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Physio-chemical properties of gamma-irradiated vermiculite and their significance for radiation protection and thermoluminescence

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Abstract

The present work reports the effects of γ irradiation on vermiculite for the first time. The radiation-induced changes of vermiculite were studied using different techniques viz. ultraviolet-visible spectroscopy (UV-Vis), dielectric measurements, X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and thermoluminescence (TL). In UV-Vis analysis, the Cody model was employed to calculate structural disorder from Urbach energy, which explained the variation of the optical band gap (direct and indirect) with different (1–2000 kGy) γ doses. XRD analysis of the pristine and irradiated samples shows that the crystallinity improved upon irradiation at γ dose up to 1000 kGy and deteriorated on further increase of the γ dose. A significant change was observed in the dielectric properties after γ irradiation. Data shows that ac conductivity is proportional to the nth power of frequency (f^n) in pristine and irradiated vermiculite, with a slope n ranging between 0.52 and 0.76, which indicates that electronic conduction takes place through an electron hopping process. No appreciable changes in characteristic bands (FTIR) have been observed after irradiation, indicating that natural vermiculite is chemically stable. A well-defined TL peak around 132 °C and enhancement in its intensity with γ dose (1–1000 kGy) make vermiculite a perfect thermoluminescence dosimeter and indicates usefulness applications in radiation dosimetry.

Keywords: Natural vermiculite, gamma irradiation, optical properties, dielectric properties, XRD, FTIR, thermoluminescence