Abstract

Radiotherapy is one of the methods of treating cancer. Its effectiveness depends largely on the accuracy of the treatment plan developed and the precision of irradiation. Radiotherapy quality control is performed by dosimetric measurements. The only group of dosimeters capable of recording information on the dose distribution in 3D are gel chemical dosimeters. In recent years, various types of gel dosimeters have been proposed, which are constantly being developed. In this work two new modifications of the Fricke gel dosimeter are proposed: (1) the addition of sodium alginate as a compound binding iron ions and (2) the addition of sorbitol to the gelatin matrix to improve the temperature and mechanical properties of the matrix. In addition, new applications of gel dosimeters in radiotherapy are proposed.

The influence of the quality of water used to produce Fricke gel dosimeters on the stability of iron ions was studied. The obtained results showed a significant influence of the quality of the water on the autooxidation rate of the dosimeter. To obtain the highest stability of iron ions, it is necessary to use deionized water or at least twice-distilled water. By dripping solutions of 1.7-3.5% sodium alginate into Fricke solution containing 0-3.5% calcium chloride, macrocapsules were obtained. The shape and mechanical strength of the capsules depended on the viscosity of the alginate used and the concentrations of sodium alginate and calcium chloride solutions. The best properties were demonstrated by capsules obtained with 3.5% alginate and 3.5% $CaCl_2$. By obtaining capsules by dripping sodium alginate solution into Fricke solution without calcium ions, the binding of iron ions to sodium alginate chains was proven. The obtained capsules are characterized by rapid diffusion of unbound metal ions and dye molecules into water. By introducing capsules into the gel matrix, a 1D dosimeter was obtained. Rapid diffusion of the active ingredients of the dosimeter from the capsules into the gel was observed, as well as a change in the capsule sizes after introduction into the matrix. The nature of the changes depended on the type of matrix material. The capsules in 25% Pluronic F-127 decreased their diameter by about 50%, while in the gelatin matrix they first decreased their diameter by about 5% and then increased it, but did not reach the initial size.

Preparation of iron alginate microgel requires further investigation. Addition of small concentrations of sodium alginate to the Fricke solution resulted in the precipitation of a white precipitate (alginic acid) due to the too low pH of the Fricke solution. Reducing the acid concentration by over 90% and removing the dye from the composition allowed obtaining microsized formations, however, further studies would be necessary to confirm the chemical composition of the obtained structures, because at the moment it cannot be unequivocally stated that it is iron alginate. Considering the mutually exclusive optimal pH of the Fricke solution and the sodium alginate solution, the need to remove the dye from the composition of the dosimeter and the potential introduction of impurities with alginate that accelerate the oxidation of Fe ions, it is recommended to search for other polymers capable of binding iron.

The effect of the addition of Fricke's solution and sorbitol on the mechanical and temperature properties of gelatin was investigated. The presence of acidic Fricke's solution lowers the gel-sol transition temperature and mechanical properties of gelatin by hydrolysis of hydrogen bonds. The presence of sorbitol partially protects the gelatin matrix from degradation, but this effect is insufficient. The gel containing Fricke's solution and sorbitol was used to prepare two-dimensional dosimeters for various applications in radiotherapy: (1) a dosimeter in a plastic container for performing a coincidence test of the radiation and mechanical isocenter of a medical accelerator, (2) and dosimeters of different

thicknesses for *in vivo* dosimetry (measurement of dose distribution on the patient's skin) acting simultaneously as a bolus During the application studies, the possibility of using Fricke-XO-Gelatin with sorbitol for performing a coincidence test was demonstrated. Verification of the treatment plans using the thick and thin Fricke dosimeters showed the need for further optimization of the manufacturing method and the search for potential materials capable of replacing gelatin. Nevertheless, gel dosimeters may be promising tools for *in vivo* measurements.

The possibility of imaging three-dimensional Fricke gel dosimeters with an optical path of 6 cm using optical computed tomography was demonstrated. In order to avoid artifacts on scans, it was necessary to optimize the composition of the dosimeters and imaging conditions. Calibration of the dosimeters showed that the addition of sorbitol increased the sensitivity of the Fricke-XO-Gelatin dosimeter by 26%, and measurements of the diffusion coefficient showed a 50% decrease in the value of the Fricke-XO-Gelatin dosimeter coefficient after adding sorbitol. Verification of the treatment plan using the Fricke-XO-Pluronic F-127 showed the necessity of further optimization of the verification process. Using Fricke-XO-Gelatin with sorbitol, a successful verification of the treatment plan was carried out. The studies carried out showed a positive effect of sorbitol addition to the gelatin matrix on the properties of Fricke-XO-Gelatin. In addition, the possibility of using gel dosimeters in new applications in radiotherapy was shown. Hence, it can be considered that the aim of the work was achieved.