APPLICATION OF THERMOLUMINESCENCE IN MEDICAL FIELD

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Ionizing radiation being used very widely in Medical field for diagnosis and treatment

Quantification of ionizing radiation is essential as part of radiation protection and dosimetry

Dose delivery which can range from μGy to kGy.

There are many radiation dosimeters available and in use for verity of applications

VARIUOS RADIATION DOSIMETERS AVAILABLE AND IN USE

A. Electronic Dosimeters

Examples: Geiger-Muller or semiconductor detector

Detection: Detect x-rays and gamma radiation

Properties: Relatively expensive, usually quite rugged, reusable

B. Quartz Fiber Electroscope (QFE):

Consist of a small ionization chamber and quartz fiber

Radiation induced charge deflects the quartz fiber

Deflection is displayed in the eyepiece lens

Major disadvantage: Easily damaged if dropped or roughly handled.

C. Film Dosimeters/Badges

Used as a personal dosimeter

Use highly sensitivity silver halide film,Fitted with a range of filters

Distinguish beta, x-ray, gamma and thermal neutrons

Dose is determined by degree of blackening (optical density) comparing it with calibrated films

Provides permanent record of an individual's dose

Adverse effects of light and heat

Relatively short shelf life (months)

Require dark room facilities (development chemicals)

Significant manual handling during assessment

D. Thermo luminescent Dosimeters (TLDs)

Used as personal and environmental dosimeter
Use Thermo-Luminescent (TL) materials
Electrons are raised/trapped at higher energy levels
The energy is released as light when heated
Light emitted is converted into an electrical signal by PMT
Light emitted is proportional to incident radiation
Lithium (LiF: Mn) based TLDs for personal dosimetry: Because they are tissue equivalent, CaSO4: Dy embedded Teflon discs,
Calcium (CaF2: Dy, CaSO4: Dy) based TLDs for environmental monitoring: due to their high sensitivity
Lithium borate (Li2B4O7: Mn) TLDs for high dose range dosimetry
TL materials are available in many different forms: e.g. powder, hot pressed chips, pellets, impregnated Teflon disks
Read-out instrument (reader): are required
Method to heat the TLD material: Electrical, hot gas or a radiofrequency heater, Heated in an inert gas during read-out
Device to convert the light output to an electrical pulse
Light signal is amplified using a photomultiplier (PM)
Small size (only milligram quantities of TL material is needed)
TLDs can be reused

The specific thermo luminescence property is required for a particular application however any thermo luminescence material to be used in radiation dosimetry should possess the basic properties like

1. The rate of fading [loss of radiation dose information] should not be more than 5 % per month
2. A single strong glow curve preferably between 100 ^{0}C to 300 ^{0} C range
3. The annealing temperature needed should be around 300 ^{0}c and procedure required for annealing should be simple and practicable
4. The TL material must be highly sensitive to radiation with lowest measurable capacity of the level of 100 µGy dose within adequate precision
5. Low background signal and noise
6. Energy response should be flat over photon energy of 15 keV – 2 MeV

Sources of error in TL dosimetry

There are many sources of possible error in TL dosimetry system which may lead to wrong results and conclusion therefore utmost care is required.

The major sources of error are

A. Related to reading technique

1. Uniform heating rate of the reader
2. Sensitivity of the PMT and light leakage

3. Thermal contact between TL material and heating plate- planchete
4. Timer and potential difference accuracy and control
5. Electronic stability of the reader system
6. Cooling rate of heater/ residual heat

B. Related to TL material

1. Variation of sensitivity within TLD batch
2. Life of phosphor, history of use and dose recorded
3. Annealing of TL material and residual dose
4. Purity and cleanliness of TL material
5. Proper selection of TL material, design and composition.
6. Variation of TL response with energy of radiation
7. Fading due to environmental conditions
8. Sensitivity to light, especially UV light
9. Effective atomic number of TL material

We have used $CaSO_4$: Dy TLD for measurement of radiation doses during various procedures as listed below

1. Patient skin entrance and exit doses in fluoroscopic examinations
2. Radiation doses to patients' organs during radiography
3. Corneal doses during external beam therapy of Head & Neck malignancies
4. Intraluminal esophageal dosimetry and inhomogeneity correction
5. Radiation doses to patient cornea, thyroid and gonads during fluoroscopic investigations
6. Rectal doses during LDR and HDR brachytherapy of cancer cervix
7. Radiation dose to contra lateral breast during treatment of breast malignancy by radiotherapy
8. Finger tip dosimetry of staff working in brachytherapy and nuclear medicine
9. Organ doses of staff during fluoroscopic investigation
10. Environmental gamma radiation dose to population
11. Verification of an empirical formula for estimation of skin exposure during Radiography
12. Radiation doses during CT examination

Evaluation of radiation doses to *patients' organs* during radiography of abdomen

In 500 patients – plain film radiography of abdomen

3 $CaSO_4$: Dy TL discs , one at center and two 5 lateral to center on skin

one TL discs on skin over thyroid- 2 cms depth dose, Two TL discs over eyelid for cornea dose, one TL disc on scrotum for male gonad dose

For female gonad dose estimation % DD at midline used

Corneal doses	11 – 77 µGy
Thyroid doses	12 – 88 µGy
Testicular doses	680 - 3800 µGy
Ovary doses	610 – 1850 µGy
Skin entrance doses	2200 – 7900 µGy
KVp	60 – 70
mAs	80 – 140
Distance	70 – 78 cms

Patient skin entrance and exit doses in some fluoroscopic investigations

94 patients undergoing fluoroscopy for barium enema, barium meal, barium swallow, HSG, myelography, cystourethrography

500 mA IITV system

fluoroscopy time 50 – 402 sec

KVp 60 – 65

skin entrance doses during barium meal	6 - 395 mGy
skin entrance doses	0.6 - 39 mGy
others skin entrance dose	9.2 - 668 mGy
skin exit doses	2.6 - 112 mGy

Corneal doses during EXRT for Head & Neck malignancy

121 cases of H & N cancer under going EXRT on Cobalt Teletherapy
Average dose per sitting of 200 cGy 1.7 – 12.06 cGy

% of tumor dose 0.83 – 6.03 %

Total corneal dose for entire treatment 49.4 – 361.7 cGy
Intraluminal Esophageal dosimetry and inhomogeneity correction
Ryles tube filled with $CaSO_4$: Dy powder 28 cases , 5 times each positioned under fluoroscopy
Treatment delivered, powder evaluated
variation of dose 3.8 - 17.8 %
Further entrance & exit dose measurement- anatomical thickness and in homogeneous thickness in esophagus, cancer cervix, Rectal dosimetry in cancer cervix by LDR & HDR, Contra lateral breast dose during EXRT,
Nuclear medicine staff doses, Fluoroscopy staff doses

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