ISSN 2277 – 6362
International Journal of Luminescence and Applications Vol.1 (I)

Characterization of Ceramic Tiles and Raw Materials Using Thermoluminescence Technique

K. Ankamma Rao[1] , K.V.R. Murthy[2] and N.V. Poornachandra Rao[1]

[1]Department of Physics, VSR & NVR College, Tenali-522 201, India
[2]Display Materials Laboratory, Applied Physics Department
Faculty of Technology, M. S. University of Baroda, Baroda-390 001, India
Corresponding author. Tel.: +919030632952
E-mail address: araokonda@gmail.com

Abstract

Many flooring materials most of them are in natural form are used to manufacture floor tiles for household flooring purpose. The peoples demand for variety of flooring material Leeds to develop various types of ceramic tiles. In India ceramic industry is fast growing one, more then 450 units of manufacturing ceramic tiles, vitrified tiles and sanitary ware, situated around Morbi, Rajkot, Gujarat, India having an annual turn over of around Rs.5000 Cores. Many natural minerals are used as the raw materials required for the manufacturing ceramic ware. The following minerals are used to manufacturing the ceramic tiles i.e. Quartz, Potash, Snow White, Potash White, White Soda, Ceramic Tile Powder, etc. Most of the minerals are from Indian mines of Gujarat and Rajasthan states, some of are imported from Russian sub continent. The present paper reports the thermoluminescence characteristics of Potash and quartz minerals collected from the ceramic tiles manufacturing unit, Morbi. The as received minerals TL was recorded (NTL) and also 25Gy beta dose was given to each 5mg weighed sample and ATL was recorded. Annealed and quenched from 200, 400, 600, and 800^{o}C followed by 25Gy beta dose given from Sr-90 beta source. Further the ceramic tile may be used as accidental thermoluminescence dosimeter (TLD) for high doses also studied.

Keywords: Ceramics; X-ray diffraction; thermoluminescence dosimeter (TLD).

1. INTRODUCTION

The earliest disciplines to accept the TL technique in its fold in a variety of applications, such as dating of mineralization, igneous activities, sedimentation and evaluation of growth rate of beaches and sand dunes is Geology. The TL technique has been found useful in dating specimens of geologically recent origin where all other conventional methods fail. In a geological specimen, the TL would starts building up from the time of its crystallization and would normally continue throughout its existence due to the radioactivity present within the minerals and in the surrounding materials, till its saturates. The main basis in the Thermoluminescence Dosimetry (TLD) is that TL output is directly proportional to the radiation dose received by the phosphor and hence provides the means of estimating unknown irradiations [1]. Also, TL can provide a perfect passive measurement i.e. integrated irradiation levels over extended periods of the order of even years.

The present papers reports the thermoluminescence characteristics of the as received materials as well as annealed and quenched from 200, 400, 600 and 800^{o}C followed by 25Gy beta dose given from Sr-90 beta source. The TL was recorded for the natural thermoluminescence (NTL) and followed 25Gy beta dose. The composite material is formed after heating the base materials plate at 800^{o}C for three hours which forms a glossy and glassy structure. The results are interesting. The TL peaks observed are around 150-270^{o}C which are co-related to their natural counter parts. However the TL study of the final product i.e ceramic tile mixture is interesting in Thermoluminescence Dosimetry (TLD) point of view. Since the tiles are laid in homes, offices or schools in case of nuclear accident these tiles can act as thermoluminescence dosimetric materials[1-4].

1.1 Thermoluminescence Dosimetry

Thermoluminescent Dosimeters (TLDs) have found increasing application with the progress made in the development of solid thermoluminescent dosimeters and instrumentation for reading them. Many TLD based systems are now commercially available, and are widely used in routine personal dosimetry, environmental monitoring and clinical radiation dosimetry. The extreme sensitivity of TSL for detecting the presence of defects, as few as 10^9 within a specimen is beneficial for detecting low radiation levels which are encountered in personal and environmental monitoring. Thermoluminescent Dosimeters (TLDs) are increasingly accepted for radiation dosimetry for the following reasons[5]:

a. The existence of nearly tissue equivalent thermoluminescent materials;
b. Sufficiently high sensitivity and accuracy for both personal and environmental monitoring;
c. Commercial availabitility as small sized solid detectors adaptable for both manual and automatic processing;
d. Suitability for skin and extremity dosimetry;
e. Availability of materials with excellent long-term stability under varying environmental conditions;
f. Ease of processing;
g. Reusability;

Linearity of response with dose various radiations like α, β, γ and X-ray radiations and dose rate over a large range.

1.2 Environmental Dosimetry

The regulatory authorities in many countries have become more acutely aware of the increasing concern demonstrated by the public with regard to the potential environmental impact of "man-made" radiation exposure, controlled releases of gaseous radionuclides from nuclear power stations during day-to-day operations, low-level waste disposal, nuclear fuels reprocessing, incidents of nuclear power station accidents and activities connected with nuclear power industry have led to widespread public concern about possible detrimental effects to the public. Age determination and radiation dosimetry are the two most extensive applications of TSL. It is also used in solid state physics as a tool for detecting the presence of defects and for establishing such parameters as the trap depth and capture cross sections, along with information regarding the dynamics of the various charge recombination kinetics. Source identification for various minerals, radioactive ore, and oil and gas well prospecting[6-8].

2. MATERIALS AND METHOD

The natural minerals used in manufacturing the ceramic tiles are collected from the industry. Most of the materials are indigenous few are imported minerals. Among the collected minerals Thermoluminescence of Quartz, Potash and the composite material of the e minerals are selected to recorded thermoluminescence. In the present paper the TL set-up manufactured by Nucleonix Systems, Hyderabad was used[1]. Irradiation was carried using Sr-90 beta source. Every time 5mg of weighed irradiated samples were taken.

3. RESULTS AND DISCUSSION

Fig.1 is the TL of quartz mineral annealed and quenched from 200, 400 and 600°C for an hour followed by 25Gy beta dose from Sr-90 beta source. The quartz mineral annealed and quenched from 400°C and 600°C, It is interesting to note the TL peak temperature is found around 128°C and the peak is well resolved and isolated one. The quartz mineral annealed and quenched from 800°C did yield any good TL and TL peak temperature is found around 128°C and followed by another peak around 265°C it may be due to phase changes occurred β to γ , during annealing the mineral to 800°C and above[9-11].

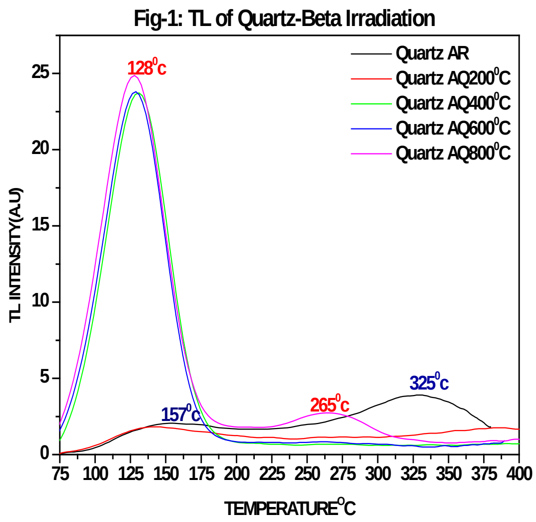


Fig.2 is the TL of beta irradiated Potash mineral. Curves 2-5 are the TL of Potash mineral annealed and quenched from 200, 400, 600 and 800°C for an hour followed by 25Gy beta dose from Sr-90 beta source. It is interesting to note the TL peak temperature is found around 150°C and followed by another peak around 300°, it may be due to phase changes occurred in the silica content of the mineral during annealing the mineral to 800°C and above[12,13].

The following minerals are used to manufacture the ceramic tiles i.e. Quartz, Potash, Snow White, Potash White, White Soda, Ceramic Tile Powder,etc in appropriate quantities.

Fig-2: TL of Potash-Beta Irradiation

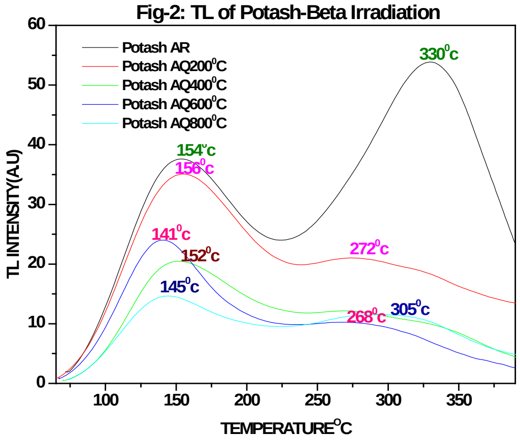


Fig. 3 is the TL of for the composite material annealed and quenched from 200, 400, 600, and 800°C and followed by various doses of beta dose to study the growth of TL peak observed around 150°C. In Fig.3 the TL of composite material annealed and quenched from 200, and 800°C the peaks are well resolved and relatively good TL intensity but the TL peak temperature is found around 157°C and followed by another peak around 350°C.Thecomposite material annealed and quenched from 400, and 600°C the peaks are well resolved and isolated, the TL peak temperature is found around 149°C . This may be due to the presence of various phases of the ceramic in the mixture. TL study of the final product is interesting in TL dosimetric point of view. Since the tiles are laid in homes, offices or schools in case of nuclear accident these tiles can act as thermoluminescence dosimetric materials.

Fig-3: TL of Ceramic Tile Powder-Beta Irradiation

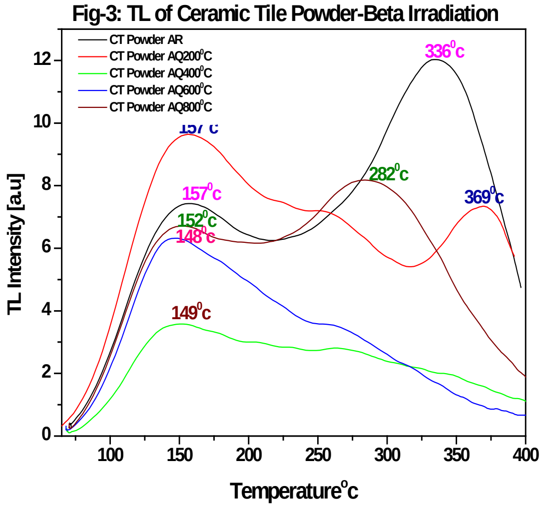


Fig.4 is the XRD of the composite material annealed and quenched form 800°C confirms the formation of ceramic.

Fig-4: XRD Pattern of Ceramic Tile Powder

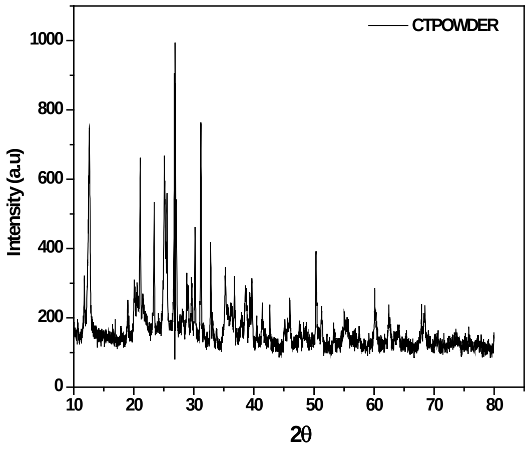
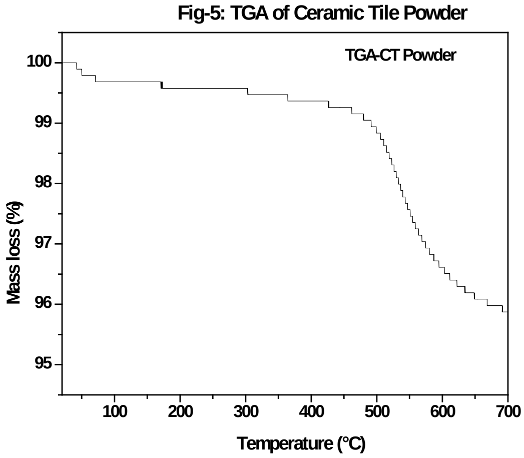


Fig.5 is the TGA of composite material. Since the composite already converted to ceramic not much change in TGA observed.

Fig-5: TGA of Ceramic Tile Powder



TL growth of 128°C peak which is universally accepted dosimetric peak found in various phases of silica and or quartz which is presented in Fig.6. The TL growth is linear for the beta dose range of 1- 300Gy may be with less TL intensity.

Fig-6 : TL Growth of Ceramic Tile Powder(AQ800°c)

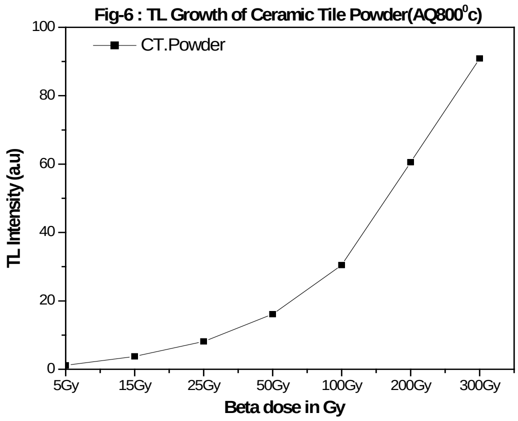
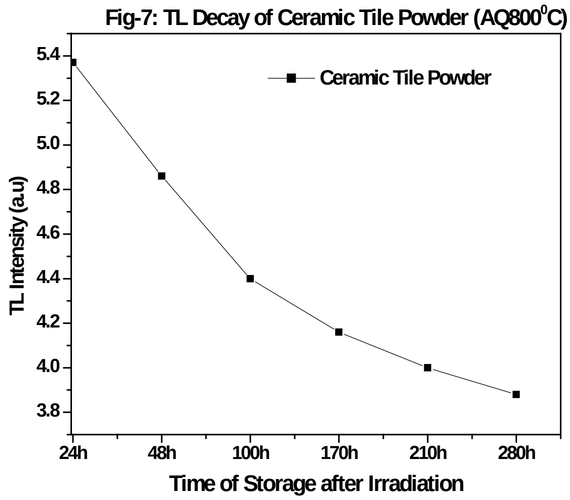


Fig. 7 is the TL decay of 150°C peak of the composite material stored in dark room and TL measurements were carried at various intervals prior to storage 25Gy beta dose was given to all the samples. The results are interesting and also the TL growth observed is liner at higher doses and TL decay is around 20%. The TL peak observed in composite material is nothing but from the glassy form of the various minerals wherein the quartz as well Silicon dioxide percentage is predominant. Since this phase is formed when the mixture is heated to 800°C for a moment (Upto 10minutes) and not allowed to form individual crystal formation. However the individual silica grains showed TL dosimetric property from the composite material. Therefore the TL peak observed at 150°C in composite material is nothing but dosimetric peak observed from the glassy phase of the slab[14].

Fig-7: TL Decay of Ceramic Tile Powder (AQ800°C)



4. CONCLUSIONS

The formation of ceramic is confirmed by XRD as well as TGA. Thermoluminescence growth and TL decay characteristics of the ceramic tile mixture under TLD study, it is inferred the material (Ceramic Tiles) are suitable for accidental TL dosimeter (TLD) for high radioactive dose range.

.

REFERENCES

[1]. Murthy, K.V.R. and Reddy, J.N. Thermoluminescence basic theory application and experiment , Feb.2008, Pub. Nucleonix, Hyderabad.

[2]. Murthy, K V R., Patel, Y S.,Sai Prasad, A S., Natarajan.,V.,Page,A.G, 2003 *Radiation Measurements* 36, 483.

[3]. .Mandavia,H.C.,Purohit,R.U.and Murthy, K.V.R., Journal of Science Government of Gujarat, Vol.1, Issue:1/2010,72-74

[4].Mandavia, H.C.,Purohit, R. U. and .Murthy, K.V.R Spark e journal,Vol.2,2010, 287-292, ISSN0975-7929.

[5]. Mckeever, S W S 1985 *Thermoluminescence of Solids*, Cambridge University Press, Cambridge, 205.

[6]. Aitken M J, 1974 *Physics and Archaeology*) Oxford, U.K.: Oxford Univ. Press.

[8]. McKeever , S W S, Akselrod, M S and Markey, B G 1996 *Radiation .Prot. Dosim.* 65 267.

[9]. Kumar, S. Source Book of Ceramic, 1998.

[10]..Mandavia,H.C., Purohit,R.U.and Murthy, K.V.R, 167-169,.ISSN 0975-7486 Material science an Indian Journal Vol-6,3,.2010.

[11].Mandavia,H.C..,Purohit,R.U. and Murthy, K.V.R, Journal of science and Tech. Research, Vol-1,2,July-Dec2010,ISSN 0974-9780,33-36.

[12]. Murthy, K. V. R. IOP Conference Series; Mat. Science and Engineering, 2, (2009)012024. P.1-5. ISSN; 1757-8981.

[13]. Murthy, K V R., S P Pallavi, R Ghildiyal, M C Parmar , Y S Patel , V Ravi Kuma, A S Sai Prasad, Natarajan,V.,Page,A G, 2006 *Radiation Prot. Dosim.* 120 238.

[14]..Murthy,KVR.,Pallavi,SP,Ghildiyal,R.,Patel,Y S., Sai Prasad, A S.,Elangovan, D, 2006 *Radiation Prot. Dosim*, 119, 350.

[15].Murthy,K.V.R.et.al, IOP Conference Series; Mat. Science and Engineering 2 (2009)012046. P.1-3. ISSN; 1757-8981.