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Study of the possibility of using food salt as a gamma ray dosimeter

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ABSTRACT

For the possibility of using table salt as a dosimeter to measure the dose of gamma rays, the characteristics of thermoluminescence have been studied in detail for (3) different salt samples represented by Iraqi, Iranian and English salts (BDH limited, Poole, England) because they are affordable, available in the markets and equivalent to human body tissues.

On obtaining the results, it is possible to use table salt as a dosimeter to measure the dose of gamma rays within the range 0–10 Gy according to the following conditions:

1. Pre-irradiation annealing at temperatures 400 °C/h, 100 °C/2 h.
2. Post-irradiation annealing at temperature 100 °C/20 min.

Also, it is possible to use the samples mentioned above as gamma ray dosimeters within the range 0.01–50 Gy without the use of annealing depending on the high temperature peaks; thus it is possible to use salt as accidental dosimeter.

1. Introduction

In the past, sodium chloride has been claimed as suitable candidate for TL dosimetry (1980–1983) . Heywood and Clarke [1,2]used pure NaCl and NaCl:Ca in order to understand the TL properties after exposure to gamma rays. Some recent TL studies on alkali halides including those of Purohit and Joshi [3], Davidson et al. [4], Ortiz et al. [5] and Davidson et al. [6] have discussed the TL glow curves and the effect of impurities on TL of NaCl crystals. In this work we report some dosimetric aspects of the different salt samples brought from different sources. Some of them are Iraqi food salts, the others include English salt, which has high purity, obtained from the College of Engineering, University of Basrah, and Iranian salt brought from the market. We suggest food salt to be used because of its availability, low cost and equivalence to human tissue.

2. Materials and methods

The samples mentioned above are prepared in the form of powder; therefore, they are ground very carefully using a porcelain mortar. Then the powder is passed through two sifting nets, with sizes 63 and 45 μm. The choice of grains falls on those with similar sizes between 45 and 63 μm. The purpose of grinding in this way is to make the amount of thermoluminescence resulting from mechanical exertion (breaking) negligible. All the samples are kept in a dissicator that contains silica gel to absorb the moisture. The specimens have been irradiated with gamma rays from a Cs-137 gamma source mark (IV TLD dosimeters irradiator), made by JL Shepherd and Associates Company, California. The strength of the Cs-137 low-dose source was 3.7×10^{10} Bq in 1985 and the strength of the Cs-137 high-dose source was 44.4×10^{10} Bq in 1982. In every experiment that requires irradiation, the sample is put in a container made of plexiglas so as to obtain the electronic equilibrium and to guarantee absorption of the sample in the same irradiation dose.

The TL-reader used in the present work is a Toledo 654 manufactured by the English Pitman company; the food salt samples reading is registered by the thermoluminescence reader at a heating rate of 5 °C/s and up to a temperature of 350 °C.

3. Characteristics of TL of food salt samples

In order to use food salt in this research as a dosimeter to measure the radiation doses of gamma rays, the thermoluminescence characteristics of this material must be studied. They include the following.

3.1. Glow curve

The glow curve has a great importance in identifying the extent of utility of the material to be used in measuring the

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radiation doses. A suitable peak is selected from this curve to conduct the measurements. Three different samples of table salt under study are used. After preparing them according to Section 2, these samples are given a random fixed dose. Then the thermoluminescence is read by the TL-reader by raising their temperature from room temperature to 350 °C and with a linear heating rate of 5 °C/s. This experiment is conducted under the same conditions in relation to the sample weight, which reaches 1 mg, and the linear heating rate of 5 °C/s in order to uncover the qualities of the thermoluminescence curves of salt samples mentioned earlier. As a result, we obtained thermoluminescence curves, which are illustrated in Figs. 1–3, where we notice the following:

1. The appearance of two clear peaks for all salt samples at high temperature peak (HTP) and low temperature peak (LTP).
2. The emergence of sensitivity difference in Iraqi food salt, Iranian salt and English salt.
3. The behaviors of the thermoluminescence curves of salt samples under study are generally similar to the behavior of the thermoluminscence curve of sodium chloride crystal in relation to the number of peaks [3,7].

The slight differences among thermoluminescence curves are attributed to the differences in type and the amount of impurities, which depend on the places from which the samples are obtained. These impurities have strong influence on thermoluminescence [8].

The reason for the appearance of two clear peaks for all table salt samples is because salt is considered a non-organic, ionic crystal. Thus, when it is exposed to an ionizing radiation there appear in the spectrum of these crystals absorption bands in both the visible and the ultraviolet regions and even in the infrared region where the ultraviolet absorption corresponds to electronic transitions, while the infrared absorption is related to the vibration of the ions composing the solid [9]. It is worth mentioning that the appearance of the high-temperature peaks supports the use of salt samples in radiation dosimetry on using these peaks.

3.2. Dose–response

The samples studied are exposed to different doses of gamma rays from the radiation source, which has an activity of 44.4×10^{10} Bq. The doses are between 1.22 and 5.60 Gy for Iraqi salt sample. The radiation doses are between 1.68 and 8.40 Gy for English salt and between 2.80 and 14.00 Gy for Iranian salt. Using the thermoluminescence reader where the temperature is raised from room temperature to 350 °C with a linear heating rate of

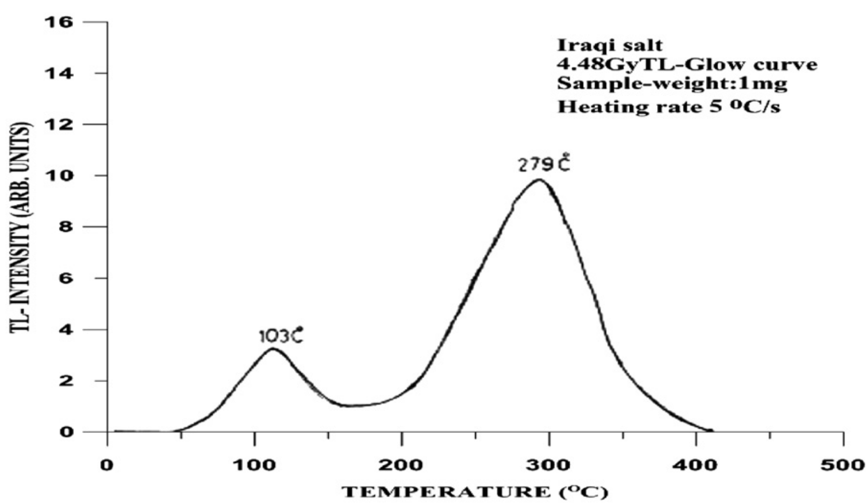

Fig. 1. TL glow curve of Iraqi salt.

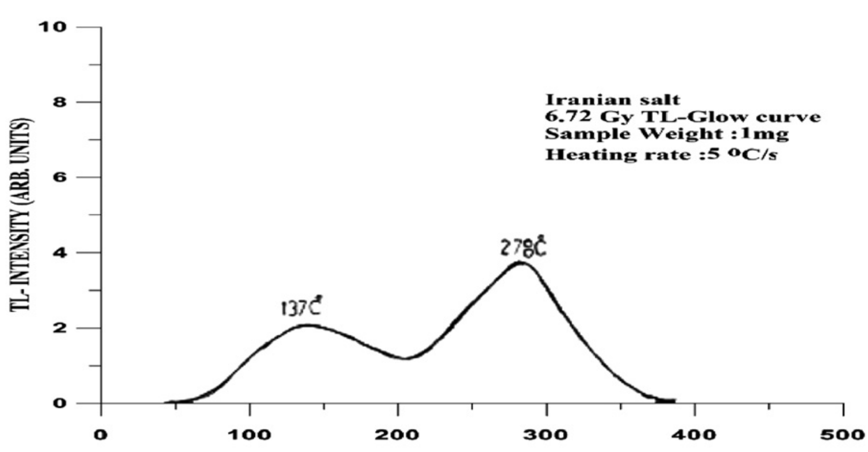

Fig. 2. .TL glow curve of Iranian salt.