Short Communication

Graphite-rich Media, a Sustainable and Cost-effective Dosimetry Solutions

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Abstract: This study suggests commercially accessible graphite-based media to offer outstanding value for dosimetry solutions in order to get over the current constraints as well as the poor spatial resolution and hygroscopic features of the widely utilized phosphor-based systems (TLD-100 chips). According to our research, graphite media has several advantages over other materials, including low cost, less reliance on photon energy, great spatial resolution, human soft tissue equivalence (7.4), and the ability to conduct in vivo dosimetry. Insensitivity to environmental factors, low fading from temperature and light impacts, and the ability to perform real-time measurements and device downsizing with high-scale production are further benefits of this unique dosimetric material that are anticipated.

Keywords: Graphite, Spatial resolution, Low-cost dosimetry, Tissue equivalence, Nuclear medicine

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1. INTRODUCTION

According to the World Health Organization, there were 48,639 new cancer cases in Malaysia last year, and the incidence of cancer in Malaysia is anticipated to double by 2040. Compared to the 2007–2011 report, the 2012–2016 Malaysia National Cancer Registry Report indicates a rise of 11% in new cancer cases and an increase of approximately 30% in cancer-related deaths. As the rising cancer burden continues to place enormous physical, mental, and financial strain on cancer patients, communities, and the nation's health care system, the rising incidence of cancer will become a major public health concern.

Among the most effective means to treat people who have been found to have the malignant disease are radiotherapy techniques. Of the major radiotherapy techniques, most use ionizing radiation, either in the form of X–rays or gamma rays for the treatment of deep-seated tumors while for more superficial tumors electrons are often used, as in for skin cancers. However, it is well documented that ionizing radiation has various effects on human health, typically regarding deterministic and stochastic biological risks associated with DNA alterations, genetic mutation, etc. It means that the risk of ionizing radiation can overweigh the benefits if it has not been used in a controlled manner. Thus said, to protect society from the potentially harmful effect of radiation, it is critical to measure the radiation dose received by patients as well as radiation workers. Therefore, a dosimeter is a device that plays an important role in the undertaking of radiation protection monitoring and quality control of radiation therapy treatment. Over the past few decades, in the quantification of absorbed dose and also in QA programs, several dosimeters such as semiconductor diodes, radiographic and radiochromic films, thermoluminescence dosimeters (TLDs) and metal–oxide field effect transistors have been utilized. Note that each type of dosimeter has its inherent limitations including poor spatial resolution, non-tissue equivalence, and the requirement of high bias voltage to achieve an acceptable collection of charges, especially for ionization chambers. Therefore, there is a need to develop new technologies that offer low-cost and high spatial resolution dose monitoring systems throughout the treatment process to improve the accuracy of the treatment delivery.

2. MATERIALS, METHODS AND FINDINGS

To overcome the aforementioned limitations as well as the poor spatial resolution and hygroscopic characteristics of the widely used phosphor-based systems (TLD-100 chips), we propose commercially available graphite-based media to provide exceptional value for dosimetry solutions. In our investigations, it has been revealed that the graphite media offers advantageous features such as low cost, low dependence on photon energy, high spatial resolution, human soft tissue equivalence (7.4), and the potential to perform in vivo dosimetry. The advantages of this novel dosimetric material are also anticipated to include insensitivity to environmental conditions, low fading due to light effects and temperature, also the possibility to realize real-time measurements and device miniaturization with high-scale manufacturing. These have encouraged us to obtain the detailed dosimetric features of carbon-based media by irradiating a range of sources of ionizing radiation, typically used in clinical applications. Thus, we provided proof via our recent research (conducted at Sunway University and University of Malaya, since 2019) that commercially available graphite-rich media provides high value for dosimetry solutions, because of its low-cost (< 2 USD/per piece compared to commercial TLD-100 chips, which cost between 15 – 20 USD per piece) and other favourable dosimetric features (Bradley et al., 2020; 2021; 2022a; 2022b; Mat Nawi et al., 2020; 2021a; 2021b; 2021c; 2022; Khandaker et al., 2021; 2022). This production may aid in the development of a cost-effective dosimetry system in Malaysia for practical applications in the healthcare industry, particularly in the procedure of radiation medicine as a dosimetric probe of skin and lip dose.

3. CONCLUSION

While ionizing radiation remains a cornerstone of diagnostic radiology and interventional procedure, its inherent risks necessitate precise dose monitoring for both patients and radiation workers. The limitations of existing dosimeters, particularly concerning cost and spatial resolution, highlight the urgency for innovative solutions. Our investigations into commercially available graphite-based media have revealed its potential as a cost-effective dosimetric material with advantageous features such as high spatial resolution and tissue equivalence. This research, substantiated by our findings since 2019, suggests that graphite-rich media can contribute significantly to the development of affordable and accurate dosimetry systems in Malaysia, particularly for applications radiation dose measurements during applications of radiation in diagnosis and treatment. This advancement holds promise for enhancing the safety and efficacy of radiotherapy treatments within the Malaysian healthcare landscape.

Conflict of Interest: The author declares no potential conflict of interest

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