ANALYSIS OF THE FRICKE-PMMA INTERACTION AND ITS EFFECTS IN FRICKE DOSIMETRY.

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Background and Objective

The Fricke dosimeter is a chemical solution whereby oxidation of ferrous ions to ferric ions occurs when sub-mitted to ionizing radiation. It has been shown to be an effective standard method to improve the accuracy of dosimetry procedures and as an alternative to ionization chambers. The main objective of this paper was to verify the effect of the chemical interactions between the new PMMA holder and the Fricke solution over time, which could potentially reduce the accuracy of the end dosimetry results.

Methods

As previously reported the ABS of Fricke solution experiences a natural increase over time [1]. The ABS increase of Fricke solution due its chemical interaction with the PMMA may possibly be due to acid hydrolysis of the ester groups of the PMMA depending on the contact surface extension of the solution with the PMMA. In order to evaluate more extensively this effect, the optical density (or ABS) of the Fricke solution was measured for different periods of time, and compared to the ABS of a control solution, not in contact with the PMMA.

- The control solution was carefully stored in a glass dispenser away from natural and artificial light sources and at regulated room temperature, maintained within a few degrees of variation
- The difference between the readings of the control solution and the one inside the PMMA holder was determined by Eq1:

$$\Delta Int = ABS_{PMMA} - ABS_{control} \quad (1)$$

- The PMMA holder was carefully filled with Fricke solution to avoid any air bubbles inside the vessel and the readings, both for the PMMA- exposed and control solutions, were performed consistently over a period of 3 months. On weeks 1, 4, 8 and 12, ABS readings were per-formed at 1, 2, 4, 24, 48 and 96 h after the holder was filled with new solutions. The ABS readings of the control solution were also performed for the same period.

Results and Discussion

The comparison between the OD_{PMMA} and $OD_{Control}$ shows a percentage difference of 3.4% in the first hour and up to 25.8% in 96 h, in worst cases. These results make it evident that the OD of Fricke solution increased due to the contact with the PMMA walls in the first weeks of use. This was observed for the first eight weeks of measurements.

This behavior was not observed on the 12th week, where there was no difference in the ΔInt when comparing the results for 1 h and 96 h after PMMA contact. This increase in ΔInt on the 12th week was less than 3% compared to the control Fricke solution (ΔInt of around 0.002), independent of how many hours the solution was in contact with the PMMA vessel.

The results indicate that the chemical reaction between the Fricke solution and the PMMA vessel reaches equilibrium after 12 weeks.

After reaching stability, the solution inside the PMMA holder was exposed to 39.4 Gy over 15 min using a research irradiator RS 2000 Biological Research Irradiator (Radsource, CA, USA) with 150 kV and 20 mA. The reproducibility of the system was assessed from nine repetitions with the same dose. The absorbed dose to the Fricke solution (DF) was calculated based on Eqs. (2) and (3) as reported by Klassen [2]

$$\Delta OD = (OD_i - OD_c).[1 + 0.0012 \times (25 - T_i)].[1 + 0.0069 \times (25 - T_r)] \quad (2)$$

$$D_F = \frac{\Delta OD}{G(Fe^{3+}).L.\rho.\varepsilon} \quad (3)$$

The vessel, filled with Fricke solution, was irradiated, and the DF was calculated using Eq. (3). Fig. 4 shows the results for the repeatability test. The average dose obtained was 38.99 ±0.26 Gy

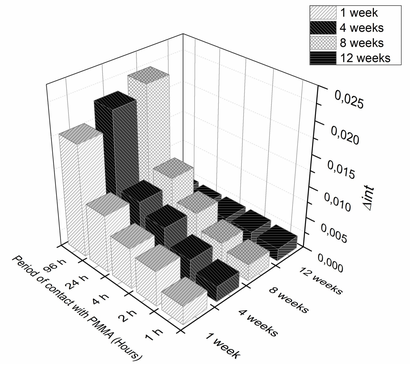

Figure 1: ΔInt of Fricke solution after different periods (1, 2, 4, 24 and 96 h) of contact with the new PMMA holder on the 1st, 4th, 8th and 12th weeks of use.

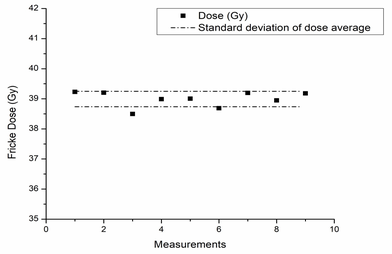

Figure 2: Repeatability of the Fricke measurements after irradiation within the PMMA holder. The irradiation time was calculated to deliver a dose of 39.4 Gy to the center of the Fricke compartment. Dashed-dotted line indicates the standard deviation of the nine measurements.

Conclusions

- Interaction between the PMMA vessel causes an increase in the absorbance measurements in the first three months of use that could result in a wrong dose measurement.
- After the period of adaptation of the new vessel, the increase in OD of Fricke solution due PMMA interaction was less than 3%, ranging from 2.4% to 2.8%.
- The authors suggest a period of adaptation, not less than 3 months, before using a PMMA vessel for Fricke dosimetry.

References

[1] **Nath et al.** Dosimetry of interstitial brachytherapy sources: recommendations of the AAPM radiation therapy committee task group No. 43. Med. Phys 1995; 22; 209-234.
[2] **Klassen et al.** Fricke dosimetry: the difference between G(Fe3+) for 60Co-gamma rays and high-energy x-rays. Phys Med Biol 1999; 44; 1609