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OPTICAL CHARACTERIZATION OF PMMA DOPED WITH AN ORGANIC POLYMER

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ABSTRACT

In the field of communication, optical fiber has a vital role in transmitting light between two ends of the fiber. Optical fiber is made of three layers core, cladding and outer jacket. The significant property of optical fiber is that, the refractive index of core must be greater than the cladding. Mostly silicon is used as the core material in the making of optical fiber. Here, we are replacing silicon by PMMA which has good refractive index than silicon. Doping of different polymers of high refractive index possess greater optical properties. In this project, core is made by doping of two different polymers by the method of spin coating. Two samples are made and its optical characterization is done by FTIR analysis, which indicates the various optical properties of the sample. XRD has also been done for the sample to know its crystalline structure. Optical properties of two different samples have been compared for better results. The characterization of the sample is done at the wavelength of 600-850 nm in which it is used for small distance communication.

KEY WORDS
Optical fiber, XRD,FTIR

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INTRODUCTION

Polymer composites have steadily gained growing importance during the past decade. Optical properties constitute one of the convenient and sensitive for studying the polymer structure. They are affected not only by the structure and nature of the dopant but also by the doping procedure. Optical properties of polyvinylchloride (PVC) and polymethyl methacrylate (PMMA) have been investigated [1]. These transparent conductors have found major applications in a variety of active and passive electronic and opto-electronic devices ranging from aircraft window heaters to charge coupled imagining devices. [2]The composition of organic polymer plays a vital role in the making of optical fibers.[3] Here, by using different ratio of Polyvinylchloride [4] (PVC) and PMMA, the resulting optical properties vary each other. And from these samples the best composition has been taken and analyzed for the best outcome of fibers.

What are polymers

Polymers are very large molecules that are made up of thousands - even millions - of atoms that are bonded together in a repeating pattern. The structure of a polymer is easily visualized by imagining a chain. The chain has many links that are connected together. In the same way the atoms within the polymer are bonded to each other to form links in the polymer chain.

The molecular links in the polymer chain are called repeat units that are formed from one or more molecules called monomers. The structure of the repeat unit can vary widely and depends on the raw materials that make up the polymer. For example, polyethylene, the polymer used to make a wide variety of plastic bags and containers, has a very simple repeat unit, two carbons that are bonded to one another to form a single link.

Polymer properties

Since many polymers are made of long, flexible chains, they become easily tangled, much like a bowl of cooked spaghetti. The disordered tangling of the polymer chains create what is known as an amorphous structure. Amorphous polymers are typically transparent and much easier to melt to make materials like kitchen cling film. Polymer chains do not always form amorphous arrangements. Under proper conditions, such as stretching, the polymer chains can line up side by side to form orderly, crystalline arrangements. Crystalline arrangements in polymers can also be achieved through slow cooling, where individual polymer chains fold over on themselves.

[5]Polymers can also be used to create huge 3-dimensional networks. These networks are made through the reaction of monomers with more than two possible sites for the polymerization to occur. The multiple reaction sites allow for the different chains to connect with each other to form cross-linked chains. The result of the cross-linked chains is a 3-dimensional solid that is essentially one huge molecule.

Requirement analysis

It determines the requirements of a composition and analyze on it and resource requirement, which is required for successful outcome. The product requirement includes the materials required to blend the organic polymers and to analyze the optical properties. As shown in [Fig.1,2 and 3]

Materials required

- PVC
- PMMA

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- THF

Fig. 1: PMMA

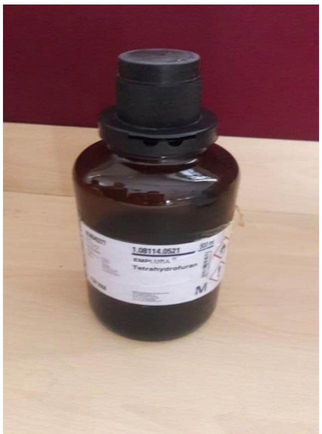

Fig. 2: THF

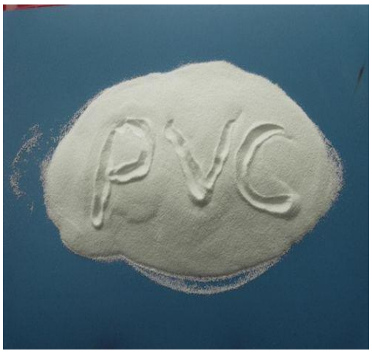

Fig. 3: PVC

Working principle

Two samples with different composition have been prepared for analyzing the optical properties of the polymers.

Preparation of the samples

Composition-1

In the first sample, 0.5gm of PMMA [6] is dissolved in 10ml of Tetrahydrofuran (THF) and 1.00gm of PVC is dissolved in 15ml of THF. These solutions are heated separately in stirring hot plate until a clear solution is obtained. Then both the solutions are mixed in 50ml beaker. This final solution is then heated and stirred in the stirring hot plate until the solution becomes semi-fluid as like gel form. A cleansed glass slide is taken for coating the gel like solution on it. It cannot be coated directly. So, a spin coater equipment is being used to coat this. In this equipment, a glass slide is kept in the center which will rotate to 1000 to 2000 (revolutions per minute). When the motor is switched ON, the semi-fluid substance is then poured on the glass slide. Due to this fast rotation, that semi-fluid substance spreads uniformly on the glass slide. Then the glass slide is taken out from that equipment and dried for half an hour .And the sample is covered by a butter paper to maintain its purity. Optical characterization is done for this sample know its effective optical properties.

Fig. 4: Thin film of sample-1

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Composition-2

As shown in the [Fig .4].The next sample is prepared by taking 0.5gm of PMMA is dissolved in 10ml of Tetrahydrofuran (THF) and 2.00gm of PVC is dissolved in 15ml of THF. These solutions are heated separately in stirring hot plate until a clear solution is obtained. Then both the solutions are mixed in 50ml beaker. This final solution is then heated and stirred in the stirring hot plate until the solution becomes semi-fluid as like gel form. A cleansed glass slide is taken for coating the gel like solution on it. It cannot be coated directly. So, a spin coater equipment is being used to coat this. In this equipment, a glass slide is kept in the center which will rotate to 1000 to 2000 RPM (revolutions per minute). When the motor is switched ON, the semi-fluid substance is then poured on the glass slide. Due to this fast rotation, that semi-fluid substance spreads uniformly on the glass slide. Then the glass slide is taken out from that equipment and dried for half an hour .And the sample is covered by a butter paper to maintain its purity. Optical characterization is done for this sample to know its effective optical properties.

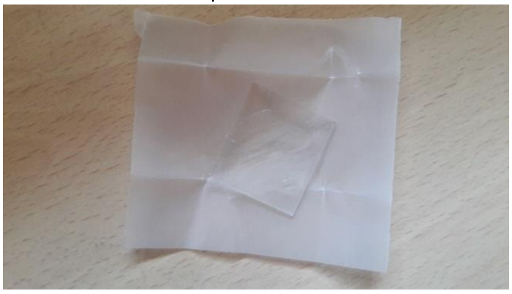

Fig. 4: Thin film of sample-2

Characterization of the samples

As shown in the [Table 1]. The dried sample is then examined in FTIR Spectrometer. Four optical properties such as refractive index, Reflectivity, absorption and velocity of light has been characterized for the wavelength range of 600-850 nm.

Fig. 5: FTIR Spectrometer

As shown in the [Fig .5]. Fourier Transform Infrared Spectroscopy (FTIR) identifies chemical bonds in a molecule by producing an infrared absorption spectrum [7]. This confers a significant advantage over a dispersive spectrometer which measures intensity over a narrow range of wavelengths at a time. It examines plastics, polymers, paints etc….,[8]

RESULTS AND ANALYSIS

This chapter shows the final output scenario of the project.

Optical characterization of PMMA and PVC

Table 1: Values of PMMA and PVC

PROPERTY	PMMA	PVC
REFRACTIVE INDEX	1.4905	1.54
REFLECTIVITY	0.0387	0.457
ABSORPTION	83.13 cm-1	286.12 cm-1

VELOCITY OF LIGHT	55.965 kmps	54.147 kmps
TRANSMITTANCE	6.514e-184	7.8498e-184
SCATTERING EFFECT	3.56A2/amu	6.96A2/amu

Refractive index of PMMA and PVC

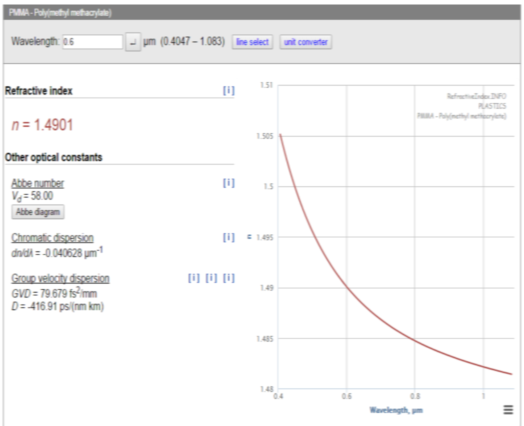

Fig. 6: Refractive index of PMMA.

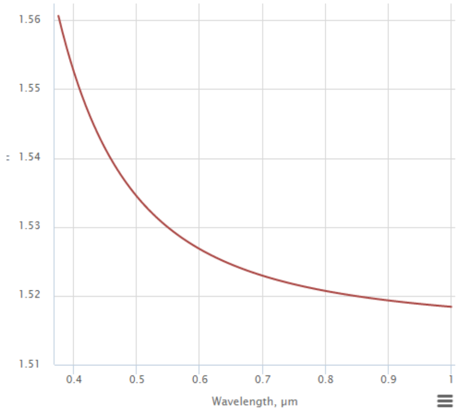

Fig. 7: Refractive index of PVC.

Reflectivity of PMMA and PVC

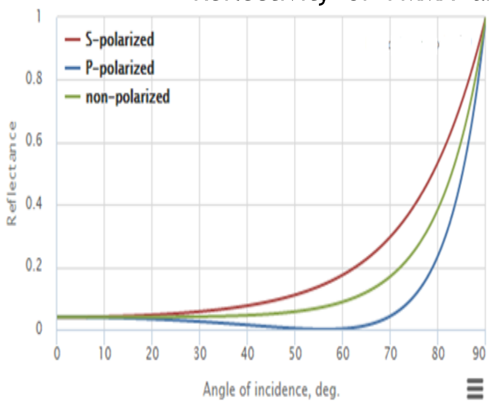

Fig. 8: Reflectivity of PMMA .

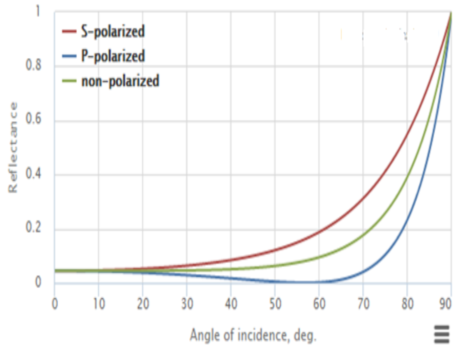

Fig. 9: Reflectivity of PVC.

Ratios of sample

Table 2: Quantity of samples

Material	Sample 1	Sample 2
PMMA+THF	0.50gm+10ml	0.50gm+10ml
PVC+THF	1.00gm+15ml	2.00gm+15ml

Characterization of pmma and pvc blends by ftir

Analysis

As shown in the [Fig .6, 7, 8 and 9] FT-IR spectroscopy has long been recognized as a powerful tool for elucidation of structural information.[9] The position, intensity, and shape of vibrational bands are useful in clarifying conformational and environmental changes of polymers at the molecular level. This analysis

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depicts the graph of refractive index, reflectivity, absorption and transmittance [8] which are some of the optical properties of fibers. As shown in the [Table 2].

Sample-1

As shown in the[Fig. 10,11,12] ,0.5gm of PMMA and 10ml of THF+ 1.00gm of PVC and 15 ml of THF

Step 1: Refractive index

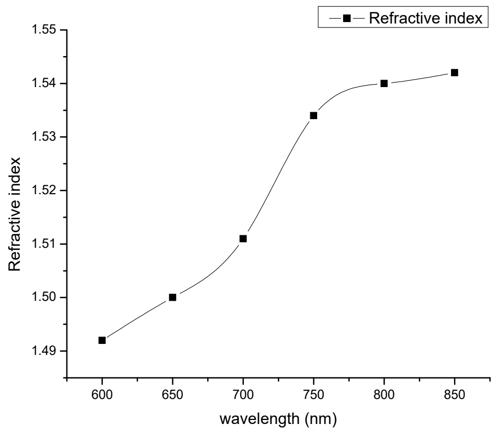

Fig. 10: Refractive index of sample -1.

Step 2: Reflectivity

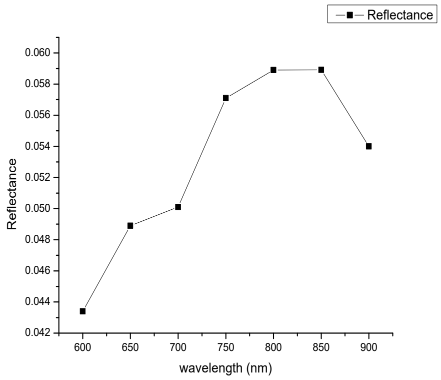

Fig. 11: Reflectivity graph of sample 1.

Step 3: Absorption

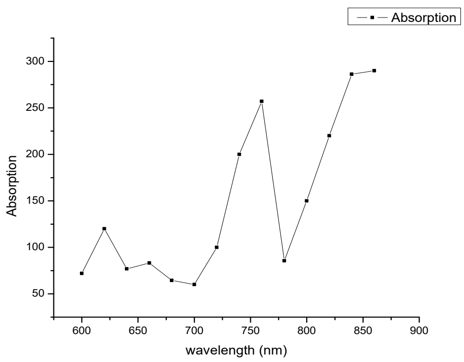

Fig. 12: Absorption of sample 1.

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Step 4: Transmittance

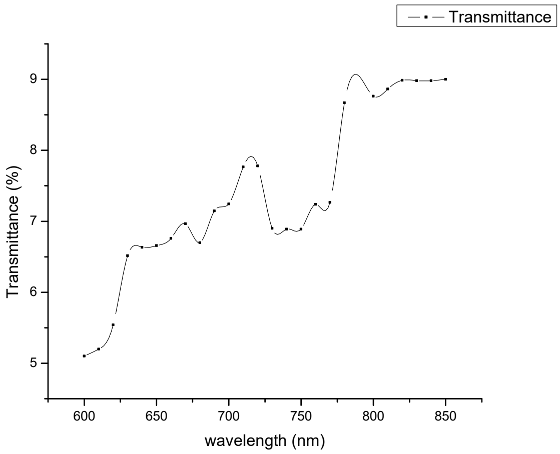

Fig. 13: Transmittance of sample 1.

Table 3: Values of PMMA, PVC and SAMPLE-1(0.5gm of PMMA and 10ml of THF + 1.00gm of PVC and 15 ml of THF)

PROPERTY	PMMA	PVC	SAMPLE-1
REFRACTIVE INDEX	1.4905	1.53	1.542
REFLECTIVITY	0.0389	0.0434	0.0589
ABSORPTION	83.13 cm-1	286.12 cm-1	280.12 cm-1
TRANSMITTANCE	6.514e-184	7.8498e-184	9.00e-184

Sample-2

0.5gm of PMMA and 10ml of THF + 2.00gm of PVC and 15 ml of THF

Step 1: Refractive index

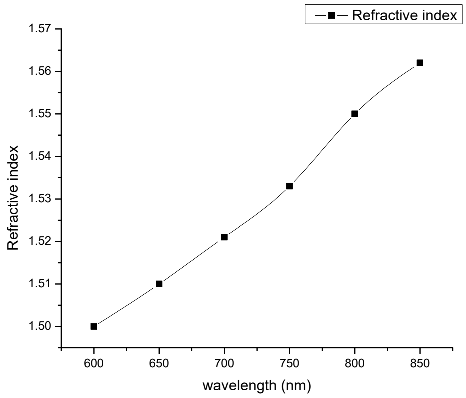

Fig. 14: Refractive index of sample -2.

STEP 2: Reflectivity

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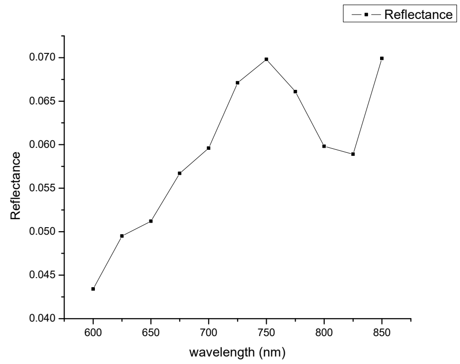

Fig. 15: Reflectivity graph of sample 2.

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Step 3: Absorption

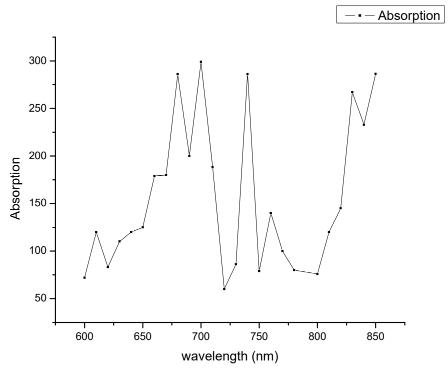

Fig. 16: Absorption of sample 1.

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Step 4: Transmittance

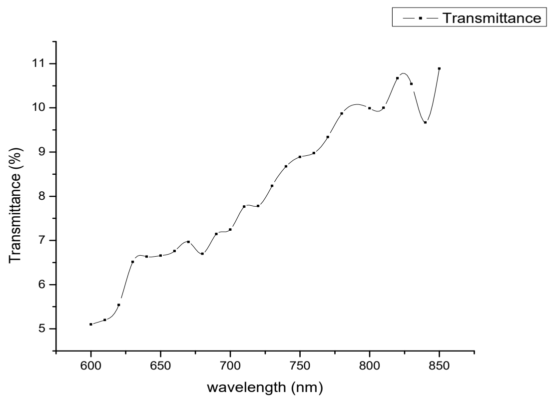

Fig. 17: Transmittance of sample 2.

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Table 4: Values of PMMA, PVC and SAMPLE-1(0.5gm of PMMA and 10ml of THF + 2.00gm of PVC and 15 ml of THF)

PROPERTY	PMMA	PVC	SAMPLE-1	SAMPLE-2
REFRACTIVE INDEX	1.4905	1.53	1.542	1.562
REFLECTIVITY	0.0389	0.0434	0.0589	0.0699
ABSORPTION	83.13 cm-1	286.12 cm-1	280.12 cm-1	284.1 cm-1
TRANSMITTANCE	6.514e-184	7.8498e-184	9.00e-184	10.89e-184

The above [Table 3 and 4] clearly depicts that the doping of two organic polymers, PMMA and PVC have proved to be good material in the making of optical fibers. The doping is done in correct composition and it is kept in stirring hot plate to form a semi-fluid like substance .After getting a thin film from this, it is then

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characterized by FTIR Spectrometer for getting the optical properties. [10] The two samples have been doped in different composition and the characterization is done. By analyzing the sample 1 in FTIR, the refractive index of the material is slightly higher than the refractive index of the [11] individual polymers .So, it can be suited as a very good core material for the making of optical fibers . As shown in the [Fig. 13, 14 ,15 ,16 and 17] The other parameters reflectivity and transmittance also has high value, when compared to the individual polymer values. It shows that light travels efficiently with low loss of data. Absorption spectra is little lesser, which in turn avoids losses.

Then the sample 2 has been analyzed, which in turn shows greater optical properties than the sample 1. The above all is calculated for the wavelength range of 600nm to 850 nm for which the frequency range is between 499.65THz to 352.69THz.

CONCLUSION

PMMA has found various applications in the optical fibers. In the doping process, PMMA remains constant and the PVC is varied by weight(1.00gm, 2.00gm,....). The thin film samples are optically characterized and its various optical properties such as refractive index, reflectivity, absorption and transmittance have been analyzed by using FTIR spectrometer. From the above result and discussions, it is recommended that PVC is supposed to be a very good material for doping with PMMA .Since PMMA has better optical properties; it can be used instead of silica in the optical fiber for better data transmission. In the future work, many samples can be made by varying the PVC in weight (gms) with PMMA. Then with the thin film, FTIR analysis can be done for all the samples. From this, the best sample can be taken as the core material for the fabrication of optical fibers. The wavelength 600-850 nm is considered to be a good range and which can be used in various applications of optical fibers.

CONFLICT OF INTEREST
The authors declare no conflicts of interest regarding this paper.

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FINANCIAL DISCLOSURE
None

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