THE APPLICATION OF RUTHERFORD BACKSCATTERING TECHNIQUE TO DENTAL HARD TISSUE

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Rutherford backscattering of 2 MeV $^4He^+$ particles has been employed for compositional analysis of the inorganic substances of human dental hard tissue. The dentine region of thin sections of teeth taken from a number of subjects were analyzed in respect of calcium, phosphorous and oxygen. This technique gives an atomic spectrum of all elements present in the tooth sample, except hydrogen. Among the important experimental details discussed are the need to keep the analysing beam current and number of counts collected to a minimum so as to avoid the possibility of compositional change in the samples, and the need to vacuum dry the samples at 10^{-5} Torr, and 30°C for 24 hours to remove water and volatile organic substances.
The results of the analysis has indicated that Ca/P ratios of dentine region has a value of 1.84 ± 0.22 which is consistent with previous work on Ca/P ratios of 2.07 obtained by conventional chemical analytical technique. Other ratios such as Ca/O and P/O were found to be 0.482 ± 0.052 and 0.268 ± 0.035 respectively. These were found to be 17-48 % lower than that expected if dental hard tissue were hydroxyapatite (Ca/P = 0.96 and P/O = 0.44). Such differences have been explained by the presence of hydroxyl water in dental calculus. Furthermore, the results of decayed teeth showed Ca/P ratio of 1.29 which is 50 % lower than that of healthy teeth. This is in conjunction with the fact that decayed teeth contain less amounts of Ca than the healthy teeth.

J. T. Devreese et al. (eds.), *Recent Developments in Condensed Matter Physics*

1. INTRODUCTION

The Rutherford backscattering technique has become an established technique of great versatility taking its place beside other modern surface analytical techniques, X-ray fluorescence, Auger spectroscopy, chemical microanalysis and neutron activation analysis. Today, the applications to which this technique[1,2] has been applied have grown enormously, and particularly so in the areas of materials surface analysis and semiconductor research[3] where there is the need for a rapid non-destructive technique which can quantitatively determine the number of trace atoms located in the first few thousands atomic layers of a surface. However, more recently, greater attention has been paid to the application of this technique to the study of biological materials such as enzymes[4], blood and various other organic and inorganic solids[1,5,6]. Attempts to establish the technique on a routine quantitative analytical basis have begun. On the other hand, the analysis of dental hard tissue has also been approached in many different ways depending on the information required and the methods available to the experimentalist. Among the techniques employed in earlier studies were chemical analysis and X-ray microradiology[7]. However, in these techniques, the specimens must first be burnt to ash or broken down with acid before commencing the analysis. In contrast, the advantage of Rutherford back-scattering over other techniques is that it does not require such preparation and that all the compounds except hydrogen can immediately be seen from the same spectrum. Good precision can be obtained for the main biological elements of interest and this in a short period of time. Moreover, only small samples are required and quantities of the order of 1 μg can be detected with this technique.

The main aim of the present work, therefore, is to apply the Rutherford backscattering technique as an accurate method for the quantitative determination of elements such as calcium, phosphorous and oxygen in the dentine region of thin sections of human teeth. The results obtained are compared with the 'standard' composition obtained by the conventional chemical analytical techniques[7].

2. COMPOSITIONAL ANALYSIS

The use of Rutherford backscattering in compositional analysis of materials has been described by several authors[8,9]. The methods of obtaining the composition from the scattering yield are well reported and will only be briefly stated here. Figure (1) shows a 2 MeV He^+ backscattering spectrum from a dentine region of thin tooth section. The three common atomic