Screening of PHB and Bacterial Cellulose blends and its mechanical properties impact

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Introduction

Biopolymers are polymers that are produced by or derived from living organisms, such as plants and microbes, rather than from petroleum, the traditional source of polymers. Bacterial cellulose (BC) is a natural biomaterial synthesized by bacteria. It possesses a unique structure of cellulose nanofiber-weaved three-dimensional reticulated network that endows it excellent mechanical properties, high water-holding capability and outstanding suspension stability. However, drawbacks such as high production cost and processability and consequently constant application are the reason why this material still has the attention of the scientific community.

This work contains information related to the first three months of data collection, with preliminary results.

Aim

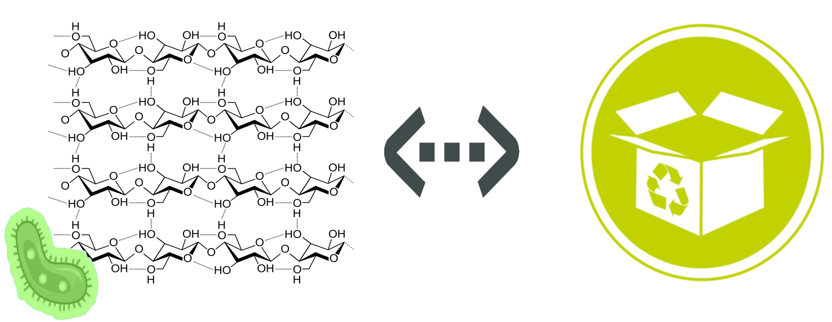


Figure 1. Cellulose structure (left); active food packaging representation.

Development of a **bacterial cellulose**-based material with application on **active food packaging**.

Objective

Investigate the mechanical properties of the bacterial cellulose blends against pure bacterial cellulose by:

- Evaluate the mechanical properties impact of Polyhydroxybutyrate (PHB) incorporation on bacterial cellulose.
- Evaluate the mechanical properties impact the antimicrobial activity of PHB and curcumin incorporation on bacterial cellulose.

Methods

Bacterial cellulose production

Figure 2. Batches with *Komagataeibacter medellinensis in* HS medium.

The film of bacterial cellulose was extracted as a result of *Komagataeibacter medellinensis* metabolism from a batch originally containing HS medium (2% w/v Glucose, 0.5% w/v Yeast extract, 0.5% w/v Bacterial peptone, 0.27% Na_2HPO_4 and 0.15% citric acid), on a 5L Duran® Schott for 3 weeks at 30°C. In order to remove any remaining organism and impurities, the original sample was washed with KOH 0.5M per 30 – 60 mins and left to air dry for 48h.

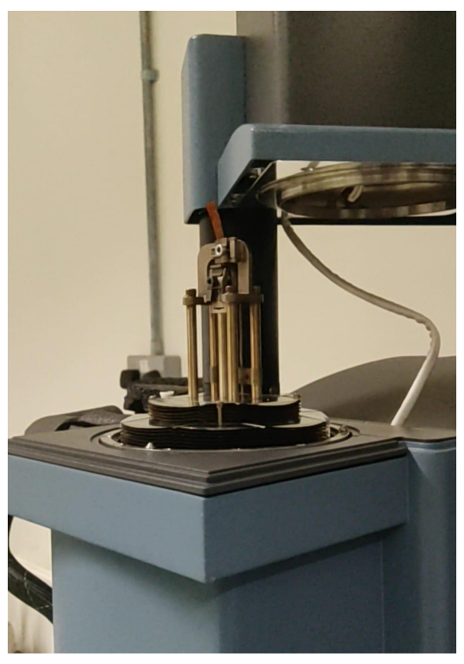
Blend preparation

Four types of blends were made by dissolving the compounds in chloroform with the pieces of bacterial cellulose accordingly to Table 1.

Table 1. Blend treatments

Sample Name	Treatment
BC	Untreated
BCPHB20	PHB 20 g/L
BCPHB40	PHB 40 g/L
BCPHBC20	PHB 20 g/L + 2% curcumin
BCPHBC40	PHB 20 g/L + 2% curcumin

DMA analysis



Also called Dynamic Mechanical Test (Figure 3), we used it to analyze the behaviour of the samples in terms of stress applied on and deformation of them. The instrument was used with a tensile film clamp, applying a ramp force of 1 N/min to 18 N at 25 °C.

Figure 3. DMA Q800 V21.2 Build 73

Young's module and elongation at break

We evaluated two mechanical proprieties from the samples. First, the uniaxial stress – or pressure unit – is needed to deform the material, **Young's module** (E). And second, the ratio between changed length and initial length after breakage of the test specimen, **elongation at break** (Ɛb). Both parameters were calculated based on the curves of stress (MPa) and strain (%) from DMA output.

Statistical analysis

To be able to determine any statistical evidence differences on component's impact on the mechanical proprieties of pure BC, we compared the mean values of E and Ɛb from each sample replicas and submitted these into a One -Way ANOVA analysis with a significant level of 0.05, in others words, a 95% confidence level that there is a difference between the samples.

Results

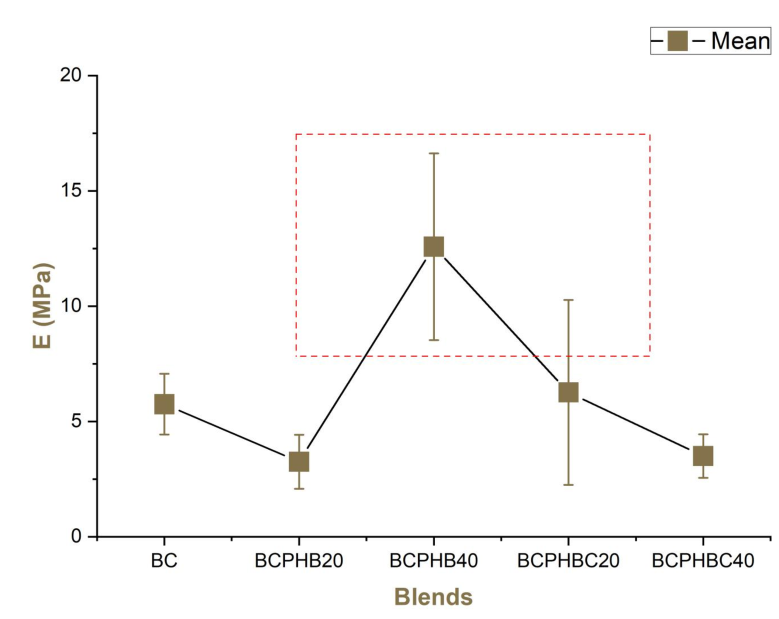


Figure 4. Young's module comparison from blends and pure bacterial cellulose. After running One-Way ANOVA, the plot above was built from data means (SD as means). Turkey's analyses describe that the only group with the significant statistical difference on E compared with the pure BC is the blend BCPHB40.

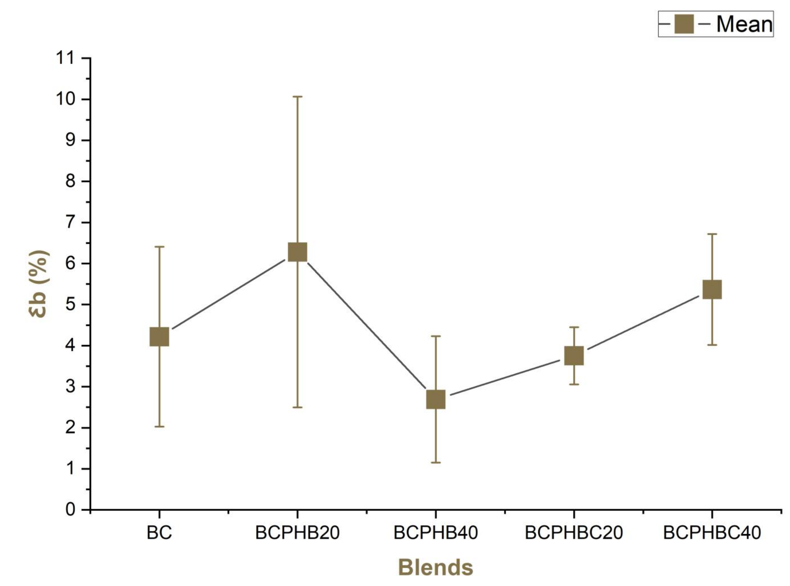


Figure 5. Elongation at break comparison from blends and pure bacterial cellulose. The plot above was built from data means (SD as means). Turkey's analyses described that there is no difference between the groups analysed.

Results

Results obtained from **E**, the effect of PHB on BCPHP40 showed mechanical propriety of greater stiffness than pure bacterial cellulose, which could accuse a reinforcement effect like observed in literature[3]. However, it isn't possible to establish strong evidence about the difference between the two groups (different and not different from pure BC) based on this dataset. In terms of elongation at break **(Ɛb)**, no difference was established between the blends. Also, the variation between groups also presented an inaccurate set of data, which demands a greater number of valid replicas[4].

Conclusion

The use of 40 g/L of PHB as a blend component with bacterial cellulose indicates a possible impact on material reinforcement in terms of stiffness. However, improvements are necessary in terms of the sample quality in order to obtain a better set of data needed to build the strongest pieces of evidence.

Future Work

These preliminary results showed us the need to improve in the following areas:

- BC production optimization.
- Data processing optimization in order to be more accurate on data from bacterial cellulose stress curves.
- Prospecting of new candidates for blending processing.

Acknowledgements

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