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Apparel industry is known for its tremendous contribution to environmental pollution, human health problems and its dependency on non-renewable resources. Using bio-based renewable materials could help reduce the industry's dependency on non-renewable resources and help to solve some of its social and environmental problems. Bacterial cellulose (BC), a biopolymer produced by bacteria, has been proposed as a novel renewable material for sustainable apparel products (Lee et al., 2014). As a sustainable material, BC offers a range of advantages. It is highly pure, requiring no processing for removal of substances such as lignin and hemicellulose, while it has a molecular structure and morphology similar to plant cellulose (Gama et al., 2013). In addition, no harsh chemicals are required for BC production.

While there is considerable research on the application of BC in various fields (e.g., biomedical engineering, cosmetics), research on its use for apparel applications has received little attention. Lee et al. (2014) studied BC for sustainable apparel applications, identifying procedures for producing cellulose fiber mats as well as conducting experiments for improving the material properties for use in apparel. Electrospinning was used to coat the material with polyurethane nanoparticles to reduce its moisture absorbency and a thicker coating was recommended for better results after conducting material testing. Trials for dip-coating the fiber mats in polylactic acid dispersion were also conducted with unsatisfactory results. Lee et al. (2014) recommended further research on the limitations of BC in terms of its structural and functional characteristics (e.g., moisture absorbency, tensile strength) and modifying/enhancing these characteristics to make the material suitable for apparel products.

With the purpose of reducing BC's moisture absorbency, this study aimed to experiment another method of modifying BC, specifically, incorporating commercially available bio-based sustainable films. Five bio-based eco-friendly films, used to make biodegradable or compostable products (e.g., shopping bags, food packaging), were obtained from three U.S. companies for this experiment. These films were produced from renewable plant-based sources or sustainably harvested wood pulp. First, tea medium for growing BC was prepared in six plastic containers, following the method outlined by Lee et al. (2014). The medium consisted of green tea prepared with distilled water, vinegar, sugar and starter bacterial culture (SCOBY). After combining the ingredients, the tea medium is usually left in a static condition for a number of weeks for the cellulose to develop and grow thicker on the surface of the medium (see Figure 1a-c). For our specific experiment, as an additional step, the five film samples were carefully laid on the surface of the tea medium in five containers (see Figure 1d). No film was added to the sixth container for a control sample. All six samples were placed in a room temperature in a static condition to grow cellulose mats for three weeks.

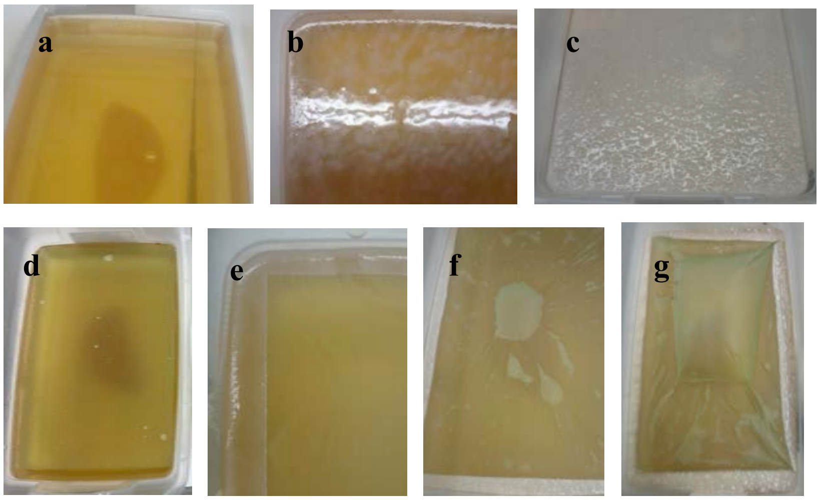

Figure 1. Bacterial cellulose growing process with and without bio-based film. (a) tea medium ready for cellulose growth, (b) cellulose growth after 5 days (no film), (c) cellulose growth after 3 weeks (no film), (d) bio-based film sample laid on tea medium surface, (e) cellulose growth around the film after 5 days, (f) cellulose growth after 2 weeks (with film), (g) cellulose growth after 3 weeks (with film).

All five samples with bio-based films showed similar growth patterns. As shown in Figure 1, in five days cellulose growth was visible around the edges of the films (e), while the sample with no film developed cellulose all over the surface, as expected (b). At two weeks, the control sample had a uniform cellulose layer on the surface, which grew thicker by the third week (c). The samples with films developed the cellulose only around the edges of the film where the tea surface was not covered with films. The tea beneath the films became acidic and bubbly by the second week (f), getting worse by week three (g). It can be assumed that the films inhibit the cellulose growth as they obstruct the adequate airflow that is necessary for the BC growing process.

This experiment shows that the selected films could not be incorporated with BC at their present state. Punching tiny holes in the films to allow airflow during BC growing process may be a solution that should be explored for future research. Further studies should be undertaken to experiment with other bio-based films, specifically with more porous and breathable ones. Upon successful results, the cellulose/film composites should be evaluated for moisture absorbency, tensile properties, long-term stability and other material characteristics suitable for apparel. Finding appropriate methods to incorporate commercially available bio-based films could offer an efficient way to enhance bacterial cellulose properties and make it a viable material for apparel products.

References

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