Calibration of charcoal cassettes for radio-Iodine sampling

S. Levinson, O. Pelled, I. Ballon, S. Oved, U. German

Nuclear Research Centre Negev, P.O.B. 9001, Beer-Sheva, 84190, Israel.

Introduction

$^{131}$I is considered a high hazard radioisotope due to its abundance as a fission product, and its concentration in the thyroid gland. Monitoring $^{131}$I in laboratories and determining its concentration in air is of great importance for Radiation Protection purposes. In order to achieve good collection efficiencies, monitoring devices are based on active charcoal cassettes, usually impregnated with TEDA 5% to enhance Iodine trapping (retention) efficiency. We employ at NRCN at the radio-iodine production laboratory continuous monitoring by air sampling through a cassette containing $\sim 26$ gram activated coal, with a diameter of 57.4 mm and a height of 22 mm (TE2C 30x50 Mesh, manufactured by F&J, USA). A monitoring device, the RIS system, was described in the past (1). The charcoal cassette is replaced periodically, and the activity of the radio-Iodine is determined by gamma counting or spectrometry.

The counting efficiency of the cassette

The gamma spectrometry method is relative, and the counting efficiency must be determined for the exact geometry of the sample. For most applications in routine sampling with cassettes, it is supposed that the radioiodine is retained in the first thin layer of active carbon. Only for very high radio-iodine quantities, as in accident situations, can the charcoal become saturated, and breakthrough occurs. In this case, the radio-iodine activity will be more homogeneously distributed through the cassette volume. In an article dealing with calibration of charcoal cartridges (2) it is proposed to prepare two counting standards: a face-loaded cartridge with the radioactivity on the inlet side and a homogeneously loaded cartridge with the radioactivity distributed throughout the filter.

Wheeler and Robell (3) developed an equation for adsorption of gas penetrating a bed of active charcoal. For the steady state situation, where the input and output concentrations are constant, it was shown that the concentration attenuation along the cassette follows an exponential function. Several experimental works (4) validated the exponential behavior. Experimental data (4) have shown that over 85% of the activity is located in the front layer of the cassette in the first 3 mm.

In some publications it was shown that the parameters for adsorption capacity are influenced by different physical and environmental conditions. Wren and Moore (5) found that the efficiency of TEDA charcoal can be seriously degraded by the presence of NO$_2$ and SO$_2$ in the air sampled. Besides, the efficiency of the charcoal depends strongly on the moisture content adsorbed, and may be influenced also by the presence of non-radioactive Iodine in the air. If the adsorption properties of the charcoal are decreased, the first charcoal layers may become saturated by relatively small amounts of radioiodine and the rest will be retained in the further layers, a process which will cause a distribution of the absorbed radioiodine different from the thin layer geometry, for which the cassette was calibrated. The resulting problem is that the calibration factor of the counting system will no longer be adequate, and errors may be induced in the activity determination.
**Experimental results**

As a representative test, a cassette which was employed for continuous air sampling during one month were opened, and the charcoal content was divided into 8 portions, each consisting of a layer of \(~2.5\) mm containing \(~3\) grams of charcoal. The coal grains in each group were mixed to obtain a homogeneous mass and the content was spread on a flat plastic vial, for which the counting efficiency is well known. Each plastic vial, containing a different layer of activated charcoal, was counted by a spectrometry system, and the radio-iodine content was determined. Figure 1 presents the original counting results and the mass of each layer.

![Graph showing count rates and weights of charcoal layers](image1)

Figure 1: The count rates (□ - left scale) and weights (△- right scale) of the charcoal layers as a function of depth in the charcoal bed of the cassette.

![Graph showing radio-iodine concentration](image2)

Figure 2: The radio-Iodine actual concentration as a function of depth in the charcoal bed in our work and in Reference (4).
Figure 2 presents the weight-normalized percent of activity content in each layer, as obtained in our work and in the work in reference (4). The conclusion in reference (4), which analyzed layers of charcoal from the cassette in steps of 1mm, immediately after Iodine sampling, is that the behavior is exponential, in accordance to theory. From figure 2 we can see, that the results in our work show that the distribution is not exponential, and even after a depth of 20 mm, at the end of the cartridge, radio-Iodine could be detected.

**Discussion and conclusions**

The one month sampling seems to have deteriorated the absorption properties of the active charcoal in the sampling cassette. Due to the different distribution of the radioactivity in the cassette volume, the calibration constants must be changed accordingly.

A simple way to determine the characteristics of the activity distribution in the cassette is to count also the turned cassette (counting the cassette laid on both faces on the counter). The ratio of the count rates is dependent on the location of the radio-Iodine. We obtained the following ratio values for a thin layer of radio-Iodine absorbed on a paper filter, located at two depths in the charcoal bed:

<table>
<thead>
<tr>
<th>Depth in charcoal bed (mm)</th>
<th>Counts ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.03</td>
</tr>
<tr>
<td>5</td>
<td>1.54</td>
</tr>
<tr>
<td>10</td>
<td>1*</td>
</tr>
</tbody>
</table>

* 10 mm is the middle of the cassette, and because of symmetry the theoretical ratio is 1.

The cassette for which the data in figures 1 and 2 is given, produced a counts ratio of ~1.8. By using the original calibration factor, it is estimated that an error of about 50% would have been obtained. Other cassettes gave also values different from the expected thin layer, which indicates that the problem is more general.

It is proposed to use the counts ratio as an indication of the activity distribution in an activated charcoal cartridge, and to prepare and use efficiency correction factors for non-normal distributions. The results presented here are preliminary, and work is to be continued on this subject.

**References**


