Methodology Assessment of the Total Beta Activity in Tobacco and Tobacco Products and Certain Results

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Abstract. The presence of alpha and beta radionuclides in tobacco and tobacco products is a frequently discussed issue. However, any information in publications about them and their presence in tobacco products is too scarce. World Healthcare Organization monitors the influence of tobacco smoking on human health. In 2003, a Framework Convention on Tobacco Control was accepted with the aim to protect human health, which was signed by 179 countries, including Bulgaria. The first debates on the presence of radionuclides in tobacco products are raised in Moscow in 2014. These were instigated by data on the findings of polonium-210, reported by USA and Russia. The aim of the report is to outline a metholdology to detect the presence of beta-active radionuclides in tobacco and its products.

Keywords: beta activity, geiger counter, samples with infinite thickness, tobacco samples

1 Introduction

The presence of alpha and beta radionuclides in tobacco and tobacco products is a frequently discussed issue. However, the publications on their contents is too scarce.

On May 21, 2003 World Healthcare Organization (WHO) launches the Framework Convention on Tobacco Control (FCTC) in Geneva. Currently the convention is ratified by 179 countries. Bulgaria has also ratified the convention by a law passed by the 40th National assembly [1].

At the latest meeting Conference of the Parties to the WHO Framework Convention on Tobacco Control, the issue about the contents of radionuclides in tobacco and tobacco products was raised [2].

That was instigated by the publications of American and Russian scientists, who after a lot of time consuming experiments have managed to extract and identify quantitatively polonium-210 in tobacco.

The aim of the report is to devise a methodology to detect the presence of beta-active radionuclides in tobacco and its products.

The hereby experiments are carried out in the radiometric lab of Tobacco and Tobacco Products Institute in Markovo.

2 Methodology for Identification of Specific β-Activity of Powdery Samples

The identification of total β-activity in food products is regulated by industry standards No 165/1985 by Ministry of Healthcare. For the experiments, the radiomeasured item is burnt at 450°C and 200 mg ash is taken to be analysed.

The sample's activity is identified using a method of relativity. Potassium chloride is used as a reference compound. It has a specific activity (A_{sp}) 14.6 Bq/g due to the natural radionuclide potassium-40 in it. The masses of the samples are small, so they are "infinitely thin".

When burning tobacco products some radionuclides are released with the smoke. To avoid this, all tobacco samples are primed by being dried at up to 38°C. Hence, specific activity of the tested sample is not increased. Thus, when radiomeasuring samples with small mass (of about 200 mg), radiation can be detected background values.

From all of the above, it can be inferred that industry standards 165 about the identification of the the total beta activity is inapplicable to tobacco and tobacco products.

A better methodology is the one reported in [3] "Methodology for identification of total activity in powdery samples", where the measurements are carried out with "infinitely thick samples", at identical geometric conditions.

To prove the applicability of the methodology, the two fundamental experiments were repeated for measuring tobacco samples.

Figure 1 shows the results of those measurements, carried out to establish the dependence of the detected intensity of the beta radiation on one and the same tobacco, for samples of dissimilar surface density d (g/cm^2), at identical measuring conditions. To rise statistics accuracy, 20 g of potassium chloride per 100 g tobacco was added to the sample. The laboratory results show that the infinite thickness when radiomeasuring powdery tobacco probes is $0.35 \div 0.40$ g/cm^2, as it is reported in [3] value for pure potassium chloride.

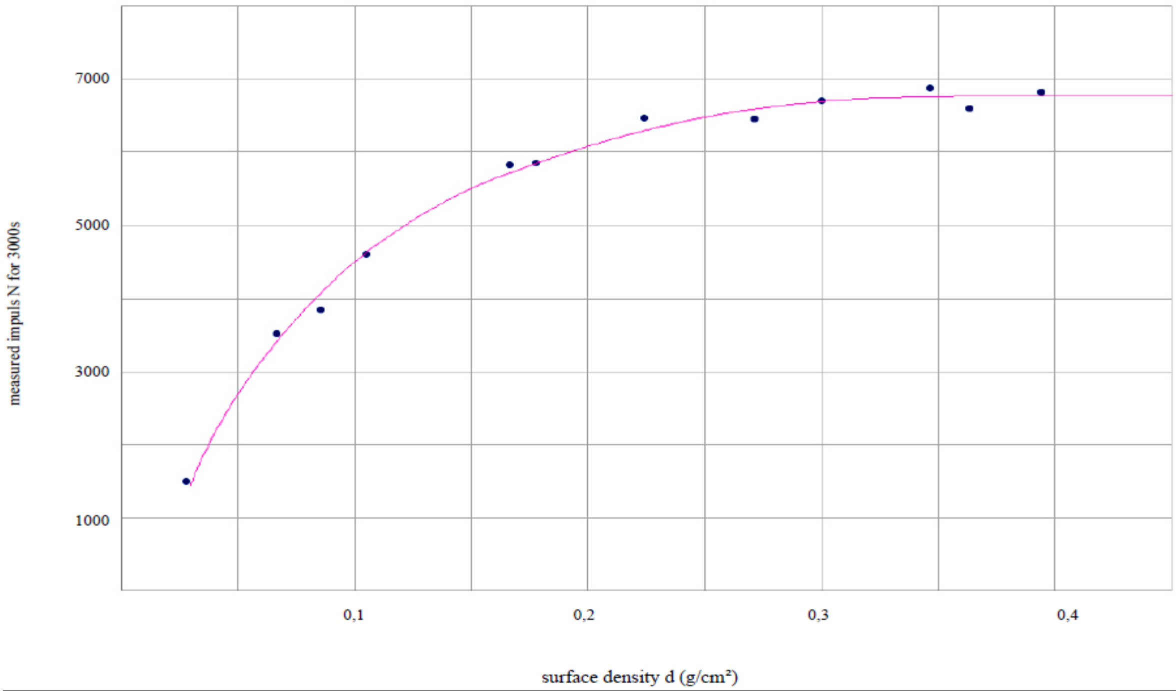

Figure 1. Dependance on the registered intensity of the samples' surface density.

The second experiment was carried out to establish the equation $I = f(A_{\text{sp}})$ of infinitely thick samples of one and the same tobacco blend. The samples were primed by adding of various amounts of potassium chloride. The specific activity A_{sp} (Bq/g) of each sample is defined by the activity of potassium chloride, and is known in advance. The results of these measurements are shown in Figure 2. It is clear that the dependance of the detected intensity I [s^{-1}] on the specific activity of the samples is direct.

The intensity, recorded without any added potassium chloride, is determined by the activity of the tobacco. Each experimental point is determined by a standard deviation $\delta < 1\%$.

From all of the above, it can be inferred that the methodology called "identification of the specific activity of powdery samples of infinite thickness" is applicable when identifying the total β-activity of tobacco and tobacco by tobacco products. The specific activity is established, using a method of relativity, at identical geometric measuring conditions. Potassium chloride is applied as a referen-

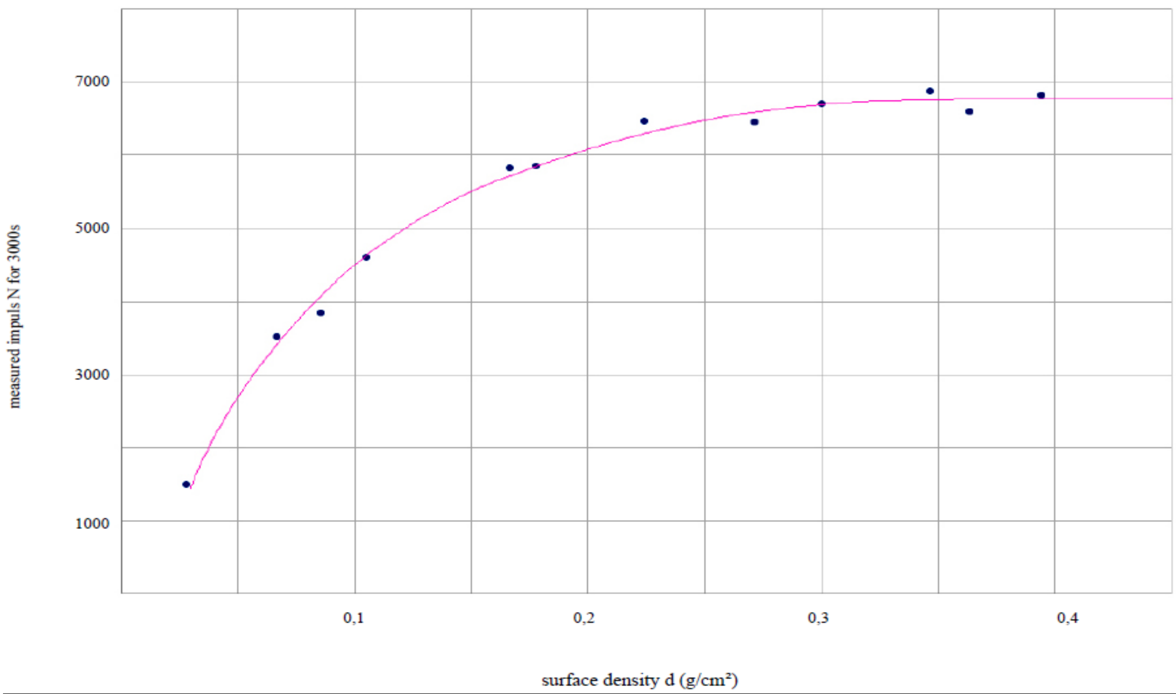

Figure 2. Dependance on the registered intensity I of the specific activity of the samples.

tial sample. To establish the specific activity of a sample A_X, we need to establish the intensity of counting I_{ET} from the reference sample with specific activity A_{ET} and from the tested sample I_X with the rate:

$$A_X = A_{ET}\frac{I_X}{I_{ET}}$$

Compared to industry standards No 165/1985, the methodology for the identification of specific activity of powdery samples of infinite thickness has the following advantages: repeatedly increased intensity counting, leading to a reduction in radiomeasuring time interval and rise in the statistics accuracy and does not require determination of the mass of the radiomeasured samples.

The radiomeasured powdery tobacco substance is of small and different density. To comply with the regulated surface density d be greater than 0.4 g/cm^2, the samples were kept in peculiar probe holders 1 cm thick. After measuring, with precision of 1%, it was found that under different surface density of one and the same tobacco blend, the measured intensity of counting I remains unchanged.

3 Radiometric Equipment

Figure 3 shows the implemented laboratory radiometric equipment R2014. It is a modification of the one outlined in [4] creation, called "Laboratory radiometer R2013" developed by a team of scientist from Optics and Atomic Physics department at the Paisii Hilendarskii University of Plovdiv. It consists of a measuring probe and an electronic unit.

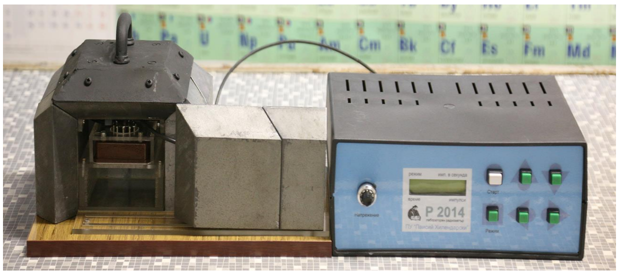

Figure 3. Laboratory radiometric equipment R2014.

3.1 Measuring probe

The main requirements for a radiometer to register small activities are:

- Minimum intensity of background impulses;
- Maximum counting intensity from the tested sample.

After the analyses of the measuring qualities of various types of Geiger–Muller (GM) counters, supplied with a thin measuring window, the GM counter type CÁT-10 showed the best indicators. It was installed in the measuring probe R2014. Due to its large measuring window, the highest counting intensity I of the sample is achieved. The GM counter is set in a protective 5 cm thick lead shield, equipped with standard lead bricks, 10×10 cm in size, and further customized details. When radiomeasuring of biological substances this passive protection is sufficient, as the concentration of potassium atoms in them, hence the activity of the samples, is big enough.

After the selection of a GM counter, a selection of geometric measuring conditions was carried out to obtain maximum intensity count I, determined by the specific avtivity of the powdery sample.

For samples of biological origin, there are no restrictions on its quantity.

Thus the identification of the beta activity of powdery substances using "infinitely thick samples" from "infinitely big measured surface" significantly increases the registered counting intensity.

The tests were carried out with unusual plastic probe holders, 9×7.6 cm in size, and surface $S_p = 68$ cm^2. The samples inside are 1 cm thick and regardless of the density of the powdery sample, the specification for the infinite thickness of the sample is fulfilled.

The measuring area of the detector is $S_d = 6.5 \times 5.6 = 364$ cm^2.

At a distance between the sample and the counter of 0.1 cm and the indicated values of S_p and S_d it could be considered that the measurements are taken from a sample with "infinitely big surface".

After selecting GM counters and geometric conditions, the quality criterion for the probe was introduced with the equation:

$$k = I_{KCL}/I_{FON}$$

where

I_{FON} – intensity of the registered background radiation;

I_{KCL} – intensity of potassium chloride (KCl) in a sample holder of infinite thickness.

The greatest value of k was obtained for the GM counter CÁT-10 with the described sample holder:

$$k = I_{KCL}/I_{FON} = (26.32 - 1.15)/1.15 = 22$$

3.2 Electronic unit of radiometer R2014 composed of

a permanent source of electricity $200 \div 1000$ V for GM counters;

b Amplifier, shaper and sound indicator of the registered impulses;

c Timer for selecting temporary measuring range $\Delta t = 1 \div 9999$ s;

d Intensimeter for the autonomous measuring [s^{-1}] with accuracy of 4 decimal signs;

e 6-digit LCD display with 16×2 characters, with backlight to indicate.

The computerized diagram of the device includes a microprocessor unit with microcontroller RIC18F97J60 for counting impulses. It has a big memory supply and computing potential that may be used to the particular requirements of the user.

Table 1. Specific activity of tobacco samples

Sample	Number of measured impulses	Measuring time Δt [s]	Registered intensity I with background correction [s^{-1}]	Specific activity of of the sample A_{sp} [Bq/g]
KCl	49004	2000	23.284	14.6
No 113	13610	6000	0.97	0.60
No 114	13338	6000	0.946	0.59
No 115	11402	6000	0.682	0.43
No 116	12192	6000	0.755	0.47
No 117	12208	6000	0.737	0.46

During the tests, outlined in this report, the P2014 mode was applied. The display marks the number of the registered impulses N, the measuring time interval Δt [s] and the counting intensity I [s^{-1}].

4 Results

The results from several measurement are given as a demonstration.

Table 1 shows data after the analysis of five tobacco samples. The detected specific activity of the samples ranges from 0,43 Bq/g to 0,60 Bq/g.

References

[1] Law Gazette, number 15 of 17.02.2006

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