UDC 678
DOI: 10.15587/1729-4061.2024.299067

THE EFFECT OF CARBON BLACK PERCENTAGE ON MECHANICAL PROPERTIES AND MICROSTRUCTURE OF POLYBUTYLENE TEREPHTHALATE/POLYAMIDE 6/ CARBON BLACK BLENDS

Pham Thi Hong Nga
Corresponding author
Doctor of Engineering, Associate Professor, Head of Department
Department of Welding & Metal Technology**
E-mail: hongnga@hcmute.edu.vn
Hua Phan Hieu*
Ngo Quoc Bao*
Ha Trong Kien*
Nguyen Vinh Tien
Doctor of Chemistry, Associate Professor, Lecturer
Department of Chemical Technology**
Nguyen Chi Thanh
Doctor of Polymer Engineering, Lecturer
Department of Materials Technology**
Pham Quan Anh
Master of Engineering, Lecturer
Department of Mechanical Practising**
*Faculty of Mechanical Engineering**
**Ho Chi Minh City University of Technology and Education
Vo Van Ngan str., 1, Thu Duc City, Ho Chi Minh City, Vietnam, 71307

This study focuses on analyzing the influence of carbon black (CB) on Polybutylene terephthalate (PBT)/Polyamide 6 (PA6) blends. This study aims to solve the source of waste from toothbrush filament during production. This PBT/PA6 mixture does not meet the mechanical properties due to the incompatibility of these two plastics, which means this waste must be discarded and cannot be reused. When combined with CB, it creates a new type of plastic with more stable mechanical properties that can be applied in many areas of life and, at the same time, helps manufacturing businesses save on waste treatment costs. To create these PBT/PA6/CB blends, the research team used injection molding with a PBT/PA6 ratio of 75/25 combined with 0, 4, 8, and 12 % carbon black. The tensile and impact strength were tested according to the ASTM D638 and ASTM D256 standards. The results found that when adding 4 % CB to the PBT/PA6 plastic mixture, the tensile strength decreased from 34.9 to 34.8 MPa. Meanwhile, the tensile strength is improved when adding 8 % CB (35.3 MPa). At 12 % CB, a difference in tensile strength results, decreasing to 29.7 MPa. This result shows that the ratio 75/25 can give the best tensile strength value of the PBT/PA6 mixture with 8 wt. % CB. The impact strength was 3.5, 2.9, and 2.7 kJ/m^2 according to 4, 8, and 12 % CB samples. Mechanical quality tests have shown that the tensile strength is improved when combining CB into the PBT/PA6 mixture, but the impact strength is reduced. SEM results show that most CB interacts with PBT/PA6 mainly because the PA6 particles are spherical and tend to separate easily from the mixture. The research found that increasing CB density worsens the bonding ability between PBT and PA6. These results help us provide experience for the most appropriate application for each purpose

Keywords: PBT/PA6 blend, PBT, carbon black, tensile strength, impact strength, microstructure

Received date 14.12.2023
Accepted date 16.02.2024
Published date 28.02.2024

How to Cite: *Nga, P. T. H., Hieu, H. P., Bao, N. Q., Kien, H. T., Tien, N. V., Thanh, N. C., Anh, P. Q. (2024). The effect of carbon black percentage on mechanical properties and microstructure of polybutylene terephthalate/polyamide 6/carbon black blends. Eastern-European Journal of Enterprise Technologies, 1 (12 (127)), 20–26. doi: https://doi.org/10.15587/1729-4061.2024.299067*

1. Introduction

As it is known, every year on Earth, people release considerable waste into the environment. They mainly come from household and production waste, including plastic, fabric, rubber, etc. Our problem today is processing and recycling it so it is possible to use it. However, we still need help in doing that. The research team will research and recycle Polybutylene terephthalate (PBT) and Polyamide 6 (PA6) materials from toothbrush bristles, the plastic part that is removed during production and after the toothbrush is no longer used. After being recycled, the research team aims to utilize this new type of plastic in the electrical, electronic, and automotive components industries [1, 2]. However, PBT/PA6 plastic liquid still has some weaknesses in mechanical properties and needs improvement. The topic of carbon black's influence on PBT/PA6 resin mixtures poses an essential challenge to address in today's context. Faced with increasing diversity and demands in the materials and manufacturing sector, understanding the impact of carbon black (CB) on PBT/PA6 resin blends brings new knowledge and an opportunity to come up with innovative and effective solutions [3, 4]. First, this topic stands out for its importance in industrial applications. PBT/PA6 plastic mixture is essential in many manufacturing fields, from automobiles to electronics. CB is an additive commonly used to improve the mechanical properties of plastics. This study provides detailed information on the interaction between CB and the PBT/PA6 plastic mixture, which helps improve the mechanical properties, fully meeting the increasing demand for diversity and efficiency of materials. A deep understanding of this interaction will help enhance product quality and create competition in an increasingly fierce market [5, 6]. Second, solving this problem while meeting increasing demand the higher the sustainable materials. Amid growing environmental concerns, understanding the impact of CB on PBT/PA6 plastic blends could create opportunities to develop environmentally friendly materials that minimize the effect on ecology and promote the green transformation trend... Third, this topic also brings opportunities for innovation in the production process [7–9]. Optimizing the interaction between CB and the PBT/PA6 resin blend can improve manufacturing processes, reduce waste, and increase performance. This material meets economic performance requirements and sets a new standard for sustainability in production [10–12]. Ultimately, the research contributes knowledge to the cutting-edge research community and opens up prospects for innovation and progress in the materials industry. Faced with ever-increasing requirements, a detailed understanding of the influence of CB on PBT/PA6 resin blends is essential to shape the future of the plastics industry.

In summary, the influence of CB on PBT/PA6 plastic mixture is not only a specific study but also an important discovery in materials and production. Addressing this topic provides opportunities for innovation, product improvement, and a complete response to the ever-evolving demands of society and industry.

2. Literature review and problem statement

Recycling to reuse PBT/PA6 plastic mixture is a complex problem for researchers [13, 14]. Research on the PBT/PA6 mixture still needs to be improved because the plastic has some limitations in mechanical properties. PBT is a thermoplastic that belongs to the polyester terephthalate family. PBT is also very popular due to its good mechanical properties and performance, good electrical insulation, water resistance [15, 16], fast crystallization rate, and high heat distortion temperature [17]. PBT plastic is an engineering plastic with stable mechanical and chemical properties. PA6 is a semi-crystalline polymer widely used thanks to its technical advantages, such as low temperature, high thermal deformation and chemical resistance, high strength and hardness, and resistance to wear and abrasion. However, the PBT/PA6 mixture has only recently received attention and is rarely used because the compatibility of these two plastics could be better. When combining these two types of plastic, the impact resistance will be lower than the original PBT and PA6. Therefore, few research articles have been on this PBT/PA6 material in the past ten years. Many researchers have shown the compatibility of the PBT/PA6 plastic mixture when combined with fillers. The article [13] presents research results on the surface conductivity of a PA6/PBT mixture containing carbon black. The study concluded that incorporating 6 vol. % CB increased the tensile strength of all mixtures, although they remained brittle. However, the article points out that there are still unresolved issues related to the CB ratio in the mix, and it is possible that this CB ratio could be more optimal to achieve the highest mechanical properties. However, it should be noted that the primary goal of the research is to investigate the electrical conductivity of the material rather than a detailed study of the mechanical properties. In the article [3], the research results show that the poly (methyl methacrylate-co-methacrylic acid) granules were used as strength modifiers and compatibilizers to harden the PA6/PBT mixture. The apparent impact strength of the PA6/PBT composite was significantly increased, and the water absorption capacity decreased with the addition of poly(n-butyl acrylate)/poly(methyl methacrylate-co-methacrylic acid) particles. This study also uses a third filler to improve the mechanical properties. This research gives the research team more basis to conduct research with the new CB filler, hoping to produce good mechanical properties of the plastic mixture. The study [6] showed that the degree of swelling of the PBT/PA6 mixture when extruded will change according to the viscosity ratio, and the filling composition is also a semi-empirical method to estimate the recovery time. The final restoration with experimental data obtained a clear correlation between the swelling of injection molded materials. To see the interaction between PBT/PA6, the article [18] conducted axial tensile tests under controlled temperature conditions and measurement of Poisson's ratio and volumetric deformation show that Poisson's ratio when plastic deformation is less than 0.5, through test results between finite element analysis and finite element analysis. Finite element analysis assuming non-isovolumetric plasticity found that the plastic properties of PBT and PA6 are non-isovolumetric. The study [19] researched PBT's mechanical and flow properties through injection molding. Research has continued to demonstrate the ability to improve the mechanical properties of PBT in the PBT/PA6/GF mixture. Their primary purpose is to clarify the fire resistance of the fiberglass plastic mixture's mechanical and physical properties in-depth.

Meanwhile, the study [20] also shows that the compatibilizer made from the original PA11 Renewable biology has improved the compatibility and increased the elongation at the break of the PBT/PA6 mixture. In addition, PA11 also makes this plastic mixture harder. However, PA11 is expensive and produced from renewable raw materials, making related research impractical. The article [5] successfully researched to improve the mechanical properties of the PBT/PA6 mixture when combined with epoxy. They found that epoxy can be an effective compatibilizer to reduce and eliminate the size of the dispersed phase while significantly enhancing the mechanical properties. However, there are still unresolved issues related to providing detailed information on the interactions of PBT/PA6 plastic mixtures, which help improve mechanical properties. All this suggests that a study should be conducted on PBT/PA6 blends by adding CB and using direct injection molding.

3. The aim and objectives of the study

The aim of the study is to find the CB ratio to combine with the PBT/PA6 mixture to bring the best mechanical properties for this blend. This research also helps manufacturing businesses save on waste treatment costs, creating economic value while contributing to reducing pollution caused by plastic waste released into the environment, saving resources.

To achieve this aim, the following objectives are accomplished:

– to make samples by injection molding;

– to determine the tensile strength of the PBT/PA6/CB blend;

– to determine the impact toughness of the mixture;

– to determine the microstructure of the blend.

4. Materials and Methods

In this research, three materials were used, including PBT, PA6, and CB. Specifications and material suppliers are as follows: Nylon 6 (PA6), density 1.14 g/cm^3, provided by Bina International Company Limited (Ocean Park Building, No. 1 Dao Duy Anh, Dong Da, Hanoi). PBT, with a density of 1.3 g/cm^3, is provided by TA.COMA Company Limited (Hanoi, Vietnam). CB, with a density of 1.84 g/cm^3, is supplied by HYUNDAI OCI CO., LTD (1138, Daejuk-ri, Daesan-up, Seosan-si, Chungnam, Korea). Before injection molding, the PBT/PA6/CB mixture was mixed evenly by plastic granules mixing machine according to the ratios shown in Table 1.

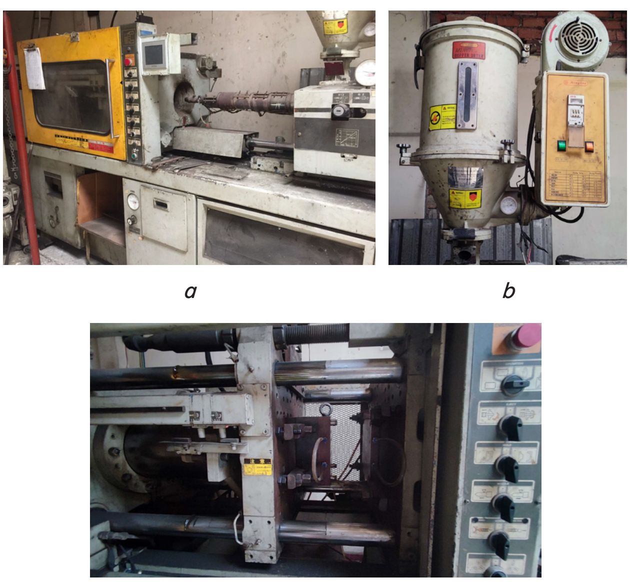
Table 1

Mixing ratio of PBT/PA6/CB blend

Samples	PBT (wt.%)	PA6 (wt.%)	CB (wt.%)
0CB	75	25	0
4CB	72	24	4
8CB	69	23	8
12CB	66	22	12

After mixing, the PBT/PA6/CB material will be injection molded using an injection molding machine to create testing samples.

Fig. 1 shows the machine used in injection molding.



a *b* *c*

Fig. 1. Injection molding machine: *a* – injection molding machine; *b* – plastic drying funnel; *c* – injection mold

Table 2 shows the technical specifications for injection molding.

Table 2

Injection molding parameters

Mold set	Unit	Parameter
Mold opening pressure	%	40
Automatic mold opening		15
Glue pump pressure		40
Automatic glue pump		40
Glue rotation pressure		50
Automatic glue rotation		50
Injection molding parameters	°C	210

The tensile sample was tested on the Shimadzu machine according to ASTM D368 standards. Impact testing is according to ASTM D256 on Tinius Olsen IT504 impact tester. Let's use a HITACHI TM4000Plus microscope to capture microstructure.

5. Results of sample after injection molding, tensile strength, and impact strength of PBT/PA6/CB blend samples

5. 1. Results of the sample after injection molding

After injection molding, let's get the result that the sample has a beautiful shape and size, the color of the 75PBT/25PA6/CB sample is black, and the sample product has burrs on the edges and is cut off.

Fig. 2 shows the product after injection molding.

Fig. 2. Sample after injection molding

Plastic samples after injection molding of 75PBT/25PA6/CB material produce plastic products with precise shapes and sizes. The surface of the plastic product is smooth without cracks or chips, and the color of the sample is beautiful. In addition, the product quality is quite satisfactory.

5. 2. Tensile strength of PBT/PA6/CB blend samples

Fig. 3 exhibits the tensile sample after injection molding and the tensile sample after tensile testing.

Recording results after performing the tensile test of the sample are shown in Fig. 4 and Table 2.

Table 3 depicts the parameter tensile max stress of PBT/PA6/CB blends.

Based on the results chart in Fig. 4 and Table 3, the uniformity of specimens PBT/PA6/4 % CB and PBT/PA6/8 % CB can be seen. For example, both samples reached a 30 to 40 MPa stress level before fracture. The maximum stresses are all in the range of 2.5 to 3.5 %. The PBT/PA6/12 % CB ratio alone has a broader range of results, although the maximum stress before fracture is 30 to 40 MPa. However, the distortion ranges from 2 to 3.5 %, mainly concentrated at 2 to 2.5 (almost all samples focus on 2 to 2.5 %). Therefore, the PBT/PA6/12 % CB ratio affects the PBT/PA6 mixture differently than the PBT/PA6/4 % CB and PBT/PA6/8 % CB blends.

a *b*

Fig. 3. Tensile testing sample: *a* – sample before tensile testing; *b* – sample after tensile testing

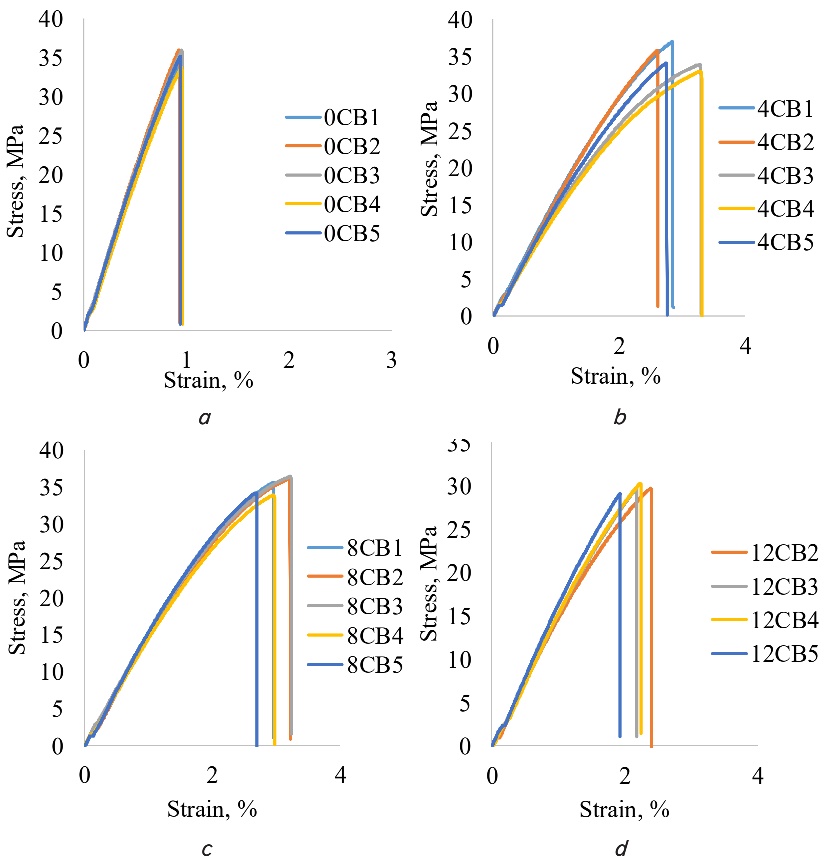


Fig. 4. Tensile stress and strain curves of 75PBT/25PA6/CB blends: *a* – PBT/PA6/0 % CB; *b* – PBT/PA6/4 % CB; *c* – PBT/PA6/8 % CB; *d* – PBT/PA6/12 % CB

Based on the tensile strength and average tensile strength results in Table 3. Adding CB to the PBT/PA6 mixture changes the mechanical properties of the mix. However, the change is insignificant. Tensile strength decreased from 34.9 MPa (0 % CB) to 34.8 MPa (4 % CB), then increased to 35.3 MPa (8 % CB), and when rising to 12 % CB, the tensile strength decreased sharply to 29.7 MPa. To confirm the above statement more clearly, look at the average elastic modulus of each specimen in the 75PBT/25PA6/CB mixture presented in Table 3.

Table 3

Tensile stress and strain of PBT/PA6/CB blends

Sample	0CB	4CB	8CB	12CB
Average of Stress (MPa)	34.9	34.8	35.3	29.7
Standard deviation of stress (MPa)	0.9	1.4	0.9	0.5
Average of Strain (%)	1.0	3.0	3.0	2.2
Standard deviation (strain) (%)	0.1	0.3	0.2	0.2

To confirm the above statement more clearly, look at each specimen's average elastic modulus of 75PBT/25PA6/CB blends shown in Table 4.

Based on the average elastic modulus results recorded in Table 4. It can be seen that the brittleness and hardness of the PBT/PA6 mixture have been reduced after adding CB filler. The PBT/PA6/4 % CB sample decreased sharply from 35.6 MPa to 11.9 MPa and slightly to 11.7 MPa when adding 8 % CB. About the PBT/PA6/12 % CB sample, the material's brittleness increases again to 13.6 MPa. Therefore, it is possible to prove that 12 % has exceeded the allowable CB content when mixed with the PBT/PA6 mixture.

Table 4

Elastic modulus of 75PBT/25PA6/CB blends

Sample	0CB	4CB	8CB	12CB
Average of elastic modulus (MPa)	35.6	11.9	11.7	13.6
Standard deviation (MPa)	1.8	1.5	0.6	1.1

5. 3. Impact strength of PBT/PA6/CB blend samples

The samples before and after the impact strength testing are described in Fig. 5.

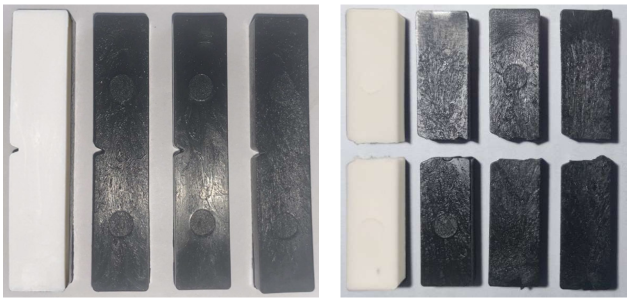
While measuring mechanical properties, the ratios of the samples do not have too much difference between measurements. That's the reason the standar deviation is small.

Table 5 shows the notched Izod impact strength of the PBT/PA6/CB samples.

Table 5

Notched Izod impact strength of the PBT/PA6/CB samples

Sample	0CB	4CB	8CB	12CB
Average of impact strength (kJ/m^2)	3.6	3.5	2.9	2.7
Standard deviation (kJ/m^2)	0.6	1.1	0.4	0.3



a *b*

Fig. 5. Impact testing: *a* – sample before impact strength testing; *b* – sample after impact strength testing

Table 5 show the change in toughness and impact when adding CB to PBT/PA6. Specifically, initially without CB, the impact strength of the sample reached 3.6 kJ/m^2, and when adding 4 % CB, the toughness and impact of the sample decreased by 3.6 to 3.5 kJ/m^2. When adding 8 % CB, the impact strength decreases to 2.9 kJ/m^2; when adding 12 % CB, it drops to 2.7 kJ/m^2. This result shows that CB particles play an important role in changing the state of the material, making the material more brittle and more susceptible to breaking. The reason may be that the density of CB in the mixture has exceeded the allowable threshold, leading to a gradual decrease in the bonding ability of PBT/PA6. Research [7] shows that the impact strength of PBT/PA6 is reduced. A V-notched impact strength sample of binary nanocomposite PA6/CB and nanocomposite PA6/30 wt. % POE-g-MA/CB adding CB in the resin mixture will make PA6 more brittle.

5. 4. Microstructure of the blend

Fig. 6 depicts the microstructure of the samples.

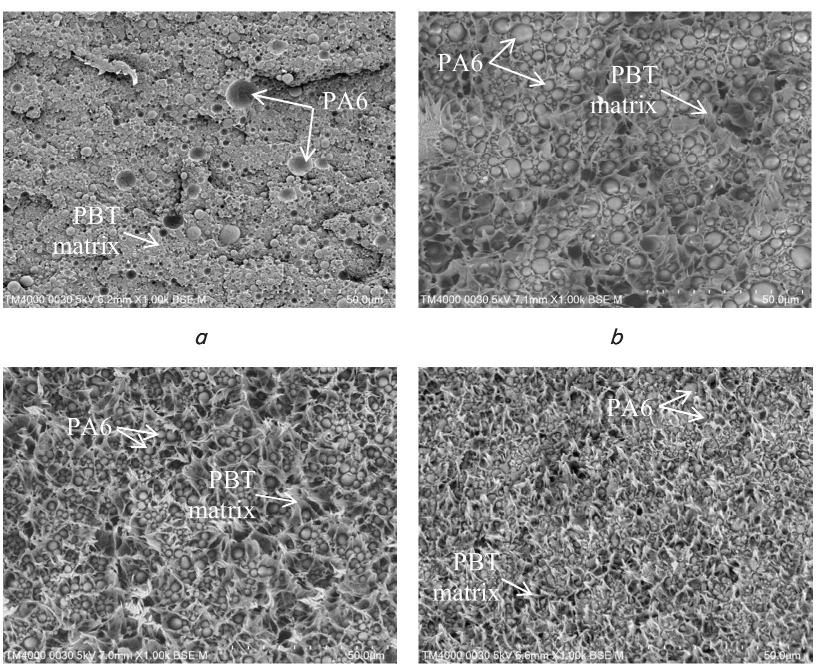


Fig. 6. Organization of the sample at X1000 magnification: *a* – 75PBT/25PA6/0% CB; *b* – 75PBT/25PA6/4% CB; *c* – 75PBT/25PA6/8% CB; *d* – 75PBT/25PA6/12% CB

Fig. 6, *a* shows that the PBT /PA6 sample has large and irregular spherical particles, leading to a decrease in the bond between PBT and PA6. It indicates that PA6 helps improve the impact resistance of the PBT/PA6 mixture compared to the original PBT. This result is proven through research [10]. Fig. 6, *b*, *c* show that when CB is involved, the spherical particles are unevenly distributed and have concave surfaces and cracks, so the bonds are easily destroyed, leading to an impact resistance compared to the PBT/PA6 mixture. Fig. 6, d shows that the CB content exceeds the allowable level, so the bonds between PBT and PA6 are broken, causing the adhesion ability of the two plastics to decrease, causing many holes and surface damage. There are cracks, and the plastic is brittle and easily broken, reducing the impact resistance significantly.

Thereby, it is easily possible to conclude that if the CB content exceeds the allowable level, the bond will be broken, causing the impact strength of the composite plastic to decrease.

6. Discussion of results tensile strength and impact strength of PBT/PA6/CB blend samples

This reduction in tensile strength is because the added CB content exceeded the maximum level the mixture could. The change when adding CB to the mix is similar to the research results of the study [13]. Their study suggested that the change in mechanical properties of the PBT/PA6/CB composite was due to the individual interactions between PBT/CB and PA6/CB. This reduction in tensile strength is due to the additional CB content exceeding the maximum achievable by the mixture. The change when adding CB to the mixture is similar to the research results [13]. Their study shows that the change in mechanical properties of the PBT/PA6/CB composite is due to the individual interactions between PBT/CB and PA6/CB. Fig. 4 shows that CB is not involved. The stress of the PBT/PA6 plastic mixture is only in the range of 0.8 % to 1 % compared to the PBT/PA6 mixture sample mixed with 4 % CB and 8 % CB shown in Fig. 4, *b*, *c*; the stress has been increased, significantly at the level of 2.5 % to 3.5 %. In the study of study [11], it was found that by adding CB to the PP/EPDM mixture, CB nanoparticles accumulated around the EPDM phase and formed a conductive network structure, leading to a decrease in the permeation threshold and an increase in both conductivity and durability. Tensile stress always represents the ability of a material to bond microcrystals. To see this more clearly, Fig. 4, *d*, and Table 3 show that the tensile strength has decreased significantly, and the stress has reduced to less than 2.5 %. The reason is that increasing the percentage of CB in the mixture increases the density of CB, leading to a decrease in the ability to bond microcrystals of PBT and PA6. Similar to the article's research results [7], using 20 % CB also reduced the tensile strength in their study. The CB ratio directly affects the mechanical properties of the PBT/PA6 mixture, and 8 % CB is the ratio that provides the best tensile mechanical properties for this plastic mixture.

Table 5 shows that the higher the CB content, the lower the impact strength. Research [12] demonstrated that adding CB to PC increases tensile strength and melt viscosity but reduces elongation and impact strength. The study also states that lower filler content should be used to avoid poor mechanical properties.

The results of the study are explained through factors affecting the mechanical properties of PBT/PA6/CB materials when mixed together. The mixing ratio between the identified materials is an important factor, with their interaction influencing the tensile or impact strength of the resin associated with the blended structure.

The limitations of this study are, firstly, partly due to the number and diversity of the study sample, which may not be sufficient to represent all real-world conditions and applications, and may limit generalizability. results for many situations. Second, the research mainly focuses on evaluating short-term mechanical properties, not monitoring material changes over a long period of time, so it is not possible to evaluate the stability and change of materials under long-term conditions and over time. Third, the analysis of production costs and integration capabilities has not been done in detail, so there is a lack of information about the ability to apply research results to industrial production processes.

To address the above limitations, it is necessary to increase the study sample size and include more representative samples for a variety of applications and usage conditions, and conduct long-term follow-up studies to evaluate stability and changes in materials over time and conduct research on production costs and evaluate the economic feasibility of using materials in industrial production processes.

The direction of this research is to develop research that can expand the application range of materials in other fields such as medical, automotive, and manufacturing industries, continuing research on stability and changes in materials over long periods of time and seek to optimize the mechanical and chemical properties of materials through new manufacturing and processing processes. There is also research into the customization of materials to meet specific requirements from different industries.

The difficulties encountered are that extensive research may face challenges when implementing large-scale experiments. Subsequent research expansion may face financial challenges due to additional requirements for equipment, human resources and materials. And finally, time management is a challenge when it comes to maintaining a balance between the research, testing, and data analysis phases.

7. Conclusions

1. The injection molding results produce a beautiful plastic model; the plastic product fills the mold cavity, and the color of the plastic is black. The product achieves material performance such as tensile strength, bending strength, impact strength, etc., saves energy, achieves cost efficiency, and ensures product uniformity when mass produced.

2. By testing the tensile strength of plastic, when CB is added, the tensile strength of the sample is generally improved. But it only sometimes achieves good results. Better samples were obtained for CB content at 8 %, and when CB content reached 12 %, the tensile strength decreased significantly. Therefore, the carbon content must be lower than 12 % to have good tensile strength.

3. Through impact durability testing, it is seen that the durability of the sample continuously decreases. It is possible to see that the higher the carbon content, the lower the impact resistance. Therefore, if it is necessary to improve the impact resistance of samples, it is not possible to combine them with CB.

4. Observing the microstructure shows that when the CB content exceeds the allowable level, it will reduce the adhesion of PA6 on the PBT substrate, causing cracks on the surface and reducing durability. The impact strength of the PBT/PA6/CB blend is reduced.

Conflict of interest

The authors declare that they have no conflict of interest about this research, whether financial, personal, authorship, or otherwise, that could affect the study and its results presented in this paper.

Financing

This work belongs to the project grant No: T2023-108, funded by Ho Chi Minh City University of Technology and Education, Vietnam.

Data availability

Data will be made available on reasonable request.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

Acknowledgments

We acknowledge Ho Chi Minh City University of Technology and Education and Material Testing Laboratory (HCMUTE). They allowed me to join their team and access the laboratory and research machines. With their appreciated support, it is possible to conduct this research.

References

1. Mohanty, A. K., Vivekanandhan, S., Pin, J.-M., Misra, M. (2018). Composites from renewable and sustainable resources: Challenges and innovations. Science, 362 (6414), 536–542. https://doi.org/10.1126/science.aat9072
2. Banik, K., Mennig, G. (2008). Effect of mold temperature on the long-term viscoelastic behavior of polybutylene terepthalate. Polymer Engineering & Science, 48 (5), 957–965. https://doi.org/10.1002/pen.20989

3. Li, H., Wang, J., Li, G., Lu, Y., Wang, N., Zhang, Q., Qu, X. (2016). Preparation of core-shell structured particle and its application in toughening PA6/PBT blends. Polymers for Advanced Technologies, 28 (6), 699–707. https://doi.org/10.1002/pat.3969
4. Lievana, E., Karger-Kocsis, J. (2003). Impact modification of PA-6 and PBT by epoxy-functionalized rubbers. Macromolecular Symposia, 202 (1), 59–66. https://doi.org/10.1002/masy.200351206
5. Chiou, K.-C., Chang, F.-C. (2000). Reactive compatibilization of polyamide-6 (PA 6)/polybutylene terephthalate (PBT) blends by a multifunctional epoxy resin. Journal of Polymer Science Part B: Polymer Physics, 38 (1), 23–33. https://doi.org/10.1002/(sici)1099-0488(20000101)38:1<23::aid-polb3>3.0.co;2-y
6. Wakita, N. (1993). Melt elasticity of incompatible blends of poly(butylene terephthalate)(PBT) and polyamide 6 (PA6). Polymer Engineering & Science, 33 (13), 781–788. https://doi.org/10.1002/pen.760331302
7. Hu, J., Zhang, H.-B., Hong, S., Jiang, Z.-G., Gui, C., Li, X., Yu, Z.-Z. (2014). Simultaneous Improvement in Both Electrical Conductivity and Toughness of Polyamide 6 Nanocomposites Filled with Elastomer and Carbon Black Particles. Industrial & Engineering Chemistry Research, 53 (6), 2270–2276. https://doi.org/10.1021/ie4035785
8. Chang, B. P., Mohanty, A. K., Misra, M. (2018). Tuning the compatibility to achieve toughened biobased poly(lactic acid)/poly(butylene terephthalate) blends. RSC Advances, 8 (49), 27709–27724. https://doi.org/10.1039/c8ra05161e
9. Tran, K. L., Pham, T. H. N., Tran, M. T. U. (2023). Research on tensile strength of PBT/PA6/activated carbon composite materials. Proceeding The International Conference on Science, Education and Viable Engineering (ICSEVEN 2023), 207–215.
10. Pham, T. H. N., Phuc, L. H. T., Ngan, L. D. H., Triem, T. D., Uyen, T. M. T., Van Thuc, N. et al. (2023). Effect of Glass Fiber on the Tensile Strength of Poly(butylene terephthalate)/Polyamide 6 Blends. Polymer Science, Series A, 65 (5), 543–549. https://doi.org/10.1134/s0965545x23701158
11. Yang, H., Li, B., Zhang, Q., Du, R., Fu, Q. (2011). Simultaneous enhancement of electrical conductivity and impact strength via formation of carbon black-filler network in PP/EPDM Blends. Polymers for Advanced Technologies, 22 (6), 857–862. https://doi.org/10.1002/pat.1588
12. Huang, J. (2002). Carbon black filled conducting polymers and polymer blends. Advances in Polymer Technology, 21 (4), 299–313. https://doi.org/10.1002/adv.10025
13. Li, H., Tuo, X., Guo, B.-H., Yu, J., Guo, Z.-X. (2021). Comparison of Three Interfacial Conductive Networks Formed in Carbon Black-Filled PA6/PBT Blends. Polymers, 13 (17), 2926. https://doi.org/10.3390/polym13172926
14. Tang, L., Wang, L., Chen, P., Fu, J., Xiao, P., Ye, N., Zhang, M. (2017). Toughness of ABS/PBT blends: The relationship between composition, morphology, and fracture behavior. Journal of Applied Polymer Science, 135 (13). https://doi.org/10.1002/app.46051
15. Xiao, J., Hu, Y., Yang, L., Cai, Y., Song, L., Chen, Z., Fan, W. (2006). Fire retardant synergism between melamine and triphenyl phosphate in poly(butylene terephthalate). Polymer Degradation and Stability, 91 (9), 2093–2100. https://doi.org/10.1016/j.polymdegradstab.2006.01.018
16. Fang, H., Wu, F. (2014). Nonisothermal crystallization kinetics of poly(butylene terephthalate)/multiwalled carbon nanotubes nanocomposites prepared by in situ polymerization. Journal of Applied Polymer Science, 131 (19). https://doi.org/10.1002/app.40849
17. Pham, N. T.-H. (2021). A Study of Recycled Poly(butylene terephthalate) and Low-Density Polyethylene Blend. Polymer Science, Series A, 63 (6), 800–803. https://doi.org/10.1134/s0965545x21060080
18. Sato, Y., Masumizu, S., Sakaue, K., Koyanagi, J., Ohtani, A., Sakai, T. (2022). Evaluation of viscoelastic non-isochoric plastic behavior of PBT and PA6. Mechanics of Time-Dependent Materials, 27 (3), 829–841. https://doi.org/10.1007/s11043-022-09552-1
19. Shuidong, Z., Lingcao, T., Jizhao, L., Hanxiong, H., Guo, J. (2014). Relationship between structure and properties of reprocessed glass fiber reinforced flame retardant poly(butylene terephthalate). Polymer Degradation and Stability, 105, 140–149. https://doi.org/10.1016/j.polymdegradstab.2014.04.009
20. Jubinville, D., Chang, B. P., Pin, J.-M., Mohanty, A. K., Misra, M. (2019). Synergistic thermo-oxidative maleation of PA11 as compatibilization strategy for PA6 and PBT blend. Polymer, 179, 121594. https://doi.org/10.1016/j.polymer.2019.121594