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Research Article

Investigation of Mechanical Properties of Domestic Black Tea Waste Filled Vinylester Composites

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Abstract:

Recently, green composites have been produced by using renewable resources in order to find a solution to problems such as increasing environmental concerns and decreasing reserves. It is a sustainable composite with its ability to adapt to nature and the environment, to use waste, to show a certain strength, to be processed in a simple way, and which does not require new production techniques, can be processed on micro or nano scale, can be recycled, have the quality of being renewed. is highly preferred. In this study, domestic black tea waste was used as a filler. As the matrix material, vinylester resin is preferred because it can be easily processed at room conditions and is less costly. Waste tea was added to the matrix as a filler in an open mould at the rates of 0%, 5%, 10%, 15%, 20% and 25%. Tensile, impact and hardness tests were performed on composite samples. Fractured surface examinations of the samples were also examined by SEM. When the results are compared, it can be said that the 10% domestic black tea waste filled vinylester composite has slightly better mechanical properties than the other samples. Thus, it was evaluated that domestic black tea waste could be used as a filler in composite applications.

1. Introduction

Composites are materials obtained as a result of combining more than one material or phase with a suitable method in order to combine the appropriate properties of two or more materials in a single material and to obtain superior new properties. It is a highly preferred material class with its positive features such as adaptability to different situations, serving specific purposes, exhibiting desired properties, resistance to chemicals and corrosion, high durability/density ratio, high modulus/weight ratio, and lightness. It is used in a wide and diverse field such as aviation, space and defence industry, land and sea vehicles, sports equipment, construction, infrastructure and energy sector [1-3].
Conventional petroleum-based composites have many advantages, but are not biodegradable due to their toxic effect. Conventional composite materials that have reached the end of their useful life are difficult and expensive to recycle, and are sometimes destroyed by burial and sometimes by incineration. The pollution caused by the destroyed materials and the rapidly decreasing natural resources pose a great problem for the future. For this reason, the interest in environmentally friendly, sustainable raw materials has increased in recent years with environmental concerns and demands of legal authorities. The use of natural fibers as reinforcement material and wood materials as filler material in composites in engineering applications has become increasingly widespread, and the concept of green composites has come to the fore [4-5].
A composite material consists of the combination of two or more materials in macro dimensions and without mixing with each other, and one or more of these materials is named as reinforcement/filler material, while the other structure surrounding the

reinforcement/filler material is defined as matrix. [6].

The most basic feature that distinguishes composite materials from the molecular structure called mixture; The two main components (matrix and reinforcement phase) appear prominently in the inner region of the composite materials and do not dissolve in each other [7].

Today, the use of composite materials in areas such as automotive, aviation, health, sports and maritime is increasing. One of the most important and most frequently produced and developed types of composite materials is polymer matrix composites. While epoxy, vinylester and polyester are used as matrix material intensively in composites, fibers such as glass, carbon and aramid are preferred as reinforcement materials. Due to many advantages such as corrosion resistance, lightness, good mechanical properties, this group of composite materials is in demand today [8].

In composites, the matrix material transmits and distributes the applied force to the reinforcement phase through the interface. The mechanical properties of the matrix material are very important for the load transfer reinforcing element to function in the composite material. The interface, which acts as the adhesive between the matrix structure and the reinforcement element, transmits the force to the reinforcement phase. This region is the most important place that affects the elastic modulus of the material. Thus, it can be said that the most important factor determining the strength of composites is good interfacial bonding [9].

Composite materials cause more than one beneficial properties to emerge in the material itself. At the same time, it is a very popular material group with its ability to comply with different conditions, to work for special purposes, to exhibit good behaviour against expected features, to be light with its high strength/density ratio, high modulus/weight ratio [10-13].

Green composites are materials that one or more of their components originate from natural origins and are in demand. Biodegradability offers alternatives to traditional composites in terms of finding alternatives to environmental problems and decreasing resources, ease of use, not harming the skin, low cost, and soundproofing and recycling. Green composites are believed to have a major impact on ecosystem problems, as they are derived from structures found in nature, and have a promising effect on shrinking oil resources. With all these positive properties, green composites, developed as a new nature-friendly polymeric composite material, show technical and low-cost benefits in commercial and engineering applications and have a dragging effect in the global market [14-15].

In this study, green composite was prepared, vinylester polymer was used as matrix material and domestic black tea waste was used as reinforcement element.

Vinylester resins are a type of resin that is produced by the reaction of epoxy resin and unsaturated acid. It is the most used version obtained by the reaction of methacrylic acid dissolved in the styrene monomer structure and bisphenol A (BPA) epoxy resin. It has high resistance to ambient conditions. Although vinylester resins are thermoset based, their simple processability and rapid curing properties have been improved with epoxy resins compared to unsaturated polyester resins. However, it shows good strength and corrosion resistance [16-17].

Numerous studies have been conducted on green composites in the literature. Some of the studies carried out are thermoset composite materials reinforced with hazelnut, paddy shells and wood shavings [18], chestnut/hornwood sawdust filled vinylester composites [19], bamboo and glass fiber reinforced vinylester composites [20], hazelnut shell filled polypropylene matrix composites [21], chestnut wood flour filled vinylester composites [22], hornbeam sawdust filled polyethylene composites [23] are just a few of these studies.

2. Material and Methods

2.1 Materials

Bisphenol-A based vinylester resin (E-275-Erco Boya, İstanbul), which is ideal for hand casting, was chosen as the matrix material. 50% active methyl ethyl ketone peroxide (Erco Ece Boya, İstanbul) was used as a reaction initiator. Cobalt naphthalate used as accelerator was used as 1% of the weight of the resin. Domestic black tea waste used as a filler was obtained from tea grown in Rize province in the Eastern Black Sea Region. After drinking Çaykur Tiryaki branded black tea, the remaining pulp was collected as waste, dried and ground (figure 1 and figure 2).

In addition, Teflon mould was used to prepare standard tensile, impact and hardness samples.

2.2 Methods

Composite samples prepared are a combination of domestic black tea waste and vinylester resin. Composite mixtures were formed by adding domestic black tea waste at different rates (0%, 5%, 10%, 15%, 20%, 25% by weight) to vinylester. 2%

by weight of methyl ethyl ketone peroxide (Erco Boya, İstanbul) was added to the resin as a hardener and 1% by weight of cobalt naphthalate (Erco Boya, İstanbul) as accelerator. The mixtures were poured into an open Teflon mold and solidified. Mold release agent has been applied in order to remove the composite material from the mold more easily.

The tensile test was applied to the samples in the Zwick brand Z010 universal type tensile test device according to the ISO 527 standard at a tensile speed of 5 mm per minute. The impact strength of the unnotched test specimens was used with a 5.4 J Izod hammer on the Zwick brand B5113.30 impact tester. Hardness test measurements were made on the Zwick brand Shore D tester. For SEM analysis, the samples were coated with a 10 Å thick gold/palladium alloy. The SEM test was performed with the Polaron SC branded device located in the Marmara University Faculty of Technology Laboratory.

Figure 1. *Grinding Tea in a Blender*

Figure 2. *Image of Ground Domestic Black Tea Waste*

3. Results and Discussions

The tensile strength value of a particle reinforced polymer matrix in the composite varies depending on the active charge transfer between the matrix structure and the particle reinforcements. Factors such as particle additive ratio, size, surface properties also directly affect the strength.

According to the tensile test data (figure 3), the highest tensile strength was observed in the 10% tea waste filled vinylester based composite. An increase of approximately 15% in tensile strength was obtained compared to the pure vinylester sample. A decrease in tensile strength was observed as the tea waste ratio increased (15% and later). Irregular shaped black tea waste particles in the composite structure also had a notch effect and had a positive effect on the strength of the composite structure during the tensile test.

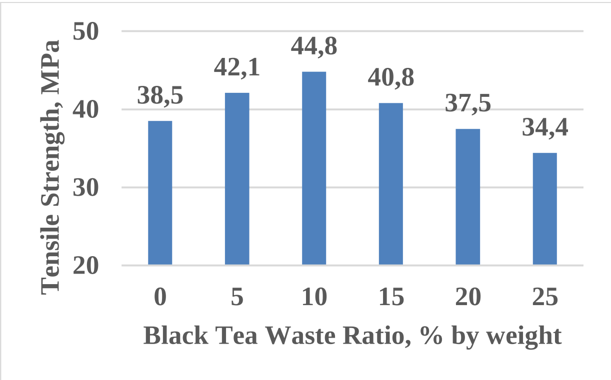


Figure 3. *Variation of Tensile Strength with Black Tea Waste Ratio*

The modulus value of the particle-reinforced polymer matrix composite can be increased by adding high-hardness particles to the polymer matrix structure. The modulus of elasticity value is dependent on the total charge present in the fiber or filler and is independent of the particle size size and interfacial adhesion ability.
As the amount of waste tea waste increased in the blends, the modulus value increased slightly (figure 4). Again, the highest value was seen in the mixtures with 10% filling ratio. In the following ratios, the module value decreased. When the variation of Izod impact strength of with the ratio of black tea waste was examined, it was observed that the impact resistance of the composite decreased

slightly with the increase of the tea waste ratio. Waste tea reduced the impact strength (figure 5).

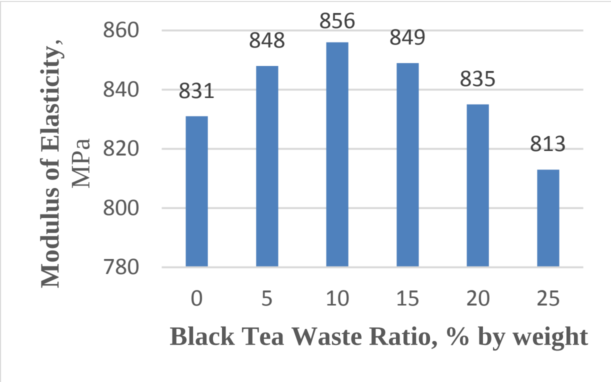


Figure 4. *Variation of Modulus of Elasticity with Black Tea Waste Rate*

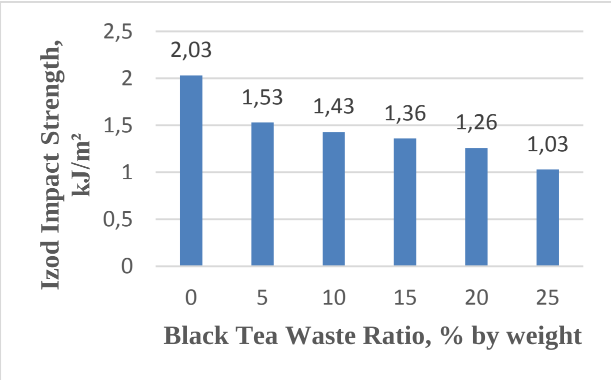


Figure 5. *Variation of Izod Impact Strength with Black Tea Waste Rate*

The reason for this is thought to be the reason that tea wastes are found in many different sizes. When the Shore D hardness test results were examined, it was determined that there was no obvious change in the hardness test values with the addition of domestic tea waste (figure 6).

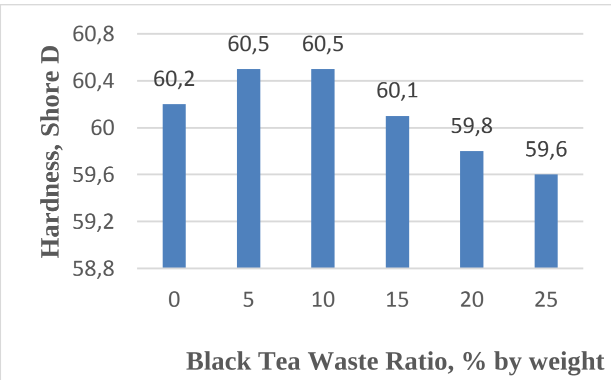
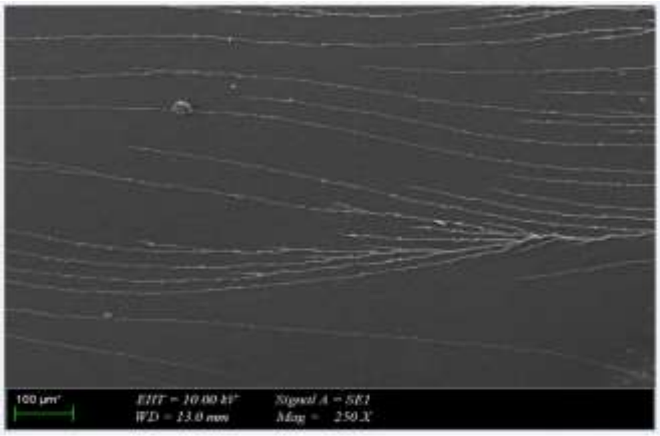
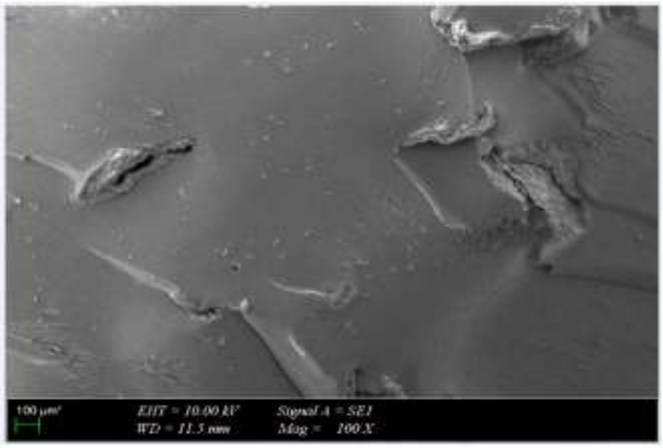


Figure 6. *Variation of Shore D Hardness Value with Black Tea Waste Ratio*

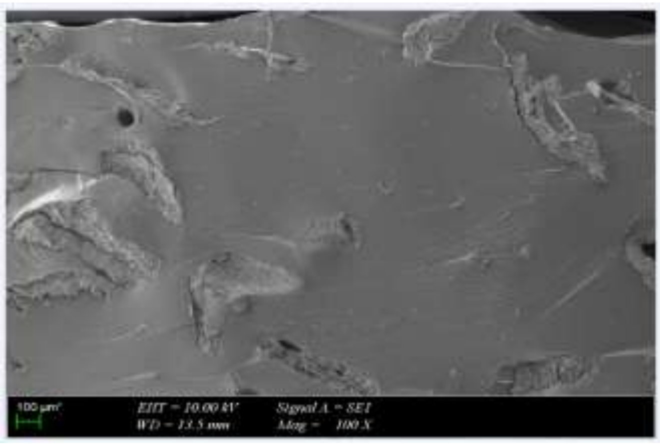
SEM images of the samples are given in Figure 7. In Figure 7a, damage lines are seen on the surface of the pure vinylester and it is understood that there is a brittle fracture. As can be seen from other SEM images, tea wastes have very different sizes and structures. After the grinding process, no size separation was made, and the wastes were used as they were. As can be seen from the images, it is seen that there is tea waste in the size of 10 microns, as well as tea waste in the size of 500 microns.



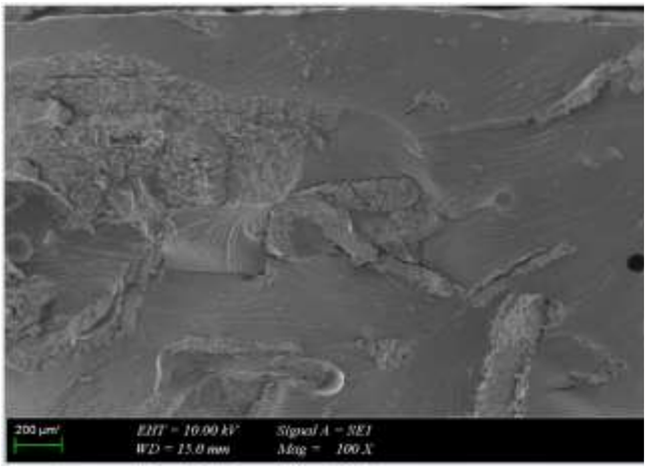
(a) *Pure Vinylester*



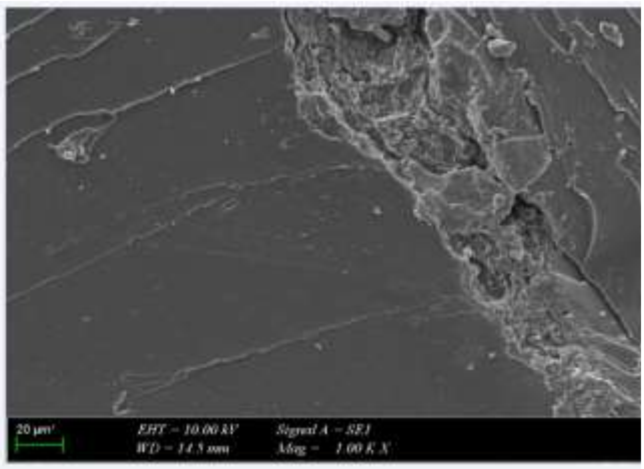
(b) *5% black tea waste filler composite*



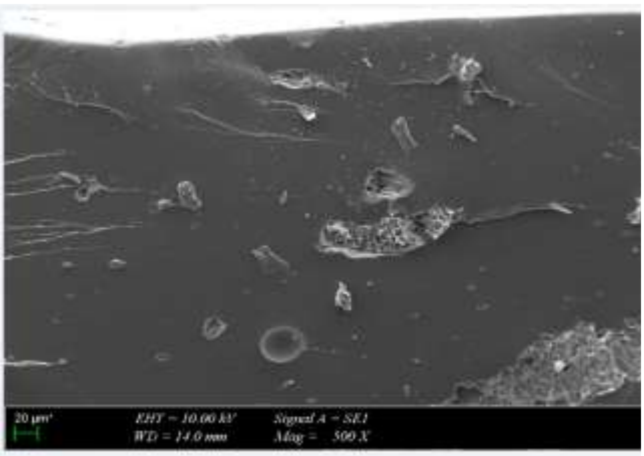
(c) *10 % black tea waste filler composite*



(d) *15 % black tea waste filler composite*



(e) *20 % black tea waste filler composite*



(f) *25% black tea waste filler composite*

Figure 7. *SEM images of pure vinylester and black tea waste filler composites*

4. Conclusions

In this study, the use of domestic black tea waste as a filler in composite material was examined. A slight improvement in mechanical properties was observed as the filler ratio increased in vinylester based composite materials. According to the tensile test data, it was observed that 10% domestic black tea waste filler showed better strength. It was determined that the modulus of elasticity value was also high at this 10% filler rate. Impact test values have decreased due to different sizes of filler in the structure. The hardness values remained almost the same.

At the end of this study, it was concluded that in addition to contributing to the solution of environmental problems, it even allows for improvement in some mechanical and physical properties, and the use of such fillings in composite materials may be a suitable decision.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

References

[1] Jose A.M., Kim Y.A., Leal-Ekman S., Hunter C.P. (2012). *Conserved tyrosine kinase promotes the import of silencing RNA into Caenorhabditis elegans cells*, Proc. Natl. Acad. Sci. USA., 109: 14520–14525.

[2] Sabu, T., Kuruvilla J.; Kumar, M., Goda, K., Sreekala M. S. (2012*). Introduction to Polymer Composites*, *Polymer Composites*, Volume 1, First Edition, Wiley-VCH Verlag GmbH & Co 209.

[3] Kandpal, B.C., Chaurasia, R., Khurana, V. (2015). Recent Advances in Green Composites – A Review, *International Journal For Technological Research In Engineering (IJTRE)* 2(7)

[4] Santulli, C., Sarasini, F., Tirillò, J., Valente, T., Valente, M., Caruso, A.P., Infantino, M., Nisini, E., Minak, G. (2013). Mechanical Behaviour of Jute

Cloth/Wool Felts Hybrid Laminates, *Materials and Design*, 50,309–321.

[5] Yan, L., Chouw, N., Jayaraman, K. (2014). *Flax Fibre and Its Composites*, Composites: Part B Engineering (Compos Part B- Eng), vol. 56, pp. 296-317.

[6] Sanjay, M. R., G. R. Arpitha, and B. Yogesha. (2015). Study on mechanical properties of naturalglass fibre reinforced polymer hybrid composites: A review. *Materials today proceedings*. 2(4-5), 2959-2967.

[7] Sabu, T., Kuruvilla, J., Kumar, M., Goda, K., Sreekala M. S. (2012) *Introduction to Polymer Composites*, Polymer Composites, 1st Edition., Springer, Boston, MA.

[8] Post, W., et al. (2017), Healing of a glass fibre reinforced composite with a disulphide containing organic-inorganic epoxy matrix. *Composites Science and Technology* 152, 85-93.

[9] Qu, J. (1993). The effect of slightly weakened interfaces on the overall elastic properties of composite materials. *Mechanics of Materials*, 14(4), 269-281.

[10] Chou, T. ve Ko, F. (1989) *Textile Structural Composites*, Elsevier Science Publishers, Amsterdam.

[11] Kandpal, B.C., Chaurasia, R., Khurana, V. (2015) Recent Advances in Green Composites – A Review, *International Journal For Technological Research In Engineering (IJTRE)*, 2, 742-747.

[12] William D. Callister, J. D. (2014). *Composites. J. D. William D. Callister içinde*, Materials Science and Engineering an Introduction (s. 636). United States America: Wiley.

[13] Qu, J. (1993). The effect of slightly weakened interfaces on the overall elastic properties of composite materials. *Mechanics of Materials*, 14(4), 269-281.

[14] Thakur, V. K., Thakur, M.K., Gupta, R.K. (2014). Review: Raw Natural Fiber–Based Polymer Composites, *International Journal of Polymer Anal. Charact. (IJPAC)*, 19,256–271.

[15] Paul, W., Jan, I., Ignaas, V. (2003). Natural Fibers: Can They Replace Glass in Fiber Reinforced Plastics, *Comput Sci Technol*, 63,1259–1264.

[16] Blankenship, L.T., White, M.N., Puckett, P.M. (1989). *Vinyl Ester Resins: For Composites*, Dow Chemical U.S.A, Freeport, Texas, pp. 1-36.

[17] Astrom, B.T. (1997). *Manufacturing of Polymer Composites*, Department of Aeronautics, Royal Insitute of Technology, Chapman & Hall, pp. 1-175.

[18] Kartal, İ., (2018). Kord bezi ile takviye edilmiş polyester kompozitlerin kırılma özelliklerinin incelenmesi. *BAUN Fen Bilimleri Enstitüsü Dergisi*, 20 (2), 396-400.

[19] Boriaa S., Pavlovicb A., Fragassab C., ve Santullic C. (2016) Modeling of Falling Weight Impact Behavior of Hybrid Basalt/Flax Vinylester Composites, *Prodecia Engineering*, 167, 223-230.

[20] Kartal İ., Naycı G., Demirer H., (2019) Cam ve Bambu Lifleriyle Takviyelendirilmiş Vinilester Kompozitlerin Mekanik Özelliklerinin İncelenmesi, *International Journal of Multidisciplinary Studies and Innovative Technologies*, 3(1),34-37.

[21] Demirer H., Kartal İ., Yıldırım A., Büyükkaya K., (2018) The Utilisability of Ground Hazelnut Shell as Filler in Polypropylene Composites, *Acta Phys. Pol. A* 134, 254-256.

[22] Kartal İ., Naycı G., Demirer H., (2020) The effect of chestnut wood flour size on the mechanical properties of vinyl ester composites, *Emerging Materials Research*, 9(3), 960-965.

[23] Kartal İ., (2020), Effect of hornbeam sawdust size on the mechanical properties of polyethylene composites, *Emerging Materials Research* 9(3): 979–984.