EXOEMISSIVE PROPERTIES OF A MIXTURE OF ALUMINIUM OXIDES IN α AND β PHASES : DOSIMETRY APPLICATIONS

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1. INTRODUCTION

In general, exoemissive materials are ionic crystals. The exoelectrons emitted from their surfaces are usually detected using a particle counter. The use of these non conductive materials produces a discontinuity in the electric field between the sample and the anode which disturbs the normal function of the detector. As such, these materials are unsuitable for radiation dosimetry since one obtains poor reproducibility.

During the last decade these difficulties have been eliminated by mixing the microcrystalline exoemitter with a powdered electrically conductive material. The most frequently used is graphite. This technique has expedited the use of reproducible exodosimeters (1,2,3).

However the realization of solid compact dosimeters by the classical procedures of compression and sintering the mixture of exoemitter and graphite, presents technological problems which are difficult to resolve.

In order to eliminate these difficulties we have replaced powdered graphite by a material having a good ionic conductivity - β-aluminium oxide ($Na_2O.11\ Al_2O_3$). The major advantage of this material is that it may be sintered (4). Our preliminary results have already been published elsewhere (5,6). We have mixed this ionic conductor with α-aluminium oxide (Merck), an excellent exoemitter, which we have studied for a number of years (3,7).

2. MATERIALS AND METHODS

These experiments have been carried out using the TSEE* detector and sample preparation methods described in (3). The exodosimeter comprise :
1) An exoemissive material : Anhydrous aluminium oxide (Merck-extra pure). This is converted to the α-phase by heating in air at 1200°C (8).
2) A conductive material : This has been chosen after studying different β-aluminium oxides. The results obtained enabled selection of the following two types.

(a) β-aluminium oxide ALCOA superground
(b) β-aluminium oxide C.G.E. 1/30

3. RESULTS

Merck α-aluminium oxide without addition of a conductive material (graphite or β-Al_2O_3) shows T.S.E.E. characteristics disturbed by electrical discharge phenomena (fig.1). These cause a deterioration of the detector anode. On the contrary, addition of β-Al_2O_3 (50 % by weight) enables one to obtain a response which is in every respect identical to that obtained with a mixture

* Thermally Stimulated Exoelectron Emission.

of $\alpha-Al_2O_3$ and graphite (3,7). These results demonstrate that graphite can be replaced by $\beta-Al_2O_3$.

The T.S.E.E. glow curves of the two β-aluminium oxides we have studied (Alcoa and C.G.E.) are shown in figures 2 and 3.

After sample preparation, triboemission is eliminated by a thermal pre-treatment at 700°C in the detector (Methane gas).

The characteristics obtained with the C.G.E. samples show a much weaker background noise than those seen with the Alcoa material. With the former the "signal to noise" ratio is increased by one order of magnitude.

In order to confirm these promising results we have studied the T.S.E.E. response as a function of the dose as seen is fig. 4. The behaviour shown is in accordance with that previously demonstrated using the $\alpha-Al_2O_3$ - graphite mixture (3). We have obtained a linear response over the dose range 10^{-1} to 10^2 rads (log-log plot slope 45°).

The above results have been obtained using microcrystalline aluminium oxides. Our present studies are directed towards the use of sintered exodosimeter pellets. Using the latter, preliminary results show a sensitivity* comparable to that of the powder mixtures. However, the solidity of these dosimeters is still insufficient and must be improved. Furthermore, to gain the optimum exoemissive characteristics of these pellets, it will be necessary to study their behaviour after different thermal treatments in vacuum and controlled gas atmospheres. This work is now in progress.

4. ACKNOWLEDGEMENT

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* Sensitivity : the sensitivity of an exodosimeter is expressed by the number of electrons emitted from its surface by a unit dose.

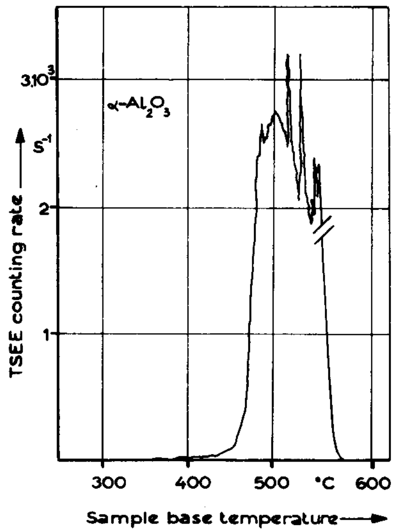

FIG I TSEE glow curve of α alumina without any admixture

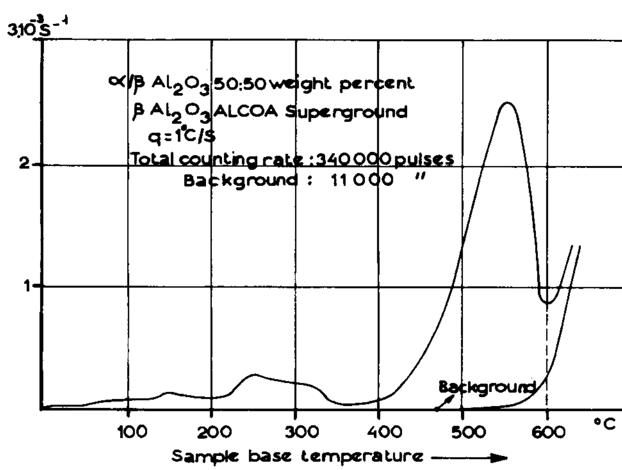

FIG II TSEE glow curve of α/β alumina mixture (β alumina ALCOA superground)

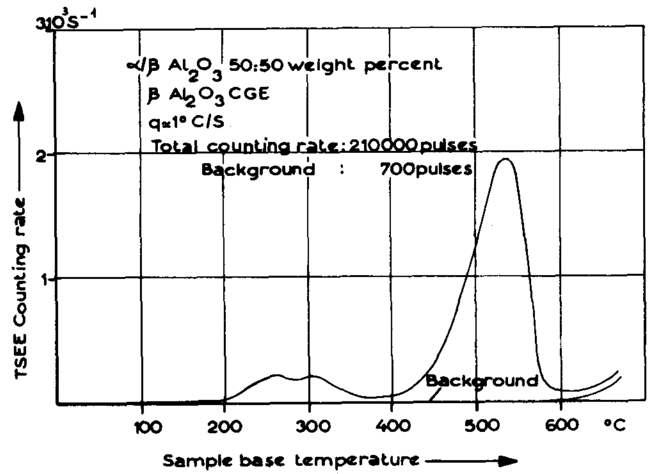

FIG III TSEE glow curve of α/β alumina mixture (β alumina CGE)

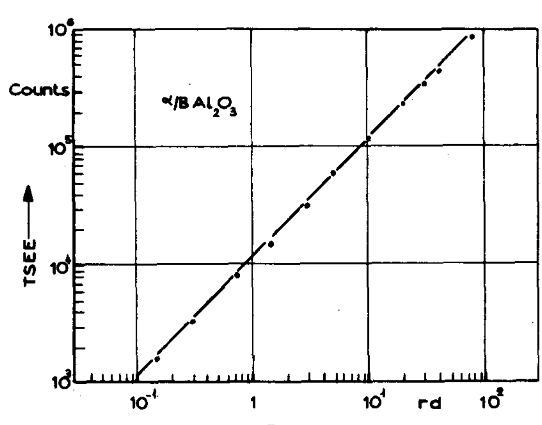

FIG IV α/β alumina mixture: TSEE response versus increasing doses