Low-background Gamma-ray Spectroscopy Applied to Measuring the Uptake of Metals by Bacteria

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Low-background gamma-ray spectroscopy offers a sensitivity to U of 10 micro-grams of depleted U and 100 nano-grams of ^{235}U by direct counting. Following neutron activation, sensitivities of 0.01 nano-grams have been observed for 29 elements in semiconductor-grade silicon [1], and should be similar for pure life-elements (H, C, N, O). In real organisms, this sensitivity will be reduced due to trace elements such as Na and Fe. However, the sensitivity to per-cent level uptakes in micro-gram sized samples or PPB sensitivities in gram-sized samples should have many applications in studying the uptake of metals by bacteria. Two proof-of-principle experiments follow:

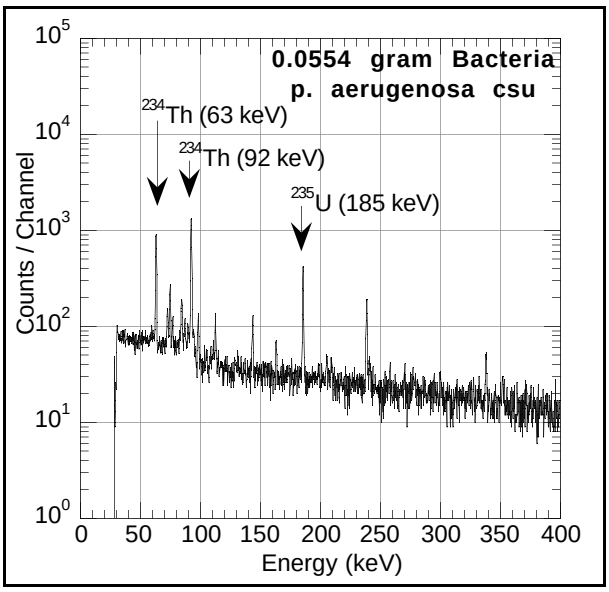
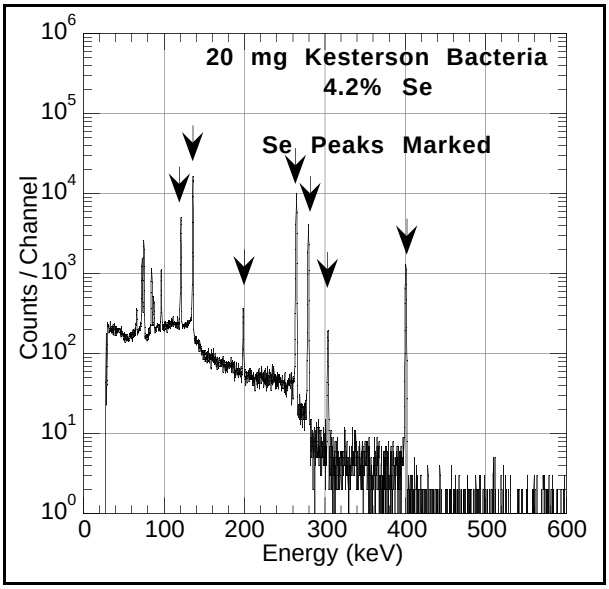


Figure 1 shows a gamma-ray spectrum observed from a 0.055 g sample of p. aerugenosa bacteria which absorbed 1.55 mg (2.8%) of (depleted) U. Characteristic gamma-ray lines at 63 and 92 keV are observed from the decay of the 24.1 day half-life ^{234}Th (the first daughter of ^{238}U) and at 185 keV from ^{235}U. Observed over 30 days, the Th activity "grows in" to a level of 2.8% of the sample mass by weight. Not knowing the relative abundance of ^{235}U compared to ^{238}U in the depleted solution, there was no way to correlate this measurement with that from ^{235}U as a check. This technique can be used, for example, to screen large numbers of bacteria and characterize their ability to take up U as a function of variables such as pH and concentrations of other elements in the growth medium.

Figure 2 shows a gamma-ray spectrum observed following neutron activation of 0.84 mg Se absorbed by 20 mg of bacteria (4.2%). Since most of the bacteria is composed of H, C, N, O, the background is favorably low. Fe, at the 0.2% level is observed, and Compton-scattered gamma rays reduce somewhat the sensitivity to Se compared to pure H, C, N, O or Si. Again, because of the accuracy and the small sample size, this technique can be used to determine uptake in large numbers of samples as functions of a number of variables, including other contaminants such as Cr, in the growth medium.



Footnotes and References

1. A.R. Smith, R.J. McDonald, H. Manini, D.L. Hurley, E.B. Norman, M.C. Vella, and R.W. Odom: J. Electrochem Soc. **143** (1996) 339-346