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Review Paper

New trends in thermo luminescent dosimetry materials

Shashi Kant Rathore*, Manendra Mehta and Usha Rathore
Govt. E. Raghavendra Rao PG Science College, Bilaspur, CG, India
shashikantrathore49@gmail.com

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Abstract

This article provides a chronological overview of the developments in thermo luminescent dosimetry (TLD) materials, from the early discoveries of LiF:Mg,Ti and $CaSO_4$:Dy in the 1950s and 1970s, respectively, to the emerging trends and recent advancements in the field. The article describes the unique properties and characteristics of traditional TLD materials, as well as the limitations associated with their use in radiation dosimetry. It then discusses the emerging trends in TLD materials that have emerged in recent years, such as nanotechnology, organic-inorganic hybrid materials, and rare earth materials, and their potential advantages over traditional TLD materials. The article also covers the most recent advancements in TLD materials, such as the use of machine learning algorithms and wearable dosimetry devices, and their potential impact on the field of radiation dosimetry. Finally, the article discusses the potential applications of these new TLD materials and technologies, as well as the challenges associated with their development and implementation. Overall, this article highlights the need for continued research and development in TLD materials to improve the accuracy and reliability of radiation dosimetry.

Keywords: 0020 Thermoluminescence Dosimetry, Glow Curve, Sensitivity.

Introduction

Thermoluminescentdosimetry (TLD) is a widely used technique for measuring ionizing radiation in various fields, including radiation therapy, environmental monitoring, and nuclear power plants. Traditional TLD materials, such as LiF:Mg,Ti and CaSO4:Dy, have been used for several decades, but they have certain limitations, such as sensitivity to environmental conditions, poor reproducibility, and low detection efficiency at low doses. Therefore, there is a need for new TLD materials with improved properties to overcome these limitations and improve the accuracy and reliability of radiation dosimetry.

Over the years, several new TLD materials and technologies have been developed to address these limitations and improve the field of radiation dosimetry. This article provides a chronological overview of the developments in TLD materials, starting from the early discoveries of LiF:Mg,Ti and $CaSO_4$:Dy in the 1950s and 1970s, respectively, to the emerging trends and recent advancements in the field. This article will describe the unique properties and characteristics of traditional TLD materials, as well as the limitations associated with their use in radiation dosimetry. It will then discuss the emerging trends in TLD materials that have emerged in recent years, such as nanotechnology, organic-inorganic hybrid materials, and rare earth materials, and their potential advantages over traditional TLD materials. The article will also cover the most recent advancements in TLD materials, such as the use of machine learning algorithms and wearable dosimetry devices, and their potential impact on the field of radiation dosimetry.

Early Developments in TLD Materials

The earliest TLD materials were LiF:Mg,Ti and $CaSO_4$:Dy, discovered in the 1950s and 1970s, respectively. LiF:Mg,Ti is a well-known TLD material, widely used in radiation dosimetry due to its high sensitivity and relatively low fading rate. $CaSO_4$: Dy is another commonly used TLD material, which has good sensitivity and high reproducibility. These traditional TLD materials have been studied extensively and have been shown to be reliable and effective for various applications in radiation dosimetry[1].

However, LiF:Mg,Ti and $CaSO_4$:Dy also have certain limitations. For example, LiF:Mg,Ti has a relatively low sensitivity at low doses, which limits its use for applications that require detection of low-dose radiation. In addition, both LiF:Mg,Ti and $CaSO_4$:Dy are sensitive to environmental conditions such as humidity and temperature, which can affect their accuracy and reliability[2].

Despite these limitations, LiF:Mg,Ti and $CaSO_4$:Dy have remained the primary TLD materials used in radiation dosimetry for several decades. However, with the advancements in material science and technology, new TLD materials with improved properties have been developed, which have the potential to overcome the limitations of traditional TLD materials and improve the accuracy and reliability of radiation dosimetry.

Emerging Trends in TLD Materials

In recent years, there has been a growing interest in developing new TLD materials with improved properties for radiation dosimetry. Several emerging trends can be identified in the development of TLD materials, including:

Nanomaterials: The use of nanomaterials in TLDs has shown promising results in improving sensitivity, dose response, and stability of the TLDs[3,4]. Nanoparticles such as ZnO, TiO_2, and SiO_2 have been incorporated into TLD materials to enhance their performance.

Hybrid materials: Hybrid TLD materials, which combine two or more different materials to form a composite, have also been developed. These materials have shown improved performance compared to traditional TLD materials, including enhanced sensitivity and dose response[5,6].

Organic materials: Organic TLD materials have gained attention due to their biocompatibility, flexibility, and ease of processing. Materials such as polyvinyl chloride (PVC) and polyurethane (PU) have been studied for their potential as TLDs[7].

New dopants: The use of new dopants in TLD materials has also been explored. For example, rare earth elements such as Pr, Ce, and Eu have been added to TLD materials to improve their performance[8,9].

These emerging trends have shown promise in improving the performance of TLD materials for radiation dosimetry, and continued research in these areas may lead to the development of new TLD materials with even better properties.

Recent Advancements in TLD Materials

Recent advancements in TLD materials have led to the development of new materials with improved properties and performance for radiation dosimetry. Some of the recent advancements in TLD materials are:

Metal-organic frameworks (MOFs): MOFs have gained attention as potential TLD materials due to their tunable properties and high surface area[10]. The use of MOFs in TLDs has shown enhanced sensitivity and dose response, as well as improved stability.

Perovskite materials: Perovskite materials have been studied for their potential as TLDs due to their high sensitivity and good linearity over a wide range of doses[11,12]. These materials have also shown good reproducibility and stability.

Nanocomposites: Nanocomposites, which combine nanoparticles with other materials such as polymers, have been studied for their potential as TLDs. These materials have shown improved performance compared to traditional TLD materials, including enhanced sensitivity and dose response[13].

Machine learning algorithms: Machine learning algorithms have been used to improve the accuracy and reliability of TLD dosimetry. These algorithms can be used to predict dose response and identify potential sources of error in TLD measurements[14,15].

These recent advancements in TLD materials have shown promising results in improving the performance and accuracy of radiation dosimetry. Continued research in these areas may lead to the development of new TLD materials with even better properties.

Applications of TLD Materials

TLD materials have a wide range of applications in radiation dosimetry, including in medical, environmental, and industrial settings. Some of the applications of TLD materials are:

Medical dosimetry: TLDs are commonly used in medical dosimetry, including in radiation therapy for cancer treatment[16,17]. TLDs can be used to measure the radiation dose delivered to a patient during treatment, ensuring that the dose is accurate and safe.

Environmental dosimetry: TLDs can be used for environmental dosimetry, including in the measurement of background radiation levels and in monitoring radiation levels in contaminated areas[18]. TLDs can provide accurate and reliable measurements of radiation levels over time.

Industrial dosimetry: TLDs are commonly used in industrial dosimetry, including in the monitoring of radiation levels in nuclear power plants and other industrial settings[19,20]. TLDs can provide continuous and accurate measurements of radiation levels, ensuring the safety of workers and the public.

Personal dosimetry: TLDs can also be used for personal dosimetry, including in the measurement of radiation doses received by workers in radiation-related occupations[21,22]. TLDs can provide accurate and reliable measurements of radiation doses over time, ensuring the safety of workers.

These applications of TLD materials demonstrate their importance in radiation dosimetry, with a wide range of uses in medical, environmental, industrial, and personal settings.

Challenges in the Development and Application of TLD Materials

While TLD materials have numerous advantages in radiation dosimetry, there are also several challenges in their development and application. Some of the challenges include:

Sensitivity: TLDs are typically less sensitive than other types of radiation detectors, such as ionization chambers[23]. This can make it difficult to measure low doses of radiation accurately.

Fading: TLDs can experience fading, which is the loss of stored energy over time[24]. This can lead to inaccuracies in dosimetry measurements if the TLD is not read soon after exposure.

Annealing: TLDs must be annealed before use to remove any existing stored energy and reset the material to a known state[25]. The annealing process can be time-consuming and may require specialized equipment.

Environmental factors: TLDs can be affected by environmental factors such as temperature and humidity, which can impact their performance[25]. This can make it challenging to use TLDs in field settings where environmental conditions may not be controlled.

Cost: TLD materials can be more expensive than other types of radiation detectors, which can limit their accessibility and use in some settings[24].

These challenges highlight the need for continued research and development to improve the performance and accessibility of TLD materials in radiation dosimetry.

Conclusion

In recent years, there have been significant advancements in the development and application of TLD materials for radiation dosimetry. These advancements include the use of new materials, such as carbon-based TLDs and nanostructure TLDs, as well as improvements in the performance of existing materials, such as LiF-based TLDs.

The increased sensitivity, stability, and accuracy of these TLDs have led to their wider use in various fields, including medical, environmental, and occupational radiation dosimetry.

Despite these advancements, there are still challenges in the development and application of TLDs. These challenges include sensitivity, fading, annealing, environmental factors, and cost. However, continued research and development efforts are addressing these challenges and improving the performance and accessibility of TLD materials in radiation dosimetry.

In conclusion, the new trends and advancements in TLD materials are promising, and their use in radiation dosimetry is expected to continue to grow.

The ongoing research and development in this field will further improve the performance and capabilities of TLD materials and make them even more valuable for radiation dosimetry in various fields.

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