1D, 2D AND 3D DOSIMETRY - A BRIEF OVERVIEW OF THE DOSLAB GROUP'S RESEARCH WORK

AUTEX 2022
21st World Textile Conference

Elżbieta Sąsiadek-Andrzejczak, Malwina Jaszczak, Piotr Maras, Mariusz Dudek, Michał Piotrowski and Marek Kozicki (*)

Lodz University of Technology, Lodz, Poland

(*) Corresponding e-mail: marek.kozicki@p.lodz.pl

INTRODUCTION

The DosLab group deals with innovative and interdisciplinary research, covering the area of materials engineering, radiation chemistry and medical physics. Currently, the main research topic of the team is dosimetric systems for 1D, 2D and 3D ultraviolet (UV) and ionizing radiation measurements.

Radiation dosimetry is a branch of physics and metrology dealing with the measurement, calculation and analysis of basic quantities related to the transfer of radiation energy (UV and ionizing) to matter and the variability of their values in time and space. Dosimeters are used as part of a process control system used in industrial and medical applications. They guarantee the correct application of radiation processes and allow to exclude unknowns related to the measurement system of a given radiation source, instrument indications errors, device calibration errors, etc. They are also used to prepare documentation on measurement standards and directives regarding protection against high-energy radiation.

A good dosimeter should be characterized by: i) high accuracy and precision of measurement, ii) linear measurement range, iii) independence of energy, iv) spatial distribution of the dose, v) stability of the physical dimension and shape of the dosimetric system, vi) easy reading and vii) comfort of use.

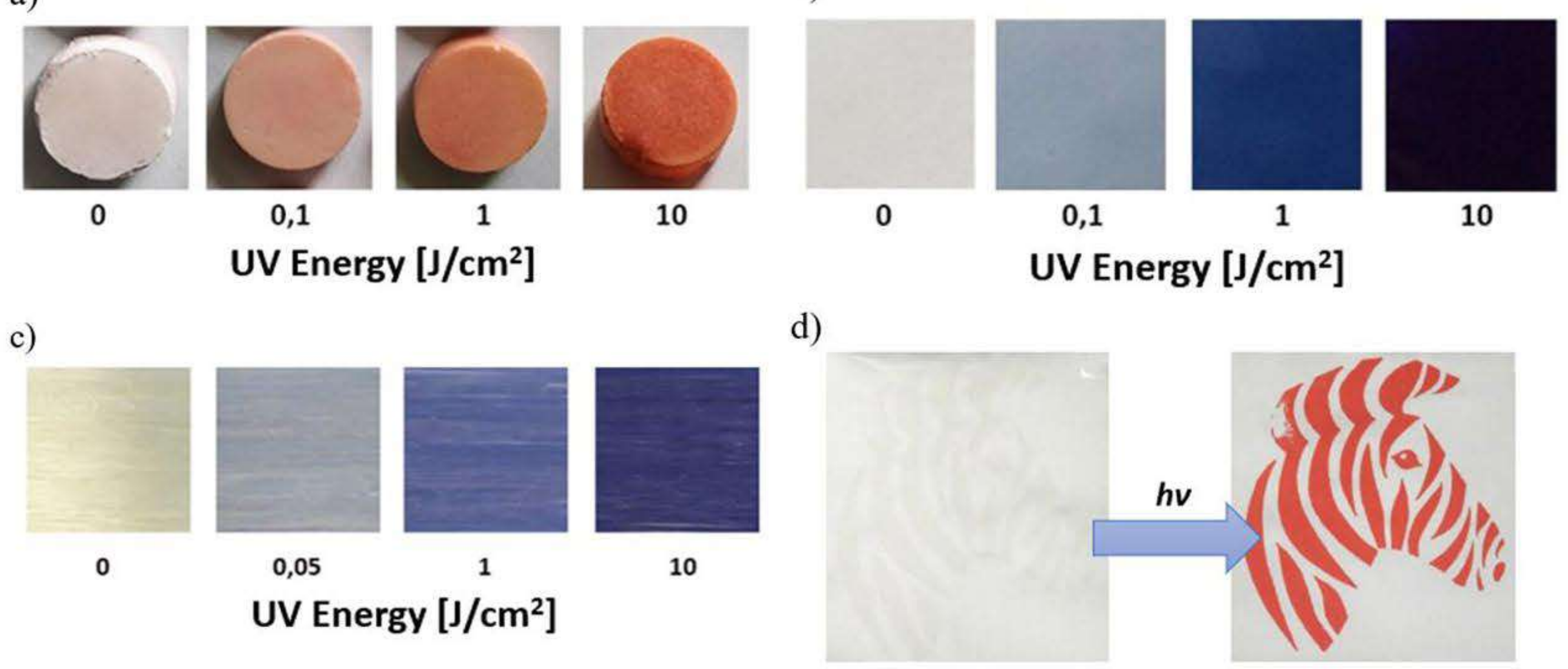
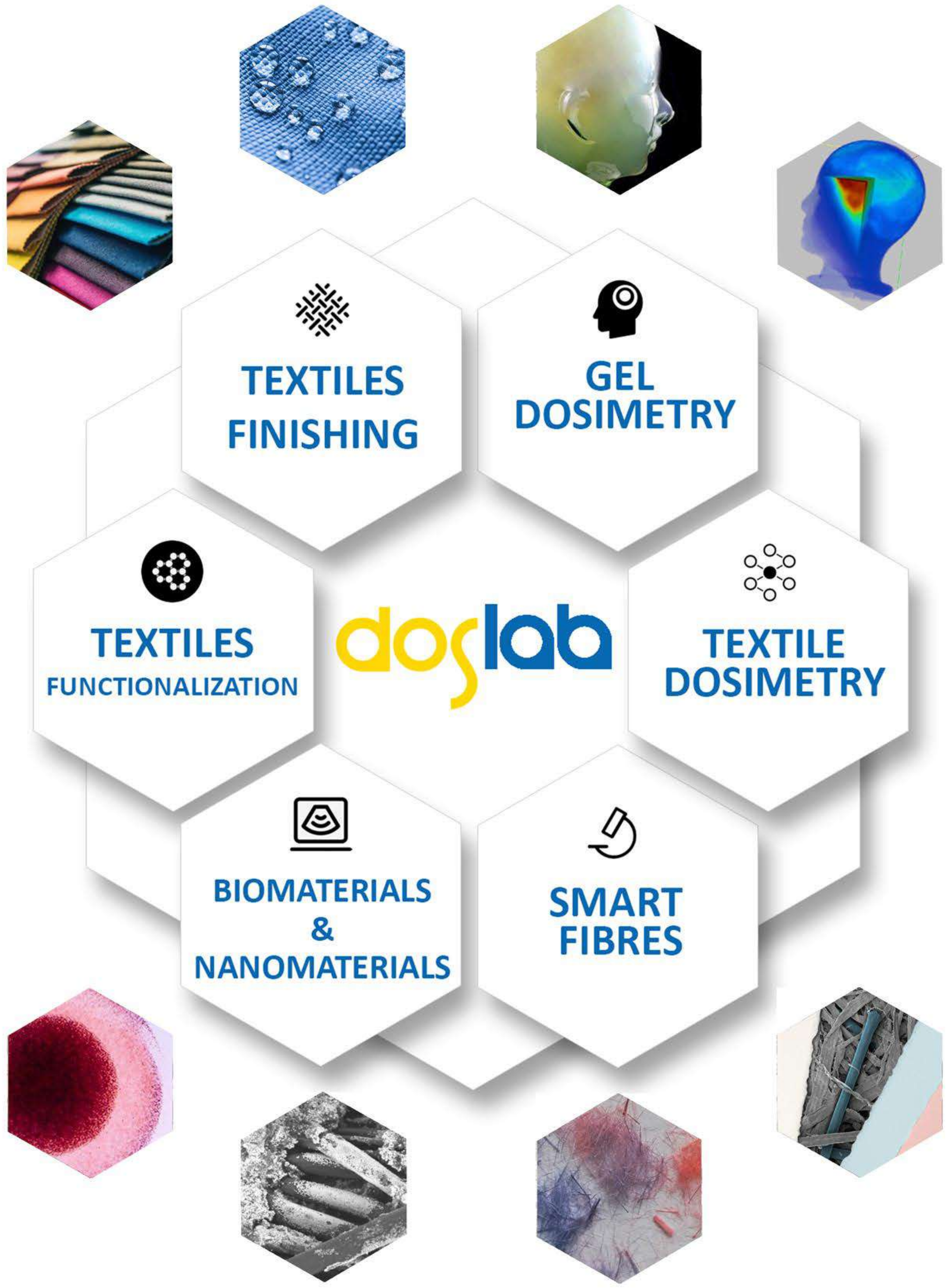


Figure 1. An example photographs of colour changes of the dosimeters in the form of: (a) 1D tablets, (b) 2D foils, (c) 1D fibres and (d) 2D printed woven fabrics after absorbing UV radiation.

1D AND 2D DOSIMETRY

The DosLab group has been involved in chemical research in 1D and 2D dosimeters of UV and ionizing radiation in the form of polymer tablets, films and textiles including surface-modified woven fabrics and functional fibres containing radio-sensitive compounds, e.g. tetrazolium salts, diacetylenes or leucodyes. These dosimeters, as a result of absorbing a dose of UV or ionizing radiation, change their colour from white, to red, blue, violet or brown depending on the used colour precursors, and the intensity of these changes is proportional to the absorbed radiation dose (**Figure 1**). Regardless of the chemical composition and structure of 1D and 2D dosimeters, colour changes can be measured by using a reflectance spectrophotometer and flat-bed scanner. From the obtained measurements, it is possible to determine the calibration parameters of the dosimetry system, such as the measuring range, dose sensitivity, threshold dose and stability of dosimeters before and after irradiation.



3D DOSIMETRY

Another subject that the DosLab group deals with is 3D dosimetry for use in radiotherapy. Radiotherapy is one of the leading treatments for cancer. It is constantly being improved to minimize the risk of damage to the patient's healthy tissues during therapy. Radiotherapy planning is a multi-stage process and one of its most important stages is the verification of the treatment plan with dosimeters. Currently, for the verification stage, 1 and 2-dimensional dosimeters are used, mainly ionization chambers (1D), semiconductor detectors (1D), film dosimeters (2D) and 2D matrixes. They enable dose measurements in 1D or 2D, respectively, which are then converted to 3D. Therefore, they do not allow for a sufficiently high measurement resolution, which is especially important for irradiation with dynamic techniques. According to the literature, this can only be provided by three-dimensional (gel) dosimeters that imitate tissues and measure the dose distribution in 3D space.

The 3D gel dosimeters for use in radiotherapy must meet appropriate requirements, such as, inter alia, high sensitivity to radiation dose, thermal stability, stability over time, tissue equivalence and the possibility of imaging using diagnostic techniques, such as magnetic resonance imaging (MRI), computed tomography (CT) and optical computed tomography (OCT). There are two main groups of gel dosimeters: polymer and radiochromic dosimeters. Under exposure to ionizing radiation, in polymer dosimeters monomers polymerize and convert to crosslinked structures, which is visible as a gel turbidity, while radiochromic dosimeters change colour as a result of a change in the chemical structure of the radiochromic dye. These changes are visible only in the irradiated parts of these gels (**Figure 2**).

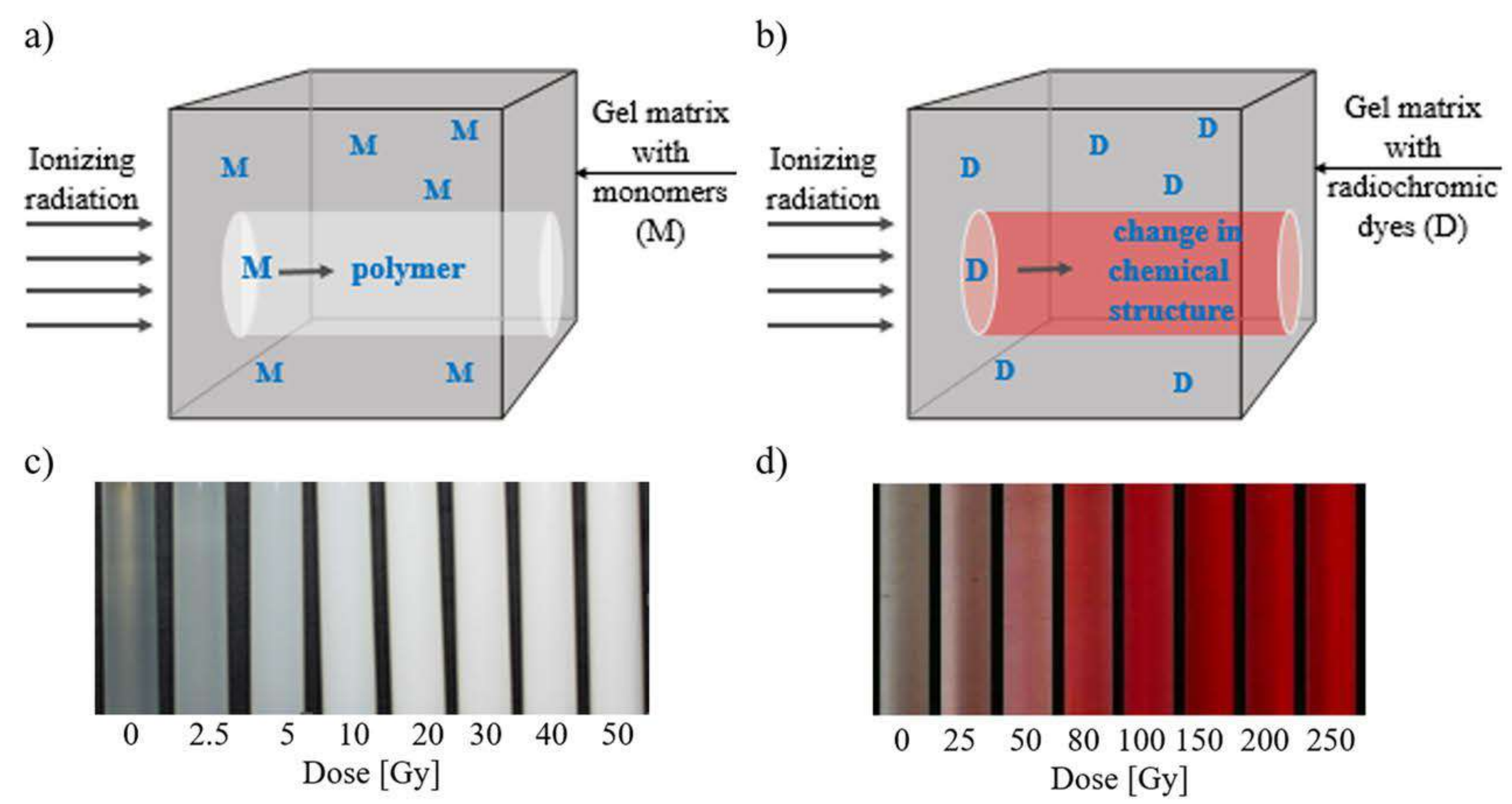


Figure 2. The diagram of changes taking place in the polymer (a) and radiochromic (b) dosimeters under exposure to ionizing radiation and photographs of changes in an exemplary polymer (VIC, c) and radiochromic (TTC–Pluronic F–127, d) dosimeter after irradiation with ionizing radiation.

WHO WE ARE?

The DosLab group operating at the Lodz University of Technology, under the leadership of Professor Marek Kozicki, deals with innovative and interdisciplinary research, covering the area of materials engineering, radiation chemistry and medical physics.

Professor Marek Kozicki, DosLab Head, chemist

Ph. D. Piotr Maras, medical physicist

Ph. D. Elżbieta Sąsiadek -Andrzejczak, chemist

Ph. D. Malwina Jaszczak, chemist

MSc. Michał Piotrowski, chemist

D. Sc., Ph. D. Mariusz Dudek, prof. of LUT, phisicist

CONTACT

Department of Mechanical Engineering, Informatics and Chemistry of Polymer Materials, Lodz University of Technology

http://mkozicki-sci.eu/
https://katedrak41.wixsite.com/home/doslab