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DOSIMETRY USING HS GafChromic FILMS
The influence of readout light on sensitivity of dosimetry

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Abstract

The goal of this study is to compare the sensitometric curves for HS model of GafChromic film using different dose read-out systems. Two commercial densitometers using fluorescent light source were tested and compared with results obtained using spectrophotometry. It was found that sublinear response of densitometers is due to the polychromaticity of emitted light and that response curve can be predicted by analysing absorption spectra of the film.

Introduction

Radiotherapeutic irradiation requires the exact knowledge not just about the dose but also its 3-dimensional or at least 2-dimensional distribution. The introduction of GafChromic radiochromic films (especially high sensitivity, HS films) has solved some of the problems associated with conventional 2D radiation detectors [1-3]. Blue coloration of films induced by irradiation is stable so radiochromic films do not require post-processing but a critical component in the GafChromic dose measurement process is the densitometer used for the film's optical density (OD) readout [3]. Here we examined how the nature of the analyzing light used by different densitometers affects the sensitivity curves obtained for HS films.

Experimental

Gafhromik HS dosimetric radiochromic film (ISP Technology, USA) were uniformly irradiated using either ^{60}Co γ–source or radiotherapeutic linear accelerator (PRIMUS, Siemens). The absorbance of irradiated films was measured in the wavelength range of 200 nm – 800 nm using a Perkin-Elmer Lambda 5 spectrophotometer or determined by scanners that use a fluorescent light source (FLC) with broad band emission spectra (250 – 75 nm): a desktop flat-bed Epson Perfection 1240U scanner operating in a transmission mode and VIDAR VXR-16. In addition, films were scanned using a red acetate filter overlay [4]. Data obtained from scanners were analyzed IMAGE J program.

Results and Discussion

Radiation induced absorption spectra of HS films are shown in Fig.1A. The absorption maxima at ~ 615 nm and ~ 675 nm are simmilar to those found for HS and other GafChromic films (e.g. MD-2) [1]. As expected, the highest sensitivity (defined as a fractional increase of A with the dose, i.e., the initial slope) can be achieved by using

the scaner operating at 675 nm (Fig. 1B). Departure from linearity (sublinear response) for doses above around 10 Gy is due to the high values of absorbance so the Lambert-Beer law is no longer valid, which is of no great concern since doses above 10 Gy are seldom used in radiotherapy. Unfortunately, only non-commercial densitometric scanners operate at this waveleght [3]. The sensitivity at 615 nm is lower and in addition no densitometers operate at this wavelength. Measurements at 633 nm would yield even lower sensitivity (but almost linear response over the investigated dose range), however this is the wavelenght of He-Ne laser utilized by commercial scanners (e.g. LKB Pharmacia UltroScan XL).

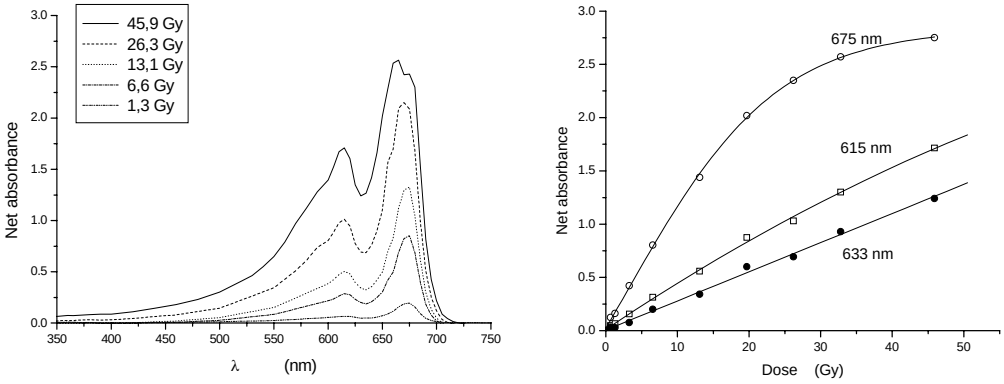

Fig. 1. (*A*) Gamma ray induced absorption spectra for HS GafChromic films irradiated to different doses. (*B*) The dose response curves measured at the indicated optical wavelengths.

Although measurements of the dose response using scanning monochromatic source at 633 nm occurs at a local minimum on the apsorption spectra (Fig. 1) such measurements would be still more sensitive than using fluorescent light sources (Fig. 2A). Both scanners gave identical results and response was independent of the irradiation source.

Based on the common wisdom that the reduction of the bandwidth of the analysing light should result in increased sensitivity, an inexpensive red acetate filter has been proposed for that purpose [4]. The filter absorbs between 320 nm and 560 nm, i.e. bellow wavelengts of film spectral peaks. Sensitivity is significantly improved (Fig. 2A). Even further improvement can be achieved by using the RGB mode (Fig. 2A), but a Vidar scanner does not have such option. Unlike measurements using a single wavelenght all response curves are sublinear and the low values of A indicate that a sublinear response should be due to the polychromaticity of emitted light [5].

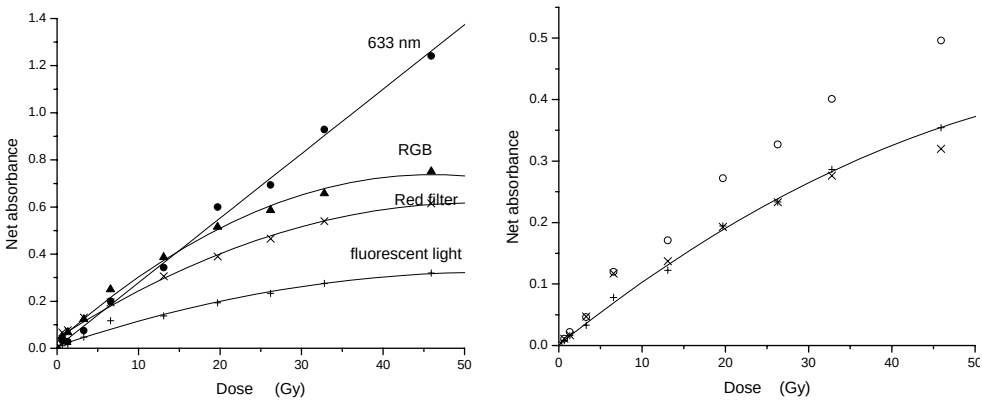

Fig.2. (*A*) The dose response curves for irradiated HS GafChromic films as measured with different setups of scanners using fluorescent light. Spectrophotometric data are given for comparison. (*B*) x – fluorescent light. Integrated absorbance from spectra (Fig. 1A): o - 500 nm range; + - 600 nm range.

Results shown in Fig. 2A are not particularly novel and simmilar conclusions can be extracted from literature [3, 4]. However, the effect of polychromaticity on the shape of the response curve have not been adressed so far. Using data in Fig. 1A we integrated the area under the spectrum for all absorbed doses and compared data with dose response obtained for 'white light' (Fig. 2B). Results clearly show that sublinear response is due to the polychromaticity. However, it should be noted that agreement with the measured response curve is achieved not for the proper range of emitted wavelenghts, but for the slightly higher range. The reason for this is that a proper comparison can be obtained only when data obtained by integration are corrected with the spectral distribution of the source, which is not known in sufficient detail.

In conclusion, there are conflicting requirements for scanners (availability, price, sensitivity) for radiochromic film dosimetry. Spectrophotometry can not be used for 2D scanning, but results can be used to predict the dose response curve for any selected light source.

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