A Study on the Effects of Aging on Radio Chromic Film

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Abstract
The aim of this study was to identify the effects of aging on the validity of data collected from radiochromic film. We took three scans on three types of RCF over the course of sixteen months. For the study, we chose to focus our attention on HDV2; the most commonly used RCF. From the data we collected, it was clear to see that the effects on aging caused minimal effects on the quality and the longevity of RCF as a diagnostic tool.

Introduction

Radio Chromic Film (RCF) is one of the most regularly used diagnostic tools utilized in the Vulcan target areas. It can be used across a wide range of experimental setups to detect the presence of heavy ions, x-rays, or any other ionizing radiation; however its main use in today's experiments is to detect the energy and shape of highly focused electron and proton beams. The RCF's active layer undergoes polymerization reaction when irradiated by radiation [1,2], which increases its optical density, making it darker. It is a very beneficial diagnostic due to its simplicity, as it requires no processing or developing to extract an image.

RCF consists of a single or double layer of radiation-sensitive organic microcrystal monomers [2,3], which lie on a thin polyester base that has a transparent coating [1]. On experiments the following types of RCF are typically used: EBT2, HD810, and HDV2. Figure 1 shows examples of these films with a circular region of exposure. RCF is so widely utilized because it is the most simple and reliable dosimetry imaging technology available.

Once the RCF has been removed following an experimental shot, it should be stored in a dry and dark environment to remove the potential risk of further polymerization of the active layer.

The aim of this study is to gain a better understanding of how used RCF changes over time; from the point of exposure to when it is scanned over a year later; to assess the longevity and long term usefulness of it as a diagnostic tool.

The films in figure 1 are the calibrated copies of the RCF, they are used as a reference for experimental film to determine the dose of ionizing radiation that the samples are exposed to.

Method

Each set of scans were carried out in as short a space of time as possible, so that the RCF was not at risk to over exposure. The scanning process was carried out on a Nikon Coolscan 9000. The first set of scans took place in May 2012, after the RCF had been subject to controlled radiation. The final scans were taken in September 2013, with an intermediary scan in April 2013.

Once the RCF had been scanned, we used an image analyzing software, ImageJ [4], to split the channels and extract the average pixel count and standard deviation corresponding to different doses.

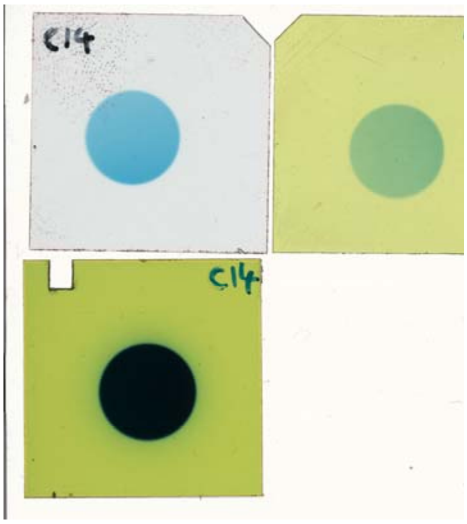

Figure 1. The three samples of RCF, having been exposed to 100.08 Gy (at the centre of the beam spot). HD810 is the film in the top left, HDV2 is in the top right, and EBT2 is at the bottom.

Results

For the purposes of the study, we will only be considering the green channel for the HDV2 RCF, as it is the fairest representation of the general pattern of the data collected. Figure 2 shows the average pixel count as a function of deposited dose for the three scans. The data showed bears resemblance to the other channels for HDV2, in which the September 2013 and April 2013 trend lines follow very similar paths up until the dose approaches 1000 Gy. The May 2012 trend line follows a similar shape, but it is not as closely grouped to the other data. This is a trend that is observed throughout the data for HDV2 and HD810. Beyond 1000 Gy mark, the April 2013 data deviates from the other data.

Conclusion

The data from figure 2 shows us that the average pixel count and appearance of used HDV2 does not diminish over time. Initially, it seems as though it does, due to the large drop in the pixel count data from May 2012 to April 2013. This is true up to a radiation dose of 800 Gy. But if this was truly ageing, we would expect to see a further drop for the September 2013 data, which is not observed. This leads to a conclusion that the April 2013 data is anomalous. This is the reason the standard deviation is shown for the April 2013 data. The standard deviation shows that the error on the April 2013 data is large enough to show that the true values could in fact be included in the range between the May 2012 and September 2013 data. This large standard deviation suggests that the method of scanning or the scanning settings were not optimal. The earliest data from May 2012 has the highest pixel count for the detection of radiation below 900 Gy, but this data series drops below the later recording for April 2013 for higher doses of radiation. This is accounted for in the standard deviation for the April 2013 data, as the error bars show that this is a possibility for the majority of the data in the series. Its trend is comparable to that of the May 2012 data, which suggests that in a year the RCF still holds its intrinsic diagnostic usefulness. The abnormal shape of the April 2013 data is consistent with other channels of HDV2 , and also with other RCF types. For the high dose region before the film saturates at 8000 Gy, the scanner's response varies a lot from around 800 Gy, so this data is unsuitable to judge the ageing effects. Apart from the obvious detrimental quality of one data set, it is clear that the effects on aging caused minimal effects on the quality and the longevity of RCF as a diagnostic tool.

References

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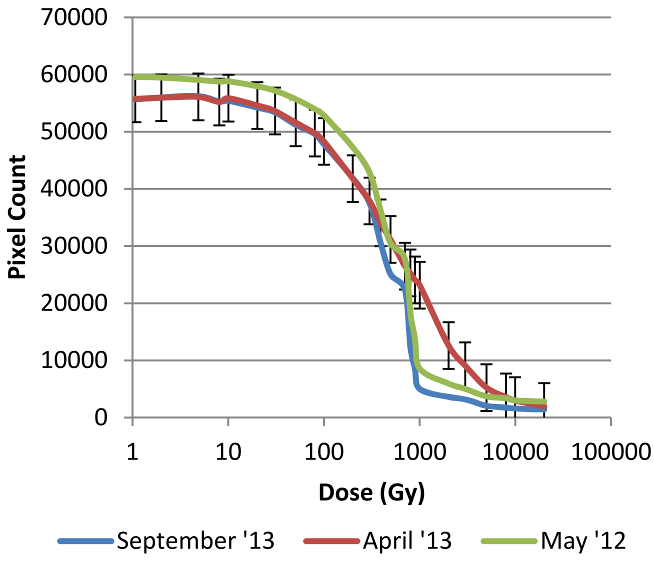

Figure 2. The average pixel count for scanned HDV2 RCF samples as a function of proton dose that samples of HDV2 RCF were exposed to. The graph shows the data from the green channel from three separate scans across 16 months.