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# Thermoluminescence studies of Himalayan salt Materials

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ABSTRACT

The goal of this work was to evaluate the thermoluminescence features of Himalayan salt (HS) for the purpose of radiation dosimetry. As a result of its low cost, widespread availability in the market, and similarity to the tissues found in the human body. Irradiation of the samples was performed with a radiation source that utilised $^{137}$Cs. With a heating rate of 15 degrees Celsius per second and a final temperature of 320 degrees Celsius, the samples were subjected to TL analysis with the help of the Harshaw Model 2000B/C TLD Reader. In commercial salt samples, the glow curve (gwc) reveals the presence of a strong glow peak at temperatures ranging from 204 to 282 degrees Celsius. For the salt sample, the grain size (gz) is exactly proportional to the total light intensity (TL) of the glow curve shown in the graph. Not only that, but the findings also demonstrate that the TL intensity of the HS has a linear relationship with dosage throughout a wide range, spanning from 250 mGy to 20 Gy. The post- irradiated fading rate are investigated and shows the rate of thermal fading of HS, found to be equal 32% at storage time for 24 days. These results indicate that this material is very interesting for useful for TL-dosimetric applications.

## 1. Introduction

Salt was traditionally produced by boiling brine that was derived from a broad variety of natural sources, including ocean, wells, lakes, and salt springs. The alkali halid such as NaCl, once perhaps the purest materials studies in solid state research. Schafer has recently reported the first observation of an infra-red vibration absorption of a point defect in the alkali halides [1,2]. It is likely that HS is the most well-known sort of unprocessed salt [3] that is utilized around the world. In recent years, there has been a rise in the appeal of HS, particularly pink HS, which has been made possible by greater media attention [3,4]. It is frequently advertised for the purported health advantages that it offers and is positioned to be nutritionally superior to white table salt through marketing. When compared to white table salt, the sodium content of HS is significantly less. The rock salt or halite that is known as HS originates from the Punjab area of Pakistan. In addition to containing minor amounts of a wide variety of trace minerals, it is composed of 95-98% sodium chloride, 2-4% polyhalite (which includes potassium, calcium, magnesium, sulphur, oxygen, and hydrogen), 0.01% fluoride, and 0.01% iodine. The crystals of salt have a colour that ranges from off-white to clear,

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while the impurities that are present in some veins of salt, impart a colour that is either pink, reddish, or what is known as cow red. It is because of the presence of components in polyhalite and trace minerals that the colour is reddish [5]. Within the framework of retrospective dosimetry, a number of different luminescence methods have been utilized to investigate a variety of materials. There are a few materials that are particularly noteworthy, such as ceramics [6], blocks made of concrete [7,8], materials for building that are cementations [9] materials that give nonlinear behaviour [10-14], shielding materials[15] and nuclear track detector[16,17]. These materials are found permanently in structures that are located in close proximity to radiation incidents. It has been asserted in the past that sodium chloride is an appropriate choice for TL dosimetry (1980–1983) [18,19]. For the purpose of gaining an understanding of the TL characteristics that occur after being exposed to rays, Heywood and Clarke utilized both pure sodium chloride and NaCl:Ca. Recent years have seen a significant increase in the number of research conducted in this area [20-24]. The purpose of this paper is to explore the glow-curve, thermal fading, and influence of grain size on the TL-intensity of HS in order to determine whether or not it might be used as an unintentional dosimeter.

## 2. Materials and methods

The HS has been collected from local supermarkets in Iraq, Powdered forms of the samples that were discussed before are the ones that are produced. Because of this, they are pulverised with great care using a porcelain mortar, and after that, the salt powder is sifted through sifting nets of varying sizes 45,150,300 and 750 micro-meter. The goal of grinding in this manner is to reduce the quantity of triboluminescence that is produced as a consequence of mechanical effort (breaking) to a minimal level [25]. After that, the substance is prepared in the shape of a solid disc that is kept in containment together with silica gel in order to regulate the amount of moisture that is present. It has a diameter of 4 millimeters and a thickness of 1 millimeter, and it weighs an average of 23 milligram’s plus or minus 2.5 milligram’s. It was crushed for fifty seconds at a force of three tones. There was a wide range of grain sizes, from 45 to 750 micrometers. We utilized a delicate electronic balance in order to determine the mass of the pellet. Every sample was created without the use of any binder, and we made use of components that were extremely pure (99%). We were able to generate the samples by utilizing a tool that was specifically designed for the purpose, as well as a hydraulic hand press that was located in the Department of Physics at the University of Basrah. The pressure that was applied to each pellet was 0.8 tones. At all times, the salts are stored in a desiccator that is equipped with silica gel for the purpose of absorbing moisture. The rays that were used to irradiate the samples came from a $^{137}$Cs source mark (IV TLD dosimeters irradiator) that was manufactured by JL Shepherd and Associates Company in California. This effort resulted in a reduction in the strength of the $^{137}$Cs low-dose source from 20 mRad/min in 1985 to 8.4 mRad/min over the years in question. A container constructed of Plexiglas is used for each and every experiment that requires irradiation. The sample is placed inside of the container. This is done in order to achieve balance in the electrical system and to ensure that the HS is absorbed in the exact amount of irradiation. The name of the TL reader is the Harshaw model 2000B/C; it is a model. Nitrogen gas was used to clean the read chamber during the measurement in order to reduce the effects of oxygen-induced light [26].The thermoluminescence reader was used to register the sample reading at a heating rate of 15 degrees Celsius per second and up to 320 degrees Celsius.

## 3. Results and discussion

It is necessary to look into the TL properties of this material in order to use HS in this study as a dosimeter or an accidental dosimeter to measure the $\gamma$ radiation doses in the past. The topics being investigated in these studies are the gwc, the dose-response relationship, and fading

### 3.1. glow-curve

For the purpose of establishing whether or not the material is appropriate for monitoring radiation doses, the glow curve is a very important factor. In the case of light peaks, for instance, the fact that they only show at low temperatures suggests that the phosphor loses its stored TL with time, which renders it inappropriate for measurements that are taken over an extended period of time. A light curve that has peaks at extremely high temperatures is indicative of a phosphor that is capable of producing infrared radiation at the temperature required to release the TL. With regard to the instruments, this presents a dilemma. Choosing the right endpoint for integration is made more challenging when the glow curve does not include peaks that are clearly defined. Therefore, a gwc should, in an ideal scenario, only disclose a single thermoluminescent peak that takes place at a temperature that is high enough to guarantee that the temperature remains stable at ambient temperature, but not so high that it causes issues for the instruments. Approximately 200 degrees Celsius seems to be the ideal temperature. On the other hand, the rate at which a TL peak is observed is significantly influenced by the rate at which the temperature is being heated [27]. It is clear that there exist two broad emission bands (See Fig.1), one centered around 204 °C and the other around 284 °C, with a heating rate of 15 °C/sec. The single prominent peak in the gwc suggests that only two luminescence centers are formed during-ray irradiation. In a sample of salt, the presence of two separate peaks can be attributed to the fact that the salt is classified as an ionic crystal that is not organism. Therefore, when these crystals are subjected to ionizing radiation. An absorption band may be found in the spectra of these crystals, and it can be found in the visible and ultraviolet regions, as well as in the infrared range. Compared to the absorption of the infrared IFR area, which is connected to the oscillations of the ions that make up the solid, the absorption of the ultraviolet region relates to electronic transitions [28].

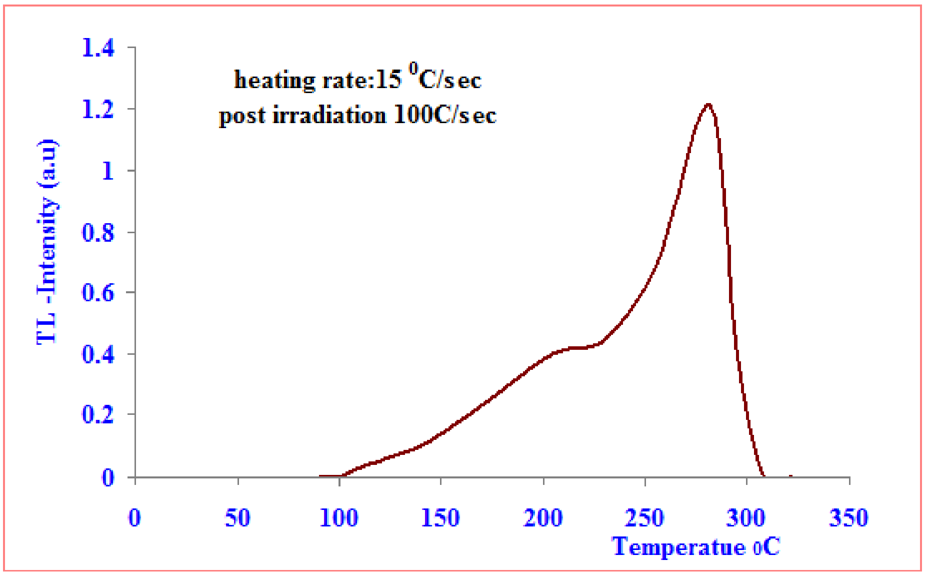

**Fig.1.** TL gwc of HS at 83.8 mRad

### 3.2. The Effect of Grain Size

The importance of testing the TL sensitivity of the various samples lies in the fact that the TL insensitivity of a HS sample is contingent not only on the dosage that it was given but also on the quantity of TL phosphors and activators that are present in their composition. A total of four samples are taken for each size sample. The picked salt samples were irradiated with a set test dosage of 83.8 mrad. For the various salt samples that have been subjected to irradiation, Fig. 2 illustrates how the TL intensity varied as the temperature increased from 100 to 320 degrees celsius and how it altered in relation to the average gz. In accordance with the findings presented in Fig. 2 the results show a similar behavior in relation to the mean grain size , i.e, the increase in TL intensity is observed as the gz decreased for all samples. The less intensity in the large gz may be due to the fact that small gz of salt lead to the increase in surface area of the sample [29].

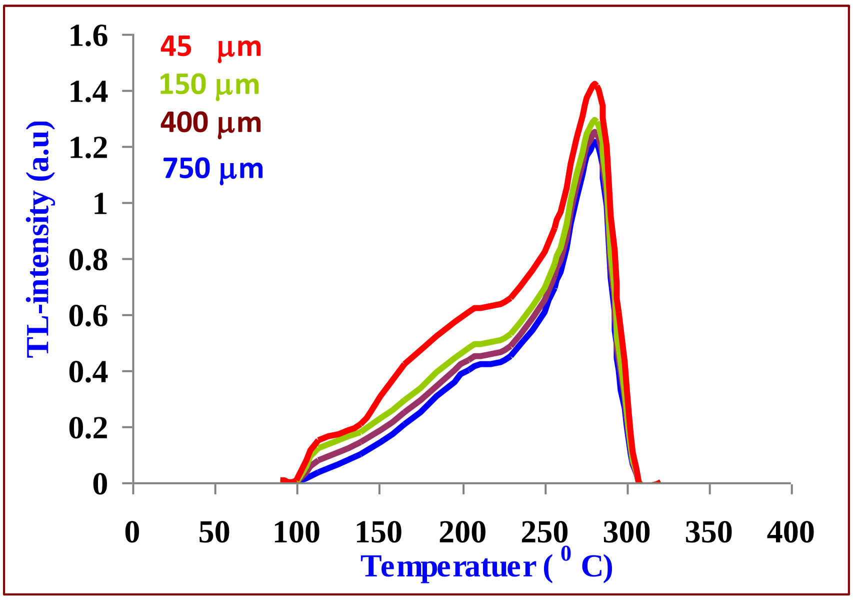

**Fig. 2.** A variation intensity of TL for HS with varying gz.

### 3.3. Dose – Response

Disc samples of gz 750µm were used in dose response because of their higher response, according to the above study. Figure 3 illustrates the integrated TL-response for HS from 5 to 79.980 mrad as a function of the absorbed dose of rays. The results obtained from this curve demonstrate linear relationships between absorbed dose values and TL- responses, as well as their responses in the 5–79.980 mRad dose range. The following equations show how the response (RTLD) of the TLD material changes with the absorbed dose value. They also show how well the fit parameters of this curve work. These results show an exact mono-polynomial fitting for this type of TLD material.

$$\text{TLD-INTENSITY} = 0.1505 \times \text{Dose} - 0.0253 \qquad (1)$$

It has been known for a long time that one of the primary benefits of using HS for radiation dosimetry is from the relatively strong energy response that it possesses.

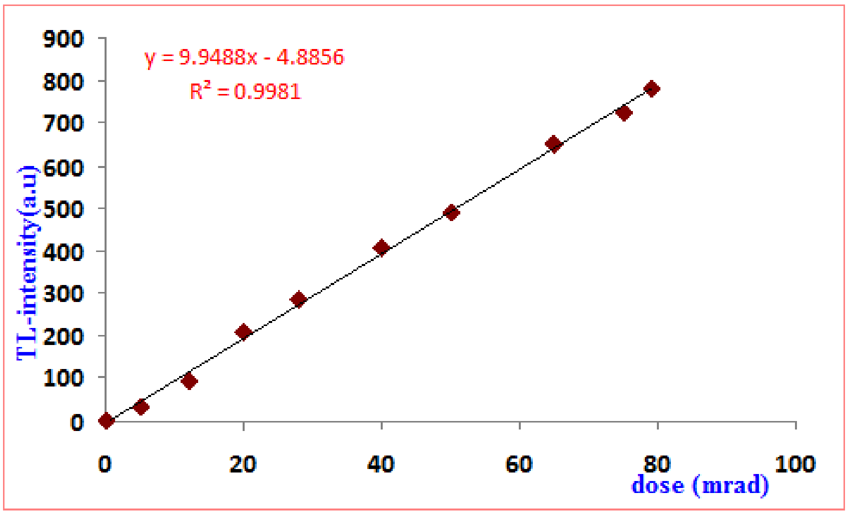

**Fig. 3.** The response of the intensity of HS vs $^{137}$Cs $\gamma$ rays

## 3.4. Fading

The mechanism by which latent information, or reaction, is lost without the aim of doing so is referred to as fading. The most common reason for fading is thermal, although numerous other reasons exist. During the process of thermal fading, traps that have lower entrapment energy will fade more quickly than those with higher entrapment energy because of the higher possibility of transition being present in the former. This has the potential to result in significant mistakes in the dosage assessment. Therefore, in order to conduct an analysis of the fading process, ten groups of HS were carried out, with each group consisting of nine instances of the substance. The weight of each sample is 23 milligram's, with a standard deviation of 2.5 milligram's. Irradiating each of the 10 groups with a constant 15 Gy dosage allowed us to assess the material's fading qualities. We keep the irradiation samples at room temperature in polypropylene containers with silica gel inside to protect them from excessive moisture. Four hours, one day, two days, three days, six days, nine days, sixteen days, twenty-one days, and twenty-four days were the intervals at which we carried out further measurements. The evolution of the TL intensity over the course of many days at room temperature is seen in Figure 4.

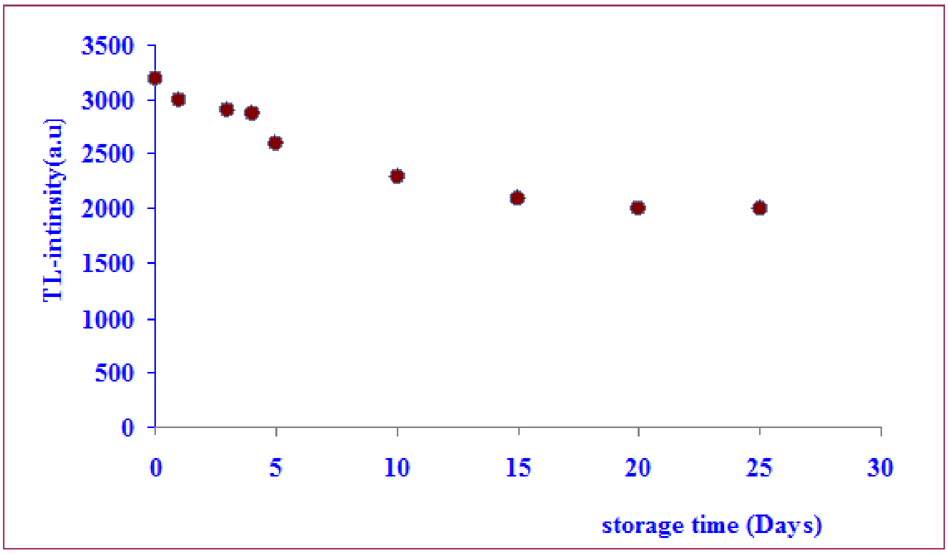

**Fig. 4.** The glow curve of $\gamma$ -irradiated HS is affected by the amount of time.

This figure shows that the TL strength of the area under the gwc fades after irradiation and is only 32% of what it was right after the irradiation. This fading does not significantly diminish the material's ability to function as a dosimeter, especially when considering high dose rates and short irradiation intervals. These findings are consistent with those obtained by other researchers through experimentation. [30].

## 4. Conclusion

The current study investigated the thermoluminescent characteristics (gwc, dose-response, gz effect, and fading) of HS for low dose measurement. We have come to the following conclusions:

1-The TL gwc shows the appearance of two distinct peaks at both low and high temperatures.

2-There are linear relationships between absorbed dose values and TL-intensity, as well as their responses in the (250 mGy to 20 Gy) dose range. There is an increase in TL-intensity as the gz increases.

3-Thermal fading occurs over 24 days, with about 32% decaying at room temperature. The fading results showed that the change in TL intensity is caused by the redistribution of trapping levels. They also showed that the strong TL peaks at 204 °C and 284 °C can be used for TL-dosimetric purposes.

## 5. References

[1] H. James and W. Dale "Color Center In Solid" Pergamon Press,Oxford. Landon.New York. Paris 1963.

[2] G. Schaeer, j. phys , Chem. solid 12, 233 1960.

[3] P. Zsigmond "Morphological and microchemical characterization of Himalayan salt samples," Rev. Roum. Chim, vol. 61, pp. 169-174, 2016.

[5] C. Palache, H. Berman, and C. Frondel, "The System of Mineralogy of JD Dana and ES Dana, 7th Edit," ed: Wiley, New York, 1951.

[6] I. Bailiff, "Retrospective dosimetry with ceramics," Radiation Measurements, vol. 27, pp. 923-941, 1997. Doi:https://doi.org/10.1016/S1350-4487(97)00217-5

[7] M. Jain, L. Botter-Jensen, A. S. Murray, and H. Jungner, "Retrospective dosimetry: dose evaluation using unheated and heated quartz from a radioactive waste storage building," Radiation protection dosimetry, vol. 101, pp. 525-530, 2002.Doi:https://doi.org/10.1093/oxfordjournals.rpd.a006041

[8] K. J. Thomsen, M. Jain, L. Botter-Jensen, A. Murray, and H. Jungner, "Variation with depth of dose distributions in single grains of quartz extracted from an irradiated concrete block," Radiation Measurements, vol. 37, pp. 315-321, 2003.Doi:https://doi.org/10.1016/S13504487(03)00006-4

[9] H. Göksu, I. Bailiff, and V. Mikhailik, "New approaches to retrospective dosimetry using cementitious building materials," Radiation measurements, vol. 37, pp. 323-327, 2003.Doi:https://doi.org/10.1016/S1350-4487(03)00005-2

[10] A. Imran, S. J. Bader, A. Al-Salihi, and H. A. Badran, "Gamma irradiation impact on the morphology and thermal blooming of soda-lime glass," in AIP Conference Proceedings, 2020.Doi:https://doi.org/10.1063/5.0031473

[11] H. A. Bdran, R. C. Abul-hail, and M. T. Obeed, "Study on effect of gamma radiation on some linear and nonlinear properties of Pyronine Y," in AIP Conference Proceedings, 2020.Doi:https://doi.org/10.1063/5.0027452

[12**]** M. T. Obeed, R. C. Abul-Hail, And H. A. Badran, "Gamma Irradiation Effect On The Nonlinear Refractive Index And Optical Limiting Behavior Of Pyronine Y Dye Solution," *Journal Of Basrah Researches (Sciences)*, Vol. 46, 2020.

[13] A. Al-Salihi, R. D. Salim, R. F. Alfahed, and H. A. Badran, "Effect of Solar radiation induced and alpha particles on Nonlinear behavior of PM-355 film," in IOP Conference Series: Materials Science and Engineering, 2020, p. 072056.Doi:https://doi.org/10.1088/1757-899X/928/7/072056

[14] F. A. Tuma, M. T. Obeed, A. A. Jari, H. A. Badran, and T. Alaridhee, "Effect of gamma ray on self-induced diffraction patterns of organic compound Poly (methyl-methacrylate films," Results in Physics, vol. 52, p. 106858, 2023.Doi:https://doi.org/10.1016/j.rinp.2023.106858

[15] R. Alfahed, D. Alameri, Z. Yassar, H. A. Badran, and K. K. Mohammad, "Preparation and characterization of tin chloride-based polymeric composite for gamma shielding applications," Applied Radiation and Isotopes, vol. 196, p. 110774, 2023.Doi:https://doi.org/10.1016/j.apradiso.2023.110774

[16] R. F. Alfahed, A. Imran, M. S. Majeed, and H. A. Badran, "Photoluminescence characterizations and nonlinear optical of PM-355 nuclear track detector film by alpha-particles and laser irradiation," Physica Scripta, vol. 95, p. 075709, 2020.Doi:https://doi.org/10.1088/1402-4896/ab7e33

[17] T. M. Salman, A. Y. Al-Ahmad, H. A. Badran, and C. A. Emshary, "Diffused transmission of laser beam and image processing tools for alpha-particle track-etch dosimetry in PM-355 SSNTDs," Physica Scripta, vol. 90, p. 085302, 2015.Doi:https://doi.org/10.1088/00318949/90/8/085302

[18] E. Heywood and K. Clarke, "Australasia Phys," Eng. Sci. Med, vol. 3, p. 210, 1980.
[19] E.F.Heywood and K. H. Clarke, Australasia Phys. Eng. Sci. Med. Vol. 3, pp. 219, 1980.
[20] C.G. Reddy, S.N. Reddy and K.N. Reddy, "Thermoluminescence in pre-heat treated NaCl crystals doped with yttrium," Materials Letters, vol. 58, pp. 1127-1129, 2004.Doi:https://doi.org/10.1016/j.matlet.2003.09.004
[21] R. Purohit and T. Joshi, "Development of NaCl: Tb (T) as gamma and beta radiation dosimetry material," Journal of Luminescence, vol. 87, pp. 1295-1296, 2000.Doi:https://doi.org/10.1016/S0022-2313(99)00595-5
[22] K. A. Khazal and R. C. Abul-Hail, "Study of the possibility of using food salt as a gamma ray dosimeter," Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 624, pp. 708-715, 2010.Doi:https://doi.org/10.1016/j.nima.2010.08.01
[23] R. Abul-Hail, Journal of Basrah Researches ((Sciences)) vol. 40, pp83-8, 2014.
[24] F. M. Khamis and D. Arafah, "Improved Thermoluminescence Properties of Natural NaCl Salt Extracted From Mediterranean Sea Water Relevant to Radiation Dosimetry," European Journal of Applied Physics, vol. 2, 2020. Doi:https://doi.org/10.24018/ejphysics.2020.2.3.8
[25] D. Sears and S. McKeever, "Measurement of the TL sensitivity of meteorites,"Modern Geology,vol. 7, pp. 201-207, 1980.
[26] W. Morrison, J. Spaulding, J. Noakes and G. Murphy, Health physics, vol. 48, 1985.
[27] J. Cameron , N. Suntharalingam and G. Kenney, Thermoluminescent Dosimetry, The University of Wisconsin press Madison, Milwaukee, and London ,1968.
[28] Schulman and Compton, Color Centers in Solids, Pergamon Press .Oxford. London. New York . Paris 1963.
[29] Jcan Themson, The Influence of Previous Irradiation on Thermoluminesce Sensitivity ,Ph. D Thesis, University of oxford 1970.
[30] C.D. Gonzales-Lorenzo, D.J. Callo-Escobar, A.A. Ccollque-Quispe, T.G. Rao, F.Aragón, J.C. R. Aquino, et al., "Effect of annealing temperature on the structural, thermoluminescent, and optical properties of naturally present salt from Lluta region of Peru," Optical Materials, vol. 126, p. 112215, 2022. Doi:https://doi.org/10.1016/j.optmat.2022.112215

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# دراسة التالق الحراري لمواد ملح الهملايا

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**معلومات البحث**

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**الكلمات المفتاحية**

التألق الحراري،الفقد ، حجم الحبيبات ، ملح الهملايا

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## الملخص

في هذه الدراسة، تم دراسة خصائص التألق الحراري لملح الهيمالايا بهدف استخدامه لقياس الجرعات الإشعاعية. لأنه واطئ التكلفة ومتوفر في الأسواق ومكافئ لأنسجة جسم الإنسان. تم تشعيع العينات بمصدر اشعة جاما باستخدام Cs-137. وتم قراءة العينات باستخدام قارئة التالق الحراري امريكية المنشأ ، بمعدل تسخين خطي 15 درجة مئوية / ثانية الى درجة حرارة نهائية 320 درجة مئوية. وقد لوحظ قمم التألق بصورة واضحة في منحنى التألق عند حوالي 204-282 درجة مئوية من عينات الملح التجارية. بالنسبة لعينة الملح، تتناسب شدة التألق الحراري لمنحنى التألق بشكل مباشر مع حجم الحبيبات. أظهرت النتائج أيضًا أن شدة التألق لملح الهيمالايا لها استجابة خطية مع الجرعة لمدى واسع من 250 مللي كراي إلى 20 كراي., تم دراسة معدل الفقد الحراري بعد التشعيع وتبين أن معدل الفقد الحراري لملح الهيمالايا يساوي 32% عند وقت التخزين ولمدة 24 يوما. تشير هذه النتائج إلى أن هذه المادة مثيرة جدًا للاهتمام ومفيدة لتطبيقات قياس الجرعات الاشعاعية

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