Generation of mammographic x-ray spectra transmitted by a tissue-equivalent material using Monte Carlo method

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In the present work, transmission properties of a material used as breast tissue substitute (phantom) was studied using computer simulations. The breast tissue material used was the BR12 (GAMMEX RMI, Middleton, MI). This material is an epoxy resin composed of several low atomic number elements homogeneously combined and it is used in dosimetry and quality control routines of mammography equipment. This device is designed to simulate the transmission characteristics of a radiation beam similar to the transmission of a standard breast composed by a mixture of 50% of glandular tissue and 50% of adipose tissue. This material consists in 10.00 cm by 12.55 cm plates. Seventeen BR12 plates with thicknesses in the range of 0.5 cm to 8.5 cm were considered in the simulation of the transmitted spectra. The computer simulation was performed using the Monte Carlo method (PENELOPE penEasy-v20120601). This code simulates the transport of photons in different materials with known compositions and allows simulating the attenuation properties of these materials, without the need of prior experiments. Boone-Fewell-Jennings polynomial model for calculating mammography spectra was used to generate the entrance spectra of the simulation process. The x-ray tube voltages chosen were 20, 28 and 31 kV. The used entrance x-ray spectra represent beams produced by a tungsten target x-ray tube using a 0.030 mm molybdenum filter. In order to simulate each x-ray transmitted spectra, 1.65×10^{10} photon stories were considered during the Monte Carlo simulation. A total of 51 transmitted spectra were generated by the combination of three x-ray tube voltages and BR12 thicknesses. The resulting transmitted spectra are representative of the expected transmitted beams (i.e., presence of bremsstrahlung and characteristic lines, attenuation according to the thickness of the material, etc.) and it validate the method as an adequate benchmark for simulating other beam geometries, target materials and filters. Therefore, the developed method shows potential use for characterizing phantom materials used in radiation dosimetry.