

Abstract

Thermoluminescent dosimeter (TLD) is a device used to evaluate integrated dose of ionizing radiation. Natural mineral topaz as a thermoluminescent (TL) material has been studied for radiation dosimetry. The northern area of Pakistan along with Himalayas, due to its geological settings, is rich in topaz which is found in pegmatite rocks. Four mines namely: Kharguluk, Nyit, Sabser, and Yono in district Skardu were selected for sampling of topaz. Relatively big pieces of topaz were converted into chips and powder of micron size. Pellets of topaz composites with glass 1:2 wt.% and teflon 2:1 wt.% were prepared by compressing and sintering.

The mineral was recognized as topaz through phase identification by XRD (X-ray diffraction). The mineral collected from Kharguluk mine was not topaz rather mixed with quartz. The elemental analysis by the XRF (X-ray fluorescence) of topaz of understudy mines resulted about 56.554, 22.030, 11.293, 9.560 and 0.453 at.% of the elements O, Si, Al, F and H respectively. These results confirmed the mineral as topaz. The irradiation of topaz pieces with fast neutrons and thermal treatment produced deep and London blue colours in topaz. The TL response of virgin topaz of understudy mines generated a single huge peak in glow curve at temperature around 250 °C, which is the gesticulation of topaz. The INAA (Instrumental Neutron Activation Analysis) of topaz of these mines detected the elements Na, Ga and Cs in the three mines, while As and Sb were detected in Yono and Nyit mines respectively. The photoinduced emission spectra of topaz powder from three mines at the excitation wavelength 230 nm produced two bands. One band is at 430 nm and other at 470 nm which are the characteristics of topaz.

The pellets of the composites were sintered at 400 to 1200 °C. The TL response of the composites and [OH]/[F] ratio decreased with increasing sintering temperature. The optimum temperature selected for preparation of topaz composites was 900 °C. The effect of ultraviolet (UV) and visible light on topaz revealed that UV and visible light contribute to phototransference of charge.

The TL glow curves of topaz chips, topaz-glass and topaz-teflon composites showed stable peaks (dosimetric peaks) at about 250-260 °C, 250-260 °C and 257-265 °C respectively. Initially, the fading was maximum (27-30 %) and became 6-9% after few days. Chips and pellets showed the linearity with dose, good

reproducibility, independent dose rate, linear dose response and strong energy dependence below 600 keV. The chips and pellets were found suitable for dosimetry for dose greater than 0.01 Gy at high energy beams. Saturation in the TL response was observed above 2000 Gy. The pellets of topaz-glass showed better mechanical stability than topaz chips and topaz-teflon pellets. The cutting of topaz chips was found difficult and time consuming, while the preparation of pellets of topaz-glass and topaz-teflon was relatively easy. Topaz-glass showed better TL dosimetric features as compared to topaz chips and topaz-teflon composites. These are recommended to be used at the facilities where high radiation doses are involved. The TL analysis of the glow curves using IRM (Initial Rise Method), T_m-T_{stop} , PSM (Peak Shape Method) and VHR (Variable Heating Rate) method showed that topaz and its composites with glass and teflon follow second order kinetics. The thermal activation energies 0.976-1.576 eV for natural topaz were found to be greater than 0.488-0.627 eV for topaz-glass and 0.447-0.616 eV for topaz-teflon. The thermal activation energy found by VHR was 1.35 times higher than determined by PSM and IRM.

The OSL (optical stimulated luminescence) dosimetric characteristics of the pellets of topaz-glass and topaz-teflon composites were studied for various energy beams of photons and particles using CW (continuous wave)-OSL mode. Blue light as a stimulation source for OSL generated a rapid decaying response within 10 s and then a long non-zero tail was observed. The integrated OSL (IOSL) response met the dosimetric requirements for topaz-glass and topaz-teflon at dose greater than 0.01 Gy and 1.0 mGy respectively. The TL response of topaz before and after OSL measurement showed two peaks in the glow curve at the same position. After OSL measurement, decline of about 1.35 times less in intensity of peak 2 was observed.

Radiation dose was measured at IPEN, Brazil with the TLDs: LiF, topaz-chips and the composites of topaz-glass and topaz-teflon. Using the respective calibrations curves and applying the fading corrections, the measured dose proved that topaz and its composites are suitable for radiation dosimetry at high radiation areas. The price of topaz based TLDs is less than commercial dosimeters.

Topaz-glass and topaz-teflon pellets can be recommended for the measurement of dose greater than 0.01 Gy by the TL method, while topaz-teflon are suitable for dose greater than 1.0 mGy using OSL read out. Further exploration of

topaz from other mines of Pakistan, their TL/OSL analysis and applicability at sterilization, irradiation and medical centres is strongly recommended.