

Cotton versus bacterial cellulose: A comparison of single ply yarns

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Introduction. Cellulose is a polysaccharide of glucose units making up the main component of cell walls of several plants (Merriam-Webster, 2019). Cellulose fibers include cotton, hemp and flax. Cotton contains a relatively low amount of impurities, being 90 to 95% cellulose (Grishanov, 2011). Impurities present in this fiber are wax and pectin (Grishanov, 2011). Cotton also requires large amounts of water, pesticides and land to produce. Bacterial cellulose (BC), in comparison, requires little land, no pesticides and less water to produce. This material typically grows as a nonwoven fiber mat which restricts use for apparel products. This research investigated the properties of the material once twisted into yarns in comparison to cotton.

Literature Review. *Acetobacter xylinum* is a Gram-negative, acetic-acid bacterium that thrives in aerobic conditions (Iguchi, Yamanaka, & Budhiono, 2000). BC possesses unique properties in comparison to plant cellulose. Such properties include being highly biodegradable, pure and strong (Iguchi, et. al., 2000; Bae & Shoda, 2004). Moreover, this textile is markedly distinct from traditional cellulosic fibers as it lacks hemicellulose and lignin (Iguchi et. al., 2000). The traditional method of BC cultivation relies on static fermentation using carbon sources such as glucose, fructose and sucrose (Bae & Shoda, 2004).

The three main methods of textile fabrication are woven, knitted, and nonwoven. Yarns for woven fabrics, in particular yarns located in the warp, need to have higher strength, more uniform structure, and higher twist (Kadolph, 2007). Yarns for knitted fabrics, however, need more elongation due to the fabrics interloped structure (Kadolph, 2007). When woven versus nonwoven surgical gowns were investigated for tensile strength, woven gowns were found to be superior in strength (Pamuk et. al., 2008). In a comfort ratings on operating gowns, the woven gown was rated as less snug, stiff, and heavy than the nonwoven gown (Barker, 2002). When comparing woven to nonwoven fabric of the same fabric density, woven materials have less water absorption and retention (Premkumar & Thangamani, 2016). Furthermore, woven textiles offer consumers better breathability (Kadolph, 2007).

Experiment Methodology. To test the possibility of improving strength by growing the pellicles in static fermentation and twisting into typical yarn form, ATCC A. xylinus strain 53524 was cultivated in Hestrin Schramm Mannitol (HSM) media. Bacteria were grown and transferred to medium sterilized at 121 C for 25 minutes. Containers were incubated at 32 C for 21 days. Then, mats were harvested and placed in a 1% NaOH soak for 24 hours at 70 F. Afterwards, the mats were treated with a 4% glycerol, 1% germaben solution at 70 F for 24 hours. The mats were rinsed and drained. Mats 3 and 4 in both conditions were cut horizontally and made into flat and twisted sections. Other pellicles were cut into 3/8 to 1/2 inch strips vertically, half twisted and half

flat. All samples were dried in a freeze dryer set to -42 degrees F. For testing, ASTM methods 1059 and 2256 were used. There were 4 samples in each group. Samples were 80 mm long and tested for strength with a 50 mm gauge length on an Instron tester after conditioning for at least 6 hours.

Results. HSM 1



HSM 2



HSM 3



HSM 4



The average breaking strength of the BC yarns was superior to cotton yarns in every condition, ranging from 36.33 N to 219.96 N. This is compared to the unmercerized cotton samples average at 5.83 N and commercial cotton samples which registered 3.19 N average. In terms of average breaking extension, BC yarns were superior to cotton yarns in almost every condition ranging from 5.51 mm to 18.59 mm. In comparison, unmercerized cotton samples averaged 5.67 mm and commercial cotton samples which registered 6.84 mm average.

After taking the tex of the yarn into account, many twisted sample groups failed to outperform cotton in terms of tenacity. Interestingly, the area of performance where BC yarns significantly outperformed cotton yarns was in breaking extension and breaking elongation. Only 1 BC group displayed a lower average breaking extension than cotton. Breaking elongation percent ranged from 11.01% to 37.18% for the BC yarns. Looking at twisted versus flat conditions, elongation ranged from an average of 16.51% to 37.18% in the twisted conditions and 11.01% to 20.51% in the flat conditions. Cotton yarns averaged 11.35% for unmercerized cotton samples and 13.68% for commercial cotton samples in average breaking elongation.

Conclusion. Strength suffered when the BC was twisted into yarns. However, elongation was superior to cotton in most sample groups.

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