



Biomedical Technologies
Bioimaging – Experimental Radiology

Lab Report:
"Radiation Safety"

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1. Introduction

^{32}P is a strong beta emitter which means that it is an unstable isotope which decays and radiates electrons (β -particles). Beta-radiation can be easily shielded with acrylic glass or aluminium as its penetration power is minimised drastically inside these materials. However, lead shouldn't be used with beta radiation as the beta radiation causes Bremsstrahlung in atoms with high ordinal numbers. The radiation can be measured with many different measuring devices and principles, LSC (liquid scintillation counting) being one of them. LSC is an accurate, safe and measures light impulses which are created when a beta emitter interacts with the "scintillation cocktail", a chemical agent in which the ^{32}P is embedded.

The light impulses can be translated into activity, a rate which describes the radioactive decay per time. It can be computed the following way:

$$A = \frac{R_N}{\eta * 60} = \frac{(R_B - BG)}{\eta * 60}$$

As to evaluate the measured activity the uncertainty 2σ can be calculated.

$$2\sigma = 2\sqrt{N}$$

The strength of the detected radiation is referred to as intensity. The intensity detectors, however, have limits on the maximal and minimal level of intensity they can measure.

When the intensity is greater than the limit, the typically linear relationship between activity and intensity begins to shift, with the slope of this relationship gradually decreasing until it reaches zero. This is called saturation, as the intensity level isn't dependent on the amount of radiation anymore.

2. Procedure

In the first experiment, which determines activity levels of a ^{32}P -sample, 10 μl of scintillation cocktail is gently mixed with 5 μl of the ^{32}P sample in a Maxi-Vial. To achieve a more precise activity measurement, this process is repeated three times as the results can be averaged afterwards. These three vials, along with a separate vial containing only the scintillation cocktail as a background measurement, are analyzed in an LSC counter.

The second experiment examines the relationship between the volume of the ^{32}P sample and the measured intensity. A TLC plate is divided into four sections, each receiving a different volume of ^{32}P (5 μl , 15 μl , 30 μl , 60 μl). The TLC plate is afterwards placed in a ventilated area to dry more quickly, then wrapped to prevent particle contamination in the laboratory. Next, the TLC plate is positioned onto a photo plate inside a cassette for a 20-minute exposure to incubate. Finally, the photo plate is placed in the FLA 300, where the resulting scan allows intensity calculation using the accompanying software. The program calculates intensities after manually selecting the four sections of the TLC plate for measurement, along with an additional background window for reference.

During the entire practical a careful handling of the radioactive material and the samples, as well as the contaminated materials, like gloves or pipette-tips, is provided. The activity within the working field was constantly checked with a Scint-based alpha and beta radiation detector.

3. Results

The acquired radiation with the LSC is expressed in Counts per min. In *Table 1* the results as well as the computed Activity and 2σ standard deviation are shown.

Table 1 Activity Concentration Determination of 5 μ l Samples

Sample No	Counts per min [cpm]	2 σ calculate [cpm]	Activity [Bq]
1	685550	1655,96	11778,76
2	699800	1673,08	12023,61
3	725350	1703,35	12462,62
BG	26	-	-

Shown in *Table 1*, the counts per minute vary from 685550 cpm to 725350 cpm. The calculated activity values reach from 11778,76 Bq to 12462,62 Bq.

As to reach the most accurate Activity, the mean of the previously computed Activity is formed. This results in a mean Activity of 12088,33 Bq. Finally the standard deviation for the mean is computed.

$$A = 12088,33 \pm 346,49 \text{ Bq}$$

As to evaluate the concentration of the ^{32}P -sample, the Activity per volume is considered:

$$2\sigma_c = \frac{2\sigma_A}{V} = \frac{346,49 \text{ Bq}}{5000 \mu\text{L}} = 0,069 \frac{\text{Bq}}{\mu\text{L}}$$

$$A_v = \frac{A}{V} = \frac{12088,33}{8000 \mu\text{L}} = 2,417 \frac{\text{Bq}}{\mu\text{L}} \pm \frac{0,069 \text{ Bq}}{\mu\text{L}}$$

Next the intensities of different volumes can be analysed. For that the following image was acquired.

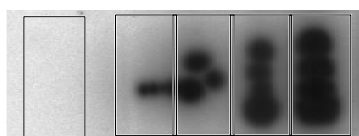


Figure 1 Different Volumes of ^{32}P on a TLC plate (scanned)

With the help of the accompanying software following intensity values were found:

Table 2 Intensities per Area for specific Volumes of P-32

^{32}P - Volume	Intensity/Area [PSL/mm ²]	Intensity/Area – Bkg [PSL/mm ²]
5 μ l	80,08	78,78
15 μ l	288,40	287,10
30 μ l	362,44	361,14
60 μ l	791,28	789,98
Bkg	1,30	-

In *Table 2* the intensities per area for the volumes between 5 μ l and 60 μ l are shown as well as the background corrected values.

When visualized in a graph (*Figure 2*), a linear fit with $y = 12,686x + 25,598$ can be applied.

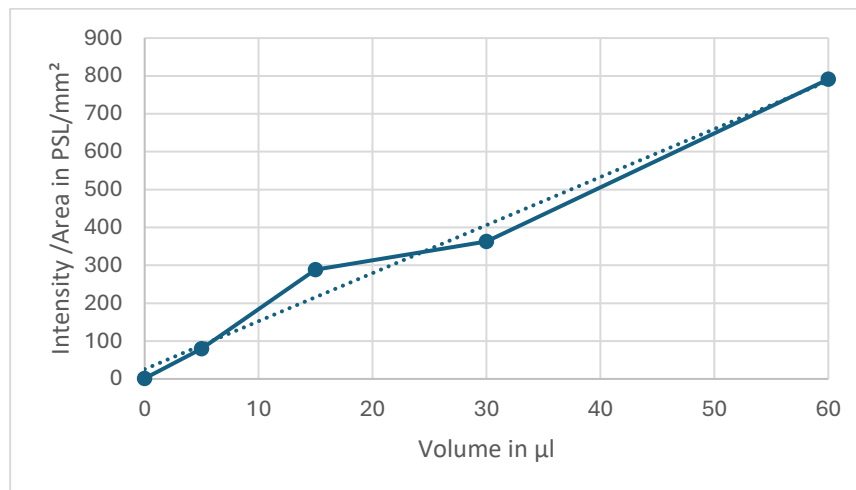


Figure 2 Correlation between Intensity per Area and Volume

4. Discussion

In part one of the exercises the measured activity shows a small standard deviation of 346,49 Bq which indicates accurate measurement and pipetting techniques. The activity concentration also shows a low standard deviation (0,069 Bq/ μl) due to the accurate lab work performed. All in all, this experiment suggests that the lab techniques performed were done accurately.

For further experiments the error of insufficient accuracy in the lab can be considered minimal.

In the experiment's second part, the increase of intensity with an increase of volume can be approximated with a linear fit as seen in *Figure 1*. This suggests that there is no saturation effect within the measured range. Saturation effects might need to be considered at higher concentrations but within this range of activity concentration the intensity can be approximated using the linear fit. The values measured can be influenced by the precision of the FLA scanner and the preparation in the laboratory. As determined earlier the laboratory procedures can be considered accurate. Therefore the majority of error possibility is due to errors from the FLA scanner.