a slight shifting is observed in all concentration and peaks are becoming clear and visible region is also going on increasing and 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 .

3.2 XRD STUDIES

Figure 8 (a) and (b) tells about the nature of synthesized silica gel solid state dye laser material

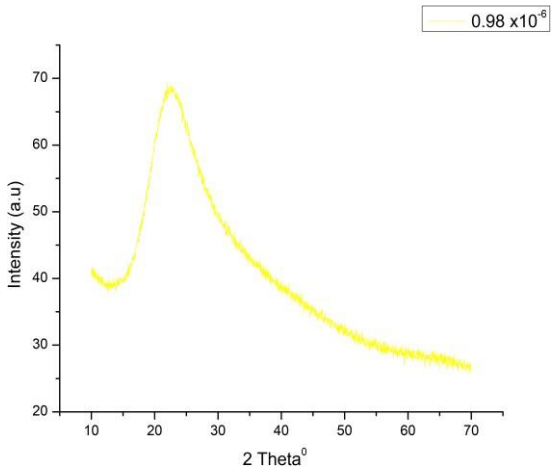

Figure 8 (a)

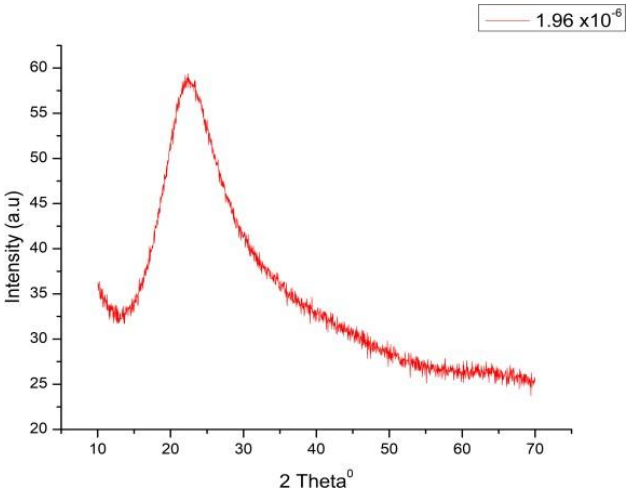

Figure 8 (b)

XRD pattern of silica normally differs because it depend upon the synthesis route , which solvent is used .As from above graphs it is clear that peaks are broad and that is a characteristicsymbol of amorphous nature materials The diffraction patterns are similar for both of the samples only difference with concentration is the intensity . A broad band is appeared at $2\Theta = 22^0$ angle with reflection because they consists of sio_2 networks . There is no extra peak observed in all these spectra only single broad peak is there and this results also tells about the absence of impurities in gel networks that means result obtained from our synthesized materials are accurate and they have good physical properties.

3.3 SEM STUDY

SEM images of three different dye concentration doped materials are shown in figures 9 (a) – (c). The concentration of dyes varies as 0.98 x 10^{-6} , 1.96x 10^{-6}, 3.92x 10^{-6} mol/l .As the concentration of dye varies or we can say as the concentration of dye increases in synthesized materials the number of dispersed dye particles increases . At higher concentrations , the difference in size of particle is seen due to agglomerates , some aggregates are also seen. Dye particles trapped in this silica gel matrix are responsible for the changes occurs in optical properties of synthesized materials .

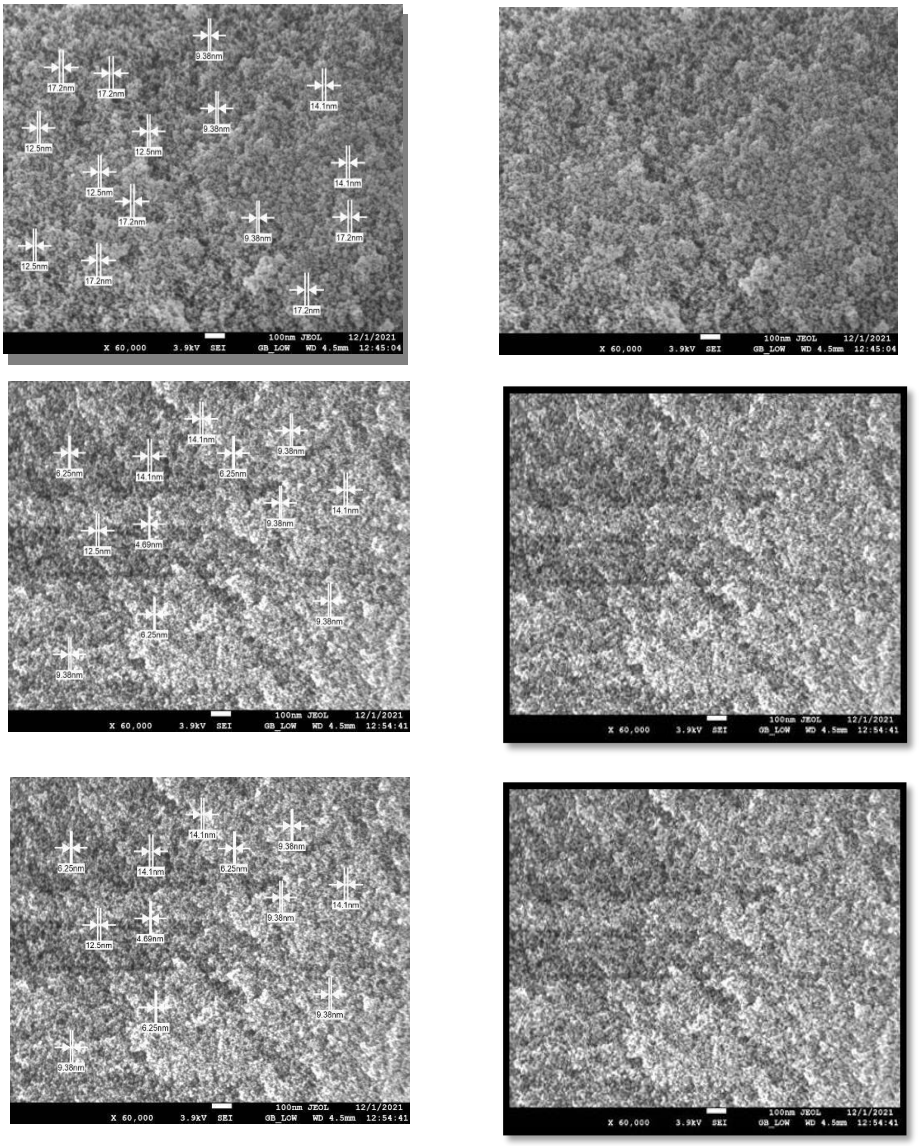

Figure 9(a) 9(b) 9(c)

4.CONCLUSION. In this present work , Oxazine 170 Perchlorate doped silica gel based dye laser materials have synthesized and characterized by UV- spectrophotometer , XRD and SEM .

From UV Studies we have found that visible band is going on increasing with increasing concentration of dye the maximum absorbance we observe at 663 nm for higher dye concentrations. From XRD the nature of synthesized materials has found the materials are of amorphous nature and from our last study of SEM we have seen that the size of silica gel particles is variating and number of particles size are also increasing with the increase in 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 testing's are very helpful in exploring the new possibilities for the development of more advanced silica gel based solid state dye laser materials .

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