PREFACE

Thermoluminescence had many different explanations but in simplest and modern form, thermoluminescence can be defined as the emission of light from a semiconductor or an insulator when it is heated, due to the previous absorbed and stored energy from irradiation. In today’s evolving world, minerals are becoming more and more important for many industrial areas including radiation dosimetry, which is the most common and the most important application area of thermoluminescence. Because of numerous efforts of the scientists, thermoluminescence now has various application areas such as radiation dosimetry, age determination and geological researches. On the other hand, there was not enough research for minerals on its thermoluminescence properties. In light of the foregoing, the purpose of this thesis was drawn. Thus, in this study it was aimed to investigate the thermoluminescence properties of pure and irradiated minerals with different dosages. At the end of the study, the results of the characterization analysis and thermoluminescence readings were discussed.

The main aim of the present study is the thermoluminescence of industrially important minerals. TL can be very useful tool in quality control in the selection of raw materials for ceramic tiles. The present minerals under study were collected from Bhor ghats, Sangamaner, Nasik and also from various ceramic industries at Morbi, Rajkot district, Gujarat state, India. Among the minerals collected from ceramic industry, the following eleven clay minerals; Ukraine Clay, White Soda, Ivory Soda, Potash, Snow White, China clay, Potash White, Quartz, Preform granuals, Mixed powder, Ceramic tile powder are selected to TL study. XRD, FTIR, Thermo Gravimetric Analysis (TGA), ICP-AES and Laser diffraction particle size analyzer
used for the characterization of collected minerals. Two samples namely Mixed powder and Ceramic tile powder are the part of the pre final and final product of ceramic tiles are also subjected to TL measurement after irradiation. The natural minerals Amethyst, Calcite, Scolecite and Stilbite collected from Bhor ghats, Sangamaner, Nasik are considered for the studies of TL and XRD analysis. FTIR study was done for Calcite as it exhibits good TL.

In ceramic tiles and sanitary ware industries, various types of minerals are mixed in appropriate quantities and ball milled for six to eight hours in distilled water, and then the obtained slurry is sieved to get appropriate particle size around fifteen micron are collected for further processes. The present TL study of minerals is intended to suggest the quality of the raw material at input stage of the ceramic tiles industry. TL dosimetric studies are done in case any accident like nuclear fallout. The present minerals mentioned above are mostly used as components in vitrified/ceramic tiles in turn the tile can be used as accidental TL Dosimetry to detect the quantum of radiation in a particular period.

Now a day ceramic tiles and ceramic ware are becoming basic requirement of people in the world. The people demand various types of high quality ceramic tiles and other ceramic products. Also high demand of ceramic tiles and sanitary product in estate market in the world is increasing day by day. Ceramic tiles and other ceramic material are useful in industries, scientific research, medical science, electronics components, space science etc.
In the early days, the tiles were hand-made, each tile was hand-formed and hand-painted, thus each was a work of art in its own right. Ceramic tile was used almost everywhere on walls, floors, ceilings, fireplaces, in murals, and has an exterior cladding on buildings. In fact most modern houses throughout use Ceramic tiles in every vital area of the premise. Ceramic tiles are also the choice of industry, where walls and floors must resist chemicals. And the Space Shuttle never leaves Earth without its protective jacket of high-tech, heat resistant tiles.

Morbi, the most promising ceramic tiles manufacturing hub of India, is a city located in Saurashtra region of Gujarat. More than 400 units manufactures more than 70% of total ceramic production in India with total installed capacity of 1.8 million Sq.ft. tiles per day. The raw materials used to manufacturing ceramic tiles are mainly from Gujarat, Rajasthan and Andhra Pradesh mines. The following raw materials are used to produce ceramic tiles. Ukraine Clay, White Soda, Ivory Soda, Potash, Snow White, China clay, Potash White, Quartz, etc.

The present TL study of minerals is intended to suggest the quality of the raw material at input stage of the ceramic tiles industry. TL dosimetry studies are done in case any accident like nuclear fall out these ceramic tiles fixed in the toilet, bathroom, and flooring, may be used to get total radiation received from the accident day to sample analyzed day.
For convenience the thesis is divided into seven chapters including conclusions and future work.

**Chapter-1:** The first chapter covers the general introduction on mineralogy, Ceramics, Ceramic tiles and basics of thermoluminescence process. In this chapter the details of ceramics and applications and basic applications of thermoluminescence are discussed along with the methodology of the study are also presented.

**Chapter-2:** Chapter two of thesis is dedicated to the Thermoluminescence basics, phenomena and radiation dosimetry. The first part devoted to basics of luminescence, types of luminescence and thermoluminescence. In addition, this part includes the application areas of thermoluminescence. In the second part of this chapter, general introduction, properties of radiation dosimeters and its applications are discussed.

**Chapter-3:** Chapter three gives a brief description of experimental techniques used in the present study. This details of the instruments used for the present study like : TL glow curve recorder, XRD, TGA (Thermal Gravimetric Analysis), Laser diffraction particle size analysis, FTIR and ICP-AES used for the characterization of collected minerals are discussed.

**Chapter-4:** Chapter four includes the materials under study and the sample preparation techniques on collected natural minerals and clay minerals from different sources. The materials and the details of initial treatments, procedures as well as the analysis methods and conditions employed for characterization of samples are included.
Chapter-5: Chapter five gives the results and discussions from the experimental techniques stated in Chapter 3. The results include the outputs from the XRD, FTIR, TGA, Laser diffraction particle size analyzer, ICP-AES and TL studies followed by discussions.

Chapter-6: Chapter six mainly deals with the TL dosimetry studies. The first part of chapter six deals with TL growth and discussion of glow curves for few samples which show good TL. The second part deals with TL decay and discussion of glow curves for few samples which show good TL. Also growth and decay graphs are presented.

Chapter-7: Finally, chapter seven provides conclusions and recommendations pertaining to this study.

Each chapter is followed by the list of references and cross references.

Few Conclusions from the thesis:

i). All the materials under study were subjected to various characterizations. XRD study reveals all the minerals and materials under study are mostly pure in form. It is interesting to note the crystallite size calculated using Scherrer’s formula \( t = \frac{K \lambda}{B \cos \theta} \) reveals the minerals under study are in nano form.

ii). The average crystallite size of mixture powder is around 43 nm even though the minerals added to make the mixture having higher crystallite size. It is interesting to note that the crystallite size of Ceramic Tile Powder, final form of the mixture of the minerals obtain after heating 1200°C, is 171nm which is four times more than individual minerals.
iii). It is concluded the process of sintering the mineral mixture around 1200°C not only forms the Ceramic tile which is very hard and on mohs scale more than 7.

iv). TGA study of ceramic tile powder confirmed the complete formation of ceramic tile, since there is no variation in Thermogram. The average particle size of as received mixed powder was 24 µm but the average particle size of powder annealed and quenched from 800°C was 45 µm, the increase in particle size by 88%.

v). The particle size analysis of mixed powder (Ceramic tile powder which was obtained from mineral mixture after heating 1200°C) which was 24 µm annealed and quenched from 800°C the particle size is 45 µm which is an increase of 87%. This lead to conclude the addition of more potash mineral may lead to a conducive environment within the crystal led to agglomerate the crystallites to increase the particle size.

vi). The ICP – AES studies of mixed powder, it is found more than 30% of elements from periodic table are present in ppm levels. The presence of Ferro – magnetic ions is also seen from the ICP – AES studies. It is concluded that the process adopted by the industry to remove the ferrous ions is inadequate. It is suggested that the industry should adopt more care to remove the ferrous ions from the slurry.

vii). From the FTIR studies of ceramic tile powder, it is concluded that the Al – O – H stretching, Si – O – Si stretching, Si – O – H stretching, Si – O – Fe stretching and H – O – H stretching are mainly from various ingredients present in the mixture.

viii). From TL decay and TL growth studies of Calcite mineral, it is concluded the Calcite mineral what ever be the form it can act as a radiation detector. Only a linear TL decay of 40% is observed in the time zone of 0 to 300 hours. This can be considered as an environmental TL dosimeter as well as accidental TL dosimeter.