Test of household salt read by optically stimulated luminescence (OSL) as a personal dosemeter

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Abstract. This study has investigated the optically stimulated luminescence (OSL) of household salt and chemically pure NaCl after exposure in different radiation environments. The response relative to thermoluminescent dosimetry using LiF has been investigated to determine if OSL in NaCl can be considered as an alternative to measurements of thermoluminescence in LiF. A selection of staff members at the Diagnostic Centre and the Department of Radiation Physics at Malmö University Hospital (UMAS) carried small light-tight tubes, 3 mm (Ø) x 27 mm filled with salt. The measurements were accompanied by LiF-TL dosemeters using the regular system for personal dosimetry at UMAS. Similar kits of salt dosemeters were also positioned on the inside walls of a nuclear medicine laboratory and a proton therapy room at the The Svedberg Laboratory in Uppsala. NaCl-OSL dosemeters were also placed in the primary radiation beam of a mammography unit. The OSL in the salt was measured using an OSL reader (Risö TL/OSL DA 15) at a temperature of 100°C using continuous wave OSL (CW-OSL) with blue LEDs (λ=470 nm). The TL-measurements were made with a TLD reader (Rados Dosacus) using 4.5 mm (Ø) x 0.9 mm LiF: Mg, Ti (Harshaw). Preliminary results show that household salt can be used to measure absorbed doses down to 200 µGy. Measurements also indicate a somewhat higher response relative to LiF-TL dosemeters at low photon energies. The effect may be attributed to the higher atomic number of NaCl (Z=11, 17) compared with LiF (Z=3; 9). We conclude that NaCl-OSL dosemeters appear to be an interesting alternative to TL dosemeters at occupational exposure.

KEYWORDS: OSL; household salt; personal dosemeter.

1. Introduction

Measuring the optically stimulated luminescence (OSL) of a crystalline material after it has been exposed to ionising radiation is a way to estimate the absorbed dose to the material [1,2]. For years OSL of crystalline materials, such as quarts and feldspar, has been utilised to date geological and archaeological samples through determination of accumulated absorbed dose in the material. This technique is now becoming of increased interest in connection with retrospective dose assessments of inadvertent exposure to humans (e.g. potential exposure from orphan sources or terrorist attacks). Studies have been conducted on the OSL-properties of crystalline materials in the home environment and in residential buildings, such as bricks in building walls, chemicals for domestic use (e.g.; detergents, washing powders and spices) [1]. It has been found that common salt (NaCl), aimed for household use, has interesting possibilities as a radiation dosemeter using OSL [3,1].

The potential of salt as a compliment to existing personal dosimetry systems using TL, should be explored since salt is cheaper than LiF tablets and offers more versatile geometrical configurations. This study has investigated the response to ionising radiation of NaCl in different radiation environments and for different radiation qualities; photons at various energies, and the mixed radiation field inside a proton therapy room.

2. Materials and methods

2.1 Dosemeters

The particular brand of household salt used for the photon energies (Falksalt™; a naturally fine grained salt consisting of NaCl≥99.6%), was chosen due to its advantageous performance in terms of light yield per unit absorbed dose observed in a previous comparative study on the dosimetric properties of household salts [4]4]. For a comparison between the OSL-response between protons and ^{60}Co, salt in the form of chemically pure NaCl was used (pro analysis, Apoteksbolaget, Stockholm, Sweden).

2.2 Radiation modalities investigated

During four weeks, a selection of staff members working in the radiology and nuclear medicine departments at Malmö University Hospital (UMAS) carried a kit of dosemeter specially designed for the study. The kits consisted of small light-tight tubes, filled with salt as described previously, that were placed in a plastic holder. The holder was attached to the investigated personnel's regular LiF TL dosemeter. Similar kits of salt-dosemeters were also attached to LiF-TL-dosemeters that were positioned on the inside walls of the nuclear medicine and proton therapy laboratory, respectively. Some of these dosemeter kits were also placed in the primary radiation field from a mammography X-ray unit.

2.3 Read-out of dosemeters

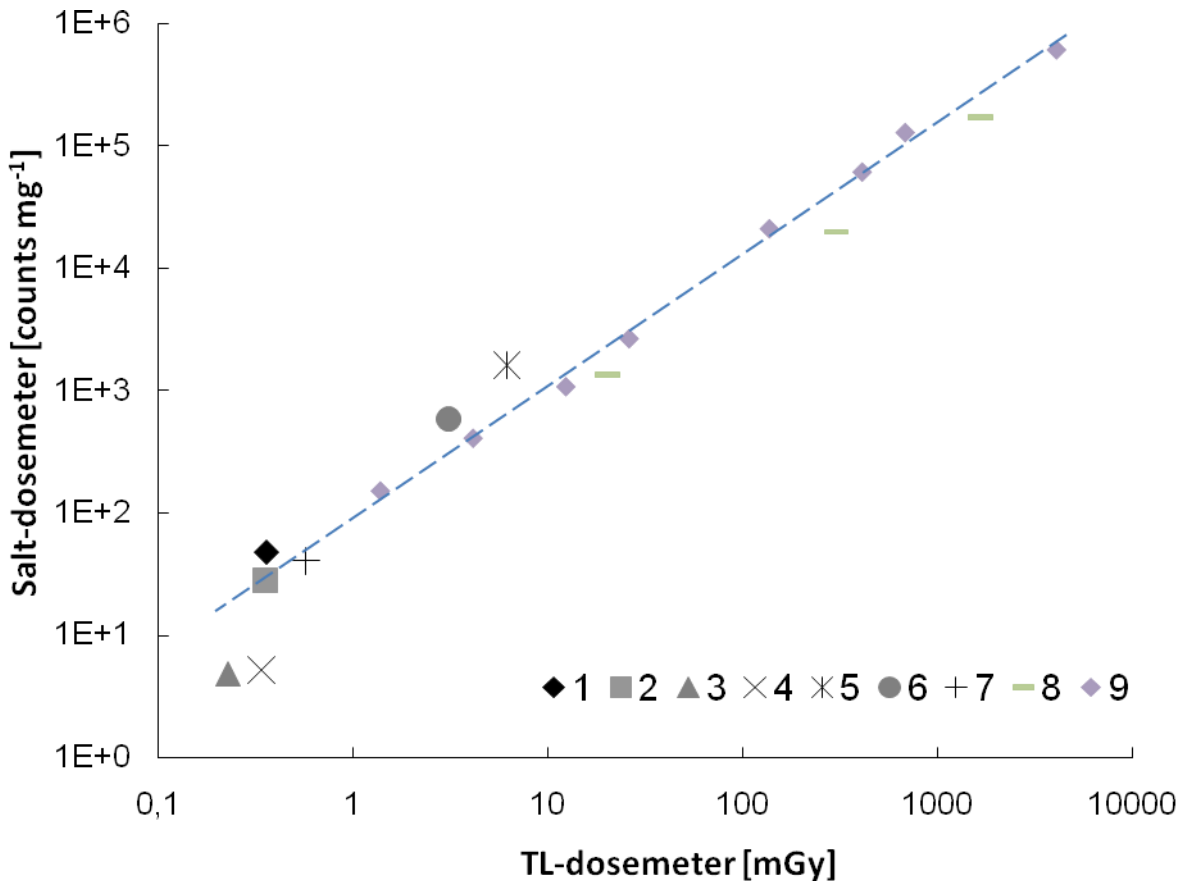
The OSL in the salt was measured using a TL/OSL reader (TL/OSL DA 15; Risø National Laboratory, Roskilde, Denmark). The measurements were made at an elevated temperature of 125°C using continuous wave OSL (CW-OSL) with blue light emitting diodes (λ=470 nm). A pre-heat of 220°C was used before the CW-OSL From each dosemeter kit the salt was weighted and portioned into at least six different aliquots, which were read out individually. The mean OSL-signal per unit mass [counts mg^{-1}] was taken as the average value of these six or more aliquots. The time of CW-OSL was 900 s for each aliquot, using a stimulation power ranging from 40-90% of the maximum value (60 mW cm^{-2}) of the LEDs.

The TL-measurements were made with a TLD reader (Rados Dosacus, Rados Technology, Finland) using 4.5 mm (Ø) x 0.9 mm LiF: Mg, Ti (Harshaw). The TL dosemeters were read using the normal protocol for TL dosimetry at Malmö University Hospital, which is regularly calibrated in the ^{60}Co beam.

3. Results and discussion

Figure 1 shows the relation between the OSL-signal in salt and the absorbed dose as measured by LiF (TLD) in the ^{60}Co beam. The same relation is also shown for measurements on the personnel in diagnostic radiology and nuclear medicine. At low photon energies (mammography), the OSL-measurements indicate a somewhat higher response relative to LiF-TL dosemeters. The effect may be attributed to the somewhat higher atomic number of NaCl (Z = 11; 17) compared to LiF (Z = 3; 9).

Figure 1: The OSL signal from NaCl as a function of absorbed dose measured by LiF (TLD) for ten dosemeter kits (OSL and TL) positioned at the following locations; *i.)* on personnel in diagnostic radiology (no 1 and 2), *ii.)* on personnel at the nuclear medicine department (no 3 and 4), *iii.)* in the mammography primary radiation field (no 5 and 6), *iv.)* on the interior walls of a nuclear medicine laboratory (no 7) and on the interior wall of a 175 MeV proton therapy unit (no 8). The OSL response vs. absorbed dose determined by LiF-TL dosemeters placed in a ^{60}Co beam is shown for comparison (no 9).



4. Conclusions

Preliminary results show that household salt can be used to measure absorbed doses down to 200 µGy. Measurements also indicate a somewhat higher response relative to LiF-TL dosemeters at lower photon energies. The effect may be attributed to the higher atomic number of NaCl compared to LiF, and differences in directional dependence in sensitivity.

We conclude that NaCl as a personal OSL-dosemeter appear to be an interesting alternative to TL dosemeters even at absorbed dose levels associated with annual occupational exposure (<10 mGy).

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