Jurnal Pendidikan Kimia (JPKIM)
p-ISSN: 2085-3653| e-ISSN: 2549-3116
https://jurnal.unimed.ac.id/2012/index.php/jpk/index

OPEN ACCESS
10.24114/jpkim.v16i2.56532
J. Pendidik. Kim 2024, 16(2), 185– 190

Original Research Article

Mechanical properties of water hyacinth (*Eichhornia crassipes*) and sansevieria (*Sansevieria trifasciata*) fiber reinforced composite with polyester matric

Nurfajriani - https://orcid.org/0000-0003-1598-9969
Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, Medan 20221, Indonesia

Ahmad Nasir Pulungan - https://orcid.org/0000-0001-9024-6546
Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, Medan 20221, Indonesia

Ajat Sudrajat
Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, Medan 20221, Indonesia

MS Manurung
Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, Medan 20221, Indonesia

Rahayu
Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, Medan 20221, Indonesia

Corresponding authors: Nurfajriani (e-Mail: nurfajriani@unimed.ac.id)

Citation: Nurfajriani, N., Pulungan, A.N., Sudrajat, A., Manurung, MS., & Rahayu, R. (2024). Mechanical properties of water hyacinth (Eichhornia crassipes) and sansevieria (Sansevieria trifasciata) fiber reinforced composite with polyester matric. Jurnal Pendidikan Kimia (JPKIM), 16(2), 185 – 190. https://doi.org/10.24114/jpkim.v16i2.56532

ARTICLE INFO

Keywords:
Composite;
Polyester resin;
Sansevieria;
Tensile test;
Water hyacinth

History:
♦ Received - 06 March 2024
♦ Revised - 09 July 2024
♦ Accepted - 08 August 2024

ABSTRACT

Sansevieria (Sansevieria trifasciata) fibers and water hyacinth (Eichhornia Crassipes) fibers as natural fiber producers with good quality have good potential to be developed. This study aims to examine the production and characteristics of composites made from sansevieria fiber and water hyacinth fiber with a polyester matrix through the employment of the hand lay up method. This composite uses variations in the composition of the fiber mixture by soaking 5% NaOH for 2 hours at room temperature, for the resulting composite material. The resulting composite material is then subjected to a bending test to determine its mechanical properties, utilizing the ASTM D638 test standard. Based on the conducted research, the most favorable outcomes in terms of bending test results and modulus of elasticity are observed with a 10% incorporation of sansevieria fiber, yielding an average of 5.520 MPa for bending test and an elastic modulus of 7.444 MPa. Alternatively, when combining both fibers, the optimal mixture consists of 20% sansevieria fiber and 20% eceng gondok fiber, resulting in an average bending test value of 7.503 MPa and a modulus of elasticity of 7.873 MPa.

Introduction

At present, the progression of time is experiencing an increasingly advanced and sophisticated trajectory, alongside the escalating demands and necessities of the populace. Consequently, individuals must demonstrate adeptness in harnessing the resources provided by nature in order to satisfy their economic requirements. A viable approach to achieving this objective involves the creation of novel materials derived from natural sources (Drabczyk et al., 2023; Phiri et al., 2023). This course of action is predicated upon the recognition that the demand for materials will invariably rise over the years. As a result, the necessity for cost-effective, non-corrosive, lightweight, and structurally robust materials becomes paramount. Consequently, researchers continue to delve deeper into the development of composite materials reinforced with natural fibers. The quest for materials that are both low-cost and of superior quality is imperative. The realm of research pertaining to fiber-based composites is characterized by its wide-ranging diversity. Moreover, there has been a steady increase in the exploration of natural fiber materials for the production of various types of synthetic substrates. This is particularly significant considering the extensive application of composites across a multitude of everyday domains. Additionally, enthusiasts of composite materials perceive them as a viable alternative to metals (Hairiyah et al., 2018).

The utilization of *Sansevieria trifasciata* (Fig-1a), commonly known as mother-in-law's tongue, is primarily limited to its employment as an adornment for the purpose of embellishing edifices, residences, corporate establishments, and similar structures. Notably, mother-in-law's tongue exhibits an exceptional capability to assimilate noxious gaseous pollutants, thereby ameliorating the quality of ambient air. Furthermore, the foliage of this botanical specimen shares resemblances with that of the pineapple, as it possesses commendable attributes such as resilience, elongated fibers, and a lustrous appearance. Additionally, it must be emphasized that the leaves of mother-in-law's tongue exhibit a substantial concentration of the chemical constituents lignin and cellulose (Widodo et al., 2024). The Sansevieria trifasciata fiber is characterized by its cost-effectiveness, extensive accessibility, notable specific strength, renewable nature, and low density, making it a viable option for serving as a reinforcing agent in polymer composite materials (Adeniyi et al., 2020). Consequently, this particular plant has garnered attention as a potential substitute material for the production of natural fibers in diverse industrial applications (Raj et al., 2023). In order to avail the fibers for such purposes, extraction techniques encompass two approaches, namely mechanical means employing a decorticator apparatus and manual extraction methods (Napitupulu et al., 2019).

a b

Fig-1. Sanseviera plant (a); Water hyacinth (b)

Water hyacinth (*Eichhornia crassipes*) (Fig-1b) is an aquatic botanical specimen that resides afloat on the water's surface. This particular variety of aquatic plant exhibits a remarkable capacity for prompt proliferation and has posed a persistent global predicament for over a century. It is noteworthy that the water hyacinth has even garnered the dubious distinction of being listed among the one hundred perilous plant species worldwide. The expeditious growth of this vegetation has precipitated a host of issues, including disturbances to the equilibrium of ecosystems, the eradication of indigenous organisms, the shallowing of water bodies, and the concomitant diminution in fish yield (Harun et al., 2021). In recent years, numerous researchers have embarked upon investigations aimed at harnessing the water hyacinth as a fundamental component of their scientific inquiries, encompassing domains such as herbal chemistry, the introduction of natural predators, and the exploration of the plant's potential applications (Guna et al., 2017; Li et al., 2021). Indeed, a plethora of academic investigations have been initiated with the goal of elucidating the manifold advantages offered by the water hyacinth. Considerable attention has been devoted to scrutinizing its aptitude for absorbing waste dyes, serving as a source of biogas and biofuel materials, sequestering heavy metals, and even serving as a reinforcing agent in composite materials (Ajithram et al., 2021; Jirawattanasomkul et al., 2021; Sulardjaka et al., 2020). Dass and Chellamuthu (2022), reported that the Water Hyacinth fiber comprises a greater proportion of cellulose and lignin content alongside a reduced quantity of ash and wax content. Consequently, the utilization of Water hyacinth fiber reinforced epoxy composites results in enhanced properties.

Polyester resin possesses the advantage of cost-effective mechanical strength and is highly suitable for utilization due to its commendable attributes such as remarkable resistance to heat, chemicals, alkalis, and acids (Nurfajriani et al., 2015). Additionally, it exhibits a reasonably good adhesive force, albeit inferior to that of epoxy resin, and effectively forms a durable composite with wood, plastic, metal, glass fiber, and natural fibers (Flores Ramirez et al., 2015). Therefore, acknowledging the potential of the aforementioned fiber varieties, both were included in this study as composites alongside polyester that has received relatively limited attention in academic literature. This study aims to examine the production and characteristics of composites made from sansevieria fiber and water hyacinth fiber with a polyester matrix through the employment of the hand lay up method.

Methods

Materials

The tools implemented encompass composite molds, mixing containers, stirrers, analytical slides, hot presses, caterpillars, saws, and scissors. The materials used consist of mother-in-law's tongue fiber and water hyacinth fiber taken from Simodong, Sei Suka District, Batu-Bara Regency. Other materials are polyester resin, methyl ethyl ketone peroxide (MEKPO) catalyst, 5% NaOH (p.a Merck), and aluminum foil.

Sample Preparation

The water hyacinth is split from top to bottom and dried in the sun for ± 10 days, the fiber and skin are separated by brushing with a wire brush, the fiber will be separated from the plant flesh. The skin alkalinization process is carried out by soaking water hyacinth skin for 2 hours in 5% NaOH solution, drying in the oven for 1 day at a temperature of 60°C. The fibers were cut to a length of 80 mesh (Hastuti et al., 2019).

The leaves of the mother-in-law's tongue plant that are utilized are of the variety characterized by yellow leaf margins and a uniform leaf length. The mother-in-law's tongue leaves are damaged, leading to rapid decay and facilitating the extraction of the fiber. The fiber is immersed in water and subject to the water retting process within a container for a duration of 7 days. It is then manually cleaned and rinsed with water to acquire a pale, bone-like appearance. Following this, the fiber is left to dry in the air for a period of 24 hours. In the present experiment, the fiber is submerged in a 5% sodium hydroxide (NaOH) solution for 2 hours, after which it is subjected to a drying process in an oven for 24 hours at a temperature of 60 °C. Subsequently, the fiber is cut into pieces of 100 mesh size (Lokantara et al., 2020).

Composite Manufacturing

This investigation employs the Hand Lay Up technique for the bonding process utilizing Polyester resin, while the reinforcement involves a combination of mother-in-law's tongue fiber and water hyacinth fiber. The formation of the composite material took place at the Polymer Laboratory, located at the University of North Sumatra. In this study, the composites varied in fiber and polyester matrix composition as shown in Table 1.

Table 1. Variations in composite composition

Fiber volume fraction		Polyester matrix (%)	Alkalization of NaOH (5%)
Mother-in-law's tongue fiber (%)	Water hyacinth fiber (%)		
0	0	100	-
10	0	90	✓
0	10	90	✓
10	10	80	✓
15	15	70	✓
20	20	60	✓

Sample Printing

Specimens were fabricated through manual lay-up utilizing a glass mold. The preparation of the fibers and binders was conducted in accordance with volumetric calculations. Subsequently, the mold was thoroughly cleansed, and its interior was lined with aluminum foil and flattened. The polyester resin and MEKPO catalyst were combined in a measuring cup with a ratio of 1% MEKPO and stirred until achieving uniform distribution. The introduction of mother-in-law's tongue fiber and water hyacinth fiber into the resin and catalyst mixture ensued, followed by meticulous stirring to ensure conformity with the predetermined volume percentage. The resulting blend of fiber and resin was then poured into the mold, leveled, and compressed with a stirrer to guarantee even distribution of the reinforcement and binder across all regions of the mold. The mold was then covered with glass and subjected to pressure by means of placement within the Hot Press apparatus for approximately 5 minutes, with the objective of minimizing voids or cavities within the specimen. Subsequently, the demolding process involved the extraction of the specimen from the mold through the utilization of a knife or cutter. The subsequent phase encompassed the curing process, whereby the specimen was left to undergo drying within a room until attaining complete dryness; should the initial drying prove insufficient, an extended drying process may be implemented. The final step entailed finishing the specimen, whereby a smooth surface was achieved.

Bending Test

The bending test is carried out by applying a bending load slowly until the specimen reaches the breaking point. In the bending test treatment, the upper part of the specimen experiences compression and the lower part experiences a tensile process so that as a result the specimen experiences fracture at the bottom because it is unable to withstand the tensile stress.

Results and Discussion

Bending Test Data

The experimental procedure for the bending test involves the gradual application of a bending load to the specimen until it reaches its breaking point. During the bending test, the upper portion of the specimen is subjected to compressive stress, while the lower part experiences a tensile process. Consequently, the specimen fractures at the bottom due to its inability to withstand the applied tensile stress. Fig-2 depicts a bending test sample of a polyester resin matrix combined with composite fibers derived from sansevieria and water hyacinth. The bending test results for several variations in composite composition are summarized in Table 2 and Fig-3.

Fig-2. Sample Bending Test

Based on the data presented in Table 2 and Figure 3, the bending strength and bending modulus of elasticity values of fiber composite specimens can be determined after subjecting them to a 5% NaOH alkaline treatment for a duration of 2 hours. Modification of the fiber surface through alkalization also increases the fiber's ability to interact with the matrix, thereby improving the properties of the resulting composite (Widodo et al., 2024).

Table 2. Bending test data

Sample code	Sample	Bending Strength (MPa)	Modulus of Elasticity (MPa)
1	100% Polyester resin	2.329	0.895
2	10% Water hyacinth fiber	5.434	5.209
3	10% Sansevieria fiber	5.520	7.444
4	10% Water hyacinth fiber + 10% Sansevieria fiber	4.327	4.532
5	15% Water hyacinth fiber + 15% Sansevieria fiber	4.002	4.300
6	20% Water hyacinth + 20% Sansevieria fiber	7.503	7.873

An experiment was conducted to assess the average bending properties of composite materials reinforced with water hyacinth fiber and Sansevieria fiber, with polyester matrices. The results indicate that for composites with a 100% polyester matrix, the average bending stress was found to be 2.329 MPa, while the elastic modulus was determined to be 0.895 MPa. Conversely, in the case of composites with a 10% water hyacinth fiber content, the average bending stress increased to 5.434 MPa, accompanied by an elastic modulus of 5.209 MPa. Similarly, when the composite material contained 10% Sansevieria fiber, the average bending stress was found to be 5.520 MPa, with an elastic modulus of 7.444 MPa. Moreover, when a combination of water hyacinth fiber and Sansevieria fiber was present in the composite material at a 10% variation, the average stress reached 4.327 MPa, and the elastic modulus was determined to be 4.532 MPa. Furthermore, when the variation was increased to 15%, the average stress decreased to 4.002 MPa, while the elastic modulus was found to be 4.300 MPa. Finally, at a variation of 20%, the average stress reached 7.503 MPa, accompanied by an elastic modulus of 7.873 MPa. These results are in line with Mesfin et al. who reported that enhancing fiber content enhanced the mechanical characteristics of water lily fiber reinforced polyester composites. The enhancement in flexural strength can be elucidated by the interactions between the fiber and matrix, as well as the capacity to bear loads, which is a typical occurrence in polymer composites reinforced with fibers. The existence of a greater number of fibers within the matrix hinders the propagation of cracks through the matrix (Mesfin et al., 2023).

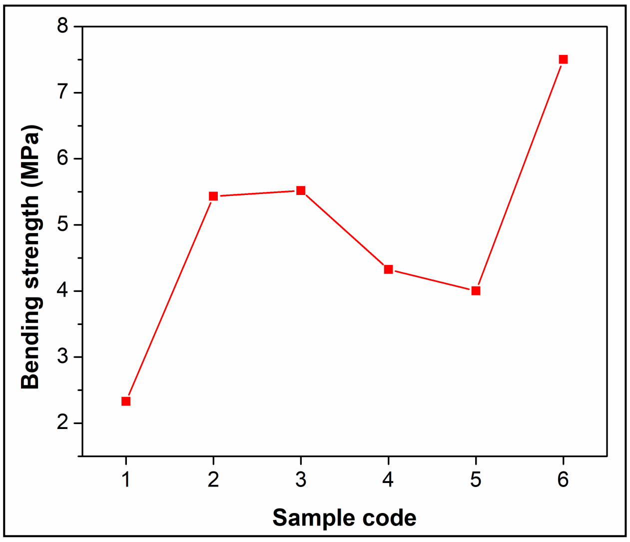

Fig-3. Composite bending strength

In the bending test, the composite reinforced with water hyacinth fiber and Sansevieria fiber exhibited varying values. However, the composite reinforced with Sansevieria fiber proved to have the highest value, with a bending stress of 5.520 MPa and an elastic modulus of 7.444 MPa. This finding was consistent with the results obtained from the tensile test, wherein the composite reinforced with Sansevieria fiber displayed greater strength. This can be attributed to the longer length of the Sansevieria fiber, as the length of the fiber plays a significant role in determining the strength of the composite. Additionally, when considering variations in the combination of the two fibers, it was observed that the 20% variation yielded an average bending stress of 7.503 MPa and an elastic modulus of 7.873. It is worth noting that as the fiber composition increases, the bending stress also tends to increase.

Conclusion

The bending test outcomes were identical to those of the six samples utilized in the tensile test. During the bending test, the highest bending value was observed in the 10% mother-in-law's tongue fiber, exhibiting an average bending stress of 5.520 along with an elastic modulus of 7.444 MPa. Furthermore, when examining the variations in the combination of the two fibers, the highest value was found in the 20% variation of mother-in-law's tongue fiber and water hyacinth fiber, which demonstrated an average tension of 7.503 and an elastic modulus of 7.873.

Conflict of Interests

The author declares that there is no conflict of interest in this research and manuscript.

Acknowledgment

The author would like to acknowledge the Rector of Universitas Negeri Medan for the financial support provided through the 2023 applied research scheme with grant number No. 0137/UN33.8/KPT/PPT/2023.

References

Adeniyi, A. G., Adeoye, S. A., & Ighalo, J. O. (2020). Sansevieria trifasciata fibre and composites: a review of recent developments. *International Polymer Processing*, 35(4), 344-354. https://doi.org/doi:10.3139/217.3914

Ajithram, A., Winowlin Jappes, J. T., & Brintha, N. C. (2021). Water hyacinth (Eichhornia crassipes) natural composite extraction methods and properties – A review. *Materials Today: Proceedings*, 45,1626–1632. https://doi.org/10.1016/j.matpr.2020.08.472

Dass, A., & Chellamuthu, S. (2022). Physico Chemical and Mechanical Properties of Natural Cellulosic Water Hyacinth Fiber and Its Composites. *Journal of Natural Fibers*, 19(15), 11413–11423. https://doi.org/10.1080/15440478.2022.2025979

Drabczyk, A., Kudłacik-Kramarczyk, S., Korniejenko, K., Figiela, B., & Furtos, G. (2023). Review of geopolymer nanocomposites: novel materials for sustainable development. *Materials*, 16(9), 3478. https://doi.org/10.3390/ma16093478

Flores Ramirez, N., Sanchez Hernandez, Y., Cruz de Leon, J., Vasquez Garcia, S. R., Domratcheva Lvova, L., & Garcia Gonzalez, L. (2015). Composites from water hyacinth (Eichhornea crassipe) and polyester resin. *Fibers and Polymers*, 16(1), 196–200. https://doi.org/10.1007/s12221-015-0196-5

Guna, V., Ilangovan, M., Anantha Prasad, M. G., & Reddy, N. (2017). Water Hyacinth: A Unique Source for Sustainable Materials and Products. *ACS Sustainable Chemistry and Engineering*, 5(6), 4478–4490. https://doi.org/10.1021/acssuschemeng.7b00051

Hairiyah, N., Amalia, R. R., & Widyastuti, A. (2018). Pembuatan Mikrokomposit Dari Serat Alam Purun Tikus (Eleocharis Dulcis) Dan Eceng Gondok (Eichornia Crassipes)Sebagai Filler Dengan Limbah Plastik Polyethylene Terephthalate (PET) Sebagai Matriks. *Jurnal Teknologi Agro-Industri*, 4(2), 61–72. https://doi.org/10.34128/jtai.v4i2.50

Harun, I., Pushiri, H., Amirul-Aiman, A. J., & Zulkeflee, Z. (2021). Invasive water hyacinth: Ecology, impacts and prospects for the rural economy. *Plants*, 10(8). https://doi.org/10.3390/plants10081613

Hastuti, S., Pramono, C., & Paryono. (2019). Utilization of palm fiber waste as reinforcement composite material for the manufacture of public housing panel. *AIP Conference Proceedings*, 2097(April). https://doi.org/10.1063/1.5098190

Jirawattanasomkul, T., Minakawa, H., Likitlersuang, S., Ueda, T., Dai, J.-G., Wuttiwannasak, N., & Kongwang, N. (2021). Use of water hyacinth waste to produce fibre-reinforced polymer composites for concrete confinement: Mechanical performance and environmental assessment. *Journal of Cleaner Production*, 292, 126041. https://doi.org/10.1016/j.jclepro.2021.126041

Li, F., He, X., Srishti, A., Song, S., Tan, H. T. W., Sweeney, D. J., Ghosh, S., & Wang, C.-H. (2021). Water hyacinth for energy and environmental applications: A review. *Bioresource Technology*, 327, 124809. https://doi.org/10.1016/j.biortech.2021.124809

Lokantara, I. P., Suardana, N., Surata, I., & Winaya, I. (2020). Effect of Alkali Treatment on the Tensile Strength of Lidah Mertua Fiber/ Polypropylene Recycled Biocomposite. *International Journal of Engineering and Emerging Technology*, 4(2), 50. https://doi.org/10.24843/ijeet.2019.v04.i02.p09

Lumbangaol, T.N., & Nurfajriani, N. (2023). Biodegradation Study of Polymer Composites Reinforced by Areca catechu fibers (Areca catechu L.) and Snake plant fibers (Sansevieria Trifasciata). *Indonesian Journal of Chemical Science and Technology*, 6, 35-39.

Mesfin, S., Gnanadurai Rengiah, R., Shiferaw, M., & Guadie, T. (2023). Effect of Fiber Content on Tensile and Flexural Strength of Water Lily Fiber Reinforced Polyester Resin Composite. *Composites Theory and Practice*, 2023(3), 113–117

Napitupulu, L. O. B., Widyasanti, A., Thoriq, A., & Yusuf, A. (2019). Kajian Proses dan Karakteristik Kain Tenun Serat Alami Tanaman Lidah Mertua (Sansevieria trifasciata P.). *Jurnal Ilmiah Rekayasa Pertanian dan Biosistem*, 7(2), 207-220.

Nurfajriani, Widiarti, L., Gea, S., Thamrin, & Wirjosentono, B. (2015). Mechanical properties of oil palm trunk by reactive compregnation methode with dammar resin. *International Journal of PharmTech Research*, 8(1), 74–79.

Nurfajriani, N., Herlinawati, H., Yusuf, M., Siregar, M. I., & Yunus, M. (2022). Mechanical properties of polyethylene matrix composites with areca fruit peel powder filler (Areca catechu) and sugar cane fiber (Saccharum officinarum L). *Journal of Physics: Conference Series*, 2193, p. 012058). https://doi:10.1088/1742 6596/2193/1/01205

Nurfajriani, A, Sudrajat., A, N, Pulungan., M, Yusuf., I, D, Pardosi. (2023). Mechanical Characterization of Composites Reinforced by Corn Husk Fiber (Zea mays) Waste and Coffee Husk Fiber (Coffea arabica L). *Materials Science Forum* 1080, 75-81. https://doi:10.4028/p-55mlh7

Phiri, R., Mavinkere Rangappa, S., Siengchin, S., Oladijo, O. P., & Dhakal, H. N. (2023). Development of sustainable biopolymer-based composites for lightweight applications from agricultural waste biomass: A review. *Advanced Industrial and Engineering Polymer Research*, 6(4), 436–450. https://doi.org/10.1016/j.aiepr.2023.04.004

Rahman,A., Farid,M dan Ardhyanata, H, (2016), Pengaruh Komposisi Material Komposit dengan Matriks Polypropylene Berpenguat Serat Alam Terhadap Morfologi dan Kekuatan Sifat Fisik, Jurnal Teknik, 5(2).

Raj, F. I., Appadurai, Pushparaj, L., & Thanu, C. (2023). Mechanical characterization of randomly oriented short Sansevieria Trifasciata natural fibre composites. *International Polymer Processing*, 38(5), 564-581. https://doi.org/10.1515/ipp-2023-4377

Sulardjaka, S., Nugroho, S., & Ismail, R. (2020). Peningkatan Kekuatan Sifat Mekanis Komposit Serat Alam menggunakan Serat Enceng Gondok (Tinjauan Pustaka). *Teknik*, 41(1), 27–39. https://doi.org/10.14710/teknik.v41i1.23473

Widodo, E., Pratikto, Sugiarto, & Widodo, T. D. (2024). Comprehensive investigation of raw and NaOH alkalized sansevieria fiber for enhancing composite reinforcement. *Case Studies in Chemical and Environmental Engineering*, 9, 100546. https://doi.org/10.1016/j.cscee.2023.100546