In this work, R-12 drop have been suspended homogeneously in a viscous fluid containing 3.9% of 3H. Protons deuterated from a radiocarbon source were detected by a R-12 detector at room temperature. The total efficiency of the R-12 detector is about 6%.

Abstract

Department of Physics, Bose Institute, Calcutta 700 009, India

PHOTON SENSITIVITY OF SUPERHEATED DROP AT ROOM TEMPERATURE
glass vial was exposed to gamma rays (59.54 keV) from $^{241}\text{Am}$ (0.5 Ci) at an average room temperature of 25°C and the nucleation was observed by counting the number (N) of drops vaporised per minute (t). This was done by detecting the pressure pulse produced due to each drop vaporisation with the help of a piezo-electric transducer\[8\], coupled to a drop counter and multichannel scaler (MCS). The nucleation rate ($dN/dt$) has been recorded continuously in MCS. The results presented in figure 1 shows nucleation rate ($dN/dt$) with time (t). The nucleation rate at any time is proportional to the flux of incoming photons and the number of drops present in the sample at that time. Therefore $dN/dt$ decreases with time as nucleation proceeds.

Nucleations due to background radiations and due to the presence of heterogeneous nucleation sites, if any, have been recorded for 65 minutes at the beginning of the experiment. The radioactive $^{241}\text{Am}$ was then placed very close to the detector (at a distance of 1.2 cm from the centre of the detector vial) to observe the nucleation prominently and the nucleation rate was noted. Nucleation due to background was noted again after removing the radioactive source. As can be seen from Fig. 1, there is significant increase in nucleation above background when the source is placed near the detector, thus confirming the gamma ray sensitivity of R-12 at room temperature. However, the efficiency of R-12 for detecting such photons at room temperature is quite small as has been observed experimentally. When the present source was placed at a distance greater than 2.5 cm from the centre of the vial (containing R-12 drops) there was no nucleation.

In a separate experiment, the R-12 sample was exposed to 32.5 mCi $^{137}\text{Cs}$ (662 keV) and 0.45 mCi $^{60}\text{Co}$ (average energy of 1225 keV), and no nucleation was noted. This result confirms the earlier observation of Apfel\[5\] and Ing et. al.\[3\].

One may ask why R-12 is sensitive to low energy photons rather than higher energies at room temperature. The answer lies on the nature of interaction of photons with matter. Gamma rays are detected by the initiation of vapour bubbles caused by the energy deposition of electrons produced by photons while passing through the liquid. Looking at the linear energy transfer ($dE/dx$) of electrons at these energies (from tens of keVs to close to 1 MeV), one may find that $dE/dx$ is larger at lower energies than higher electron energies. Therefore the energy deposition in the liquid is larger for lower energy photons and favourable for nucleation compared to higher energy photons. As the temperature of the detector sample increases, the degree of superheat of the liquid increases and it requires lesser and lesser amount of energy for nucleation of drops. This explanation was found to be true in a separate experiment, where the sample was found to be sensitive to higher energy photons (662 keV and 1225 keV) at higher temperatures. Complete investigation on this subject will be reported elsewhere.

The present discovery of the photon sensitivity of R-12 at room temperature opened up a new vista of investigation. More importantly this discovery demonstrates that it is wrong to assume that R-12 is insensitive to photons at room temperature.
and constitutes a valid warning to the users of R-12 as neutron dosimeter while assessing the actual neutron dose. Further investigations on the sensitivity of R-12 to lower energy photons are needed.

References.
1. R. E. Apfel US patent 4 143 274. (1979)