Exposure Rate Dependence of the CO$_3^{3-}$ Signal Intensity in ESR Dosimetry of Human Tooth Enamel\textsuperscript{1}

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Experiments were made to determine the exposure rate dependence of CO$_3^{3-}$ signal intensity in ESR dosimetry of tooth enamel. Packages containing 100 mg of mixed tooth enamel of particle size of 500–850 µm were irradiated by $^{60}$Co gamma-rays with various exposure rates ranging from $5.17 \times 10^{-3}$ to $3.48 \times 10^{-3}$ C kg$^{-1}$ h$^{-1}$ up to a total exposure of about $1.290 \times 10^{-4}$ C kg$^{-1}$ (500 R). The irradiated tooth enamel samples were then subject to ESR measurements and the relative response was determined as a function of exposure rate. The response was found to be almost independent of exposure rate. No significant difference of response is observed between dry-irradiated and wet-irradiated samples.

Key Words: electron spin resonance, tooth enamel, dosimetry, exposure rate dependence

1. Introduction

ESR dosimetry utilizing human tooth enamel is being applied to the dose estimation of A-bomb survivors and residents close to Chernobyl\textsuperscript{1}–\textsuperscript{3}. However, it has many problems to solve on which we continue experimental studies so far to obtain both basic and technical data for use to practical dental ESR dosimetry\textsuperscript{6}–\textsuperscript{9}).

Tooth enamel samples, after the initial ESR measurements, are irradiated with known amount of gamma-rays for calibration of ESR signal intensities. Usually, the exposure rate of this post irradiation is not mentioned. According to our experiences, response of tooth enamel is supposed to be independent...
Table 1 Detailed conditions of irradiation

<table>
<thead>
<tr>
<th>Exposure rate (C kg⁻¹ h⁻¹) × 10⁴</th>
<th>Exposure (R h⁻¹)</th>
<th>Exposure rate (C kg⁻¹) × 10⁴ (R)</th>
<th>Sample condition</th>
<th>Exposure facility</th>
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</thead>
<tbody>
<tr>
<td>51.65</td>
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<td>1291.29</td>
<td>500.5</td>
<td>Dryness</td>
</tr>
<tr>
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<td>50.01</td>
<td>1290.00</td>
<td>500.0</td>
<td>Dryness</td>
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<tr>
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<td>1290.00</td>
<td>500.0</td>
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<td>507.5</td>
<td>1290.00</td>
<td>500.0</td>
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<tr>
<td>1309.35</td>
<td>507.5</td>
<td>1290.00</td>
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<td>Wetness</td>
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<td>Dryness</td>
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<tr>
<td>34825.12</td>
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<td>1291.29</td>
<td>500.5</td>
<td>Dryness</td>
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</tbody>
</table>

Fig. 1 Dependence of the CO₃³⁻ signal intensity on the exposure rate.

of the exposure rate. This time we performed a confirmatory experiment on the exposure rate dependence. In addition, the tooth enamel samples were irradiated in dry and wet conditions to investigate the possible difference in the amount of radiation-induced radical in these conditions.

2. Materials and Methods

Since the "radiation sensitivity" of tooth enamel is known to be variable for each tooth even from a person, we have prepared a mixed enamel sample from many extracted permanent teeth to obtain uniform results. The sample preparation technique, particle size used, and the condition of ESR measurements are the same as were reported in the previous paper⁹.

In case of the irradiation in dryness, each 100 mg of the enamel thus prepared was wrapped in medicinal paper. In case of irradiation in wet conditions, each 100 mg of the dried enamel sample was put into a polyethylene bag with distilled water and left for one week before irradiation.

Three of these packages, sandwiched between acrylic resin plates of 4 mm thick, were irradiated simultaneously with ⁶⁰Co γ-rays up to about 1.29 × 10⁴ C kg⁻¹ (500 R). The details of the irradiation conditions are shown in Table 1. After irradiation, the samples were measured with an ESR system (JEOL RE1X), with the receiver gain of 1.6 × 10⁴. Prior to the measurement, the wet samples were dried until their weight becomes constant.

3. Results

The experimental results thus obtained were normalized to the intensity at the exposure rate of 51.65 × 10⁻⁴ C kg⁻¹ h⁻¹ (20.02 R h⁻¹) and
are shown in Fig. 1. Closed symbols are for the dry-irradiated samples, while open symbols are for the wet-irradiated ones. Circle, triangle and square symbols correspond to the samples irradiated, respectively, at Japan Atomic Energy Research Institute, Chiyoda Safety Appliance Co., Ltd. and Hiroshima University. Each experimental point is an average for measurements of three samples irradiated simultaneously. The difference between minimum and maximum values for each point was less than 7%, and, the average 4%.

4. Conclusion

As expected, the signal intensity is almost constant through the entire range of exposure rates (5.17×10⁻³ to 3.48 C kg⁻¹ h⁻¹). No significant difference of response is observed between dry-irradiated and wet-irradiated samples. This fact suggests that there would be no effect of saliva in the mouth on the “radiation sensitivity” of tooth.

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References