



## PREPARATION AND CHARACTERIZATION OF GREEN LIGHT EMITTING NAPHTHALENE LUMINOPHORS

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### ABSTRACT

Anthracene and tetracene doped naphthalene luminophors in crystalline powder form have been prepared by conventional solid state reaction technique. The powder X-ray diffraction studies show that the naphthalene forms a homogeneous solid solution with the added guests. The absorbance and fluorescence studies show high Stoke's shift for doped naphthalene systems. From this it is deduced that the exciting wavelength of the light (320 nm) is completely absorbed by the naphthalene, so that fluorescence from anthracene and tetracene moiety in mixed luminophors takes place as a result of energy transfer from naphthalene.

**KEY WORDS:** Energy transfer process, Organo-luminophors; mixed crystals; Red shift

### INTRODUCTION

Solid state fluorescence of polynuclear aromatic hydrocarbons (PAHs) finds commercial applications in fluorescence lamp technology (Posch, 1999; Ukewa, 1999 and Kallman, 1963) and as scintillators for detection of high energy ionizing radiations (Nikl, 2000, Melcher 2005). A scintillation material is a kind of converter which transforms the energy of high energy photon or high energy particle into an ultra violet or visible photons which are easily be detectable with a conventional photomultiplier tube (Ding, 2001). The new scintillators having low cost offers a light yield comparable to that of commercial scintillors making them better candidates for large area detectors. Also there has been much interest in synthesis and characterization of organo luminophors and prove their utility in solid state electronics emitting in desired colors (Kok, 2006). Naphthalene and anthracene are the efficient scintillation materials. The growth of mixed crystals is desirable for the absorption and detection of high energy gamma radiations. Doping is an efficient method to tune the emission of fluorescent materials. As compared to the doped inorganic materials the investigation of doped organic crystals is challenging. This is mainly due to weak intermolecular attractions between host and guest molecules (Ozgun, 2005; Parida, 2010; Powell, 1975). Earlier work reports that in mixed crystals of naphthalene doped anthracene, the fluorescence is completely quenched of naphthalene emission with a new anthracene like emission in the spectral region 400-475 nm (Patil, 1999). In solid crystalline state tetracene is very weak fluorescent. Tetracene is known to interact with anthracene to yield green emission (Hang, 2011). The present work aims to prepare tricomponent luminophors of naphthalene doped by anthracene and tetracene and to study their fluorescence properties by selective excitation of host naphthalene.

### MATERIALS AND METHODS

Naphthalene and anthracene crystalline powder (purity  $\geq 99\%$ ) were purchased from Merck and tetracene crystalline powder (purity  $\geq 99\%$ ) was purchased from Aldrich and used as received. The purity was confirmed by production of similar fluorescence spectra by excitation with different excitation wavelength (Berlman, 1971). Naphthalene forms a series of solid solutions with anthracene and tetracene (Talpatra, 1982). The mixed crystalline powders of naphthalene were prepared by conventional solid state reaction technique (Dutta, 1995). Appropriate amounts of host and guests were weighed and taken in a silica crucible. The crucible with lid was then heated in the electrical furnace to get the melt. The melt was cooled slowly in an evacuated chamber. The mixed crystals were crushed to fine powder.

### Instrumentations and Characterizations:

The X-ray diffraction (XRD) patterns were recorded with the help of Philips diffractometer (Philips PW 3710, Holland) with monochromatized Cu K $\alpha$  radiation ( $\lambda = 1.54 \text{ \AA}$ ). UV-Vis absorption and fluorescence spectra were measured using a Cary 5E UV-VIS-NIR spectrophotometer (VARIAN) and a Fluorolog spectrofluorometer (HoribaJobinYvon), respectively.

### RESULTS AND DISCUSSION

#### *X-ray Diffraction Studies of Mixed Crystals*

Figure 1 shows XRD patterns of mixed crystals of pure naphthalene and doubly doped naphthalene luminophors. The spectra were recorded as a function of tetracene concentration. The sharp and well defined peaks indicate the crystalline behavior of the luminophors. The XRD pattern of pure naphthalene is used as a fingerprint with which the spectra of doped naphthalene are compared. It is observed that the position of the peaks ( $2\theta$  values) does not change even after doping. No additional peaks are seen in the XRD profile of doped samples, which is an indication of formation of homogeneous mixed crystals. The system has great advantage that it forms excellent solid solutions over a wide range of tetracene concentration in spite of differences of their crystal structure.

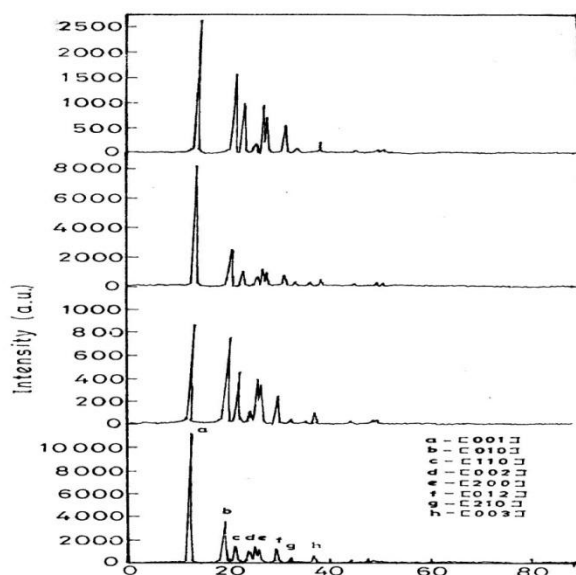


Figure-1. XRD profile of anthracene and tetracene doped naphthalene

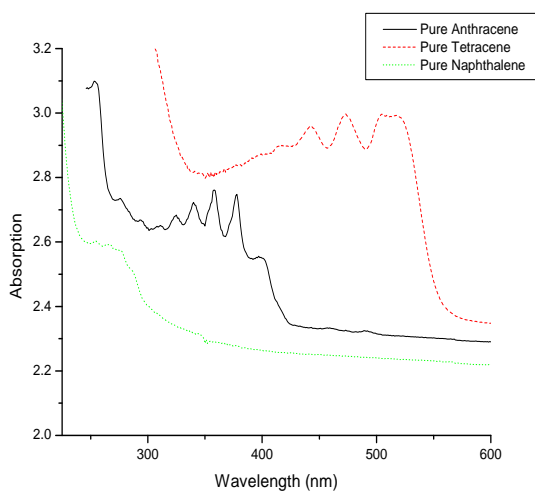


Figure- 2. Absorption spectra of pure components in solid state

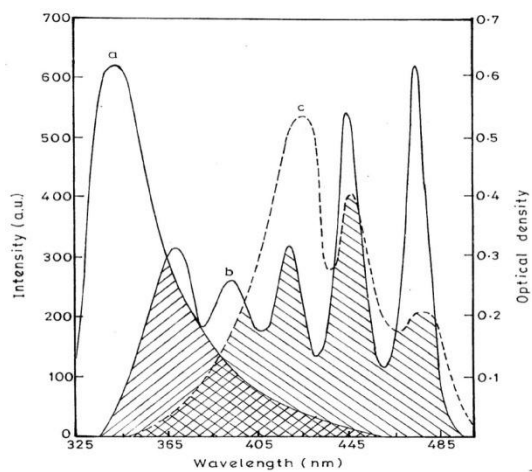
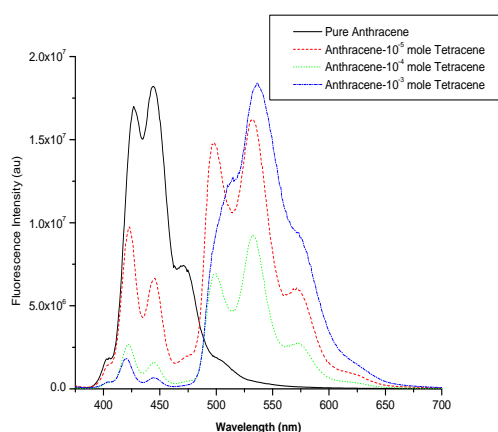
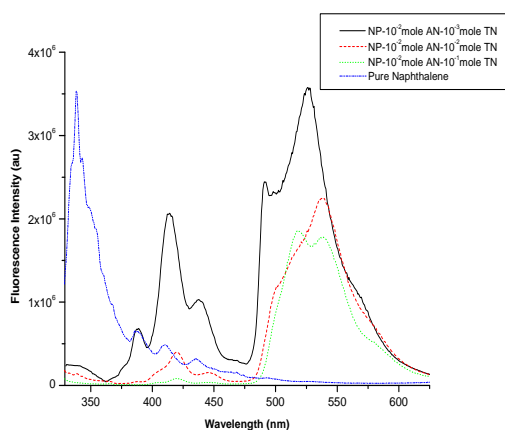


Figure-3. Region of overlap between absorption spectra of tetracene (b) and emission spectrum of anthracene doped

naphthalene (c) and undoped naphthalene (a).



**Figure- 4.** Doping effect of tetracene in anthracene matrix



**Figure- 5.** Fluorescence spectra of naphthalene luminophors containing  $10^{-2}$  mole anthracene and varying amount of tetracene.

#### *Emission Characterization by Fluorescence Spectroscopy*

Naphthalene is a wide band gap organic semiconducting material and known to fluoresce in the UV region when excited by 320 nm radiation. Naphthalene crystallizes in monoclinic unit cell and solublize in it most of the polynuclear aromatic hydrocarbons (PAHs)<sup>16</sup>. Sensitization of the anthracene like emission in naphthalene matrix by excitation energy transfer was reported<sup>13</sup>. Tetracene has strong absorption in the emission region of anthracene doped naphthalene. Therefore, mixed crystals of naphthalene doped by anthracene and tetracene were prepared. Figure-2 shows the absorption spectra of pure host and guest components in solid state. The figure reveals that the absorption range of all three components is different and there is a wide gap.

Figure-3 shows region of overlap between anthracene like emission and absorption spectrum of tetracene. The figure reveals the strong overlap between anthracene like emission and tetracene absorption spectrum. This clearly indicates the probability of significant EET from anthracene to tetracene in naphthalene matrix. To confirm the EET process from anthracene moiety to tetracene, the bicomponent luminophors of tetracene doped anthracene were prepared separately and their characterization was done. The fluorescence emission spectra of these luminophors are shown in Figure-4. With increase in concentration of guest tetracene in anthracene host, the host fluorescence decreases. This confirms the EET process from host to guest. The green monomeric emission of tetracene in the region 480-620 nm was observed which is not found in bare tetracene in solid state.

#### **Concentration Dependence of Fluorescence**

The naphthalene luminophors containing  $1 \times 10^{-3}$  mole anthracene per mole naphthalene and varying amounts of tetracene have exhibited intense green emission and spectral characteristics found to vary with the concentration of



tetracene. Figure 5 shows spectral energy distribution of anthracene doped naphthalene as a function of tetracene concentration. It is seen that as concentration of tetracene increases the emission band peaking at 492 nm is quenched and second band appeared at 526 nm get enhanced and modifies. The band peaking at 526nm gets modified with the increase in concentration of tetracene. At  $10^{-1}$  mole tetracene the second band found at 538 nm. Shifting of second monomeric band in tetracene emission with dopant concentration has been observed when concentration of both anthracene and tetracene systematically varied. This suggests that the enhancement effect observed in tetracene emission is dependent on its concentration.

## CONCLUSION

The preparation of doped naphthalene luminophors is simple, quick and less expensive. The XRD studies indicated that the mixed powder luminophors are more homogeneous. The luminophors fluoresce with intense green. One can achieve the intense green emission of tetracene monomer which is not possible in neat tetracene but in naphthalene host matrix.

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