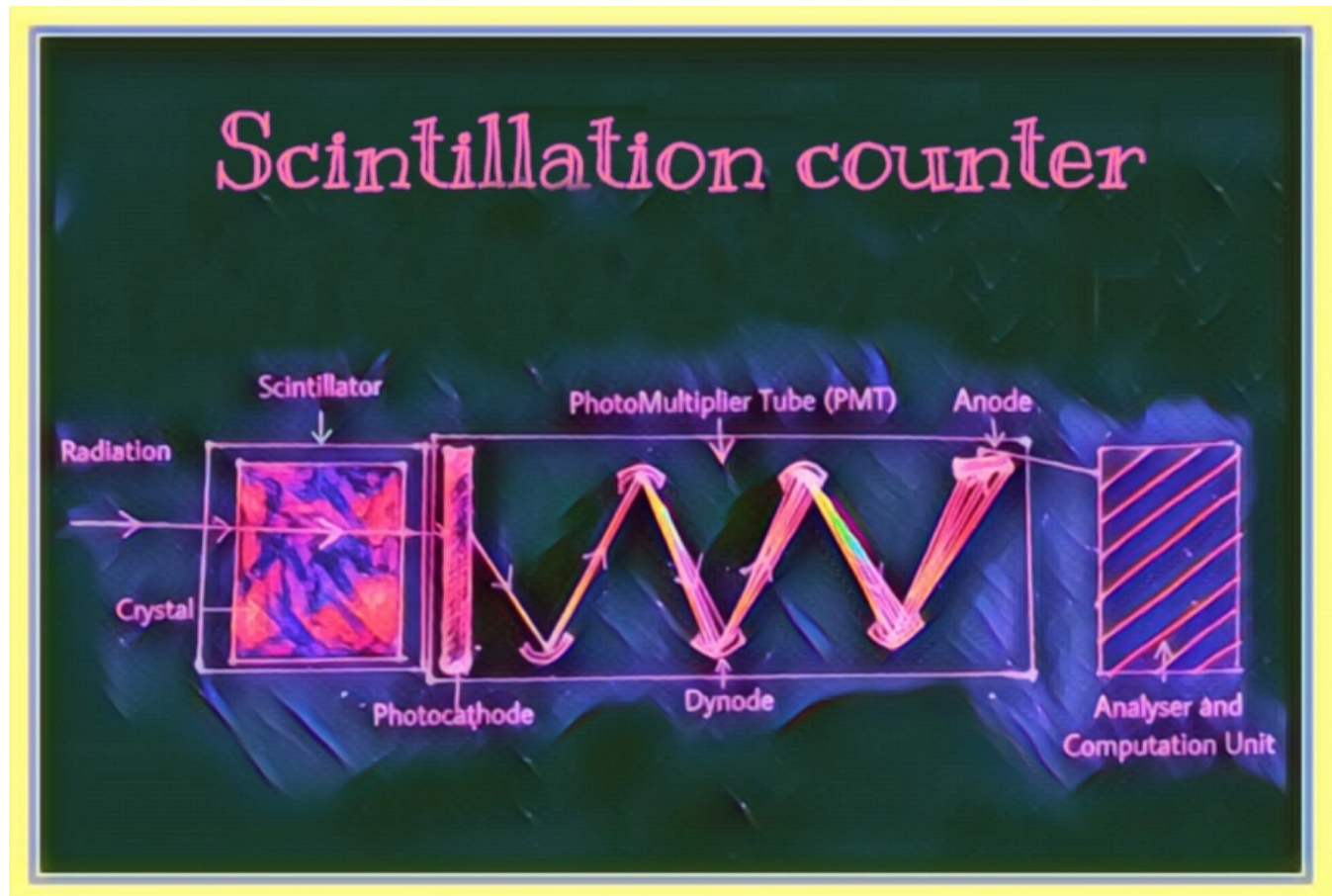


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Concepts simplified

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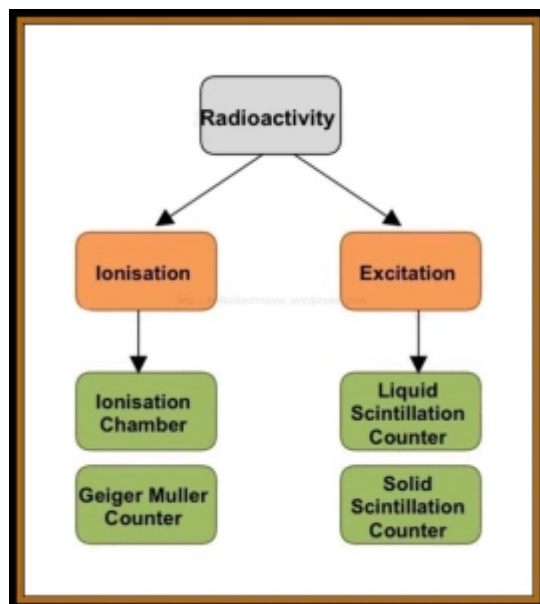
Detection and Measurement of Radioactivity: Scintillation Counter.



Solid Scintillation counter

Date: March 22, 2019 Author: The Biotech Notes 0 Comments

In the previous post, we discussed about the basics of the radioactivity. We know that the radioactive isotopes interact with the matter, causing **ionization** and **excitation** and that radioactivity can be detected by different devices on the basis of its property to ionise gas atoms.



Methods of Detection of Radioactivity

The property of the radioactive compounds to cause excitation is also used to detect the radioactive matter in the instrument called as **Scintillation counter**. In this instrument, the radiation is allowed to interact with a crystal or fluor which emits photons of light. These photons emitted appear like small flashes of light, a process known as scintillation. These flashes are detected and further analysed.

Scintillation counter can be used for both quantitative and qualitative purposes:

Quantitative:

As the number of scintillations is proportional to the rate of decay (that is the radiation emitted) of the sample, the amount of radioactivity can be quantified.

Qualitative:

Different radiation differ in the level of energy, resulting into the lights of different intensities. Hence the instrument can differentiate between different radiations.

The scintillation counter has three major parts; a scintillator, a photodetector and an analyser.

a. Scintillator:

Scintillator consists of a **crystal or a fluorescent** material. These materials absorb the energy from the radioactive radiation and get excited and fluoresce like a flash of light, phenomenon known as scintillation.

b. Photodetector:

The flash of light or photon then passes to the photodetector. The function of a photodetector is to convert the fluorescent light into electrical signal. One such photodetector is **photomultiplier**. It is a vacuum tube, in which the photon passes from the fluor to the **photocathode**. A photocathode is cathode coated with a photosensitive compound, which on getting excited by photon releases electrons. These electrons are directed towards a **dynode**. The dynodes when hit by single electron causes emission of more electrons. Each dynode hence releases more electrons than the previous dynode and amplifies the signal. Hence the device is called photo'multiplier'. The electrons emitted by the last dynodes reaches the **anode** and the flow of current is detected and further can be analyzed by the **computers**. Other photodetectors used are silicon photodiodes

There are two types of scintillation counters based on the fluorescent material used and the set up. They are:

1. **Solid scintillation**
2. **Liquid scintillation**

1. Solid scintillation:

In the solid scintillation counters, the sample is placed in a vial, just adjacent to a **crystal** or fluorescent material. Crystals are in turn placed near to the photomultiplier connected to a high voltage supply and a scaler.



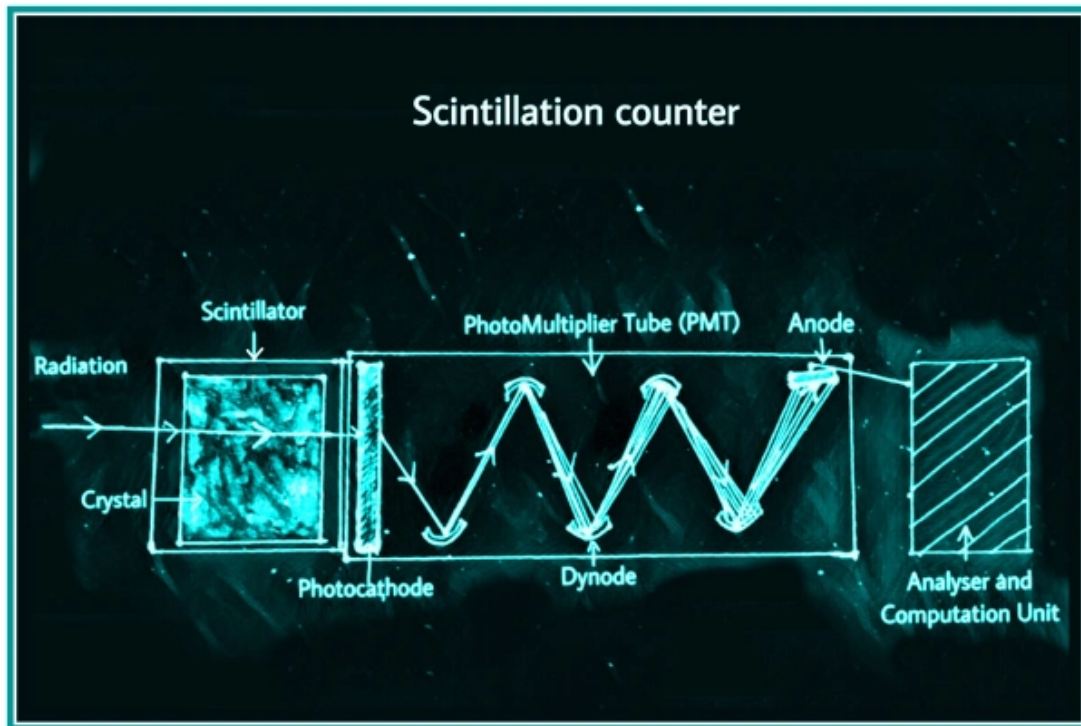
Portable handheld Scintillation Counter (Delta Epsilon)

The crystal normally used are:

- For γ -isotopes: sodium iodide
- For α -emitters : zinc sulphide crystals
- For β -emitters organic scintillators s/a anthracene

The solid scintillation counter is especially useful for **γ -emitting isotopes** as these rays are electromagnetic radiation and can collide well with the **densely packed** atoms of solid crystals. However the β -emitting isotopes such as ^3H and ^{14}C are not efficiently detected, as

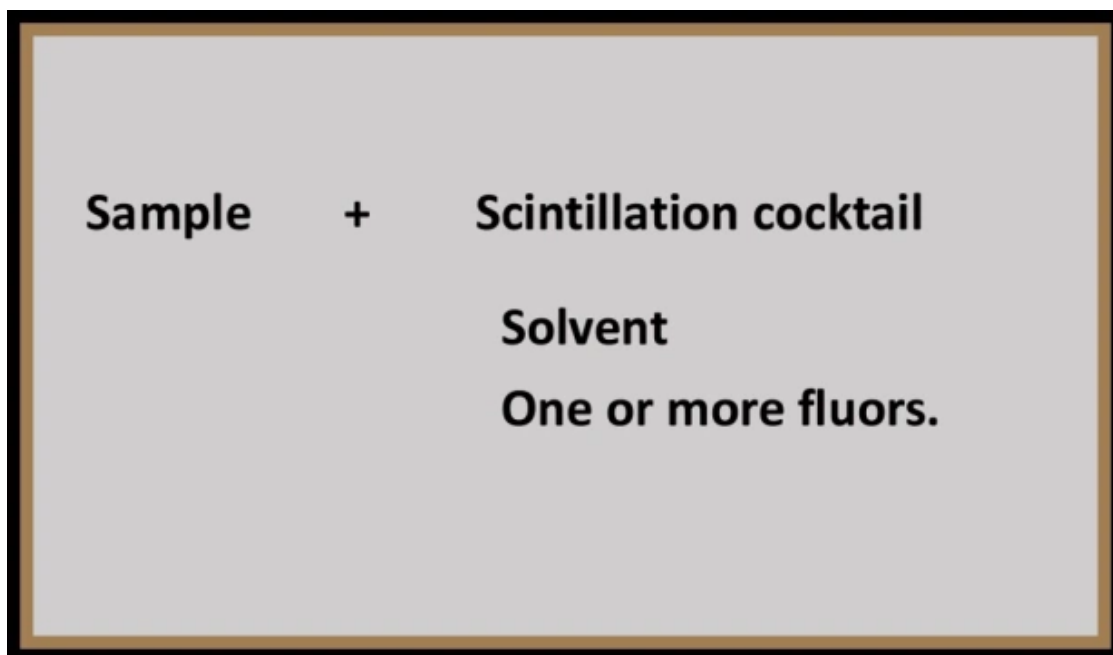
they lack energy to penetrate the wall of the sample vials.



Solid Scintillation counter

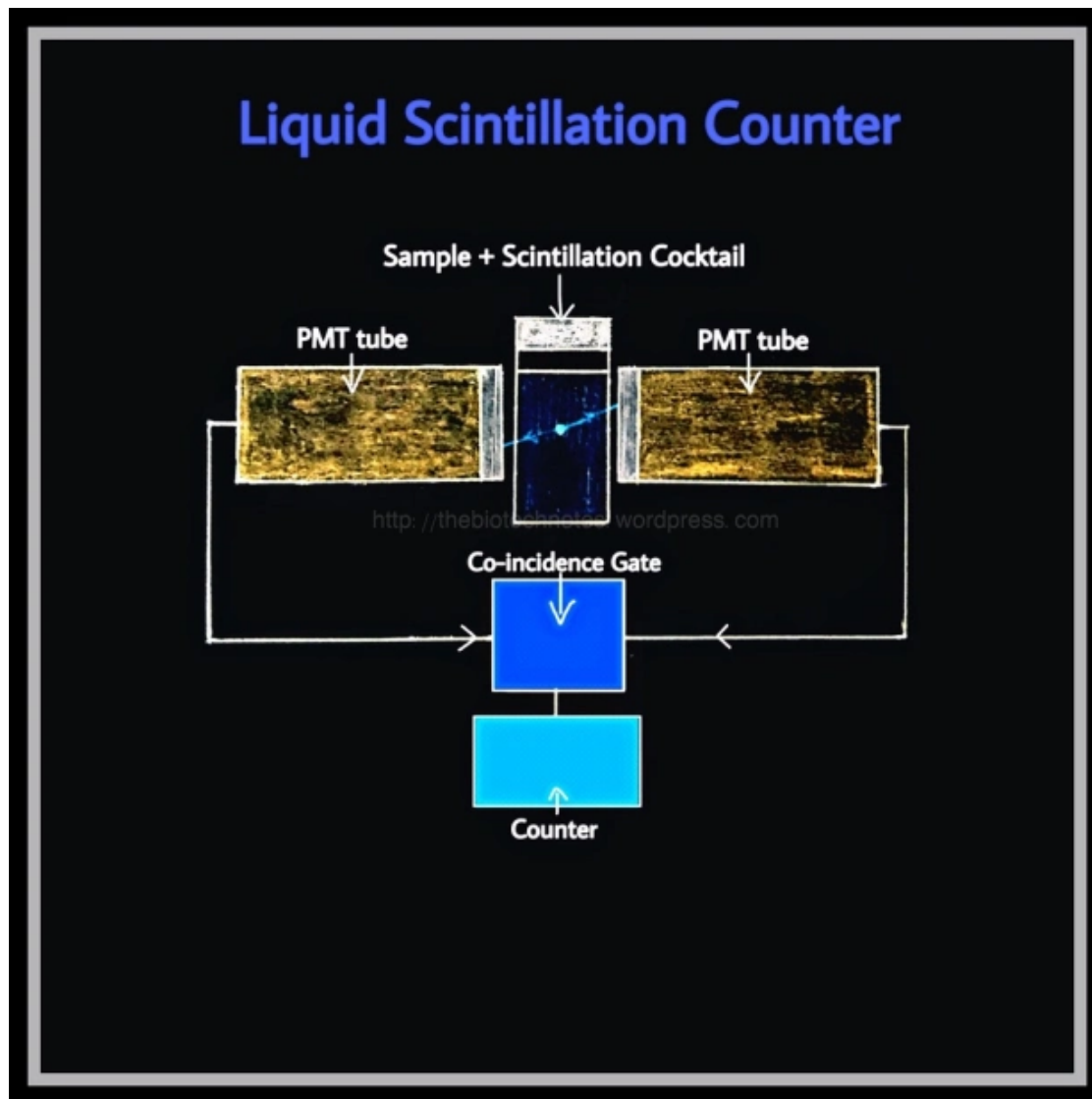
2. Liquid scintillation

In liquids scintillation counter, the sample is mixed with **scintillation cocktail**, containing a solvent and one or more **fluors**. This method is particularly useful for quantifying the weak β -emitters often used in biological work.



Scintillation cocktail

Radioactive particles interact with the organic solvent and cause fluorescence. Fluorescence produced could be of shorter wavelength and not efficiently detectable, hence a substance called as fluor is added. A primary fluor added accepts energy at shorter wavelength and fluoresces at longer wavelength, which is detected more efficiently. Most frequently used fluor is 2,5-diphenyloxazole (PPO).



Liquid scintillation counter

Addition of a secondary fluor further increases the efficiency. Commonly used secondary fluor are 1,4-bis(5-phenyloxazol-2-yl) benzene (POPOP). The liquid scintillation counter have two PMTs for better detection



Liquid Scintillation Counter by Hidex

(*Just for info*: watch this video demonstrating a Scintillation counter)

Advantages:

1. In scintillation counter especially liquid scintillation counter, there is direct interaction of the sample with the fluor, and there the radiations do not have to travel through air or pass through any window. Due to this there is minimal energy loss and higher efficiency for detection of weak β particles.
2. Different types of samples like solids, liquids suspensions and gels can be used.
3. The scintillation counter can differentiate between different isotopes in the same sample, allowing the analysis of dual labelled biological experiments.
4. This instrument can be automated and many samples can be processed at a time.

Disadvantages:

Most of the disadvantages can be overcome by modification in the design of the instrument:

1. The cost per sample of scintillation counting is high. But it is versatile, sensitive, easy to use and accurate for most applications.
2. At high voltage there occurs photomultiplier noise, that is there are electronic events independent of radioactivity.
3. The scintillation counter needs a temperature controlled environment to avoid the heating up.
4. Quenching is a problem in scintillation counter. Quenching causes interference in the energy transfer process. The quenching problem can be solved but increases the cost of the process. Quenching are of the two kinds;
 - **Optical quenching**: this occurs when scintillation vials used are dirty or improper and absorb part of emitted light.
 - **Chemical quenching**: this occurs when there is contamination in the sample, which interferes with the transfer of energy from the solvent to the primary fluor or from the primary fluor to the secondary fluor.

5. Chemiluminescence: emission of light by certain chemicals, from other sources like solvent and fluor. These light emissions are of low energy and can be excluded by setting a threshold value for photo multiplier noise. Also storing the sample for some time before counting, causes the chemiluminescence to decay.

6. Phospholuminescence: This is light emitted from other sources like components of the sample and vials. The light is absorbed and re emitted. Keeping the samples in dark prior to counting helps avoid this issue.

Applications:

The scintillation counters are used in several places to detect the radiations like portable survey meters, medical imaging, Southern blotting, ADME studies in drug discovery, radioimmunoassay, bioluminescence and so on. Other places are border security devices, nuclear plant to trace the leakage, etc

Precautions:

As mentioned radioactive photons/particles can ionize and excite other atoms. When the living matters are exposed to such radiations, there can be molecular reactions and damages. Hence it is very important to follow certain precautionary measures when working with radioactive substances. The work-place, the benches should be properly checked for radioactivity. The samples should be properly stored. Proper clothing and covering should be used when working with radioactive materials.

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This is all about radioactivity and their detection methods. Hope you find the two posts useful, if yes please comment, like and share!!

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Have a nice day!

Thank you!!

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