Bacterial cellulose yarns: Standard versus cost efficient media

Jennifer Harmon

University of Wyoming

Introduction. Cellulose is a polysaccharide consisting of chains of glucose monomers (Merriam-Webster, 2019). Cellulose is present in many fibers used to produce textiles. Growing and processing the material into useable textiles requires resources such as land, water, pesticides and chemicals. One kilogram of cotton alone requires between 7,000 and 29,000 liters of water to produce depending on the efficiency of irrigation (Bärlocher et. al., 1999). In contrast, bacterial cellulose (BC) requires little land, no pesticides and less water to produce. BC is limited for use in apparel due to the nonwoven construction of its growth. The current research investigates the properties of BC twisted and flat yarns grown from Molasses Mannitol media.

Literature Review. BC, though sharing similarities in chemical makeup to plant based cellulose, has several unique properties (El-Saied et. al. 2008). Specifically, BC has high crystallinity, degree of polymerization, tensile strength, purity and water absorbing capacity (El-Saied et. al. 2008).Lacking impurities, BC will need less environmentally damaging processing. Currently, the use of BC is isolated to high value products due to the cost of the material.

Hestrin Schramm is the conventional medium used to cultivate laboratory grade BC. The high cost of the raw ingredients for this nutrient mixture leads to a square footage cost too high for many apparel applications. Previous success with media comprised of lower cost ingredients such as molasses has been observed(El-Saied et. al. 2008).Additionally, apparel application investigators have explored growing pattern pieces to eliminate waste (Chan, Shin &Jiang, 2018). With this method, the material remains a nonwoven, which is limiting for apparel. Comparing woven to nonwoven fabrics, wovens rate better in strength, comfort, and have better breathability (Pamuk et. al., 2008; Barker, 2002 & Kadolph, 2007). Yarns for wovens need higher strength and twist, while yarns for knits need higher elongation (Kadolph, 2007).

Experiment Methodology. To test the possibility of making yarns from less expensive BC,ATCC A. xylinus strain 53524 was cultivated in Hestrin Schramm Mannitol (HSM) and Molasses Mannitol (MSM) mediums. Bacteria were grown and transferred to media sterilized at 121 degrees C for 25 minutes. Containers were incubated at 32 degrees C for 21 days. Then, mats were harvested and placed in a 1% NaOH soak for 24 hours at 70 degrees F. Afterwards, the mats were treated with a 4% glycerol, 1% germaben solution at 70 degrees F for 24 hours. The mats were rinsed and drained. 3 and 4 mats in both conditions were cut horizontally and made into flat and twisted sections. Other pellicles were cut into 3/8 to ½ inch strips vertically, half twisted and half flat. All samples were dried in a freeze dryer set to -42 degrees F. For testing, ASTM D methods 1059 and 2256 were used. Samples were 80 mm and tested for strength with a 50 mm gauge length on an Instron tester after conditioning for at least 6 hours.

Results. MSM 1 **MSM 2** **MSM 3** **MSM 4**

The MSM yarns in comparison to the HSM in the first condition tested weaker in terms of breaking strength for both twisted and flat varieties by an average of 43.51N and 55.73 N. These yarns also had lower breaking extension in comparison to the HSM yarns by 4.33 and 1.67 mm respectively. MSM 2 displayed an average of 55.10 N and 97.31 N lower breaking strength for the twisted and flat yarns. Breaking extension was less than 1 mm under the average for HSM 2. MSM 3 displayed 18.95 N and 45.86 N lower breaking strength on average for twisted and flat varieties than HSM 3. MSM 3 further displayed an average breaking extension less than 1 mm under the average for HSM 3 in the twisted variety and 3.4 mm better than HSM 3 average in the flat. Finally, MSM 4 showed a 51.64 N and 31.75 N better than average breaking load in the twisted and flat varieties in comparison to HSM 4. MSM 4 also had a less than 1 mm and 6.83mm better average for breaking extension in the twisted and flat varieties. To assess the impact of yarn number on strength performance, tenacity was also calculated. Based on preliminary results, HSM had higher tenacity in all conditions when compared to MSM.

Conclusion. Molasses mannitol yarns suffered performance issues, mainly in the strength area, when compared to Hestrin Schramm mannitol yarns. It is likely the non-nutrient components present in the MSM media contributed to the performance issues.

Acknowledgement. This project was possible with a University of Wyoming AES; NIFA grant.

References.

Bärlocher, C.,Holland, R., & Gujja, B. (1999). The impact of cotton on fresh water resources and ecosystems: A preliminary synthesis. *World Wildlife Fund,* May, 1999. Retrieved from: http://wwf.panda.org/?3686/The-impact-of-cotton-on-fresh-water-resources-and-ecosystems

Barker, R. L. (2002). From fabric hand to thermal comfort: the evolving role of objective measurements in explaining human comfort response to textiles. *International Journal of Clothing Science and Technology*, *14*(3/4), 181-200. doi:10.1108/09556220210437158

Cellulose [Def. 1.]. (2019). Merriam-Webster Online. In Merriam-Webster. Retrieved March 30, 2019 from: https://www.merriamwebster.com/dictionary/cellulose?utm_campaign =sd&utm_ medium=serp&utm_source=jsonld

Chan, C. K., Shin, J., & Jiang, S. X. (2017). Development of Tailor-Shaped Bacterial Cellulose Textile Cultivation Techniques for Zero-Waste Design. *Clothing and Textiles Research Journal, 36*(1), 33-44.

El-Saied, H., El-Diwany, A. I., Basta, A. H., Atwa, N. A., & El-Ghwas, D. E. (2008). Production and characterization of economical bacterial cellulose. *Bioresources, 3*(4), 1196-1217.

Grishanov, S. (2011). Structure and properties of textile materials. In *Handbook of Textile and Industrial Dyeing* (pp. 28-63). Woodhead Publishing: Sawston, Cambridge.

Kadolph, S. J. (2007). Textiles: Tenth Edition. Upper Saddle River, NJ: Pearson Education.

Pamuk, O., Ondogan, Z., & Abreu, M. J. (2008). Tensil strength properties of woven and nonwoven surgical gown fabrics. *TEKSTIL, 57*(9), 465-472.