Synthesis and FTIR Studies of Er^{+3} Doped Sol–Gel Derived Silica Glass

P. Kothari*[1], R. K. Nariyal[2], B. Bisht[3]

[1]*Department of Chemistry, Govt. P.G. College Berinag, Pithoragarh-262531,Uttarakhand, India.*
[2]*Research Scholar, Department of Chemistry, Graphic Era University, Dehradun, Uttarakhand, India.*
[3]*Department of Chemistry, Graphic Era University, Dehradun, Uttarakhand, India.*

***Abstract*—Er^{3+} doped Sol-Gel derived Silica glass for possible use in making laser material has been prepared successfully. The structural properties of Er^{3+} doped silica glasses has been investigated with Fourier Transform Infrared Spectroscopy (FTIR). The result of the investigations with essential discussions and conclusions have been reported in this paper.**

Keywords*— *Sol–gel silica glass, Structural properties, Fourier Transform infrared spectroscopy. Rare earth, Doped Glass.

I. INTRODUCTION

Sol–gel glasses doped with rare-earth (RE) ions are of interest for various applications including solid state lasers, optical waveguides and fibre amplifiers. Sol gel is an attractive synthetic method to metal oxide materials applied in a wide variety of fields such as ceramics, sensors, catalysts, optics, electronics and thin films[1]-[3].Rare earth ions are employed in optical applications due to their metastable excited states over the entire range of optical frequencies [4], [5]. For many years, rare-earth doped glasses have been used to make bulk lasers and amplifier devices [6]. The past literature shows that the rare earth ions find more important application in the preparation of the laser materials [7]-[12]. Rare earth doped crystals like Nd:YAG are considered to be excellent laser materials [13],[14],[15]-[19], but the rare earth doped glasses have distinctive advantages [20] over doped crystals such as flexibility in size and shape and excellent optical quality. The rapid development of rare earth doped silica fibre amplifiers and lasers have considerably increased the interest in rare earth doped planar waveguide devices. Furthermore, reliable high power CW (Continuous Wave) diode laser pumps provide the possibility of miniaturizing conventional solid-state lasers and amplifiers [21],[22]. Such glass based rare earth doped lasers and amplifiers are highly promising for producing small, compact, efficient and reliable communication, signal processing, sensing and medicine applications.

In view of the above, a comprehensive work on the synthesis of Er^{+3} doped silica glass by sol–gel technique and FTIR characterization have been undertaken.

II. EXPERIMENTAL

Silica sols containing 1mol% Er_2O_3 was prepared using tetraethyl orthosilicate, $ErNO_3$, deionized water, HCl and C_2H_5 OH. The chemicals used were all AR (analytical reagent) grade. Calculated amount of dopant salts were poured in TEOS under stirring condition at room temperature. The molar ratio of TEOS : C_2H_5OH : H_2O : HCl was 1: 4: 14: 0.01 respectively. TEOS and ethanol were magnetically stirred thoroughly till both were in well mixed state. To this well-mixed solution the remaining water was added in which the desired acid was mixed. Again the solution was magnetically stirred to get a clear solution. The sols were cast in polypropylene dishes and were sealed to avoid intercalation of external impurity. The gels were aged for one month at room temperature to obtain the sol-gel. The samples taken in silica crucibles were sintered in a Muffle furnace at 600 ºC for 3 h and then the furnace was cooled to room temperature at a rate of 0.5 ºC per minute. The highest temperature required to obtain a silica glass prepared by sol gel method is about 1000 ºC, which is lower by about 1000 ºC compared to the temperature required for the melt-quenching process. Transparent and bubble free glass was prepared reproducibly. The infrared (IR) spectra were measured with the help of Perkin-Elmer 1710 spectrometer using the Perkin-Elmer Infrared Data Manager using the KBr pellet method. All measurements were carried out at room temperature. The infrared spectrum was recorded in the range 400-4000 cm^{-1}.

III. RESULTS AND DISCUSSION

The infrared spectra (4000–400 $cm^{–1}$) of 1 mol% Er_2O_3 doped silica gels is shown in figure 1. The figure shows a broad absorbance ranging from 3700–2900 $cm^{–1}$. This is attributed to the presence of Si–OH stretching vibration and absorbed water. The peak at 1643 $cm^{–1}$ caused by the –OH bending vibration (Herzberg 1985) also behaves similarly showing escape of water from the structure of the gels. The water has no substantial effect on the structure of the glass [23]. The absorption peaks are assigned to the Si–O asymmetric stretching vibration (1171$cm^{–1}$) and the vibration of siloxane chains (1088 $cm^{–1}$). Metal alkoxides of Si(IV) are reported[24] to show absorption bands attributed to υ(M-O) stretching modes around 800 cm^{-1}, respectively. Therefore IR peaks of TEOS at 795 cm^{-1} in Figure 1 are assigned to υ (Si-O) stretching vibration. The very broad strong peak at 1088 cm^{-1} can be ascribed to composite of C-O stretching of TEOS and ethanol [25]. It is also often reported [26]-[28] that bands within the range 900-1000 cm^{-1} are composite features of Si-

OH species. The strong band at the frequency of 968 cm^{-1}, therefore, is assigned to stretching vibration of Si-OH. The peak near 443 cm^{-1} and a low frequency peak near 602 cm^{-1} is assigned to Si-O-Si out of plane bending and Si-O-Si stretching modes respectively.

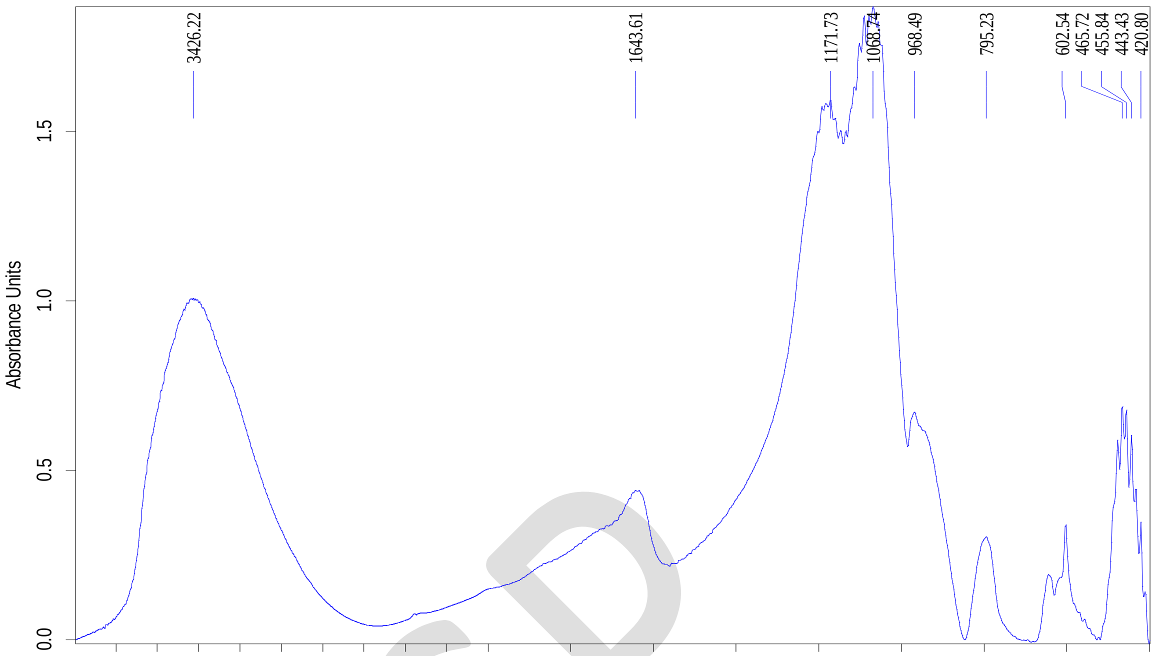

Figure 1. Infrared spectrum of Er^{+3} doped sol-gel Silica glass

IV. CONCLUSION

The synthesis of optical quality silica glass doped with rare-earth ion (Er^{3+}) has been demonstrated. FTIR spectroscopy showed the Si-O, Si-O-Si bonds were formed. The IR spectra showed that our synthesized material may be used as a laser material.

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