Chapter 5

Conclusions and future prospects in a nutshell

This chapter summarises the general conclusions and findings of the present work. Non-destructive photothermal methods as well as optical absorption and fluorescence spectroscopy are utilised to characterise three different materials, both thermally and optically. The possibility of using montmorillonite clay minerals, after textile wastewater treatment, is investigated for further applications. The laser induced luminescence studies and thermal characterization of certain rare earth titanates, prepared by self propagating high temperature synthesis method, are also presented. Moreover, effort is made to characterise rare earth doped sol gel silica glasses with the help of these non-destructive techniques. An outline of the works, which can be carried out in future, is also presented.

5.1. Major findings:

- The presence of dye in the montmorillonites changes their thermal diffusivity values depending on the concentration of the dye adsorbed.
- The sample in which the dye is repeatedly adsorbed has less thermal diffusivity value than the sample that has adsorbed once.
- The sintered methylene blue adsorbed K-10 montmorillonite samples show a higher thermal diffusivity.
- K-10 montmorillonite which is more acid leached than KSF shows significant thermal diffusivity changes on dye adsorption.
- The ultrasonicated dye adsorbed sample showed a low thermal diffusivity compared to the sample prepared by the direct dye adsorption from solution.
- Dye intercalation in montmorillonites affects the fluorescence at 421 nm arising from the silica matrix. A slight amount of dye in the clay network can enhance this fluorescence.
- Acid leaching can considerably affect the fluorescence emission of montmorillonites near 421 nm.

\[ \text{The presence of La}^{3+} \text{ ions in the lanthanum titanate enhances the luminescence of Ti}^{3+} \text{ near 610 nm.} \]

\[ \text{The lanthanum titanate, prepared by SHS method, exhibits frequency up-conversion.} \]
The approximate thermal diffusivity and thermal effusivity values of the rare earth titanates prepared by SHS method are evaluated using photothermal techniques and the possible fractal nature of the samples has been established.

- Rare earth doped sol gel glasses also show fluorescence near 421 nm on UV excitation, which arises from the silica host.
- The thermal diffusivity and thermal effusivity values of rare earth doped sol gel silica glasses are obtained using photoacoustic method.
- The higher thermal diffusivity values of these materials indicate that the preparation procedure highly influence the properties of these materials.

5.2. Scenario for future:

5.2.1. Dye intercalated clay minerals:
Construction of hybrid clay nano-films gives the opportunity to look at clay minerals from a material scientist’s point of view. Research could progress along two lines: (1) optimisation of the preparation of films towards a particular property (e.g. second harmonic light generation) or a device (e.g. sensor); (2) fundamental understanding of the film-forming process, the organisation of the molecules, and the elementary clay mineral platelets and of the stability of the films. The outcome will certainly be a better knowledge of smectites and their surface properties. This will be an advantage to clay scientists and the clay industry. This kind of research can result in new industrial applications of clay minerals with high technological value. There is also room for theoretical work to better understand the magnitude of the various interaction forces and their relative importance in the organisation of organic cations at the clay surface in the aqueous suspensions.

The formation of semiconductor nanoparticles with different layered inorganic solids is useful to construct novel layered nano-hybrid materials with controlled functions and microstructures.

Many cationic dyes and chromophores embedded in inorganic substrates are used in industry, e.g. in photography, in various materials for signal processing and memory storage media, as catalysts, as energy antennas and transducers in photochemical reactions etc. All these applications depend crucially on the optical properties of dye. Therefore, the relationship between dye aggregation and the parameters of inorganic
hosts might be very significant in the applied research and engineering of the materials.

Moreover the following works can also be taken up in future:
- Verification of the thermal diffusivity values of some commonly available dye intercalated clay minerals.
- Effect of preparation methods on clay mineral properties.
- Use of more fluorescent and non-fluorescent dyes for intercalation in clay minerals and hence to study the fluorescence near 421 nm.
- The sintering effects on the fluorescence of dye intercalated clay mineral dispersions.
- Nonlinear optical studies, photopyroelectric studies, laser induced fluorescence studies and photoacoustic spectroscopy of dye intercalated clay minerals.
- Time dependent studies to understand the dynamics of light induced processes.

5.2.2. Sol gel:
It is important to consider the industrial investment in the area of sol gel technology and seeking perspectives on future applications and markets. Future prospects for scientists in this field depend greatly on the economic prospects for the development of successful commercial products which use sol gel processes and materials to a great extent to support a thriving future research activity. Future prospects for successful new applications of sol gel technology depend on the availability of skilled researchers who are able to find solutions to outstanding obstacles to successful commercial applications and to develop innovative new high-performance materials which will in turn create new markets. To develop new functional sol gel materials, improved mechanistic understanding, a wider range of precursors and new processing methods are all desirable.

5.2.3. Rare earth doped materials:
Numerous experimental and theoretical works can be performed on rare earth doped materials due to their possible applications in the visible range of the electromagnetic spectrum. Some of the works which can be carried out based on the present experimental studies are listed below.
- High power laser studies of rare earth titanates prepared by SHS method.
- Effect of rare earth combinations on thermal and optical properties.
- Photoacoustic spectroscopy and frequency up-conversion studies using laser.
- Quantitative studies of rare earth titanate luminescence.
Conclusions

- Thermal lens and nonlinear optical studies of rare earth doped glasses.
- Thermal and optical properties of combination of rare earths in sol gel glasses.
- Effect of sintering rate on glass properties.
- Thermal and optical properties of rare earth doped polymers using non-destructive photothermal methods.