Hydrothermal degradation of biobased poly(butylene succinate)/nanofibrillated cellulose composites

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Introduction

Biobased polymers and composites have gained increased global attention owing to their abundance, renewability, and biodegradability. Natural fillers, e.g. cellulose-based fillers, improve mechanical properties of biopolymers extending their application range, while keeping the eco-friendliness of the materials. Mowing towards engineering applications, requirements imposed to materials' durability under environmental impact and high performance is necessity. Variations of ambient humidity and temperature could essentially reduce service lifetime of biobased polymer composites.

The aim is to identify the most efficient poly(butylene succinate)/nanofibrillated cellulose composition, which is characterized by a reasonable balance between the properties improvements and their susceptibility to hydrothermal degaradation.

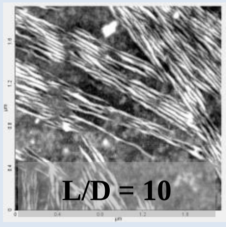
Materials

Poly(butylene succinate): PBS

BioPBS™ FZ71PB® PTT MCC Biochem Company Ltd. (Thailand)

Nanofibrillated cellulose: NFC home-made [*Platnieks et.al. 2020*]

5, 10, 20, 30, 50 wt.% NFC-filled PBS produced by cast solution method



Aging conditions:

RH98 - RH = 98% (K_2SO_4), T = 22 °C

W50 - Distilled water, T = 50 °C

Ref – "as produced"

Results

Water absorption

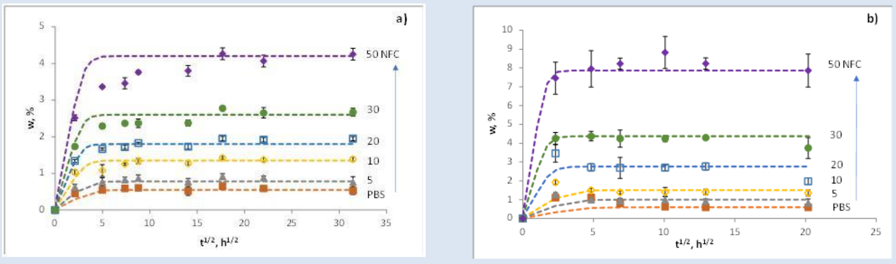


Fig. 1. Weight gain curves at RH98 (a) and w50 (b); lines are calculations by Fick's model.

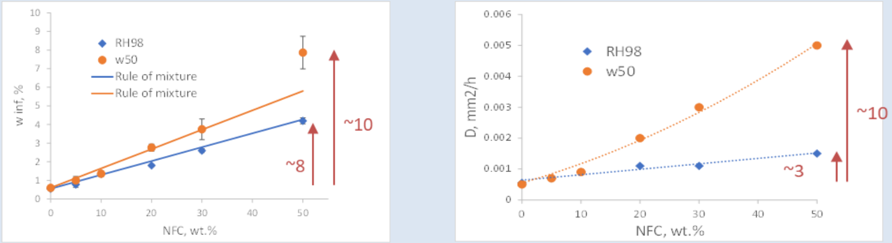


Fig. 2,3. Equilibrium water content and diffusivity and of PBS/NFC samples.

Mechanical properties

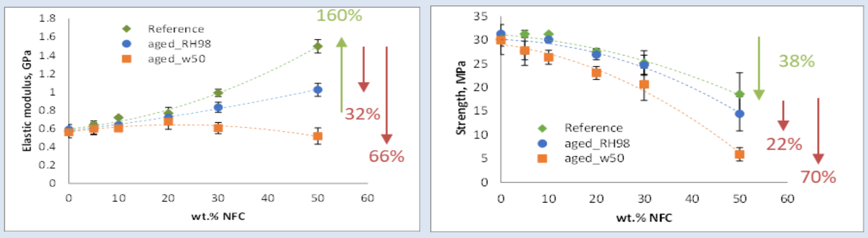


Fig. 4. Elastic modulus and strength as functions of NFC content for reference and aged samples.

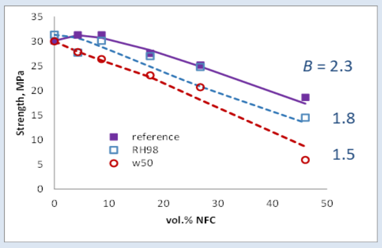


Fig. 5. Adhesion efficiency according to Pukanszky's model for reference and aged samples.

Thermal properties

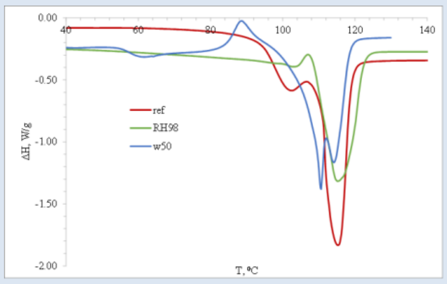


Fig. 6. Representative DSC thermograms of reference and aged samples.

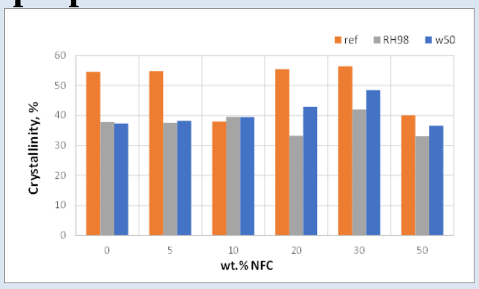


Fig. 7. Crystallinity vs. NFC content of reference and aged samples.

Dynamic mechanical properties

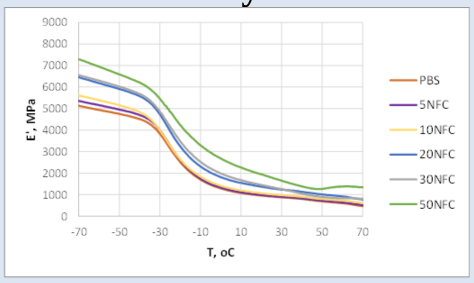


Fig. 8. Storage modulus vs. T of reference samples.

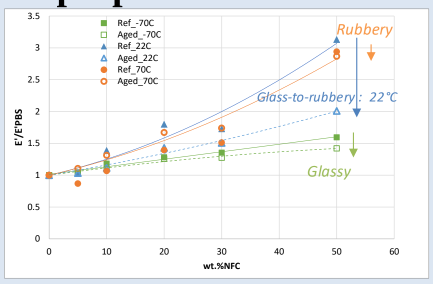


Fig. 9. Normalized storage modulus of reference and RH98 aged samples.

Conclusions

- Water absorption capacity and diffusivity increased with NFC content in PBS;
- Incorporation of NFC into PBS greatly increased stiffness of PBS, albeit with some reduction in strength;
- Hygro- and hydrothermal ageing resulted into properties' degradation: the greater, the higher NFC content is;
- Reasonable reinforcement and adhesion efficiency is maintained after hydrothermal ageing;
- 20NFC/80PBS is the most efficient composition: negative environmental degradation effects are counterbalanced with positive reinforcing effect .

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