Malays. J. Bioeng. Technol. Vol. 1, No. 1, (2024): 1-4
https://doi.org/10.70464/mjbet.v1i1.1179

MALAYSIAN JOURNAL OF BIOENGINEERING AND TECHNOLOGY

MJBeT Malaysian Journal of Bioengineering and Technology

Effect of Commercial Cationic Starch on Paper Properties Made from Recycled Pulp

Jia Geng Boon[1,*], Jing Xian Liew[1], Jeng Young Liew[2]

[1]*Faculty of Bioengineering and Technology, Universiti Malaysia Kelantan, 17600 Jeli, Kelantan, Malaysia*
[2]*Faculty of Agro-Based Industry, Universiti Malaysia Kelantan, 17600 Jeli, Kelantan, Malaysia*

**Corresponding author: jia.geng@umk.edu.my*

ARTICLE INFO

Received:19 November 2023
Accepted:24 December 2023
Online:03 June 2024
eISSN : 3036-017X

ABSTRACT

The production of packaging paper is growing steadily annually globally. Packaging paper such as liner paper and medium paper are mainly made from recycled pulp. The strength of pulp deteriorated over the cycle of recycling. To ensure the packaging paper strength produced from recycled paper is up to par, the additive is mandatory. Starch is one of the common and economical additives used in papermaking. In this research, the performance of commercial cationic starch as an additive in packaging papermaking is evaluated. Four different percentages of starch, including 2%, 4%, 6%, and 8%, were studied. Five replicates of 60gsm hand sheets were produced for each level, and 0% was introduced as a control. The properties such as thickness, Canadian Standard Freeness Test, Cobb test, tensile index, folding endurance, and tear index were evaluated according to the TAPPI Standard. From the result, an 8% dosage of this commercial cationic starch exhibited the best performance in mechanical tests without compromising the drainage of water significantly.

Keywords: Cationic starch; Recycled Pulp; Paper packaging

1. Introduction

Despite the shrinking of the graphical paper industry, the packaging paper industry has grown steadily due to the global demand increasing over the years. The change in lifestyle, particularly in online shopping, has boosted the growth of paper packaging industries, including box, wrap paper, and paper envelopes. In conjunction with the enforcement of environmental and carbon tax laws, paper-based products have become one of the popular choices as paper-based materials are mainly made from lignocellulosic materials [1]. In addition, the main fiber source for packaging paper is derived from recycled paper.

Over the past ten years, Malaysia has received several large investments from the Republic of China, including the establishment of a new paper mill. These investments not only provide job opportunities to locals but also great opportunities for the supply chain [2]. The starch factory is one of the beneficial parties. Various starches, including cationic starch, normal corn starch, and modified starch, are commonly used in paper-making industries [3]. The function of starch in papermaking is broad, including as a dry strength additive, sizing agent, brightener, and others [4].

The chemical structure of starch is a polymeric carbohydrate built up by glucose. It has a similar structure to lignocellulosic fibers (the paper pulp), which mainly consist of cellulose. Both starch and cellulose were built with the

linkage of glucose units. Starch was linked with 1,4 and 1,6 alpha linkage while cellulose had 1,4 beta linkage. Hence, this similarity allows starch to be perfectly incorporated with paper pulp. The addition of starch promotes a better bonding among pulp fibers [4]. The starch is able to fill up the gap among the fibers and cover the void on the surface of the paper. However, adding normal starch could affect the drainage of water during paper formation. The poor freeness could cause a drawback in the pressing and drying process in modern papermaking, as the pulp still contains excessive water by the end of the formation process. Compared to normal starch, cationic starch is the starch with a positive charge. It helps to pull the fine in pulp stock and make the pulp stock freer in water drainage. However, the performance of different cationic starchs can be varied.

This research attempts to reveal the effect of cationic starch made by local industries on paper properties. The mechanical properties of paper and the freeness of pulp will be investigated. The reveal of potential using locally made cationic starch in papermaking can benefit the local industries as a supply chain to the overseas invested papermill in Malaysia.

2. Materials and Methods

2.1 Materials

The cationic starch was obtained from a local supplier. The recycled paper consists of a mix of old newspapers, boxes, and graphical paper, which were collected from the local community and used as the raw material to produce pulp.

2.2 Hand Sheet Formation

The recycled papers were cut into small sizes of approximately 2cm x 2cm. The cut papers were immersed in tap water for 24 hours. The cut papers were then disintegrated using a modified food blender for 30 sec at 15% consistency. The blade of the food blender was unsharp to avoid the cutting of the fibers. The pulp was mixed with cationic starch at 2%, 4%, 6%, and 8%, respectively, and blended with a disintegrator at 3000 revolutions. The pulp, without mixing with cationic starch, served as control. The pulps were then diluted to 1.2% consistency before forming a hand sheet. The 60gsm hand sheets were formed using a hand sheet former machine (EI-CP02C eco-instrument) with a diameter of 200mm. The hand sheets were conditioned in the control room at 23 + 1°C and 50 + 2% RH overnight.

2.3 Testing

The freeness of pulp mixed with starch was evaluated with TAPPI T227 in triplicate. The hand sheets were cut and tested according to test standards. The Cobb test was tested according to TAPPI 441 om-09. The tensile index was tested according to TAPPI 494 om-01. The tearing index was tested according to TAPPI 414 using the Elmendorf-type Method. The folding endurance test was tested according to TAPPI 511 om-02 by using an MIT-type tester.

2.4 Statistical Test

The results were presented in mean + standard deviation. The mean difference was evaluated using ANOVA at 0.05 alpha level with Tukey post-hoc test.

eISSN Number: 3036-017X

3. Results and Discussion

3.1 Pulp Freeness

The Freeness of recycled pulp added with cationic starch was determined by the Canadian Standard Freeness method. The effect of the cationic starch addition is shown in Table 1.

Table 1: Effect of cationic starch addition on recycled pulp freeness

Starch addition (%)	Pulp Freeness (ml)
0	410.00 ± 0.00a
2	435.00 ± 0.00b
4	443.33 ± 2.89b
6	455.00 ± 0.00c
8	455.00 ± 0.00c

*Different alphabet within the same column indicates significant differences at alpha level 0.05

As a result, the freeness of pulp gradually increased from 0% to 6% in starch addition. The presence of cationic starch in recycled pulp has significantly improved the drainage of pulp in general. The result indicates that the freeness of pulp with 8% starch addition has no different with 6% starch addition. The addition of starch above 6% was not able to further improve pulp freeness. One of the possible reasons could be that the amount of fine in the pulp slurry is low. With the addition of 6% of cationic starch, it is sufficient to pull all the fine and attach with long fiber in the pulp slurry [5].

3.2 Hand Sheet Properties

The properties of the hand sheet made from recycled pulp with cationic starch addition are shown in **Table 2**.

Table 2: Effect of cationic starch addition on hand sheet properties

Starch addition (%)	Tensile Index (N.m/g)	Tear Index (mN.m2/g)	Folding Endurance	Cobb Test (ml)
0	41.56 ± 1.22a	4.64 ± 0.84a	8.00 ± 1.00a	1.50
2	44.81 ± 2.86b	4.80 ± 1.64ab	9.67 ± 5.77ab	1.46
4	48.02 ± 5.75c	5.04 ± 0.63bc	10.67 ± 5.77b	1.42
6	51.24 ± 4.38d	5.26 ± 1.16cd	11.00 ± 1.00b	1.32
8	54.18 ± 2.69e	5.56 ± 1.53d	11.00 ± 1.00b	1.11

*Different alphabets within the same column indicate significant differences at alpha level 0.05.

The result clearly indicates that the addition of cationic starch can significantly improve the mechanical properties of the hand sheet and reduce water absorption. The positive charge or cationic starch has become a bridge to link the fiber that ends with the OH^- group [6]. The micro size of cationic starch also perfectly fits in between the fiber and promotes fiber-fiber bonding. Hence, the mechanical strength, including tensile strength and tear strength, is significantly improved with cationic starch addition. The cationic starch has exhibited outstanding performance as a dry-strength agent. For folding endurance, the addition of cationic starch has shown improvement compared to the absence of cationic starch. However, there are no significant changes in the folding endurance among the hand sheets added with different percentages of cationic starch. Cationic starch is also commonly used as a sizing agent in papermaking industries. The result indicates that the cationic starch used in this research can improve the ability of the

eISSN Number: 3036-017X

hand sheet against water absorption. The strong bonding in the fiber web has made the paper with less pore. Such good formation of paper made the surface of the paper resist water better [7].

4. Conclusion

In conclusion, the cationic starch exhibited excellent performance as an additive to improve the properties of hand sheets made from recycled pulp. The mechanical strength and ability to resist water absorption are improved by adding cationic starch. The drainage from pulp becomes faster with the addition of cationic starch.

Acknowledgement

This research was funded by the Ministry of Higher Education Malaysia under the Fundamental Research Grant Scheme (FRGS/1/2019/STG07/UMK/02/3).

References

[1] Pajpai P. Challenges and Opportunity for the Pulp and Paper Industry. Chemistry, Accessed on November 19, 2023. www. https://scitechconnect.elsevier.com/challenges-and-opportunities-for-the-pulp-and-paper/.
[2] MIDA. (2021). Paper and Paper-products. Accessed on November 19, 2023. https://www.mida.gov.my/industries/manufacturing/paper-printing-and-publishing
[3] Liu J, Yang R, Yang F. Effect of the starch source on the performance of cationic starches having similar degree of substitution for papermaking using deinked pulp. J BioResources, 2015;10(1):922-931.
[4] Maurer HW. Starch in paper industries. In: Bemiller J, Whistler R, eds. Food and Science Technology. Academic Press, 2009;658-706.
[5] Ghasemian A, Ghaffar M, Ashori A. Strength-enhancing effect of cationic starch on mixed recycled and virgin pulps. Carbohydr Polym, 2012;87(2):1269-1274.
[6] Lindström T, Ankerfors M, Nordmark GG. On the nature of joint strength of paper - Effect of dry strength agents- Revisiting the Page equation. Nordic Pulp Pap Res J, 2016;31(3):459-468.
[7] Sibaly S, Jeetah P. Production of Paper from Pineapple Leaves. J Environ Chem Eng, 2017;5(6):5978-5986.

eISSN Number: 3036-017X