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EFFECT OF GAMMA IRRADIATION ON ELECTRICAL PROPERTIES OF F_{16}COPC THIN FILMS

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ABSTRACT

Gamma radiation and the F16CoPc were the subjects of this essay. How radiation from Gamma rays affects their electrical characteristics. Researchers have developed gamma radiation detectors based on the electrical characteristics of thermally evaporated thin films of phthalocyanine. It is possible to deposit F16CoPc thin films using a thermal evaporation process in a high vacuum environment at ambient temperature. Studying the effect of film thickness and substrate temperature on the activation energy is done. The electrical characteristics of F16CoPc thin films produced at room temperature are examined after exposure to gamma radiation. Radiation dosage is not to be confused with the unit of radioactive activity, which measures the quantity of energy deposited in materials and/or the biological consequences of radiation (Becquerel Bq). Commercially accessible F16CoPc (98 percent pure) powders are the raw ingredients required to make thin films. Dosimeters may be made using organic semiconductors that are particularly sensitive to high-energy radiation, according to the results. F16CoPc thin films produced at room temperature and subjected to gamma radiation are studied electrically. In the Ln vs 1000/T plots of F16CoPc thin films, the appearance of many linear portions supports the presence of trap levels. This information is gleaned from the linear sections' slopes, which are then used to calculate activation energies. The higher temperature activation energy E1 is determined as a result of inherent majority carriers. Because of impurity state extrinsic conduction, the activation energies E2 and E3 at the lower temperature zones are dependent on these impurity states.

Keywords: Gamma radiation, Electrical properties, F_{16}COPC, Dose, Energy

1. INTRODUCTION

Medical facilities, educational and research organisations, and nuclear fuel plants are among the many places where workers are exposed to ionising radiation on a regular basis. Radiation, radioactive materials, and nuclear energy can only be used in a safe and acceptable manner if people are properly shielded from it. Once initial characterisation has been completed for a specific product, total dosage exposure is only regulated by exposure duration in today's sterilising procedure of medical devices such as drip bags, needles, syringes, bottles, and implants, etc. In today's business, real-time monitoring of radiation levels is required to ensure the safety and well-being of workers. An alarm should sound if the predicted level is lower than the safe dosage limit.

In a wide range of fields, such as industry, medicine, radiation processing, research, and nuclear power generation, accurate radiation dosimetry is crucial for ensuring the safety of both the general

public and those working in such fields. There is a great deal of research being done on novel sensors and how to improve their performance, both in terms of material qualities and manufacturing methods. Sensors need to take advantage of the improved performance that may be achieved by tweaking the materials' physicochemical qualities. In order to better control the material properties and, as a result, increase sensor performance, new preparation methods and improved deposition techniques are required. Radiation sensors must have excellent sensitivity and linear performance throughout the specified energy range, real-time response, minimal noise, and acceptable reliability under exposure conditions2. Radiation sensors come in a broad variety of configurations due to their numerous potential uses. Optimizing the trade-offs between the requirements2 requires the employment of diverse materials, geometric layouts, and physical sensing techniques. The various device designs are often used in semiconductor nuclear detectors (planar, sandwich, grid, etc.) 3. The size of the collecting electrode may be modified to meet the needs of a specific application. Arshak describes gamma radiation dosimeters based on the electrical characteristics of thermally evaporated phthalocyanine thin films. Quality and performance are influenced by the materials used in manufacturing and the parameters used to govern the manufacturing process. F16CoPc thin films subjected to gamma radiation are described in great depth in this article.

2. LITERATUTRE REVIEW

O. Norfazlinayati (2021) The optical properties of PANI/Functionalized CNT/PVA nanocomposites were studied using gamma irradiation. Bandgaps in the UV–Vis investigation reduced when irradiation dosage was increased, according to the results. An contact between PANI and functionalized CNT was observed after irradiation, demonstrating that these two functional materials interact with one other After irradiation, the functionalized tube's surface morphology suggested that the PANI was wrapped around the CNT wall.

Dimas G de Oteyza(2009) When di-indenoperylene (DIP) is grown using the Stranski-Kranstanov method on fluorinated cobalt-phthalocyanines, a reconstruction at the organic interface is shown using AFM/X-ray research (F16CoPc) In the areas affected by DIP, the F16CoPc packing must be drastically altered in order to achieve this rebuilding. The F16CoPc interfacial layer is repaired and subsequently buried by the developing DIP film once the first DIP monolayer has been completed. We show that the thermal activation of the rebuilding of the underlying F16CoPc layers is closely connected to the morphological change from smooth to highly textured heterostructures at a threshold temperature of 70 degrees C. Further insight into the molecular-scale mechanisms that ultimately dictate the regulated development of organic heterojunctions has been gained in this research.

Esther Barrena(2005)F16CuPc films formed on bare SiO2 and on SiO2 functionalized with octadecyltrimethoxysilane (OTMS) have been compared to those grown on SiO2 functionalized with OTMS, which has a lower surface energy than SiO2. F16CuPc crystallites with good structural order are formed after SiO2 has been functionalized by OTMS, as demonstrated in the work presented. In thin-film transistors built of these films, electron mobility is boosted by almost an order of magnitude due to the increased lateral order and decrease of grain boundaries.

Michael Brendel (2015) Motivated by the prospect of altering a molecule's energy levels without significantly altering its band gap, the effects of progressive fluorination on zinc phthalocyanine (FnZnPc) thin films and bilayer cells (n = 0, 4, 8, 16) are studied. FnZnPc thin films with n = 0, 4, and 8 show comparable Q- and B-band absorption, but F16ZnPc shows a distinct absorption

pattern. Structure and electronic transport are shown to be linked. Long-range order enhances cell fill factors by 55% and short circuit current density by 18% compared to ZnPc/C60 for F4ZnPc/C 60 cells, respectively. The open circuit voltage is evaluated as a characteristic that is sensitive to the energetics of the organic/organic contact. Increases of 27% and 50% in this amount have been seen for F4ZnPc-based devices and are related to an increase in the quasi-Fermi level splitting at the donor/acceptor interface. F16ZnPc/C60 has a lower open circuit voltage than F16ZnPc/C60. It is believed that the specific energy level alignment at the photoactive materials' interface is responsible for the observed photoluminescence, photoelectron spectroscopy, external quantum efficiency, and photoluminescence.

Monica F Craciun(2006) In films of five metal phthalocyanines (MPc) doped with alkali atoms, we have seen an insulator-metal-insulator transition. When alkali concentrations are increased, electrical conductivity tests show that all systems transition to metallic states. As further doping is applied, the films return to their insulating condition. New crystal phases are formed after doping, as shown by structural and Raman spectroscopic investigations. This is compatible with charge transfer between the intercalated alkali atoms and MPc, as has only been observed previously for C60. MPc's two-fold orbital degeneracy and molecular spin make our findings interesting in the research of controlled magnetism in molecular materials and the examination of new, newly anticipated electronic phases.

3. THEORY

There are gamma rays, or particular frequency light emissions created from nuclear events happening in the interstellar medium of space, such as electron-positron annihilation and radioactive decay. The electromagnetic spectrum's greatest frequency and energy, as well as its shortest wavelength, describe gamma rays as EMR, or extremely high-energy photons. When absorbed by a substance, their tremendous energy concentration might cause significant harm.

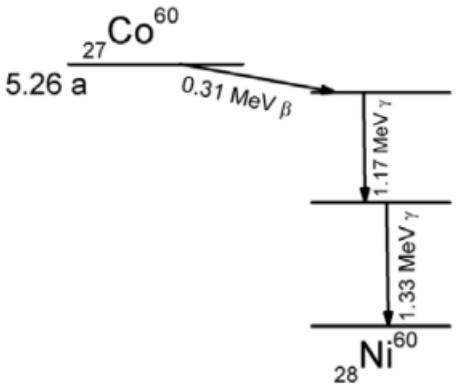
In 1900, French scientist and physicist Paul Ulrich Villard discovered gamma rays while researching uranium. He discovered that a magnetic field does not bend light rays while working in the chemical department of the Ecole Normale at avenue d'Ulm, Paris with his own self-built equipment. Through the use of crystal diffraction, Ernest Rutherford and Edward Andrade demonstrated in 1914 that gamma rays were a kind of electromagnetic radiation.

In the present study the source of gamma radiation is ^{60}Co. It is aradioactive isotope of cobalt produced by bombarding a stable nucleus of ^{59}Co with a neutron in a nuclear reator. The reaction is:

$$^{59}_{27}Co + ^{1}_{0}n \rightarrow ^{60}_{27}Co \quad \text{Radioactive} \quad \ldots\ldots (1)$$

This 60Co nucleus being unstable dcays to excited 60Ni by beta decay. Then the 60Ni drops down to the ground state by emitting two gamma rays of 1.17MeV and .33MeV.

$$^{60}Co \rightarrow {}^{60}Ni^{*} + e^{-} + \bar{\gamma}e \ldots.. (2)$$



$$^{60}Ni^{*} \rightarrow {}^{60}Ni + \gamma \ldots\ldots\ldots (3)$$

Figure 1: Nuclear shell model decay of 60Co

RADIATION DOSE

Radiation dosage is not to be confused with the unit of radioactive activity, which measures the quantity of energy deposited in materials and/or the biological consequences of radiation (Becquerel Bq). Exposure to a radioactive source result in a dosage based on the activity, period of exposure, energy of the radiation released, distance from the source, and shielding.

Calculating the amount of radiation absorbed by materials and tissue is known as radiation dosimetry. It's a branch of health physics and medical physics that studies how ionising radiation affects the body from the inside out. Biological tissue dose is expressed in sieverts (Sv) rather than grey joules (Gy), which are units of energy per kilogramme. RADs and rems are often used in non-SI units to represent the radiation and dose equivalent, respectively.

By definition, 1 Gy = 100 rad and 1 Sv = 100 rem.

Depending on the kind and stage of cancer being treated, the amount of radiation administered in radiation treatment is measured in grey (Gy). Tumors of the solid epithelial type often receive 60 to 80 Gy of radiation in curative (radical) instances, while lymphoma tumours receive 20 to 40 Gy. An adjuvant dosage of 45-60 Gy in 1.8-2 Gy portions is commonly used for prevention (adjuvant therapy) (for Breast, Head and Neck cancers respectively). Other criteria, such as whether the patient is taking chemotherapy, whether radiation treatment is being provided before or after surgery, and how successful the operation has been, are all taken into account by radiation oncologists when deciding on a dose of radiation therapy.

We have to figure out how long the sample will be exposed to radiation, which is known as the irradiation period. Every day, the dosage rate drops. 60Co has a half-life of 5.26 years. For a certain time period, BARC provides the dosage rate. The irradiation time may be determined from the dosage and dose rate using the equation.

$$Irradiation\ \ time = \frac{Dose}{Dose_{rate}} \ldots\ldots (4)$$

Radiation therapy's maximum permissible dosage is 100Gy in most cases. This is why we use gamma rays ranging from 5 Gy to 100 Gy to irradiate F16CoPc samples and analyse the electrical characteristics of these irradiated samples.

4. EXPERIMENTAL

Commercially accessible F16CoPc (98 percent pure) powders are the raw ingredients required to make thin films. Sigma-Aldrich Chemicals Pvt. Ltd., USA, is the source for them.

The substrates are 75 mm x 25 mm x 1.1 mm pre-cleaned micro glass slides. Using a "Hind Hi Vac" vacuum coating equipment (Model No. 12 A4), thermal evaporation is used to produce thin films of these materials onto the substrates at a base pressure of 10–5 mbar.

When the molybdenum boat, which has dimensions of 50 millimetres by 12 millimetres by 5 millimetres, is being used, it must be maintained 12 centimetres away from the substrate. In order to maintain a consistent rate of evaporation, By maintaining the substrate at room temperature, thin films of F16CoPc and are deposited (303 K). It is done by using a single crystal thickness monitor and Tolansky's multiple beam interference technique as described to measure the thickness of the films.

Using the gamma irradiation chamber described, thin sheets of F16CoPc are meticulously placed. The irradiation time is computed using the calculations for each dosage.

It is necessary to conduct electrical measurements using an adjustable current source mode "Keithley" programmed electrometer (Model No 617). An electrical heating element is used to heat the samples in the conductivity cell, as stated in section 2.13. Copper strands with a diameter of 0.8 mm are used to make electrical connections, and silver conducting paste is used to glue them to the film. This is done to ensure that the films are not harmed by exceeding the temperature limit. All measurements are carried out in a sub-vacuum of 10-3 mbar in order to prevent contamination. Temperatures ranging from 315 to 510 degrees Kelvin are used to measure electrical conductivity. The theory in 3.2 is used to investigate electrical conductivity. The Shimadzu 160A spectrophotometer is used to record the UV-Visible absorption spectra of F16CoPc and thin films as they are deposited and irradiated.

5. RESULTS AND DISCUSSION

5.1 ElectricalStudies

Measurements of the resistances of F16CoPc thin films subjected to gamma radiation are made using a programmed Keithley electrometer at regular intervals of 5 K in the 313–510 K temperature range. Substituting the film's length, width, and thickness into equation 3.2.8 yields the equivalent electrical conductivity. An Arrhenius type connection may be seen in conductivity's temperature dependency. On the y-axis, Ln is plotted, while 1000/T is plotted on the x-axis. Different charge carrier conduction processes are attributed to the different linear sections of these figures. Glow-in-the-dark films made of AgPc and irradiated with dosages of 5Gy, 10Gy, 20Gy, and 30Gy are shown in Figure 2. As shown in Figure 3, the Arrhenius plots of 410nm thick AgPc thin films exposed to various gamma ray dosages, such as 50Gy, 70Gy, and 100Gy, are depicted. The slopes of the linear parts of the graphs are used to compute the thermal activation energies of

these samples, which are listed in Table 1. In all measurements, the activation energy is computed with an accuracy of 0.01 eV.

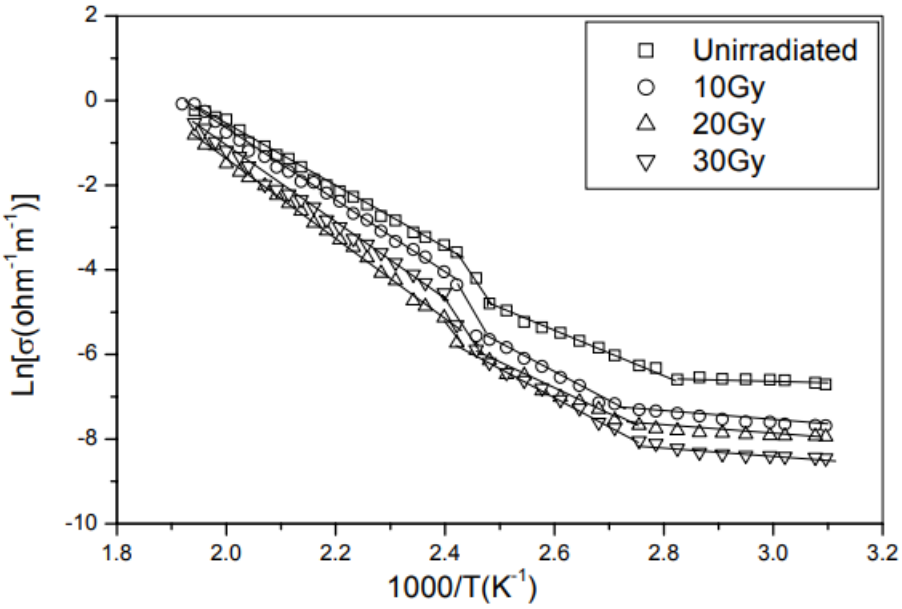


Figure 2 Plots of Lnσ vs. 1000/T for F16CoPc thin films irradiated by gamma radiation of dose 10Gy, 20Gy and 30Gy

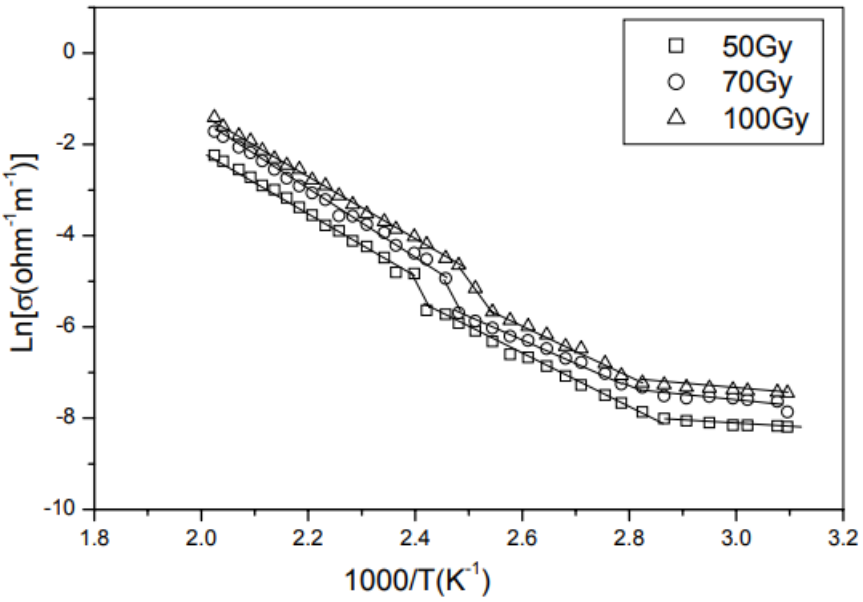


Figure 3 Plots of Lnσ vs. 1000/T for F16CoPc thin films irradiated by gamma radiation of dose 50Gy 70Gy and 100Gy

Table 1 Thermal activation energy of F16CoPc thin films irradiated by gamma radiation

Dose of gamma radiation(Gy)	Thermal activation energy (eV)		
	E1	E2	E3
Unirradiated	0.62	0.49	0.04
5	0.69	0.49	0.05
10	0.72	0.50	0.05
30	0.81	0.51	0.06
50	0.75	0.47	0.05
70	0.57	0.45	0.06
100	0.56	0.44	0.05

Figures 2 and 3 show Ln versus 1000/T plots for gamma-exposed F16CoPc thin films with a thickness of 230nm. Gamma radiation doses may be adjusted from 5-100Gy by varying exposure time. There are three distinct linear zones in each figure, regardless of the activation energy. The intrinsic activation energy E1 increases from 0.60 eV to 0.81 eV when the gamma radiation dosage is raised from 5-30Gy. As dose is increased, there is a little shift in E2 and E3 levels. The intrinsic activation energy reaches saturation at 30 Gray and lowers to a minimum at 100 Gray. For F16CoPc thin films treated with gamma radiation, the activation energies measured are given in Table 1.

6. CONCLUSION

F16CoPc thin films produced at room temperature and subjected to gamma radiation are studied electrically. In the Ln vs 1000/T plots of F16CoPc thin films, the appearance of many linear portions supports the presence of trap levels. This information is gleaned from the linear sections' slopes, which are then used to calculate activation energies. The higher temperature activation energy E1 is determined as a result of inherent majority carriers. Because of impurity state extrinsic conduction, the activation energies E2 and E3 at the lower temperature zones are dependent on these impurity states. When the C-H and C-C bonds of organic compounds are ruptured to generate new organic molecules, irreversible chemical reactions occur that make the organic compounds vulnerable to radiation. When exposed to gamma rays, the structural flaws caused by the ionising radiation vary in density. In organic semiconductors, structural and chemical defects can lead to deep trap levels, which can change charge transport. The intrinsic conductivity of phthalocyanines is dependent on their conjugation structure. The activation energy of the gamma-irradiated F16CoPc thin films increases at lower doses, while it drops and becomes saturated at higher doses. When exposed to gamma radiation, the sensitivity of thin films of F16CoPc is maximised at low

doses. Detection and dosimetry of radiation can be done with this technology. Gamma irradiation F16CoPc thin films show prominent absorption peaks.

The absorbance of gamma-irradiated F16CoPc thin films varies depending on the dose. For smaller dosages, the absorbances of these films exhibit wide ranges, while at larger doses, saturation is reached. Thin film devices are more vulnerable to low doses of radiation than thick film devices, according to Arshak et al. In order to create sensors that can detect low levels of ionising radiation, thin films of F16CoPc can be exposed to gamma radiation and their absorbance changes in response to that radiation.

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