

Determination of parameters relevant to alpha spectrometry when employing source coating

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Introduction

Alpha spectrometry is an extremely useful and sensitive method for the detection of alpha-emitting nuclides, mainly because of the detector's low background. This advantage is lost if the detector becomes contaminated.

Alpha recoil contamination of the detector can take place when fragments from the source (sample) reach the detector and become implanted in the detector surface due to the recoil energy. Most recoil contamination cannot be cleaned off. When using Polonium isotopes, such as Po-210 ($T_{1/2} = 138.4\text{ day}$) volatilization of Polonium at low pressures can also cause detector contamination. These contamination can occur, in spite of good sample preparation involving electrodeposition.

The common way to reduce the problem is to apply a lower vacuum in the chamber, which provides an absorbing layer of air molecules. Another way is to apply a slight negative bias to the sample to attract the positive recoil ions back to the sample surface.

In this work we checked the method of coating the sample with a thin layer of Mylar (metalized film made of polyester or polycarbonate coated with aluminum), that absorbed all recoil atoms. The advantage of this method is that the alpha spectrometer does not need a pressure regulator or supplementary electronics, and that the sample can be placed close to the detector without contaminating it. However a deterioration of some parameters is expected. The influence of the source coating on different parameters (efficiency, resolution and MDA) was checked.

Instrumentation and Materials

Our system consists of a low background Si(Li) detector (model: IPA-450-17*) located in an alpha spectrometer chamber (model: 7184*), connected to a multichannel analyzer (model: gammafast 5016*) with the Interwinner Alpha spectroscopy software*. The measurements were performed with a mixed alpha standard source** containing Am-241, Cm-244 and Pu-239. The source was coated with 3 different types of Mylar***: B10 (thickness of 0.25mg/cm^2), C6 (thickness of 0.53mg/cm^2) and C2 (thickness of 0.85mg/cm^2).

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*** Metalon films, manufactured by Alexander Vacuum Research, 278 Main Street, Greenfield, Massachusetts, USA.

Results and Discussion

The alpha source, coated with different types of Mylar, was placed in the vacuum chamber at 4 different distances from the detector. 3 measurements were preformed for each position and Mylar type. The averages and standard deviations were calculated for the efficiency, energy resolution (FWHM), energy calibration parameters and for the Minimal Detectable Activity (MDA).

Fig.1 shows the FWHM for the energy peak of 5.486MeV (Am-241) as a function of distance from the detector and the thickness of the Mylar film.

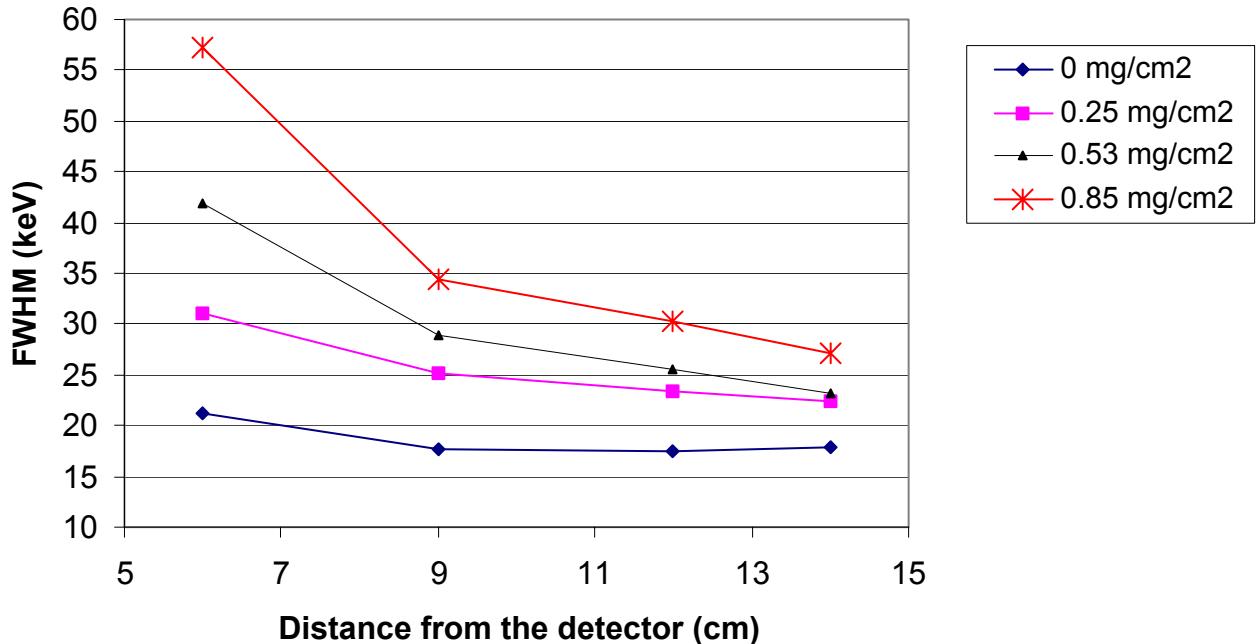


Fig.1. FWHM as a function of distance from the detector and the thickness of the Mylar film for the energy peak of 5.486MeV (Am-241).

As we can see, the FWHM increases with the thickness of the Mylar and for smaller distances from the detector. It varies from 17keV (minimal value) to 57keV (maximal value), a factor of more than 3.3 for the range shown. The increase of the FWHM at lower distances is attributed to angle effects in the detector, and this effect increases with the thickness of the coating.

Fig.2 shows the dependence of the efficiency on the alpha particle energy and the distance from the detector, for the alpha source without any coating. The efficiency decreases with the distance from the detector : for 5.486MeV, the efficiency decreases from 10.8% at a distance of 6cm to 1.8% at a distance of 14cm which is in accordance with the distance square law. The efficiency also increases as the energy increases.

We found no influence of the coating thickness on the efficiency, even for the mylar thickness of 0.85mg/cm^2 . It is due to the fact that the coating lowers the alpha particle energy, but the number of alphas reaching the detector is not changed significantly for the given range.

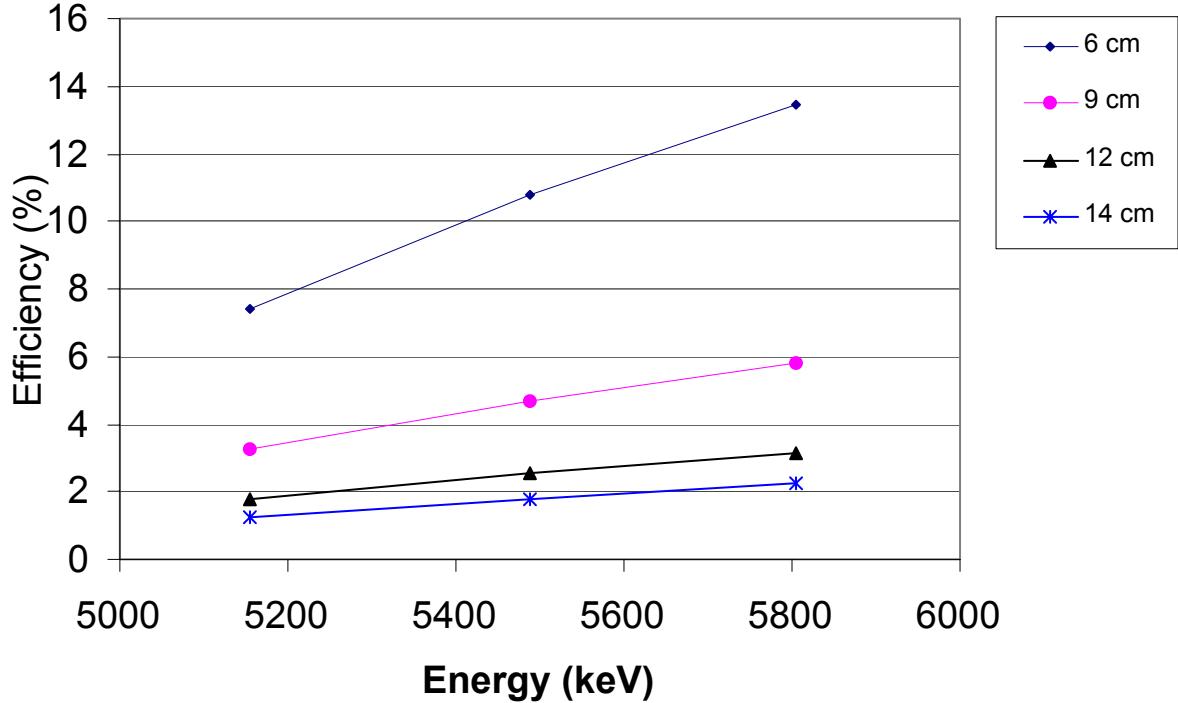


Fig.2. The efficiency as a function of the alpha particle energy and the distance from the detector.

The MDA was calculated for the different coatings and various distances from the detector by using equation (1), according to the MDA definition by the ANSI.N.13.10 Standard [1] :

$$(1) \quad MDA = \frac{4.65 * \sqrt{\frac{Rb}{t}} * 100}{\mu}$$

where :

Rb - the background (cps)

t - the counting time (sec)

μ - the efficiency (%)

The counting time was 3600 sec and the typical background value was 10^{-6} cps/keV. The total background in the peak area was calculated by multiplying the cps/keV value by the FWHM (keV).

The calculated MDA values for ^{241}Am and for different configurations are presented in fig.3.

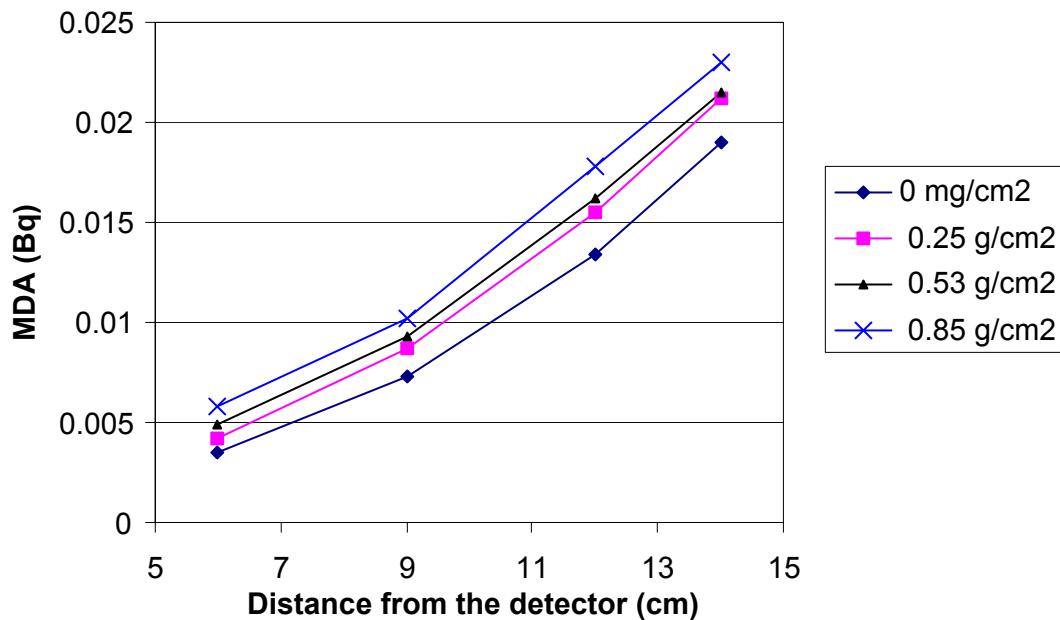


Fig.3. MDA values for Am-241 for different coatings and distances from the detector.

As shown in fig.3, the MDA is increasing mainly as a function of distance. The coating has a much smaller influence, and the difference when using 0.85mg/cm² and an uncoated source is only about 25%, compared to a factor of 4 when changing the distance from 6cm to 14cm.

Conclusions

Contamination problems in an alpha spectrometry vacuum chamber can be avoided by simply coating the sample with a thin layer of mylar. The efficiency will not be affected by coating, and the deterioration of the MDA will not be significant, especially when using thin mylars. The worsening of the resolution can also be kept acceptable by minimizing the mylar thickness.

References

[1] "Performance Criteria for Radiobioassay", An American National Standard, ANSI-N-13.30, 1996.