

Durability Properties of Bacterial Cellulose for Textile Applications

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Introduction. Cellulose used in apparel products often comes from plant sources; however, bacteria of the genus *Acetobacter* are also able to produce cellulose. Benefits of bacterial cellulose over plant cellulose include the absence of lignin and hemicellulose, high crystallinity and high mechanical strength while wet (Cai & Kim, 2010). Environmental benefits include the reduced need for water and processing chemicals. Current challenges to the material's development are the cost of raw materials, the growth rate of the material and the resulting stiffness of air-drying the product. The goal of this project was to address these concerns by comparing the material grown from low cost media. Additionally, materials were treated and dried using a variety of methods and analyzed for textile property impacts.

Literature Review. Bacterial cellulose grows as a gel-like substance, made up of net-like microfibrils (Budhino et. al., 1999). The material's unique properties make it of potential interest for textiles and apparel applications. Cost of this material remains a barrier to its utilization in many end uses. Currently, this material's use is largely isolated to specialty end uses, such as artificial skin and blood vessels (Klemm et. al. 2001; Krystynowicz et. al., 2000). Higher cost of this material can be traced to the cost of standard media ingredients, like glucose. Previous research has been successful in obtaining bacterial cellulose from a media which switches the carbon source from pure glucose to molasses (El-Saied et. al., 2008). Using these studies as a framework, an additional low cost carbon source, high fructose corn syrup, was tested.

Experiment Methodology. A culture obtained from the ATCC, #10245, was cultivated for this study. ATCC Strain 10245 has previously shown strong growth in a molasses nutrient media (El-Saied et. al., 2008). The recommended broth for this strain was used in both stages of the pre-culture and contained 5g yeast extract, 3g peptone, 25g mannitol and 1000 mL of distilled water. This initial growth phase lasted for 1 week before test tubes were transferred into 3 larger growing containers with the same broth for an additional week. Finally, the bacteria rich broth was evenly distributed into containers of the experimental broths. Four media types were tested based on previous work by Jung et al. (2010). The molasses media contained 1250 mL distilled water, 50 g H₂SO₄ treated molasses supernatants, 8.75 g polypeptone, 1.25 g yeast extract and 10 g of Sodium Dihydrogen Phosphate Dodecahydrate per container. Half of this variety also contained 50 g of mannitol. High Fructose Corn Syrup containers had the same base media, except 50g of H₂SO₄ treated high fructose corn syrup supernatants. All broth and test media were autoclaved at 120 degree Celsius for 20 minutes before bacterial addition. Containers were then transferred to an incubator set at 30 degrees Celsius and incubated for 21 days. Once the growth period was complete, the bacterial cellulose mats soaked for 24 hours in a 1% NaOH solution. Then, they were rinsed until a neutral pH was obtained. Half were transferred to a 96 hour glycerol soak and rinsed. Half of the samples were air-dried at 72 degrees Fahrenheit and half were freeze dried at -35 to -41 degrees Celsius. In each condition, 3 samples were obtained.

Results. Most Productive. When comparing the air dried cellulose, the molasses mannitol media was the most productive media, with an average of 6 grams per liter. This was nearly 5 times the average amount of cellulose produced by the other medias. *Thickness.* The thickest mat was produced by the non-soaked, freeze dried, molasses mannitol condition. This mat had an average thickness of 1 mm between the 15 points of measurement taken. *Tensile Strength.* ASTM-D 882 was used to evaluate tensile strength with three, 5 mm by 100 mm samples from each cellulose mat. The material which was subjected to the highest maximum load from the Instron testing machine was the non-soaked, freeze dried molasses mannitol material (M= 61.42 N). *Abrasion Resistance.* ASTM-D 4966-96 was used to evaluate abrasion resistance with two, 1.5 in diameter samples. Samples were tested with 50 to 100 cycles under 9 KPa weights with a Martindale testing machine until a hole or tear formed in one of the 6 samples from each group. The bacterial cellulose which was most resistant to abrasion came from the molasses mannitol medium. Both the non-soaked, air and freeze dried varieties were able to withstand 5000 rotations in the machine without puncture. These were the only samples to withstand 5000 rotations. More commonly, samples would show a puncture after 100 rotations.

Conclusion. While this material is relatively novel and has potential for apparel use, several issues surrounding the material must first be solved. Some of the textile performance issues observed in this research may be the result of the material's nonwoven structure. Additionally, the smaller size necessary for most commercial freeze dryers may prohibit the materials use in a variety of designs.

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