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Thermal Characterisation of Polypyrole/Rhodamine-B Dye Composite Synthesized by Simple Chemical Method

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ABSTRACT

In-situ chemical oxidative polymerization of pyrrole (Py) was carried out by doping it with xanthene dyes such as Rhodamine-B in the presence of oxidizing agent ammonium peroxydisulphate to synthesize polypyrrole/Rhodamine-B composites. The PPY Rhodamine-B composites were synthesized with various compositions 0.0001 M and 0.00001 M Rhodamine-B in pyrrole. Thermal characterization of synthesized composites was carried out by TGA and DTA analysis. These studies suggest that they exhibit amorphous behavior and change in surface morphology due to insertion of dopant molecules.

Key words : PPy, PPy, Rhodamine-B, APS.

I. INTRODUCTION

Until about 30 years ago all carbon based polymers were rigidly regarded as insulators. The breakthrough happened in year 1977 when somewhat accidentally Alan J. Heeger, Alan G. MacDiramid and Hideki Shirakawa discovered that plastics that are generally referred to as insulators can under certain circumstances be made to behave like metals. Today the overall insight into polymer science and technology is so deep that a chemist and material scientist can create an almost limitless range of new advanced materials with enormous number of applications. They stand with numerous applications in the textile, pharmaceutical, agricultural, electronics, and automotive industries, polymers are used today in the largest quantity of all synthetic materials [1]. The organic materials that generally possess an extended conjugation of Π-electron system along a polymer backbone chain are recognized as electroactive conducting polymers.[2] These materials with interesting electron-transport behavior to a material exhibits immense potential in technological applications such as in electrochromic devices, non-linear optical system OLEDs, photoelectrochemical devices, gas sensors, biomechanical sensors.[3]

Polypyrrole is chosen as a model conducting polymer in this research work because among conducing polymers polypyrrole is one of the extensively studied electronic materials, because it exhibits relatively high electrical conductivity, good environmental stability, low toxicity and versatility of synthesis and ease of tailoring to synthesize functionalized polypyrrole.[4] However, PPy is limited in practical use due to its very

fragile structure and insolubility. It exhibits poor processability and lacks essential mechanical properties.[5] These properties and applicability of polypyrrole can be improved by some suitable modifications of existing polymers structures. This can be achieved by judicious choice of making composites of PPy by doping it with suitable dopant material in order to prepare multifunctional molecular structures that open possibilities for almost any desired applications.[6-7]

The association of PPy with xanthene dyes such as Rhodamine-B in order to prepare its composite to study its various properties have been taken in this research paper.

II. METHODS AND MATERIAL

The oxidizing agent ammonium peroxydisulphate solution and pyrrole solution was mixed and reacted under 1:1 concentration with continuous stirring maintaining the temperature below 5°C for 5-6 hours. The precipitated polypyrrole (PPy) was filtered and dried in hot air oven and subsequently in a muffle furnace at 100 °C. for preparing PPy/0.0001 M Rhodamine composite pyrrole solution was mixed thoroughly with 0.0001 M Rhodamine B composite further mixed and reacted with oxidizing agent ammonium peroxydisulphate. Similarly PPy/0.00001M Rhodamine-B composite is also prepared by following the above procedure. The pure PPy and PPy/Rhodamine-B thin films were prepared by bath deposition technique.

The synthesized composite materials were subjected to thermal studies through TGA and DTA Analysis

III. RESULTS AND DISCUSSION

TGA/DTA Analysis of PPy/ Rhodamine-B composites

As the conducting polymers are useful in number of electronic applications, it is necessary to study its themal properties. The effect of temperature on stability of polymer is studied by TGA/ DTA analysis.TGA gives the information regarding to weight loss in material with increasing temperature and DTA is useful to determine glass transition temperature (Tg). The TGA thermograms of PPy and PP/Rhd-B composites are given in following figures.

The thermal characteristics of PPy and PPy/Rhodamine-B composite was studied by using thermogravimetric (TGA) technique (instrument DTG-60) by heating in the range 10^0 C/min from room temperature to 550°C in air.

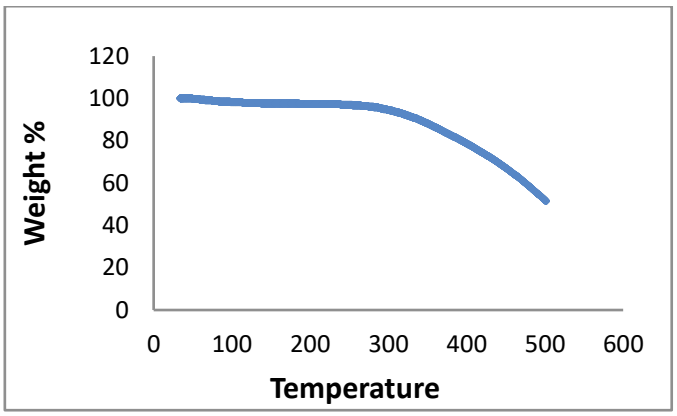

Fig (A)

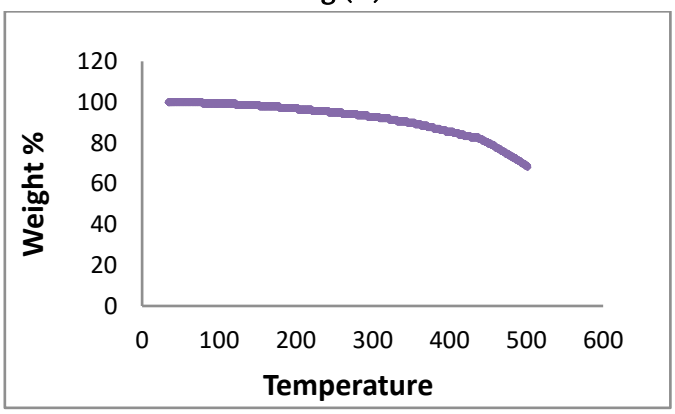

Fig (B)

Fig (A): TGA curve of PPy/0.00001M Rhd-B composite

Fig (B): TGA curve of PPy/0.0001M Rhd-B composite

All the samples of PPy and PPy/Rhodamine-B were observed to exhibit three distinct weight losses as shown in fig. The first stage of weight loss (~3%) at about 80-120°C is associated with the evaporation of solvents, moisture as well as unreacted monomers

elimination. The further heating of material at 250-400°C, a weight of about 15-20% occurs due to the loss of dopant component of the PPy. The drop in weight (~30-40 %) observed at 400-500°C is due to the degradation of the PPy itself. PPy samples are thermally stable in the temperature range of 25-400°C and beyond this range; the decomposition route becomes very rapid. The residual weight of the PPy is about 40% in the oxygen atmosphere; this indicates that PPy does not completely decompose in O_2 even at high temperature.

The weight loss in each step and total weight loss for different weight % at different temperature for different composite materials of PPy composite is given in table below

Table: Weight Loss in each step for PPy/Rhd-B composite

S. N.	Polymer Composite	Weight Loss (%)				
		Step I 50-120°C	Step II 250-400°C	Step III 400-500°C	Total wt loss (%)	Residue
1.	Pure PPy	0.38	12.57	47.65	60.6	39.4
2.	PPy/0.00001 Rhd-B	0.82	18.45	50.41	69.68	30.32
3.	PPy/0.0001 Rhd-B	0.48	13.01	40.29	53.78	46.22

Thermal properties and interaction between the polymers can also be noted from the DTA studies. DTA is most commonly used to determine transition temperatures such as glass transitions, melting cross-linking reactions and decomposition. However, it measures only the total heat flow and the sum of all thermal transitions in the sample.

DTA curves for PPy/Rhodamine-B composites are explained in figures 4.47 and 4.48, which give the glass transition temperature which determines the softening of the polymer. The TG curve is analogous to DTA curves as the variation in TG curve will give the simultaneous variation in DTA curve.

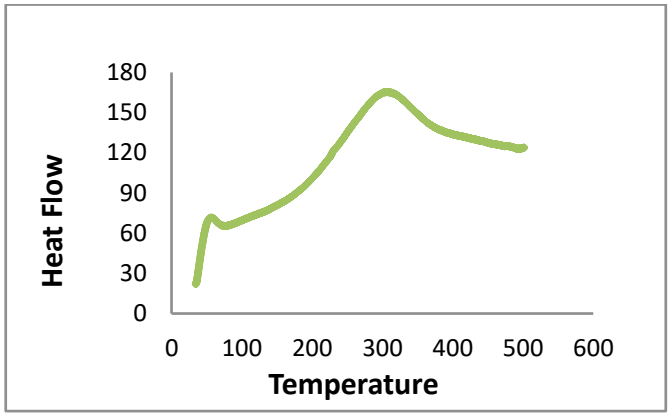

Fig (C)

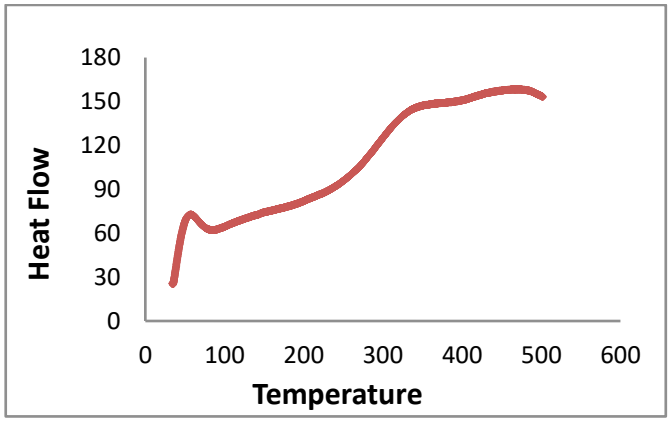

Fig (D)

Fig (C): DTA curve of PPy/0.00001M Rhd-B composite
Fig (D): DTA curve of PPy/0.0001M Rhd-B composite

The various parameters such as glass transition, onset and peak and end temperatures from DTA curves are tabulated in the table below.

It is observed that the glass transition temperature decreases with increasing content of Rhodamine-B. This means that the addition of Rhd-B relives the structure of polymer composites and it becomes soft.

The various thermodynamic parameters from DTA curve of PPy/Rhd-B composites are given in table.

Table: Thermodynamic parameters from DTA curve of PPy/Rhd-B composites

Polymer Composite	Glass transition Temp. (°C)	Crystallization Exothermic Peak		
		Onset temperature (°C)	Peak temperature (°C)	End temperature (°C)
PPy	63.49	221.42	328.21	479.23
PPy/0.00001 Rhd-B	47.39	200.44	307.22	470.6
PPy/0.0001 Rhd-B	47.19	227.96	343.57	482.64

IV. CONCLUSION

Efforts have been made to synthesize the polypyrrole/Rhodamine B composites to tailor the structural, morphological, and thermal properties of polypyrrole. Detailed morphological characterizations of the synthesized composites through XRD studies indicate the incorporation of dopant into the polymeric chain. The TGA study indicates The residual weight of the PPy dye composites is about 40% in the oxygen atmosphere; this indicates that PPy does not completely decompose in O2 even at high temperature. The various parameters such as glass transition, onset and peak and end temperatures from DTA curves is observed that the glass transition temperature decreases with increasing content of Rhodamine-B. This means that the addition of Rhd-B relives the structure of polymer composites and it becomes soft and thermally quite stable.

V. REFERENCES

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