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EFFECT OF LIGNIN ACETYLATION ON THE MECHANICAL PROPERTIES OF 3D-PRINTED PLA/LIGNIN BLENDS PARTS

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Introduction

Currently, PLA is one of the most employed polymers in 3D printing. Although PLAs present suitable thermomechanical properties for 3D printing, some characteristics still hinder the application of these polymers in additive manufacturing techniques. PLA is usually more expensive than fossil-based polymers, moisture sensitive, and prone to undergo hydrolysis and photo-oxidative degradations. On the other hand, lignin, a widely available natural polyphenol, is a promising candidate for combination with PLA for the obtention of blends that mitigate the limitations of single-PLA systems. According to the literature, lignin acetylation promotes a better interaction of this polyphenol with PLA. However, a more detailed study of the effect of lignin acetylation on the printability of PLA-lignin blends and their mechanical properties still lacks in the literature. This work aimed to evaluate the influence of lignin acetylation on the mechanical properties of 3D-printed PLA/lignin blends parts that were printed with a Fused Deposition Modeling (FDM) printer.

Experimental

Lignin Modification: the acetylation was carried out at a ratio of 1 g KL:1 mL acetic anhydride:1 mL pyridine, for 24 h at room temperature.

Uniaxial Tensile Test: five dog-bone specimens were 3D-printed and tested for each condition for the calculation of Young's modulus.

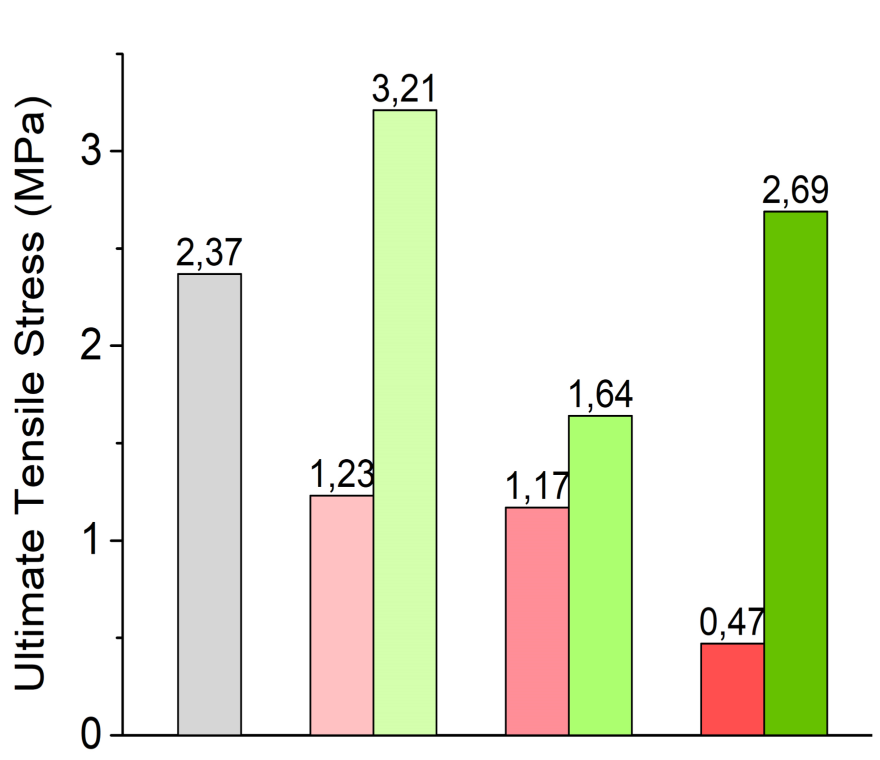
Arcan Tensile Test: five Arcan ("butterfly-shaped") specimens were 3D-printed and tested for each condition using a reduced Arcan device in tension mode (0°) and the ultimate tensile strength was evaluated for each condition.

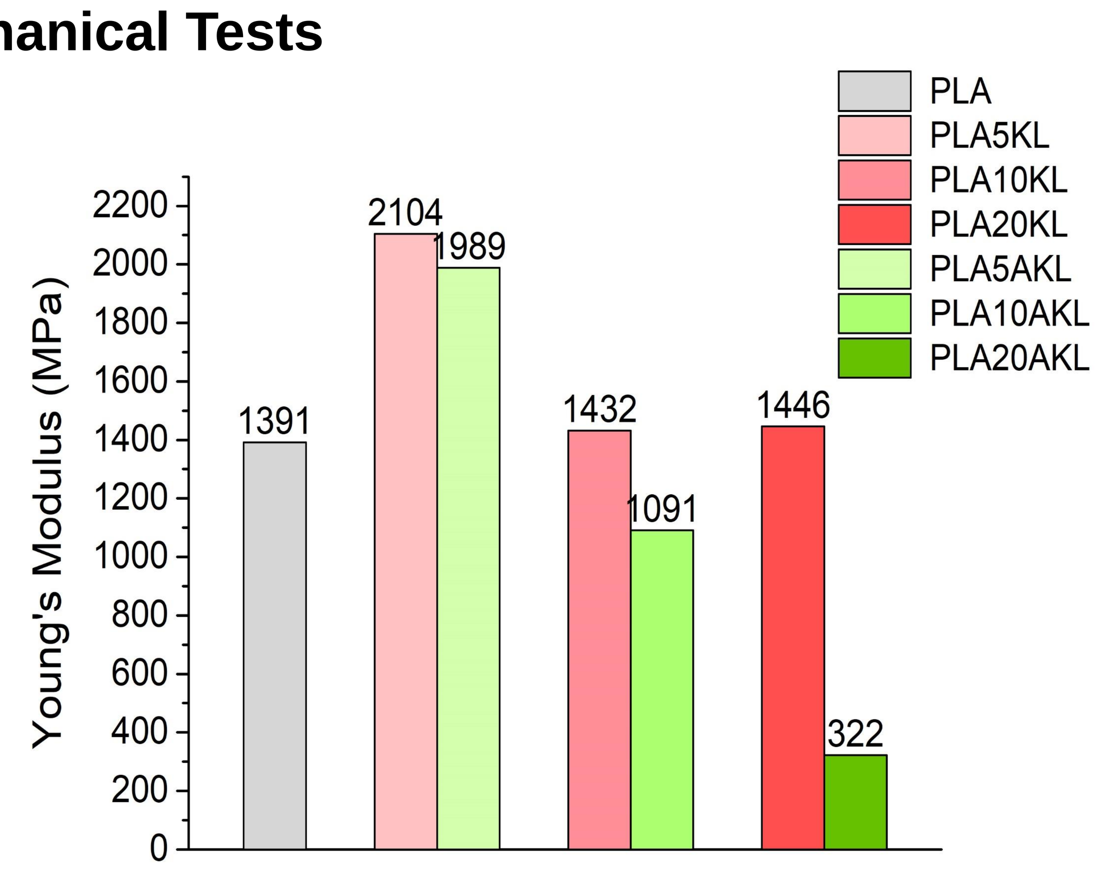
Dynamic Mechanical Analysis (DMA): three rectangular bars of each filament formulation were printed and characterized by DMA analysis to determine the glass transition temperatures (T_g).

Scanning Electron Microscopy (SEM): after the uniaxial tensile test was conducted, the specimens were coated in gold by sputter deposition, and their microstructures were examined by SEM.

Results

Mechanical Tests

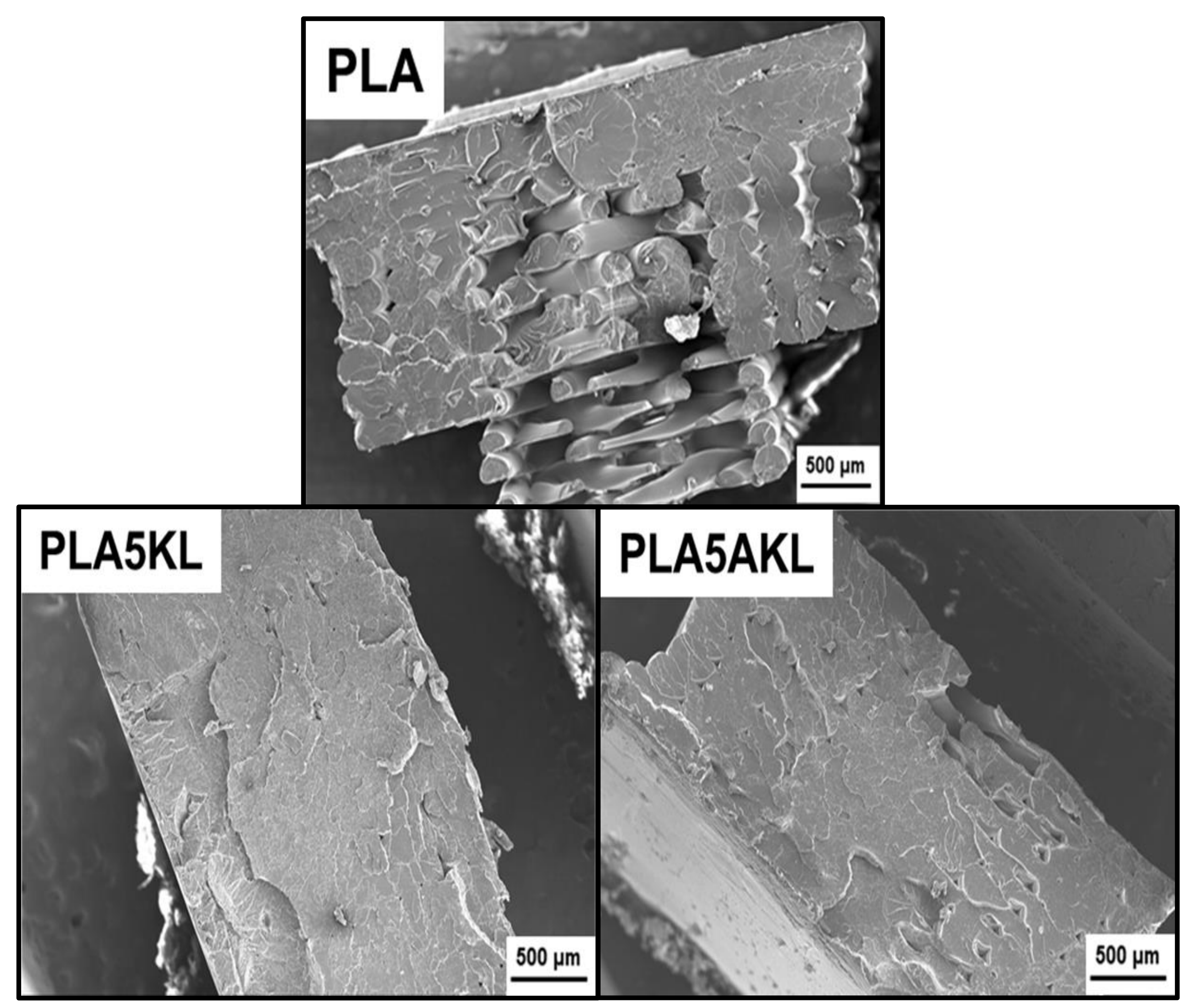




DMA

Nomenclature	T_g(ºC) peak E''	E' @ 25ºC (GPa)
PLA	63.65	7.8
PLA5KL	57.65	10.2
PLA10KL	59.95	14.6
PLA20KL	59.40	3.6
PLA5AKL	55.87	13.6
PLA10AKL	56.82	20.1
PLA20AKL	61.99	3.1

SEM



Conclusions

→ Samples containing 5% wt of KL or AKL presented better mechanical properties;

→ Acetylation increases the ultimate tensile strength, however, it progressively reduces Young's modulus while the lignin content increases;

→ The incorporation of lignin into PLA leads to a reduction in T_g, wherein this effect is more pronounced for AKL;

References

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