I-SEEC 2019
http://i-seec2019.rmuti.ac.th

Substitute materials of Foam from Trunk core of Cassava

Sopis Chuekachang, Pichet Tebumroong and Panuwat Chaiyachate*
School of Science and Mathematics, Faculty of Industry and Technology,
Rajamangala University of Technology Isan Sakon nakhon Campus,
Sakon nakhon, 47160, Thailand.
*Corresponding authors; e-mail: chaiyachate2520@gmail.com

Abstract

In this research, new inventions were applied to the use of environmentally-friendly natural materials to replace synthetic foam. In this experiment, trunk core of cassava filling was used as the primary substrate. The fibers of banana slab and fresh rubber are soldering. The characteristics of this foam were investigated. The experiments showed that the foam obtained from trunk core of of cassava, banana leaf fibers and rubber latex at 3: 1: 1 have a minimum of water absorption index was 8.2, thermal conductivity was 0.038 $W.m^{-1}.K^{-1}$ and a maximum heat resistance was 0.132 $m^2.K.W^{-1}$, which is a good property of foam. This new invention can be used as a substitute for synthetic foam, whether it is food packaging and industrial applications.

Keyword: Substitute materials; Foam; Cassava.

1. Introduction

Most of the raw materials used in packaging are mainly from petroleum, such as polyethylene and polystyrene. Removal of packaging products is an ecological problem because it can not be decomposed. The use of biodegradable packaging materials has the greatest potential in landfill countries as a major waste management tool [1]. The use of starch as an alternative source of raw materials of biodegradable polymers at low cost [2]. The starch can be used as a packaging because of the solid structure of the open cell, consisting of foam. The process consists of swelling, gelatinization and network formation by heat pressing [3]. Foam has a dense outer surface and the interior is less dense, mostly open cells [4]. Foams can be in many shapes and applications ranging from food packaging to the automotive industry [5].

Biological materials such as fiber-based cellulose fibers are used as ingredients to improve the mechanical properties of biodegradable foam. Plant fibers have been studied in many applications and have been reviewed by many authors for their unique properties such as high strength, light weight and good barrier properties [6]. In addition, adding sugarcane bagasse increased stress by cracking of tapioca starch [7].

This research project utilizes the trunk core of cassava, a natural waste material used as a substitute for synthetic foam because it is a light, easily biodegradable material which reduces the amount of waste from the environment. It also increases the value of agricultural waste. The density, water resistance and thermal conductivity of foams from trunk core of cassava were investigated.

2. Materials and methods

1. Materials

Rayong cassava, banana leaf and fresh rubber had the density of 0.050, 0.488 and 0.846 g.cm^{-3}, respectively. They were obtained from gardener in Sakon nakhon province, Thailand. Sodium hydroxide pellets was obtained from QReC Co., Ltd.

2. Foam preparation from the trunk core of cassava

2.1 Remove the white filament in the trunk of cassava and boil with sodium hydroxide solution for 20 minutes, leaving to cool.

2.2 Prepare the banana fiber and boil with sodium hydroxide solution for 20 minutes, leave to cool. Then take a banana leaf fibers are blended thoroughly.

2.3 Fill in the trunk core of cassava obtained from 1, the banana fiber from the 2, and the latex to be mixed with the blender to mix with different ratios.

2.4 From the third heat to destroy the residue and evaporate to dry at 150 degrees Celsius, turn every 5 minutes for 30 minutes.

2.5 From Article 1.4, let it cool down at room temperature to get the desired foam. Then the physical properties and thermal conductivity of the foam were tested.

3. Density

The density (g.cm^{-3}) was calculated from the mass (g) and volume (cm^3) of each sample [8]. Density tests were performed with rectangular strips measuring 100 mm by 25 mm. Each sample was weighed, and the volume was calculated by multiplying the length, width and thickness together. The reported density values were the averages of 10 samples per formulation.

4. Water resistance

Water absorption index (WAI) was measured by AACC 56-20 (1983) [9]. One gram of sample was dispersed in 30 mL distilled water in a centrifuge tube and placed in the bath was heated at 30 °C for 30 minutes. The WAI was calculated as follows:

$$\mathrm{WAI} = \frac{W_1 - W_2}{W_1} \quad (1)$$

Where W_1 and W_2 were the weight of the foam before and after water absorption, respectively.

5. Thermal conductivity [10]

Determination of the thermal conductivity using the heat flux plate principle of LEYBOLD Company. This method places one plate on top of another and crosses both with the same thermal flux. The thermal conductivity κ_x of an unknown building material plate (sample) can be calculated using the known value κ_R of a reference plate. The following applies:

$$\frac{\Delta Q}{\Delta T} = \kappa_x \left(\frac{A_x}{d_x}\right) \Delta T_x = \kappa_R \left(\frac{A_R}{d_R}\right) \Delta T_R \qquad (2)$$

Where ΔT_R is the temperature difference on the reference plate and ΔT_x is the temperature difference on the unknown building material plate. In the experiments, both plates have the same thickness $d_x = d_R$ and the same surface $A_x = A_R$. In this special case:

$$\kappa_x = \kappa_R \left(\frac{\Delta T_R}{\Delta T_x}\right) \qquad (3)$$

And thermal resistance (R) can be calculated from equation (4) as follows:

$$R = \frac{L}{\kappa} \qquad (4)$$

Where L is the thickness of test pieces (m)

3. Results and Discussion

1. Morphology of foam preparation from the trunk core of cassava

The foam from the trunk core of cassava filling was used as the primary substrate. The fibers of banana leaf and fresh rubber are soldering. It was prepared by mix and blender method with different mass ratios of fibers of banana leaf and fresh rubber. The trunk core of cassavaand foam is shown in Fig. 1.

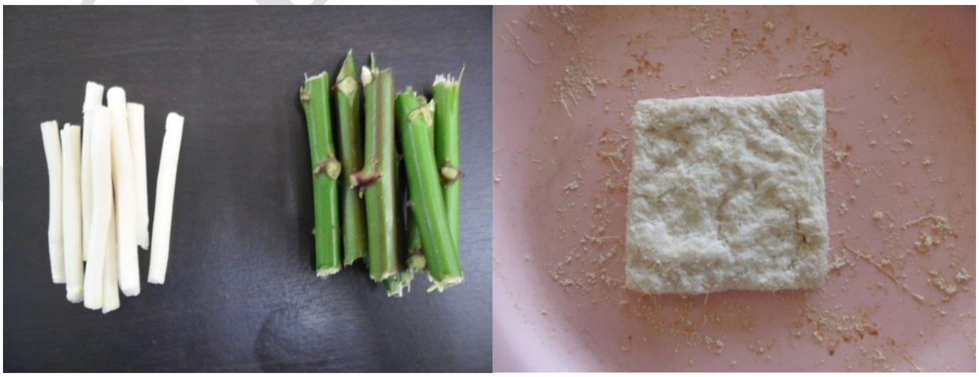

Fig.1 In the left the trunk core of cassava and the foam shown in the right

2. Density of foam

Density is an important physical property of foam, which low density is ideal for these products. The density of the volume of trunk core of cassava and banana slab remained constant, but the volume mass ratio of the rubber was changed (Fix cassava and banana v latex) at 1, 2 and 3 and the volume of trunk core of cassava and latex remained constant, but the volume mass ratio of the banana slab was changed (Fix cassava and latex v banana) at 0, 1, 2 and 3 are presented in Fig. 2. The foam density increased with increasing banana slab and latex content. However, the density of Fix cassava and banana v latex and Fix cassava and latex v banana were 0.183, 0.365, 0.657 and 0.852 g.cm^{-3} and 0.261, 0.372, 0.448 and 0.567 g.cm^{-3}, respectively. The values of density of these foams were corresponded with Salgado et al. [11] who reported that cassava starch mixed with eucalypt cellulose pulp had a density around 0.46–0.52 g.cm^{-3}.

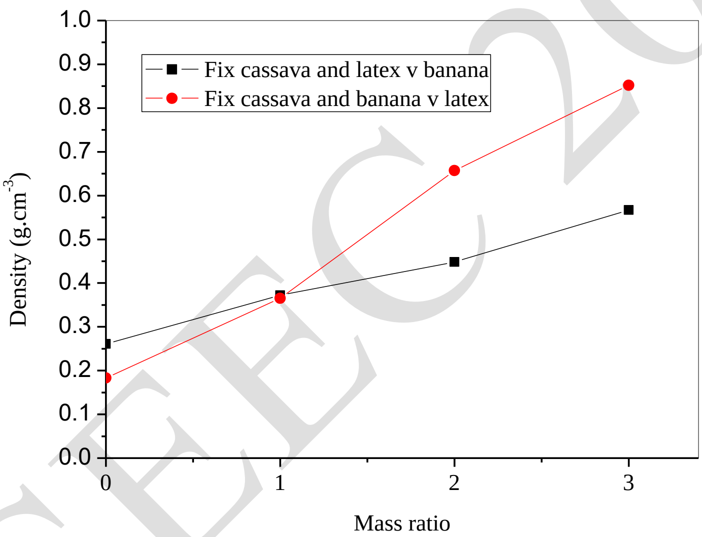

Fig. 2 Effect of banana leaf and fresh latex on density of trunk core of cassava foam.

Water resistance was an important parameter to investigate for improving the applications of foam. The WAI of Fix cassava and banana v latex and Fix cassava and latex v banana is displayed in Fig. 3. When banana leaf and fresh latex were mixed at high mass ratio, the WAI of foams decreased. The WAI decreased because the addition of banana leaf and fresh latex which the density higher than the trunk core of cassava might reduce the gap in the foam texture to absorb less water when the mass ratio increased correspond with Kaisangsri et al. [12].

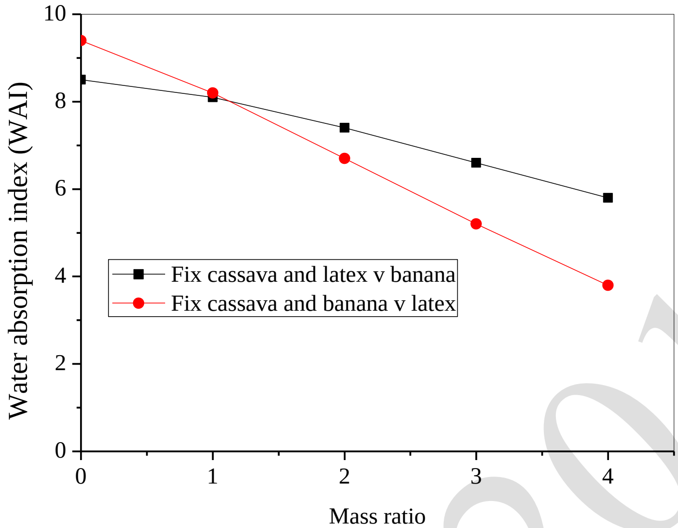

Fig. 3 Effect of banana leaf and fresh latex on water resistance index of trunk core of cassava foam.

Effect of banana slab and fresh latex on thermal conductivity of trunk core of cassava foam was shown in Fig.4. The thermal conductivity of foam increased with increasing banana slab and latex content. However, the thermal conductivity of Fix cassava and banana v latex and Fix cassava and latex v banana were 0.028, 0.045, 0.063 and 0.082 W.m^{-1}.K^{-1} and 0.032, 0.038, 0.046 and 0.055 W.m^{-1}.K^{-1}, respectively.

In addition, thermal insulation can be determined by the thermal resistance value, which is calculated from the ratio of the thickness to the thermal conductivity of the material. Good insulation requires low thermal conductivity and high thermal resistance. Thermal resistance of foam from trunk core of cassava versus the mass ratio of banana slab and fresh latex were shown in Fig. 5. The thermal resistance of foam decreased with increasing banana slab and latex content. However, the thermal resistance of Fix cassava and banana v latex and Fix cassava and latex v banana were 0.179, 0.011, 0.079 and 0.061 m^2.K.W^{-1}and 0.156, 0.132, 0.109 and 0.091 m^2.K.W^{-1}, respectively.

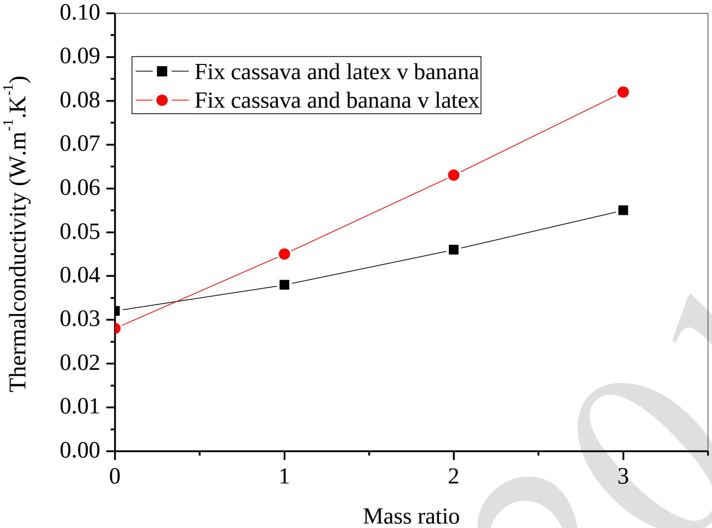

Fig. 4 Effect of banana leaf and fresh latex on thermal conductivity of trunk core of cassava foam.

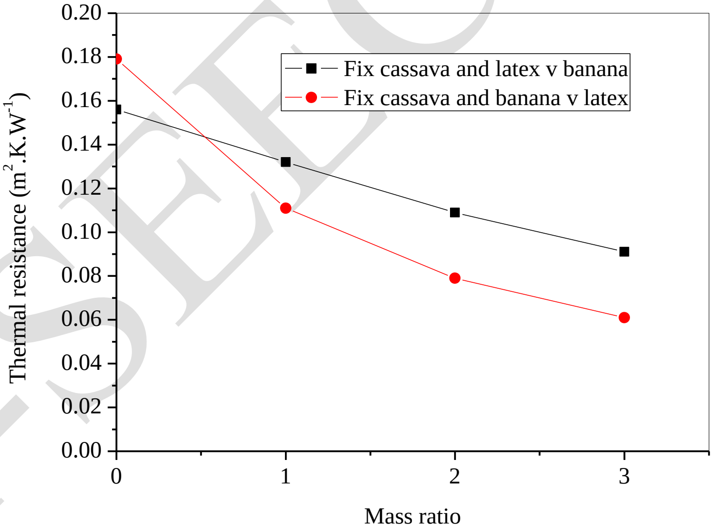

Fig. 5 Effect of banana leaf and fresh latex on thermal resistance of trunk core of cassava foam.

4. Conclusion

New inventions were applied to the use of environmentally-friendly natural materials to replace synthetic foam. In this experiment, trunk core of cassava filling was used as the primary substrate. The fibers of banana leaf and fresh rubber are soldering. The experiments showed that the foam obtained from trunk core of of cassava, banana leaf fibers and rubber latex at 3: 1: 1 have a minimum of water absorption index was 8.2, thermal conductivity was 0.038 $W.m^{-1}.K^{-1}$ and a maximum heat resistance was 0.132 $m^2.K.W^{-1}$, which is a good property of foam. This new invention can be used as a substitute for synthetic foam, whether it is food packaging and industrial applications.

Acknowledgement

We would like to thanks to National Research Council of Thailand (NRCT) for funding this research and thanks the Rajamangala University of Technology Isan Sakonnakhon Campus for support this research.

References

[1] A. Petersen, P.V. Nielsen, G. Betelsen, M. Lawter, M.B. Olsen, N.I. Nilsson, G. Mortensen, Potential of biobased materials for food packaging, Food Science and Technology 10 (1999) 52-68.

[2] J. Lörcks, Properties and applications of compostable starch-based plastic material, Polymer Degradation and Stability 59 (1998) 245–249.

[3] T. Hofmann, L. Linke, A. Tsiapouris, A. Ziems, Porous Materials made from Starch, Chemical Engineering Technology 27 (1998) 580-584.

[4] R.L. Shogren, J.W. Lawton, W.M. Doane, K.F. Tiefenbacher, Structure and Morphology of baked starch foams, Polymer 39 (1998) 6649-6655.

[5] A.K. Mohanty, M. Misra, L.T. Drzal, Sustainable Bio-Composites from Renewable Resources: Opportunities and Challenges in the Green Materials World, Journal of Polymers and the Environment 10 (2002) 19-26.

[6] A.E.S. Vercelheze, F.M. Fakhouri, L.H.D. Antônia, A. Urbano, E.Y.Y. Youssef, F. Yamashita,S. Mali, Properties of Baked Foams Based on Cassava Starch, Sugarcane Bagasse Fibers and Montmorillonite, Carbohydrate Polymers 87 (2012) 1302–1310.

[7] G.M. Glenn, W.J. Orts, Properties of starch-based foam formed by compression/explosion processing, Industrial Crops and Products 13(2) (2001) 135–143.

[8] R.L. Shogren, J.W. Lawton, W.M. Doane, K.F. Tiefenbacher, Structure and Morphology of baked starch foams, Polymer 39 (1998) 6649-6655.

[9] American Association of Cereal Chemists Approved Methods (AACC), American Association of Cereal Chemists Approved Methods, Minnesota, 1993.

[10] P.G. Klemens, Theory of the Thermal Conductivity of Solids in Thermal Conductivity, Academic Press, London, 1969.

[11] P. R. Salgado, V. C. Schmidt, S. E. M. Ortiz, A. N. Mauri, J. B. Laurindo, Biodegradable foams based on cassava starch, sunflower proteins and cellulose fibres obtained by a baking process, Journal of Food Engineering 85 (2008) 435-443.
[12] N. Kaisangsri, O. Kerdchoechuen, N. Laohakunjit, Characterization of cassava starch based foam blended with plant proteins, kraft fiber, and palm oil, Carbohydrate Polymers 110 (2014) 70-77.