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THE APPLICATION OF A SYNCHROTRON RADIATION MICROPROBE
TO TRACE ELEMENT ANALYSIS

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INTRODUCTION

Synchrotron radiation is light emitted by electrons when accelerated in a circular orbit. Some properties of synchrotron radiation important to trace element analysis by x-ray fluorescence analysis are: 1) a broad, continuous and tunable energy spectrum for K- and L-shell excitation of all elements; 2) a linearly polarized source reducing the scattered radiation backgrounds; 3) low energy deposition in the target; and 4) an appreciable flux in narrow energy bandwidths for chemical speciation.

EXPERIMENTAL

Experiments to date have generally used "white" continuous spectra with a low energy absorber and no focussing. Future runs will use focussing mirrors which increase intensities by a factor of more than 1000. Monochromators will be used to select the energy and bandwidths appropriate to the experiment.

Detection Limits

Detection limits for thin biomedical samples using a solid-state detector, a 0.5 mm beam and a 5 min counting interval were in the range of 30 ppb for calcium to 50 ppb for zinc. Future developments will include a focussed microprobe beam line producing a 30 μ m beam spot and wavelength-dispersive detectors.¹ Detection limits will range down to a few ppb in 5 sec counts.

Trace Element Analysis of Living Cells

A prototype wet cell was designed, constructed and tested using cat cardiac myocytes with the result that major trace elements such as iron could be quantitated in single myocytes. The cell compartment is formed by two thin-film windows separated by a thin-film spacer with a cut-out forming the cell. Nutrient solution can be passed through the cell during the run.

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Fig. 1. Contour plots for localization of gallium and other elements in fetal rat bone explants. The area is $1 \times 3 \text{ mm}^2$. The tick marks point in the direction of lesser counts/pixel.

Scanning Techniques

The x-ray microprobe was used to localize gallium in fetal rat bone explants after being cultured in BGJ media containing $25 \mu\text{M Ga}(\text{NO}_3)_3$. The $1 \times 3 \text{ mm}^2$ area was scanned with a $40 \mu\text{m}$ square pixel size for 2 sec/pixel. Contour plots for a number of elemental concentrations are shown in Fig. 1.²

Microtomography

The high brightness of x rays from a synchrotron source makes possible the development of computerized tomography on a micrometer scale. A tomogram of a freeze-dried caterpillar head was produced in a 50 min scan. The pixel size was $30 \mu\text{m}$ using a $20\text{-}\mu\text{m}$ beam. Maps of trace element concentrations in cross section can also be made by detection of fluorescence x rays using a point source, or in thin samples with a line source.

REFERENCES

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