

A Possible Gamma Ray Detector using Hydroquinone

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There are a number of methods to detect gamma radiation. Almost all of these methods involve either complicated or expensive instrumentation. The best gamma-ray detectors currently in operation are those that use germanium as the sensor material. However, these detectors are very expensive to be used in regular applications. The main aim of this research was to find a cost-effective mechanism to measure gamma radiation exposure using a simple organic compound, hydroquinone (benzene-1, 4-diol).

Upon exposure to gamma radiation, certain organic compounds oxidize in to their corresponding oxidized species. Hydroquinone in an oxygen saturated acidic medium oxidizes into quinone (cyclohexa-2,5-diene-1,4-dione) and 2-hydroxybenzoquinone (2-hydroxycyclohexa-2,5-diene-1,4-dione) upon exposure to gamma radiation. Hence, different concentrations of hydroquinone in oxygen saturated 1.0 mol dm⁻³ sulfuric acid medium were exposed to various doses of gamma radiation to study the amount of oxidation products. Both hydroquinone and quinone show strong absorption in the ultraviolet region. Hence, UV-visible spectroscopy was used to find the amount of hydroquinone which had been oxidized. There were two specific peaks in the UV-visible spectrum of hydroquinone at 221 nm and 289 nm with extinction coefficient of 477.1 m²/mol and 259.54 m²/mol respectively. Quinone had a peak only at 246 nm with a high extinction coefficient of 2245.6 m²/mol.

First, the hydroquinone samples (1 × 10⁻³ mol dm⁻³) were exposed to low activity gamma radiation sources such as Cs-137 (4.08 μCi) and Co-60 (0.059 μCi). However, detectable changes in the UV-visible spectrum were not observed. Then the samples were exposed to a high activity Co-60 (9492.5 Ci) gamma radiation source with a dose rate of 2.74 Gy/min at different time intervals. It was found that with the increase in the amount of gamma radiation dose, the height of the absorption peak at 246 nm due to quinone absorption increased linearly. Auto-oxidation of the hydroquinone solutions was found to be negligible within few hours of preparation. The optimum concentration of hydroquinone was selected so that the absorbance due to quinone at 246 nm was less than a unit.

This leads to the conclusion that the amount of hydroquinone oxidized to quinone changes linearly with the amount of gamma doses at high activity. Hence, it can be suggested that hydroquinone be used as a gamma detector in combination with UV-visible spectroscopy to detect gamma radiation doses from high activity sources.