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Turkish Journal of Materials

International Conference on Agriculture, Technology, Engineering and Sciences (ICATES 2018) 19-21 September 2018 Lviv /UKRAINE

Application Oriented Recycling and Machinability of Waste Bio-Composite Materials

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Published: 31.12.2018

Turk. J. Mater. Vol: 3 No: 2 Page: 58-60 (2018) ISSN: 2636-8668

SLOI: http://www.sloi.org/sloi-name-of-this-article

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ABSTRACT In this study, waste shell reinforced bio-composite materials were produced, and its machinability behavior was examined to aim the recycle able of waste natural materials and to find new usage fields of waste of natural materials. Waste walnut shell used as reinforcement and epoxy resin were used as a matrix to produce the bio-composite materials. To determine machinability behaviors; drilling, cutting and screw driving tests were performed. Furthermore, the production of tea plates was carried out in order to prove the producibility of the product using walnut shells. It is predicted from the results of these tests that produced bio-composite materials can be used in decoration and coating as an alternative to chipboard and wood. As a result, it has been found that it is possible to recycle wastes such as walnut shells in many areas where plastic or wood and wood products are used, and it is proposed as an alternative material.

Keywords: Walnut shell reinforced composite, Recycling, natural composite materials, Waste composite, Bio-composite.

Cite this article: G. Genc, N. Akkus. Application Oriented Recycling and Machinability of Waste Bio-Composite Materials. Turk. J. Mater. 3(2) (2018) 58-60.

1. INTRODUCTION

In recent years, mankind has come to realize that the depletion of natural resources and the threat of a major reduction in clean air producing areas will be faced if the environment is not protected [1] (Genç, Akkuş, and Yalçın, 2013). Thus; the development of new materials has become very important as an alternative to wood and plastic based composite materials which are widely used especially in furniture industry, construction industry, indoor and outdoor areas. With increasing population, it is obvious that the imbalance between supply and demand for wood raw materials and current supply will be inevitable [2] (Akbaş, Güleç, Tufan, Taşçıoğlu, and Peker, 2013). Some of the composite materials, which come along in the recycling context, such as plywood, various building boards, laminated wood material, chipboard, MDF have been grouped together and are called "Engineered Wood Products" [3](Gullu, 2001).

On the other hand, the fact that these recycled materials are wood-based is not sufficient solution in terms of environmental concerns. Hence; it becomes a necessity to use agricultural waste and other alternative fibers in place of wood fiber. In Turkey, the remaining parts of agricultural habitat are either mixed again to the soil or destroyed by burning [2] (Akbaş et al., 2013). From this point, it has become the focus of research on composite science that whether waste fruit kernels can be used as an alternative to wood based composite materials [4-5-6-7-8](Batalla, Nuñez, and Marcovich, 2005; Carvalho, de Andrade, Cabral, and Vital, 2015; Gürü, Atar, and Yildirim, 2008; Gürü, Tekeli, and Bilici, 2006; Mohareb, Hassanin, Badr, Hassan, and Farag, 2015). As reported in the literature produced coffee bean-reinforced composite chipboard using urea-formaldehyde matrix. They have studied the density, moisture content, thickness, swelling, water absorption, flexural strength and elastic modulus properties of the composite sheet produced [9] (Rachtanapun, Sattayarak, and Ketsamak, 2012). In addition, the chip board production by using agricultural residues such as wheat straw and corn stalks as reinforcements and soy-based adhesive as a matrix. Tensile and compressive strength tests of the produced sheet were performed and reported with these properties as 3.24 MPa and 4.29 MPa respectively [10] (Wang and Sun, 2002). According to TUIK data for 2017, 260,000 tons of walnut were produced in Turkey. This walnut production represents approximately 135,000 tons of waste walnut shells.

Therefore, as aimed in this study to produce composite material by using waste walnut shells to recycle agricultural waste and to determine new usage areas. In addition, the machinability properties will also be examined for produced waste composite samples. So; an alternative material can be obtained for applications using chemical or wood-based composites by recycling tons of waste walnut shells from the processed fruit.

2. EXPERIMENTAL

2.1. Composite Production

In the production of composites, waste walnut shells were used as a filler and epoxy resin as the matrix. Composite production stages are listed below step by step.

- Walnut shells were dried and milled in a grinding machine and passed through a 1 mm^2 sieve to obtain suitable grains.
- Matrix and these grains were mixed with a hardener.
- The mould surface was cleaned with acetone since the slags on the mould surface would interfere with the material.
- The mould release wax was applied using brush so that the material could be removed without damage from the mould.
- The prepared mixture was poured into a steel mould prepared to produce samples according to the test standards.
- This mixture was cured in the mould under 20 tons pressure and 85 ºC temperature for 300 minutes.

Composite plates were produced by the scale 250 x 200 mm. Matrix selection in composite production is crucial in terms of determining the machinability properties of the material. For this reason, epoxy was chosen as matrix in composite production. As production method open mould method was chosen to avoid the air gap and pore formation on the composite specimens. Further, the specimens were cleaned using grinding process to obtain the last product after the curing process. The machinability properties of the produced composite plates were also investigated, and the results obtained were evaluated.

2.2. Determination of Machinability Properties of Composite Material

Potential application areas of the produced composite materials especially in the decoration and furniture fields have been considered and the workability feature has been examined. In order to determine the machinability properties, the most commonly used processing methods are preferred, especially in the furniture and decoration industries. In this context, the behavior of the composite material against cutting, punching, drilling and screwing operations has been tested as show in Fig.1. The punch drain, drilling and screwing were performed respectively in Figs. 1.a and b, Fig. 1.c, and Fig. 1.d.

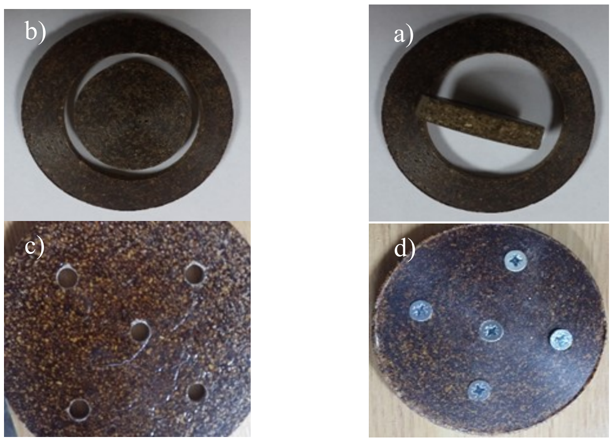

Fig. 1. Machinability properties of produced composite material a-b) punching process c) drilling process d) screwed joint process

3. RESULTS

3.1. Machinability Properties of Bio-Composite Materials

Machinability behavior of bio-composite materials has been determined in order to determine whether composite materials produced with the purpose of recycling waste shells could be an alternative to wood-based materials with a wide range of industrial uses.

According to the observations made on the materials after the operations the bio-composite material does not disperse and burrs because of punching and drilling. Similarly, multiple screwing operations were performed on the material, and any cracking was observed on the materials. As a result, this is so important observation in terms of the workability of the material.

3.2. Bio-Composite Applications

It is of great importance to be able to identify new areas of use for composite materials produced with the aim of recycling agricultural waste and to be an alternative to plastic and wood based composite materials used in this area. In this sense, the two types of applications are shown in Figure 2. Teapot base and tea plate products, which have widespread use as kitchen material, are designed and produced.

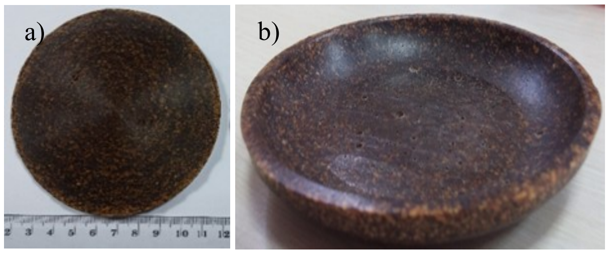

Fig. 2. Waste bio-composite applications a) teapot base b) tea plate.

In Fig. 2 it is also important that after the production of these two products both having surface quality and visually high quality, they do not need any chemical treatment (painting, coating, etc.).

4. CONCLUSION

In this study, waste walnut shells were used as filler in the composite to recycle agricultural waste and their machinability properties have been examined. According to results of this study waste walnut shells thought to be an important alternative in applications where high tensile and impact strength is not required, especially in furniture and decoration industries. This will enable the recycling of tons of agricultural waste each year, which will provide significant contributions to the national economy. On the other hand, the use of wood-based composite materials will be directed towards alternative materials to increase the green areas and thus concerns about the protection of nature will be eliminated.

Acknowledgement
This research is supported by Marmara University, Scientific Research Projects Committee (BAPKO) with grant number FEN-D-080818-0473.

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