

Investigating the Effect of Blend Composition on the Burning Rate of PTT/PP and PTT/LLDPE Blends and Mechanism Thereof

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Abstract

The present manuscript focuses on assessing the fire retardant performance of Polytrimethylene Terephthalate (PTT) polymer blended with varying proportions of Polypropylene (PP) and Linear low-density polyethylene (LLDPE), separately. The fire retardancy behavior is studied using Fourier transform infrared spectroscopy (FTIR) and the structure of the blends observed by Scanning electron microscope (SEM). The blend composition plays a vital role on the burning rate, and therefore the fire retardancy, of PTT polymer after blending. In both the blend systems, an increase in the addition of PP or LLDPE lowers the burning rate for 10-15 wt.% of addition. The burning rate increases with further addition due to the fact that pure LLDPE and PP burns faster than pure PTT. The PTT/PP and PTT/LLDPE blends under present study proves to be cost effective than pure PTT, all the while exhibiting similar burning rate characteristics, making them suitable for a wide range of applications where both cost efficiency and fire resistance are essential. The FTIR and SEM analysis provides insight into the chemical changes occurring during the thermal degradation of the blends, thereby supporting to understand the fire-resistant mechanism of the blends.

Keywords: Burning Rate, Globular Morphology, Linear Low-Density Polyethylene (LLDPE), Polypropylene (PP), Polytrimethylene Terephthalate (PTT) Blends.

Introduction

Poly (tri methylene terephthalate) (PTT) is a versatile polyester with a range of valuable properties, including high resilience, excellent elasticity, and remarkable chemical resistance, which make it an attractive material for numerous industrial applications. PTT is widely used in the automotive, textile, and packaging industries, where its ability to maintain structural integrity under various environmental conditions is highly sought after (1). Despite these strengths, PTT's high production costs limit its widespread use in some applications, particularly when more cost-effective alternatives are available. As such, blending PTT with other polymers like Polypropylene (PP) and Linear low-density polyethylene (LLDPE) has emerged as a promising strategy to combine PTT's desirable characteristics with the more affordable and process able attributes of PP and LLDPE. These blends enhance PTT's mechanical properties

while retaining its inherent elasticity, making them well-suited for industrial applications that demand a balance of performance and cost (2, 3). Polypropylene (PP) is a widely used polymer known for its low cost, ease of processing, and good mechanical properties. Similarly, LLDPE is valued for its superior flexibility, strength, and environmental resistance. When blended with PTT, these polymers can synergistically improve properties such as impact strength, tensile strength, and thermal stability. The resulting PTT/PP and PTT/LLDPE blends have shown significant promise for applications in the automotive and textile industries, where both performance and cost efficiency are critical factors. Research on such blends has demonstrated that varying the blend ratios can optimize these mechanical and thermal properties, ensuring that the resulting materials are well-suited for their intended application (4-9).

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An important aspect of the performance of PTT blends, particularly in applications where fire safety is a concern, is their flame-retardant behavior. PTT has been shown to possess inherent flame retardancy, a characteristic that makes it particularly valuable for applications in environments prone to fire hazards (4, 6). However, the cost of PTT limits its widespread use in fire-sensitive applications. It is mentioned in previous studies that while PTT exhibits excellent flame-retardant characteristics; its economic viability remains a constraint (4). Therefore, blending PTT with more affordable polymers such as PP or LLDPE offers a solution by maintaining the flame retardancy while optimizing the overall cost of the material. The incorporation of these polymers can help enhance the material's flame-retardant performance without sacrificing other desirable properties such as mechanical strength and processability (5). While numerous studies have explored the fabrication and characterization of PTT/PP and PTT/LLDPE blends (10-17), including their mechanical, morphological, and thermal properties, there remains a gap in the literature regarding their burning rate and the underlying mechanisms influencing this behavior. Previous research has focused primarily on improving the mechanical properties and processing behavior of these blends, but there has been limited investigation into how different blend compositions impact combustion characteristics. The burning rate of a material is a critical parameter for assessing its fire performance, as it directly influences how quickly a material can contribute to the spread of a fire. In addition, the combustion behavior of a polymer blend is governed by complex interactions between the polymer chains, which are not fully understood in the case of PTT blends. The motivation behind

this study lies in addressing this gap in knowledge. Understanding the burning rate of PTT-based blends and the chemical interactions that govern their combustion behavior is crucial for improving their fire safety performance. By optimizing the blend composition, this study aims to enhance the flame retardancy of PTT/PP and PTT/LLDPE blends, thereby making them more suitable for use in fire-sensitive applications. Additionally, the study seeks to provide insights into the mechanisms underlying the flame retardancy of these blends. This research is expected to contribute valuable information for developing safer and more cost-effective materials for industrial applications where fire safety is a critical concern.

Thus, the primary aim of this study is to explore the optimal blending ratios of PTT with PP and LLDPE to achieve superior flame retardancy. Furthermore, the research seeks to investigate the fundamental mechanisms that influence the burning rate of these polymer blends, with the hope of offering strategies for enhancing their fire safety performance through composition optimization. By filling this gap in the current literature, the study will provide a deeper understanding of how the composition of PTT blends affects their fire behavior and offer new insights into how these materials can be tailored for improved fire safety and overall performance.

Methodology

Materials and Sample Preparation

The PTT (Make: Corterra, Shell Chemical Co.) and PP and LLDPE (Make: Reliance Industries Limited) polymers were procured in the form of granules. The blend of PTT/PP and PTT/LLDPE were prepared with varying compositions as given in Table 1.

Table 1: Sample Details and Sample Code under Study

Sr. No.	PTT wt.%	PP wt.%	Sample Code	Sr. No.	PTT wt.%	LLDPE wt.%	Sample Code
1	100	0	Pure PTT	1	100	0	Pure PTT
2	95	5	P05	2	95	5	L05
3	90	10	P10	3	90	10	L10
4	85	15	P15	4	85	15	L15
5	80	20	P20	5	80	20	L20
6	75	25	P25	6	75	25	L25
7	50	50	P50	7	50	50	L50
8	00	100	P100	8	00	100	L100

The blending process involved melt-compounding followed by injection molding for subsequent testing and characterization. Initially, the polymer granules were mechanically mixed and pre-heated at 100°C for 4 hours in an oven. Melt compounding was performed using a 25 mm twin-screw extruder (M/s Boolani Engineering Corporation) with temperature zones set as follows: Zone I=170°C, Zone II=195°C, Zone III=210°C, and Die zone=225°C. The resulting melt-compounded pellets underwent an additional drying step at 100°C for 4 hours before film casting using melt flow index machine. On achieving the desired temperature, the barrel of machine was filled with the melt compounded granules, and with the help of plunger, the molten granules come out of the barrel; alike an extrusion process. This molten polymer is then shaped into the films by application of weight.

Flammability Test

Prior to conducting the fire retardancy test, all specimens underwent precision cutting to achieve a rectangular shape with dimensions of 100 x 25 x 1.5 mm. Following this, the thickness of each specimen was meticulously measured and recorded. Subsequently, two perpendicular lines were marked on each specimen along its longitudinal axis, positioned at 25 and 100 mm from the end designated for ignition. The specimens were clamped at the end furthest from the 25 mm reference mark, using a support structure with its longitudinal axis set horizontally and its transverse axis inclined at a precise angle of 45°. The burner apparatus was carefully positioned to ensure that the test flame made contact with the free end of the specimen to a depth of approximately 6 mm, while simultaneously activating the timing device. Alignment was crucial during this process, with the central axis of the burner tube meticulously maintained within the same vertical plane as the longitudinal bottom edge of the specimen, inclined at an angle of roughly 45 degrees to the horizontal. The test flame was applied for duration of 30 seconds, without any positional adjustments. Observations during the test were critical indicators of material suitability for evaluation. If the specimen exhibited shrinkage under the applied flame without igniting, it was deemed unsuitable for assessment using these test methods. Furthermore, excessive distortion

of the specimen throughout the test would render the results invalid. Upon completion of the 30-second flame exposure, the test flame was promptly withdrawn from the specimen to prevent any further impact. Alternatively, if the flame front of the specimen reached the 25 mm mark before the 30-second mark, the withdrawal was immediate. The timing device was then restarted once the flame front reached the 25 mm reference mark. If the specimen sustained burning, either with a visible flame or glowing combustion, subsequent to the removal of the test flame, the elapsed time (t) in seconds for the flame front to progress from the 25 mm to the 100 mm reference mark was meticulously recorded. Additionally, the length of the specimen consumed by the flame (L) was documented as 75 mm. In cases where the flame front surpassed the 25 mm reference mark but failed to reach the 100 mm mark, both the elapsed time (t) in seconds and the length of specimen consumed by the flame (L) in millimetres between the 25 mm reference mark and the point where the flame front ceased were accurately noted for analysis. The experiment was performed in accordance with the methodology of ASTM standard D635. The linear burning rate (V), in millimeters per minute, for each specimen where the flame front reaches the 100 mm reference mark using the Equation no. [1]:

$$V = \frac{60L}{t} \quad [1]$$

where:

L = the burned length, in millimeters, and

t = the time, in seconds,

If the flame front reached the 100-mm reference mark, L = 75.

Scanning Electron Microscopy

The surface morphology of all synthesized blends comprising PTT/PP and PTT/LLDPE was examined using SEM. To ensure proper surface morphology, the samples were fractured using liquid nitrogen. Subsequently, the surface was thoroughly scanned, and the size of the globules formed during the blending process of both the polymers was quantified. In order to get enhanced conductivity during imaging, a thin layer of platinum was uniformly coated over the samples using the sputter coating technique. Morphological analyses were then conducted using a JEOL 6380A Scanning Electron Microscope (SEM).

FTIR Spectroscopy

In this study, the infrared spectra of prepared films containing blends of PTT/PP and PTT/LLDPE were recorded using a Perkin Elmer Spectrum One FTIR instrument. The objective was to gain a comprehensive understanding of the chemical changes occurring in PTT following the incorporation of PP and LLDPE during the blending process. The Attenuated total reflectance (ATR) technique was employed for spectral acquisition, utilizing a scan number of 20. The

Table 2: Linear Burning Rate of All Blends Systems

Sr. No.	Sample Code	Linear burning rate (mm/min)	Sr. No.	Sample Code	Linear burning rate (mm/min)
1	Pure PTT	34.51	1	Pure PTT	34.51
2	P05	36.08	2	L05	41.36
3	P10	35.45	3	L10	39.63
4	P15	47.57	4	L15	38.57
5	P20	53.14	5	L20	71.00
6	P25	78.00	6	L25	88.63
7	P50	86.66	7	L50	111.42
8	P100	126.89	8	L100	130.00

It was found that the Linear burning rate for virgin PTT is very low as 34.51 mm/min, whereas in case of PP and LLDPE it is very high as; 126.89 mm/min and 130.00 mm/min respectively. The synergistic effect was observed on blending; all the blend systems have shown dramatically lower burning rate. Moreover; it can be specifically observed that 10% addition of PP and 15% addition of LLDPE are exhibiting the Linear burning rate of 35.45 mm/min and 38.57 mm/min respectively; which is very close to the value of burning rate of the virgin PTT. The subsequent sections provide a detailed explanation of the mechanism responsible for reducing the burning rate through blending.

SEM Study

The scanning electron micrographs were taken for each blended systems in order to study the distribution of the immiscible phase in the blend systems. Figure 1 shows all SEM micrographs of the virgin as well as all formulated blends. In both cases; i.e PTT/PP and PTT/LLDPE system the globules of respective PP and LLDPE polymers are clearly visible embedded in the PTT matrix. This visual observation is crucial for understanding the

films prepared for analysis had a thickness ranging from 1 to 1.5 mm.

Results and Discussion

Flammability Test Results

The flammability test was carried out for all the blended systems following the American society for testing and materials (ASTM) standard test as mentioned above; the results obtained for the entire set of experimentation are given in the Table 2.

structure of these polymer blends. It was also observed that the distribution of the globules in case of 10% of PP (P10) and 15% of LLDPE (L15) is relatively homogeneous. In order to study the effect of size of the globule on the rate of burning, the diameter of the globule was also measured. Table 3 gives the average size of the diameters of the globules in both the PTT/PP and PTT/LLDPE blended systems. It was observed that with increasing percentage of the polymer, the size of the globule is also increasing; irrespective of the type of the polymer. This observation aligns with a proven fact that the size of the blended polymer globules in a blend significantly influences the flame retardancy of the material. Smaller globule sizes generally enhance flame retardancy by increasing the interfacial area between PP or LLDPE and PTT. A larger interfacial area serves as a barrier, which impedes the spread of flames through the material, thus improving the overall flame retardancy of the polymer blend (18). This understanding underscores the importance of controlling globule size to optimize the flame-resistant properties of polymeric materials.

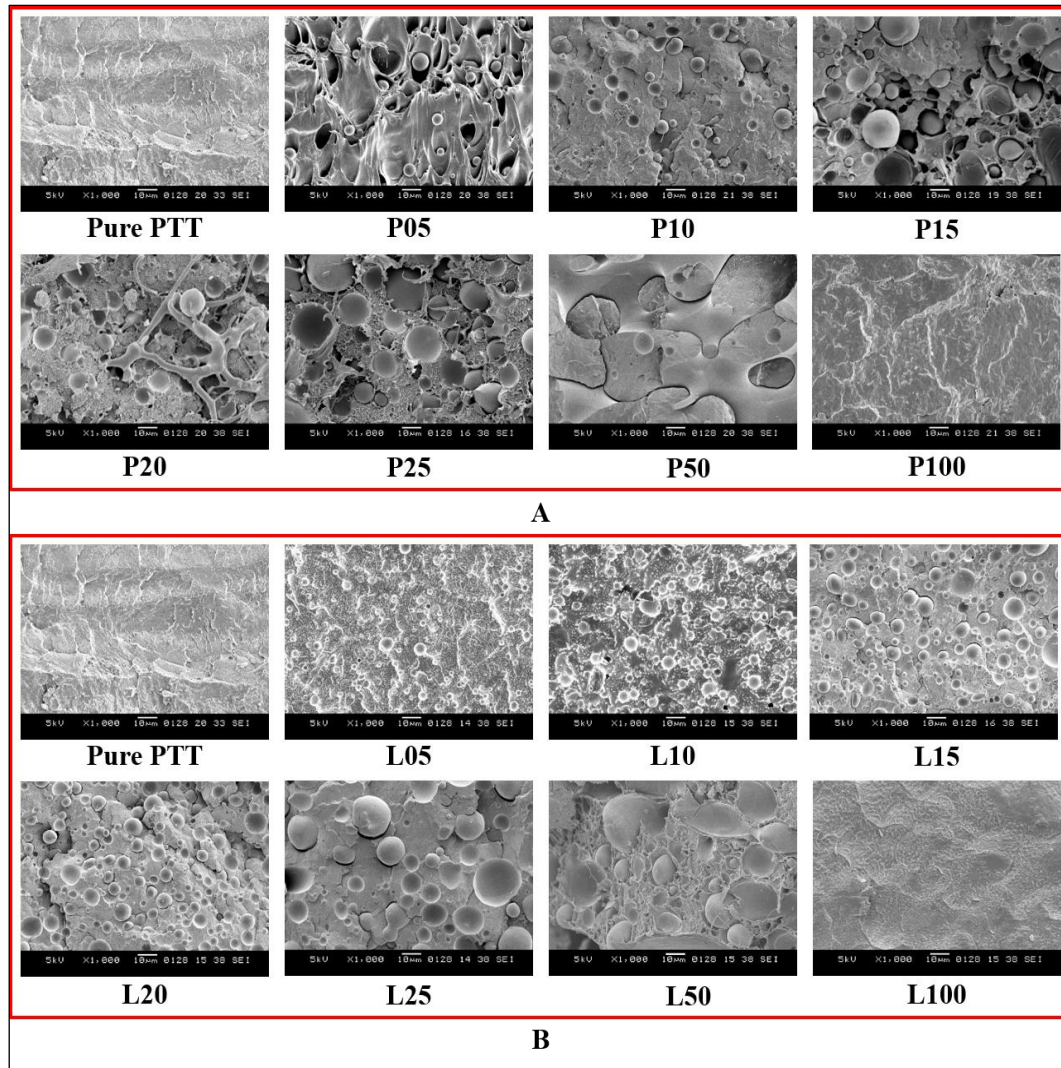


Figure 1: Scanning Electron Micrographs of (A) PTT/PP Blends and (B) PTT/LLDPE Blends

The size of the polymer globules plays a critical role in determining the flame retardancy of the blend, as smaller globules generally enhance flame resistance. This relationship is primarily due to the increased interfacial area between the dispersed polymer and the matrix material, which impedes the spread of flames (18). When the globules are small and uniformly distributed, they increase the contact surface area between the polymers. This larger interfacial area slows down the combustion process by providing more resistance to heat transfer and flame propagation. This effect is particularly pronounced in blends where the matrix polymer (such as PTT) interacts with the dispersed globules of polymers like PP or LLDPE. As the flame encounters the polymer blend, the increased interface between the phases acts as a barrier, hindering the flame's ability to spread quickly through the material. Consequently, the material exhibits improved

flame retardancy (19). Previous studies have demonstrated that smaller globules contribute to the formation of a more cohesive char layer during burning (20). This char layer acts as a protective barrier, preventing further combustion and thus enhancing the material's resistance to fire. In contrast, larger globules tend to reduce this interfacial interaction, leading to poorer flame resistance because the larger domains of each polymer phase can facilitate quicker flame spread (18, 20, 21). Additionally, homogeneous distribution of small globules across the polymer blend ensures that the material has consistent flame retardancy properties. In heterogeneous blends, where the globules are not uniformly dispersed, there may be regions with higher concentrations of a specific polymer, leading to inconsistent burning characteristics and reduced overall flame retardancy (18, 21).

Table 3: The Globule Size for all Blends Systems

Sr. No.	Sample Code	Composition	Avg. diameter (mm)
1	Pure PTT	Pure PTT	NA
2	P05	5% PP	5.58
3	P10	10% PP	8.13
4	P15	15% PP	10.48
5	P20	20% PP	11.33
6	P25	25% PP	19.21
7	P50	50% PP	19.63
8	P100	Pure PP	NA
9	L05	5% LLDPE	7.70
10	L10	10% LLDPE	11.57
11	L15	15% LLDPE	14.78
12	L20	20% LLDPE	23.38
13	L25	25% LLDPE	35.08
14	L50	50% LLDPE	36.5
15	L100	Pure LLDPE	NA

This phenomenon can also be correlated to the Flory-Huggins mathematical model which is commonly used to describe the flame retardancy enhancement as a result of smaller globule sizes in case of the immiscible polymer blend systems. The interaction parameter (χ) in Flory-Huggins mathematical model quantifies the compatibility between polymer phases and is crucial in predicting the dispersion of immiscible phase within the polymer matrix (22). The smaller PP or LLDPE globules dispersed within the PTT matrix can be an indication of reduced χ parameter owing to increased interfacial area. This signifies enhanced compatibility between PP or LLDPE and PTT, resulting in better dispersion and interfacial adhesion between the two polymers (19). Furthermore, a well-dispersed PP and LLDPE phase within the PTT matrix; especially in the case of 10% PP and 15% LLDPE added PTT blends; inhibits the mobility of PTT polymer chains during heating, creating a physical barrier against flame propagation. The increased interfacial area between PP or LLDPE and PTT hinders the diffusion of heat and flammable gases, thereby improving flame retardancy.

FTIR Analysis

The FTIR spectra for all the samples were generated in order to investigate the changes in the chemistry of the polymer on blending. The pure PTT sample reflects characteristics FTIR peaks at: 935 cm^{-1} for CH_2 rocking, 1038 cm^{-1} for C-C stretching, 1176 cm^{-1} for C-H in-plane bending, 1357 cm^{-1} and 1388 cm^{-1} for CH_2 wagging, 1505 cm^{-1} for benzene ring C-C stretch and 1708 cm^{-1} for C=O stretch. After blending with PP or LLDPE, shifting of few peaks and disappearance of few peaks was observed. In virgin PTT, the characteristic peak at 1505 cm^{-1} and 1710 cm^{-1} governing the benzene ring C-C stretch and C=O stretch, respectively, is reflected because of the crystalline component in PTT (23, 24), which was observed to be prominent. The peak at 1173 cm^{-1} due to C-H bending (in-plane) is a reflection of the amorphous content in the PTT polymer (23, 24). The details of the peaks assigned for the virgin PTT along with the PTT/PP and PTT/LLDPE blend systems are given in Table 4.

Table 4: FTIR Peaks for Virgin PTT, PTT/PP and PTT/LLDPE

Sr. No.	Sample Code	FTIR Peak Assignment						
		935	1038	1176	1357	1388	1505	1708
1	Pure PTT	CH_2 rocking	C-C stretching	C-H bending (in-plane)	CH_2 wagging	CH_2 wagging	Benzene ring C-C stretch	C=O stretch
2	P05	935	1038	1174	1357	1387	1505	1707

3	P10	936	1039	-	1357	-	1505	1708
4	P15	936	1039	-	1357	-	1504	1708
5	P20	936	1040	-	1357	-	1505	1709
6	P25	936	1040	1174	1357	1388	1505	1708
7	P50	936	1040	1174	1357	1388	1505	1708
8	L05	936	1037	1173	1357	1389	1504	1708
9	L10	936	1039	1173	1357	1389	1504	1707
10	L15	936	1039	-	1357	-	1504	1708
11	L20	936	1040	-	1357	-	1504	1707
12	L25	936	1040	-	1357	-	1505	1708
13	L50	936	1040	-	1357	-	1505	1708

It was specifically observed that the peaks at 1173 cm^{-1} and 1385 cm^{-1} , which are associated with C-H bending (in-plane) and CH_2 wagging vibrations, respectively, play a significant role in the amorphous phase of the PTT polymer and its blended systems. These peaks are characteristic of the molecular motions within the PTT structure that contribute to its amorphous nature. With increasing PP or LLDPE additions, these characteristic peaks begin to disappear or diminish. This indicates that the increase in the proportion of PP or LLDPE during the blending process has a notable impact on the molecular structure of PTT and the introduction of these polymers into the PTT system facilitates a change in the molecular arrangement, likely promoting a more ordered crystalline structure within the PTT phase. This shift from the amorphous phase to a more crystalline structure is important because it enhances the overall crystallinity of the PTT polymer. The increase in crystallinity is a critical factor that affects the flammability properties. A higher degree of crystallinity in the polymer matrix generally leads to improved flame retardancy, as crystalline structures tend to be more resistant to thermal degradation compared to amorphous regions (25). The orderly packing of molecules in the crystalline phase hinders the diffusion of heat and combustion by-products, reducing the material's susceptibility to flame propagation. Previous studies suggest that crystalline phases can sometimes be less effective in certain polymer blends, particularly when the blend is prone to poor phase compatibility (26). The morphology of the blend, especially when

phase separation occurs, could create regions where the fire retardancy is not as effective. However, in present study, while the increased crystallinity in the PTT phase might inhibit flame spread, poor dispersion or interfacial adhesion between the phases could lead to ineffective barriers to flame propagation in certain areas, resulting in an overall decrease in flame retardancy at higher polymer concentrations. This ascertains the fact that optimum percentage addition of PP or LLDPE during blending improves the crystallinity of the PTT, which is indeed essential factor, governs the good flammability.

Discussion

In PTT/PP and PTT/LLDPE blend systems, the melting temperatures of the polymers play a crucial role in their burning behavior. PTT, with a higher melting temperature around 240°C, tends to burn more slowly compared to PP (145°C) and LLDPE (135°C). During combustion, when PP or LLDPE in the PTT blend system melt and then burn, they can form a PTT mesh-like structure. The smaller sizes of PP or LLDPE globules create smaller mesh structures during burning, whereas larger globule sizes result in larger mesh-like structures. This phenomenon occurs because the PP and LLDPE particles or globules which have low melting point, melts quickly and form meshes during combustion. Herein; the diameter or size of the globule plays vital role in deciding the size of the mesh. The schematic of the proposed mechanism is illustrated in Figure 2.

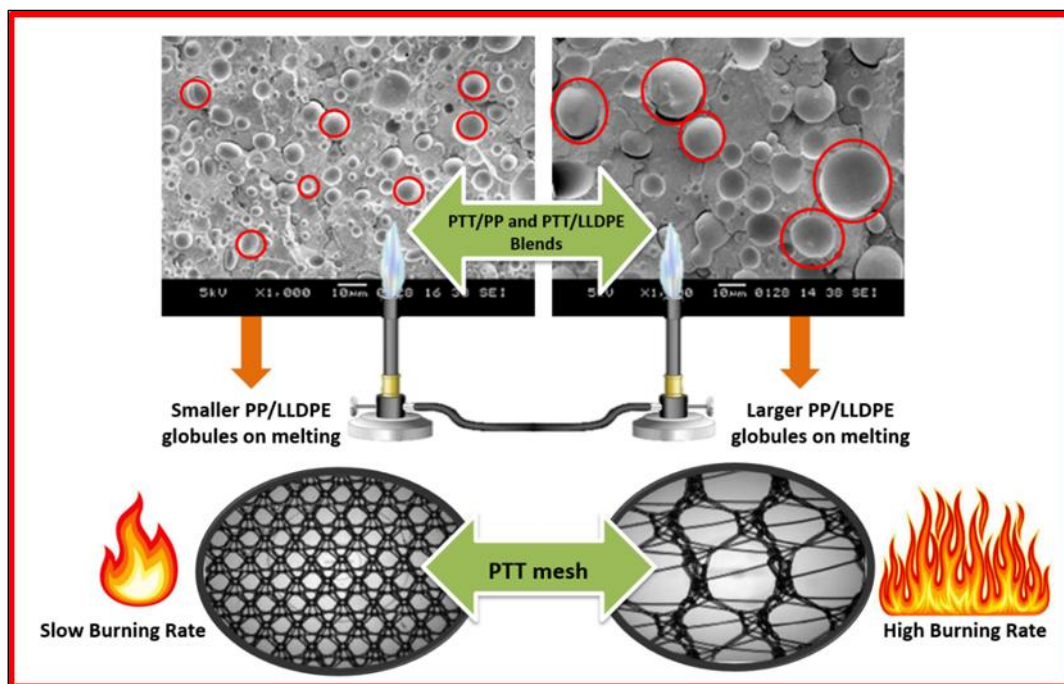


Figure 2: Schematic Diagram Illustrating the Effect of PP or LLDPE Globule Size on the Formation of PTT Mesh and Effect on the Burning Rate of the PTT/PP and PTT/LLDPE Blends

It can be seen herein that the size of PP or LLDPE particles in the blend system influences the morphology of the mesh-like structures formed during burning. This indeed affects the overall burning rate and behavior of the material. SEM results clearly depict that the diameter of globule on addition of 5% PP or LLDPE is much smaller i.e. P10=5.58 mm and L15=7.70mm respectively. Whereas for higher percentage addition of PP or LLDPE in PTT i.e. 50% the diameter changes to P10=19.63 mm and L15=35.5 mm for PP and LLDPE respectively. Now, when these blend systems were characterized for flame or burning test it was observed the burning rate of 10% PP in PTT and 15% LLDPE in PTT i.e. P10 and L15 exhibits the excellent burning rate of 35.45 mm/min and 38.57 mm/min correspondingly. This is due to the fact that; 10% of PP and 15% of LLDPE addition is proving optimum to create the smaller mesh (Figure 2). In case of lesser percent addition, the lesser globules are generated; which forms sparse network of PTT mesh, whereas much higher percent addition with larger globule size forms thin network. However, in case of moderate percent i.e. 10% of PP and 15% of LLDPE addition in PTT and smaller size of globule with homogeneous dispersion as depicted from SEM forms much dense network of PTT. This dense network indeed is a prerequisite for achieving the slow burning rate. Contradicting

this observation, there are studies reporting that the heterogeneous structure formed due to the phase separation in immiscible blends can provide good flame retardancy (27). These studies shows that selective localization of phases forms an unexpected fire-resistant surface at blend concentrations, potentially improving the fire resistance. As per the literature, the burning characteristics of PTT polymer meshes vary based on their mesh size, primarily influenced by surface area and heat transfer dynamics. Smaller PTT polymer meshes exhibit a higher surface area per unit volume, enhancing their ability to absorb and distribute heat efficiently. This increased surface area slows down the combustion process, requiring more time to burn completely (28, 29). Conversely, larger PTT polymer meshes have a lower surface area relative to their volume, allowing heat to penetrate and ignite the material more quickly. Therefore, smaller PTT polymer meshes require more burning time due to their effective heat absorption and dispersion, whereas larger meshes burn faster as heat can rapidly reach and ignite more material. The cumulative results observed so far for the FTIR, SEM and flammability test clearly indicates the fact that blending improves the burning rate. Wherein; the optimum addition of the PP or LLDPE to the PTT polymer needs to be exercised in order to achieve the techno-economic component. In the current

study it was observed that 10% addition of PP and 15% addition of LLDPE in PTT polymer are advocated for better flame retardancy.

Conclusion

This study successfully highlights the importance of controlling the ratio of PP or LLDPE in PTT polymer blends to achieve optimal fire retardancy while maintaining cost-effectiveness, without compromising the material's overall performance. The study reports that incorporating 10-15 wt.% of PP or LLDPE in the blend results in improved fire retardancy by reducing the burning rate. However, it is equally important to recognize that further additions beyond this threshold may lead to a decrease in flame resistance due to the inherently faster-burning characteristics of PP and LLDPE. For practical applications, these findings suggest that PTT-based polymer blends with PP or LLDPE could be tailored to meet specific fire safety requirements in industries such as automotive, electronics, and textiles, where flame retardancy is a critical consideration. The optimal blend composition can be selected based on the desired balance between flame resistance, mechanical properties and cost, thus offering a viable alternative to pure PTT, which may be more expensive. Furthermore, the FTIR and SEM studies provides valuable insights into the molecular interactions and structural changes occurring during blending, guiding the design of PTT blends with improved flame-retardant properties by optimizing the dispersion and crystallinity of the polymer phases. Thus, this study underscores the potential of PTT/PP and PTT/LLDPE blends as techno-economic materials for a wide range of fire-sensitive products, by precisely controlling the blend composition.

Abbreviations

PTT: Polytrimethylene Terephthalate, PP: Polypropylene, LLDPE: Linear low-density polyethylene, FTIR: Fourier transform infrared spectroscopy, SEM: Scanning electron microscope, t: elapsed time (in seconds) during Burning rate test, L: length of the specimen consumed by the flame (in mm) during Burning rate test, V: linear burning rate (in millimeters per minute) during Burning rate test, ATR: Attenuated total reflectance, ASTM: American society for testing and materials.

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Author Contributions

Shrikant Deo: Formal analysis, Investigations, Resources. Nandkishor Dalvi: Methodology, Formal analysis, Investigations, Swamini Chopra: Conceptualization, Methodology, Validation, Data curation, Writing – original draft. Kavita Pande: Conceptualization, Data curation, Writing – original draft. J. D. Ekhe: Supervision, Project Administration, Writing – review and editing. Dilip Peshwe: Supervision, Project Administration, Writing – review and editing.

Conflict of Interest

There are no conflicts between authors to declare.

Ethics Approval

Not applicable.

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