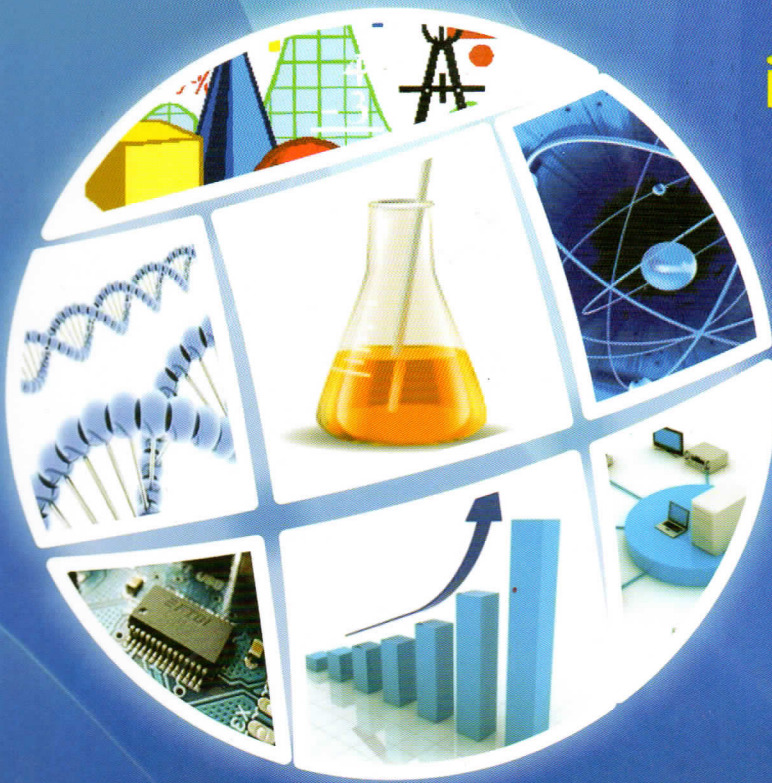


4th iSNPiNSA



International Seminar on New Paradigm
and Innovation on Natural Sciences
and its Application



Innovation
in Applied Science
for Environmental
Resource
Sustainability

PROCEEDINGS



Diponegoro University
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*The 4th International Seminar on
New Paradigm and Innovation on Natural Sciences and its
Application 2014*

Supported By:



***“Innovation in Applied Sciences for Environmental
Resource Sustainability”***

Dr. Jatro Eno Suseno, M.Si

Dr. Eng. Hendri Widlyandari, M.Si

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A Study of Antrasen Organic Material ($C_{14}H_{10}$) in a Scintillation Detector

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ABSTRACT

A scintillation detector that uses antrasen organic material ($C_{14}H_{10}$) as its scintillator to detect beta radiation has successfully been built. This research is aimed at proving the ability of antrasen ($C_{14}H_{10}$) as an organic material that can detect beta radiation from sources of known activities. The other purpose is to make a scintillator of optimum thickness that produces maximum radiation count and efficiency. The scintillator was made by putting the antrasen ($C_{14}H_{10}$) under a 120 kN/cm² Pressure. Thickness of the resulting scintillator varies from 1 mm to 5 mm with 0.5 mm variation. Test results indicate that those scintillators are capable of detecting beta radiation. This is evident in the sheer number of count ratio between background and source radiation detected. Optimum thickness for Cs-137 is 2 mm with an efficiency of 92.1%. Results also indicate that the antrasen ($C_{14}H_{10}$) improves the counts produced by the NaI(Tl) organic detector by up to 2.9% through 67.3%.

Keywords: organic scintillator, antrasen ($C_{14}H_{10}$), beta radiation, detector efficiency

1. INTRODUCTION

A research on the use of antrasen ($C_{14}H_{10}$) as a scintillator has earlier been conducted by Evi et al., [1]. This particular study produced a scintillation detector from the antrasen organic material that is able to detect beta radiation from ⁹⁰Sr and ¹³⁷Cs radioisotopes. But efficiency of the detector was still relatively low, at 8.8 % to 31.5%.

Antrasen was chosen as the main component of the scintillator as it has a very short response time (less than 1 ns) compared to other organic materials that typically have more than 1 ms response time, hence it is suitable to detect high intensity radiation. The other reason is that because antrasen does not require other materials to serve as activators. It is due to the fact that the energy gap between its conducting and valence layers is only around 3 – 4 eV. This is in contrast to other organic materials that might require activators, such as NaI that needs Tl and ZnS that depends on Ag as their respective activators. [2]

Low efficiency can be improved by, among other things, making optical contact between the scintillator and the PMT photocathode surface in order to let all intensities passing through the scintillator reach the photocathode surface with no refraction at all. Another option is by giving MgO powder as reflectors. [3]

This research also examines the effect of antrasen ($C_{14}H_{10}$) organic scintillator on the organic NaI(Tl) scintillation detector.

2. RESEARCH DESIGN

The scintillator is made by putting antrasen ($C_{14}H_{10}$) in a stainless steel mould and applying a 120 kN/cm² onto it. The resulting thickness varies from 1 mm to 5 mm with 0.5 mm variation. The scintillator mould is as depicted in Fig. 1. It measures 4.2 cm in width, 15 cm in height and 22 cm in length.

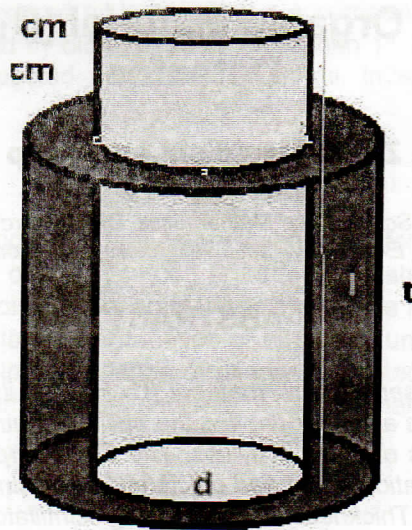


Figure 1. Scintillator mould.

The scintillator is then tested by using it to count Cs-137 beta radiation (initial activity on 1 August 2011 was 1 μ Ci) with equipment set up as depicted in Fig. 2. The voltage was at 800 V as required by the PMT (Serial 63 Type 9266B Scintiblock Crismatec Leybold)

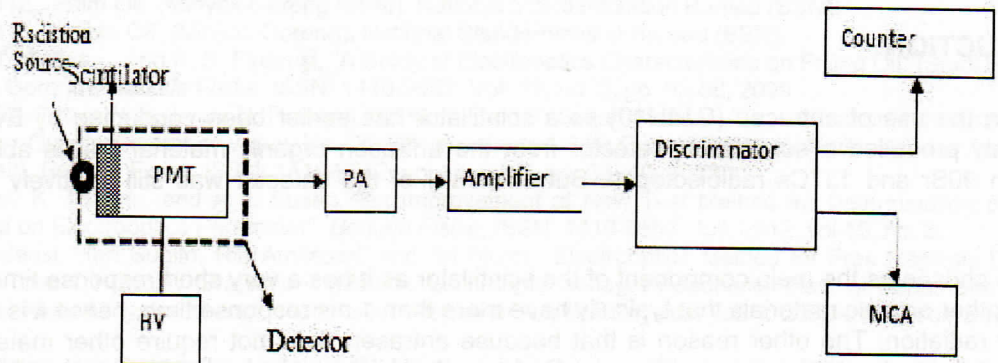


Figure 2. Instrument set up to detect radiation with antraseen (C14H10).

Additional testing was also performed to understand the effect of silicon oil addition onto the PMT surface.

Figure 3. shows the instrument set up to test the effect of antraseen (C14H10) addition on NaI(Tl) scintillation detector. The voltage used was 600 V, as it is the operational voltage of NaI(Tl) scintillation detector.

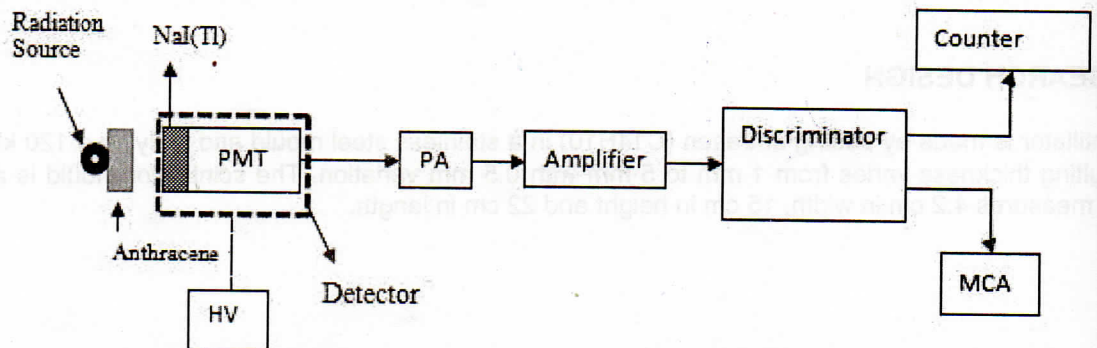


Figure 3. Instrument set up to detect radiation with antraseen (C14H10) on NaI(Tl) scintillation detector.

3. DISCUSSION

3.1. The Effect of Scintillator Thickness on Detector Efficiency

Figure 4. illustrates graphical representation of the relationship between antrasen ($C_{14}H_{10}$) thickness and Cs-137 radiation count. The equipment set up that results in this graph is the one described in Fig. 2.

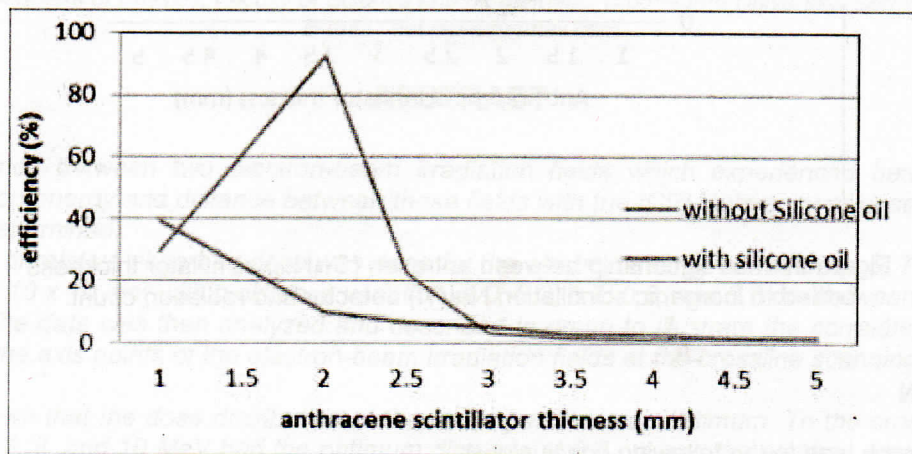


Figure 4. The relationship of antrasen ($C_{14}H_{10}$) thickness and detector efficiency.

It is readily observable from Fig. 4. That efficiency rises from 29.7% (thickness 1mm) to 92.1 % (thickness 2 mm) and then falls down sharply. It indicates that that is the optimum thickness, beta radiation (β) cannot penetrate this thickness.

Fig. 4. also shows that silicon addition onto the PMT surface only improves detector efficiency at 1 mm thickness (from 29.7% to 39.3%). This due to the fact that the silicon oil used did not also serve as an optical contact and therefore some lights are still refracted prior to reaching the photocathode. And it also added distance from the source to photocathode that it actually reduced the energy reaching the photocathode, and hence, detector efficiency.

It is recommended that the results here should further be improved by integrating it with other disciplines, such as JST [5,6,7] to determine the maximum energy of beta radiation.

3.2. The Effect of Antrasen ($C_{14}H_{10}$) Addition on inorganic Scintillation NaI(Tl) Detector

The antrasen ($C_{14}H_{10}$) scintillator turns out to be able to improve radiation count detected on the inorganic scintillation NaI(Tl) detector. The instrument set up is depicted in Fig. 3. Fig. 5. Describes the relationship between Antrasen ($C_{14}H_{10}$) scintillator thickness added to inorganic scintillation NaI(Tl) detector and detected count.

The graph indicates that the thicker the antrasen ($C_{14}H_{10}$) scintillator, the higher the count is. And up to 4.5 mm was gradually added to the antrasen ($C_{14}H_{10}$) scintillator. Count increment varies from 29 % through 67.3% of initial count when no additional antrasen ($C_{14}H_{10}$) thickness was administered.

It is also noticeable from the graph that line trend $y = 27.29x + 275.15$ exists, which means that without the addition of antrasen ($C_{14}H_{10}$), the detected count is 275.15, whereas the actual count is 296. It proves that antrasen ($C_{14}H_{10}$) scintillator significantly increases detected. This is caused by the interaction of radiation with the antrasen ($C_{14}H_{10}$) scintillator material that results in more electrons are excited to the valence band and de-excited to the valence band, as the energy gap is only 3 eV [3].

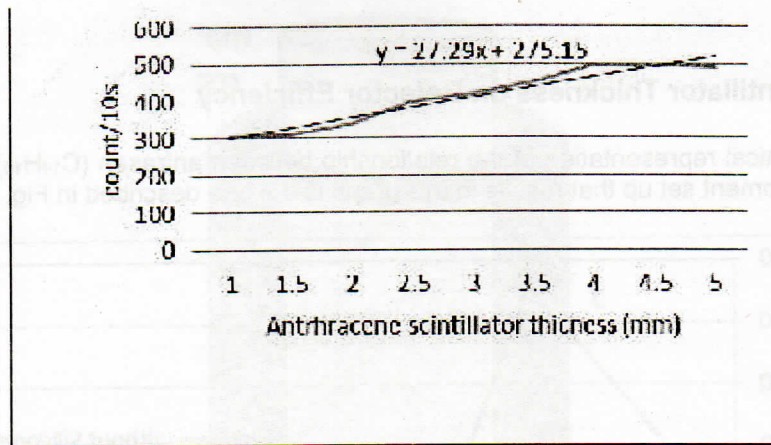


Figure 5. The relationship between antrasen ($C_{14}H_{10}$) scintillator thickness added to inorganic scintillation NaI(Tl) detector and radiation count.

4. CONCLUSION

Results of this research lead to the following conclusions:

- A scintillator made of organic antrasen ($C_{14}H_{10}$) has been built.
- The optimum thickness of organic antrasen ($C_{14}H_{10}$) scintillator is 2 mm, with efficiency 92.1%.
- The addition of organic antrasen ($C_{14}H_{10}$) material increases count on NaI(Tl) inorganic scintillation detector with values from 2.9 % to 67.3% .

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