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LUMINESCENCE, OPTICAL PROPERTIES AND ELECTRON PARAMAGNETIC RESONANCE OF ALEXANDRITE

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Introduction: Alexandrite ($BeAl_2O_4:Cr^{3+}$) is a mineral wich is a variation of chrysoberyl, widely found in Brazil. Recently researches suggest that alexandrite can be used as a natural dosimeter, due to its composition combining main oxides used to dosimetry, BeO and Al_2O_3. Dosimetric materials are essential for the evaluation of personal and environmental irradiation doses in many activities. To verify the optical and luminescent properties, two main techniques were used: optical absorption (OA) and thermoluminescent (TL) properties, lately compared with electron paramagnetic resonance (EPR) results. Complertamentaly, scanning electron microscopy (SEM)/dispersive electron spectrometry (EDS) was made to analyse the composition.

Material and method: The alexandrite samples are from Minas Gerais and it was pulverized in a size smaller than 75 μm for TL, MEV/EDS and OA. The OA measurements were taken on Shimadzu UV-2600 spectrophotometer (wavelength range 350-750 nm/spectral resolution 0.1 nm). TL measurements were performed with a Risø reader (model DA-20) composed of a beta source $^{90}S/^{90}Y$ (dose rate 10mGy/s). EPR was conducted on MiniScope 400 spectrometer (X-interval 9.44 GHz) at a modulation amplitude of 0.1 mT and frequency of 100 kHz at room temperature (central field 325 mT/range 500 mT).

Results: The SEM/EDS results were satisfactory. The main phases were identified with the presence of substances as aluminium and oxygen, being chrysoberyl compounds. Also, some impurities were identified as biotite and apatite. The average percentage in alexandrite phase of Fe detected was 1.74% and Cr was 2.20%. Beryllium could not be detected by this method.

In the optical absorption studies, two main absorption bands are identified, the band A (peak ~590 nm) and the band B (peak ~420 nm). The research focused on band A due to the superposition of two absorption bands of Cr^{3+} ions present both at the Al_1 site and at the Al_2 site. Decomposing the band A for each sample, the percentage of chromium ions at each site and the influence of beta irradiation on these samples can be estimated. The results presented that there is a proportion of Cr^{3+} distributed in both sites for synthetic and natural alexandrite: 25% in Al_1 and 75% in Al_2.

In EPR, two signals could be seen: one between 123 mT representing Fe^{3+} substituting Al in the octahedral position and the other between 279 a 387mT, with six lines centered around ~327mT, given by the Mn^{2+} ions, known for its hyperfine magnetic interaction with the nucleus spin of ^{55}Mn $I=\frac{5}{2}$ and effective electronic spin $S=\frac{1}{2}$. There is a line with a peak around 280 mT, which is perhaps given by the Cr^{3+} ions, but it was not investigated. We concluded that the spectrum remained after a irradiation of 10kGy.

Natural alexandrite showed five TL glow peaks, I (~355K), II (~405K), III (~445K), IV (~530K) and V (~580K), IV and V being dosimetric peaks, related to Fe^{3+} and Cr^{3+} ions.

Conclusions: The SEM/EDS resulted in a good distribution of alexandrite phases. The OA spectrum presented two main bands, A and B, in natural alexandrite. The EPR spectrum did not change significantly after a high irradiation dose. The TL emission peaks and the presence of impurities in alexandrite are related.

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