

GAFCHROMIC[®]

DOSIMETRY MEDIA

TYPE MD-V3

WARNING: Store below 25°C
Store away from radiation sources
Avoid exposure of film to sunlight
Handle film carefully, creasing may cause damage
Do not expose to temperatures above 50°C

CONTENTS: 5 sheets, 5" x 5"



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GafChromic™ MD-V3 Dosimetry Media

GafChromic MD-V3 radiochromic dosimetry film is designed for the measurement of absorbed dose of ionizing radiation particularly suited for high-energy photons. The structure of GafChromic MD-V3 radiochromic dosimetry film is shown in Figure 1. The film is comprised of an active layer, nominally 15µm thick, containing the active component, marker dye, stabilizers and other components giving the film its near energy-independent response. The thickness of the active layer may vary slightly from batch-to-batch. The active layer is sandwiched between two 120 µm matte polyester substrates.

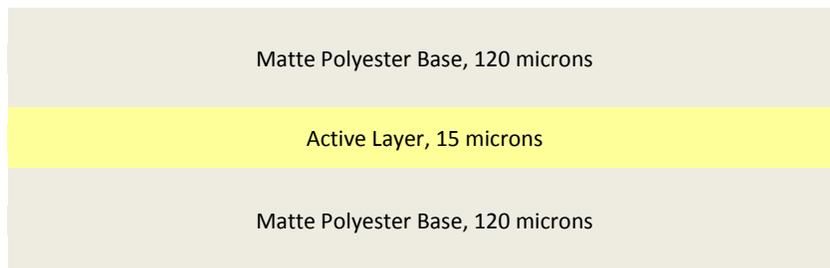


Figure 1: Structure of the GafChromicMD-V3 Dosimetry Media

Key technical features of GafChromic MD-V3 include:

- Dynamic Dose range: 1 Gy to 100 Gy
- Develops in real time without post-exposure treatment;
- Energy-dependence: minimal response difference from 100keV into the MV range;
- Near tissue equivalent;
- High spatial resolution – can resolve features to at least 5µm;
- Can be handled in room light – eliminates the need for a darkroom;
- Active coating exposed for detection of low energy photon and electron

New and improved features over the previous generation (Gafchromic MD-V2-55)

- Proprietary new technology incorporating a marker dye in active layer to enable use of multichannel dosimetry¹ with FilmQA Pro 3.0 software² Corrects scanner and film artifacts including uniformity
- Mitigates lateral response dependence
- Enables channel-to-channel consistency measurement as an integrity check
- Decreases UV/light sensitivity;
- New matte film base to eliminate Newton's Rrings artifact associated with scanning of the film
- Improved uniformity of response
- Stable at temperatures up to 60 °C;

The most exciting new feature of GafChromic[®] MD-V3 over the previous generation of GafChromic[®] HD810 dosimetry film is the incorporation of a yellow marker dye. Used in conjunction with an rgb film scanner and FilmQAPro™ software, the marker dye in MD-V3 film enables all the benefits of multi-

channel dosimetry. Using the marker dye feature is not mandatory. You can continue to perform dosimetry using only the red color channel, but you give up all the advantages of the multi-channel method that will make your film dosimetry better.

To learn more about FilmQAPro™ software and multi-channel film dosimetry, visit www.FilmQAPro.com.

SPECIFICATIONS

Table 1 Specification of GafChromic MD-V3

Property	GafChromic MD-V3 Film
Configuration	Active layer on 5 mil (120 μ) matte polyester substrate
Size	5" x 5", other sizes available upon request
Dynamic Dose Range	1 to 100 Gray
Energy dependency	<5% difference in net density when exposed at 1 MeV and 18 MeV
Dose fractionation response	<5% difference in net density ₂ for a single 100 Gy dose and five cumulative 20 Gy doses at 30 min. intervals
Dose rate response	<5% difference in net density ₂ for 10 Gy exposures at rates of 3.4 Gy/min. and 0.034 Gy/min.
Stability in light	<0.005 change in density per 1000 lux-day
Stability in dark (preexposure)	<5x10 ⁻⁴ density change/day at 23 °C and <2x10 ⁻⁴ density change/day refrigerated
Uniformity	Better than 3% in sensitometric response from mean

PERFORMANCE DATA AND PRACTICAL USER GUIDELINES

The GafChromic MD-V3 dosimetry film can be handled in normal room light for at least several hours without noticeable effects. However, it is suggested that the film should not be left exposed to room light indefinitely, but rather should be kept in the dark when it is not being handled. When the active component in GafChromic® MD-V3 film is exposed to radiation, it reacts to form a blue colored polymer with absorption maxima at approximately 633 nm.

GafChromic MD-V3 radiochromic dosimetry film may be measured with transmission densitometers, film scanners or spectrophotometers. As can be inferred from Figure 3, the response of MD-V3 is enhanced by measurement with red light. In using a spectrophotometer the greatest response is obtained by scanning the film and using the peak absorbances. Most densitometers measure over a band of wavelengths and transmission densitometers for measuring colored films measure over various narrow color bands within the visible spectrum, e.g. visual, red, green and blue. Such densitometers are commonly and widely employed in the photographic industry.

To obtain two-dimensional information in speedy fashion, flatbed color scanners will work well with all GafChromic films including MD-V3 films. The commonly available professional photo scanners such as EPSON Expression 10000XL, V750, V700 and 1680 flatbed color scanners can be used. These scanners are color scanners and measure the red, green and blue color components of the film at a color depth of 16 bit per channel.

A typical dose response of MD-V3 film on an rgb color scanner is shown in Figure 4. We recommend to fit the calibration curve to a function in form of

$$\bar{d}_x(D) = -\log\left(\frac{a+bD}{c+D}\right),$$

where $d_x(D)$ is the optical density of film in scanner channel x at dose D , and a , b , c are the equation parameters to be fitted. The advantages of these functions are:

- They are simple to invert and determine density as a function of dose, or dose as a function of density;
- They have rational behavior with respect to the physical reality that the density of the film should increase with increasing exposure yet approach a near constant value at high exposures – polynomial functions characteristically have no correspondence to physical reality outside the data range over which they are fitted;
- Since these functions have the described rational behavior, fewer calibration points are required saving time and film:
 - To cover a dose range of 1 – 100 Gy requires 4-6 dose points, for example, 0, 5, 10, 25, 50, and 100 Gy.

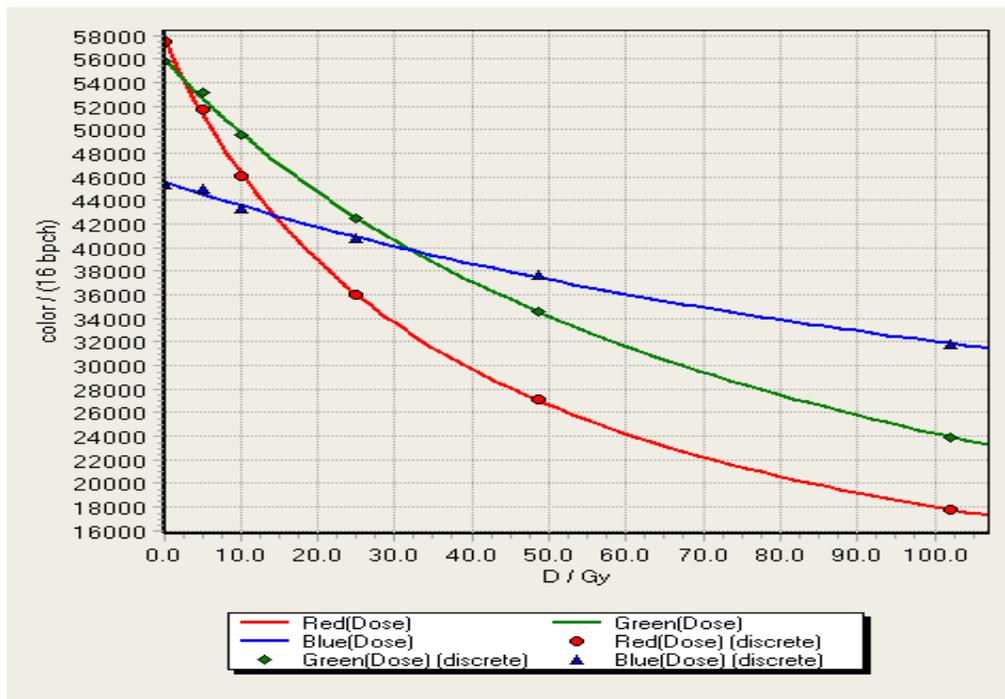


Figure 2: Response of GafChromic MD-V3 in all Color Channels

POST-EXPOSURE CHANGES

The active component in GafChromic MD-V3 dosimetry film is a radiation sensitive monomer. Upon exposure to radiation, the active component polymerizes to form a dye polymer. The polymerization has been investigated by McLaughlin, et al (ACS Symposium Series, "Irradiation of Polymers, Fundamentals and Technological Applications", Chapter 11, American Chemical Society 1996). This work showed that after flash photolysis the reaction has an incubation period of at least 1 microsecond. After pulsed electron beam radiolysis, the polymerization proceeds with first order kinetics and a rate constant of about 10^3 sec^{-1} . In the first minutes after exposure, the post-exposure density growth effect manifests itself as a significant increase in optical absorption. This corresponds to an increasing concentration of polymer within the active layer. However, the rate of change of absorption diminishes rapidly with time.

Traditionally when measurements are to be made within a few hours of the exposure, a practical and effective technique to eliminate error due to the effects of post-exposure density growth is to make the density or optical absorption measurements at a consistent time after exposure. Alternatively, errors caused by mistiming of the measurements can be practically eliminated if such measurements are delayed until 24 hours, or more, after the exposure.

The data in Figures 3 show the post-exposure density growth of GafChromic MD-V3 radiochromic dosimetry film. The densities of several film samples exposed to different absorbed doses of x-rays are plotted versus the time after exposure. This reveals that the rate of change of density behaves in a typical chemical reaction decay, decreasing continuously and rapidly with time after exposure, becoming very slow within about 24 hours. The density growth can be reasonably well fitted into log function.

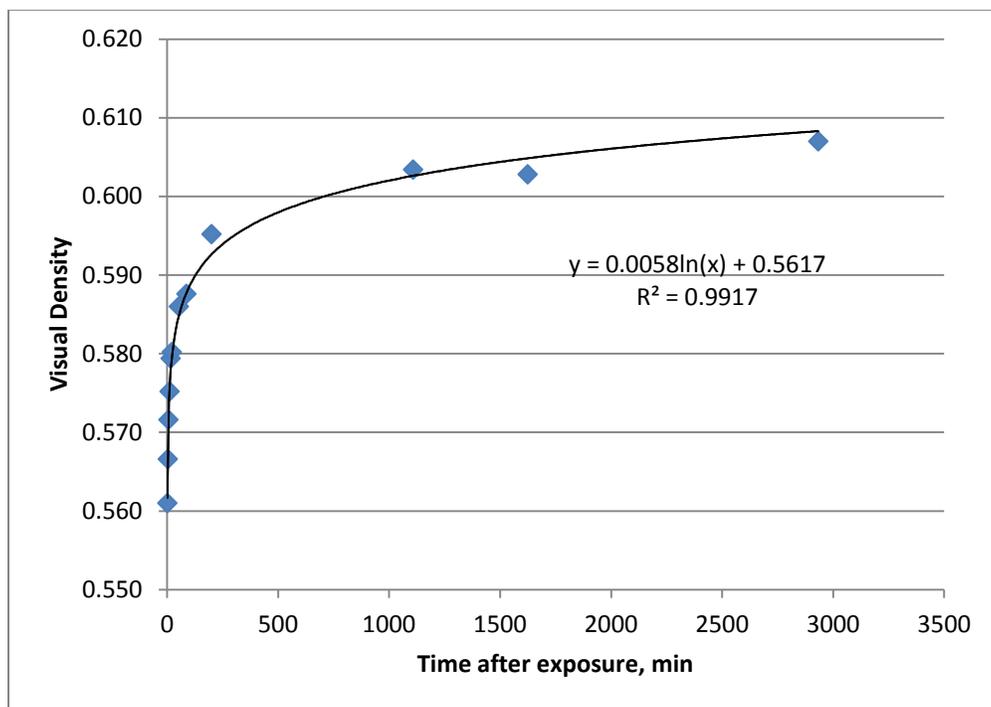


Figure 3 Post-Exposure Density Growth of MD-V3

However, a new, efficient and more accurate protocol for radiochromic film dosimetry has been introduced in which an application film and a calibration film are exposed within a few minutes of each other and then scanned together. The advantage is that post-exposure changes do not interfere with getting results in a timely fashion and most scan-to-scan variability is eliminated as a source of error. The calibration and dosimetry protocols^{3,4} are available from www.filmqapro.com

DOSE FRACTIONATION

Measurements were made to determine the effect of dose fractionation on the response of GafChromic MD-V3 Dosimetry Film. The initial densities of two film samples were measured. Each film sample was measured five (5) times. The films were given a total exposure dose of about 50Gy with 120kVp x-rays filtered through 2mm of aluminum. For one sample, the total dose was fractionated into five 10Gy increments each given 30 minutes apart. The other sample received the 50Gy dose in a single exposure lasting a few minutes. The samples were re-measured 24 hours after exposure, each sample again being read in five (5) separate locations. The density differences were calculated by subtracting the densities before exposure from the densities after exposure. Since the total exposures for the two samples were slightly different, the net density values were normalized to correspond to an absorbed dose of 50Gy. The average density changes were calculated and are shown in Table 2. Within experimental error, the results for the single and fractionated exposures are indistinguishable and demonstrate that dose fractionation effects are absent.

Table 2 Effect of dose fractionation on the response of GafChromic MD-V3 dosimetry film

Total Dose, Gy	Number of Fractions	Net Density Change
50	1	0.753±0.004
50	5 @ 30 min intervals	0.756±0.003

ENERGY DEPENDENCE

The GafChromic MD-V3 dosimetry film was irradiated with 150 kVp x-ray and Cs137 to absorbed doses of 25 and 70 Gy. The average net density changes as measured by X-Rite 310 T are shown in Table 3. The results have shown that, within experimental error, the film to have very similar response with respect of the energy of radiation.

Table 3 Effect of radiation energy on the response of GafChromic MD-V3 dosimetry film

Dose, Gy	150 kVp	Cs137
25	0.461	0.466
70	0.777	0.770

References

1. Micke, A., Lewis, D.F., Yu, X. "Multichannel film dosimetry with non-uniformity correction," *Med Phys*, 38(5), 2523-2534 (2011).
2. FilmQA Pro 3.0 software can be downloaded at www.filmqapro.com
3. An Efficient Calibration Protocol for Radiochromic Film, April 2011 available at www.filmqapro.com
4. An Efficient Measurement Protocol for Radiochromic Film, April 2011 available at www.filmqapro.com