

# EFFECT OF LIGNIN FUNCTIONALIZATION ON THE MODIFICATION OF POLYPROPYLENE SURFACE ENERGY AND ADHESION PROPERTIES

SURF - Surfaces

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## Introduction

Low surface energy and poor adhesion properties are well known characteristics of polypropylene (PP). Polymer blending can be used as a strategy to improve the wettability of PP and increase the strength of PP adhesive joints. In this context, lignin, a renewable biopolymer, appears as a promising hydrophilizing agent, due to its amphiphilic character [1]. Although encouraging results were found, the inclusion of lignin in a PP matrix is not a direct task, due to the low compatibility that severely compromises the mechanical properties. In this work the different chemical modification procedures for lignin were proposed, and their effects on surface energy modification and adhesion properties of PP showed promising results..

## Methods and Materials

**Methods:** Kraft lignin (KL) obtained as a byproduct of paper and pulping industry was oxypropylated through reaction with propylene oxide [2]. Oxypropylated KL (oxy-KL) was further acetylated by two reagents: acetic anhydride [3], and maleic anhydride [4]. (A-oxy-KL and M-oxy-KL), resulting into two conditions of modified KL. Chemical modification was confirmed by Fourier transformed infrared spectroscopy (FTIR), differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). Composites, as well as pristine PP, were prepared in a twin-screw extruder adding A-oxy-KL and M-oxy-KL to PP in three different concentrations (1.0; 2.5 and 5.0 wt%). Finally, PP and PP-composite films were bonded to aluminized bioriented polypropylene using a polyurethane adhesive by lamination according Fig 5. The mechanical test was performed in accordance with ASTM F 904-98 (2008).

**Kraft lignin** of eucalyptus hardwood (Suzano Papel e Celulose – Brazil), propylene oxide (PO), (Sigma-Aldrich, Brazil).

**Adhesive:** Bicomponent PU Loctite Liofol LA 9526 CP-22+ LA6145 10:6 (isocyanate excess); 10:0 (stoichiometric); 10:10 (polyol excess)

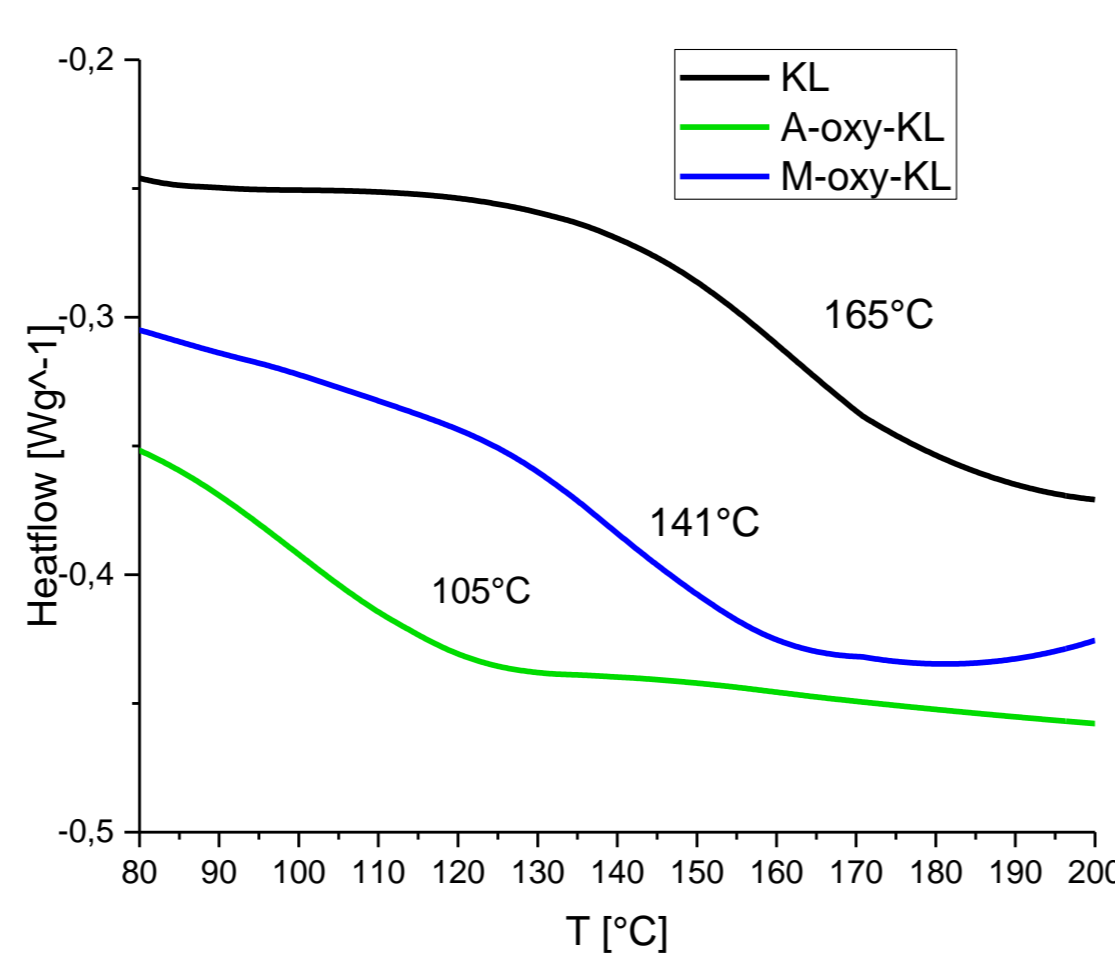
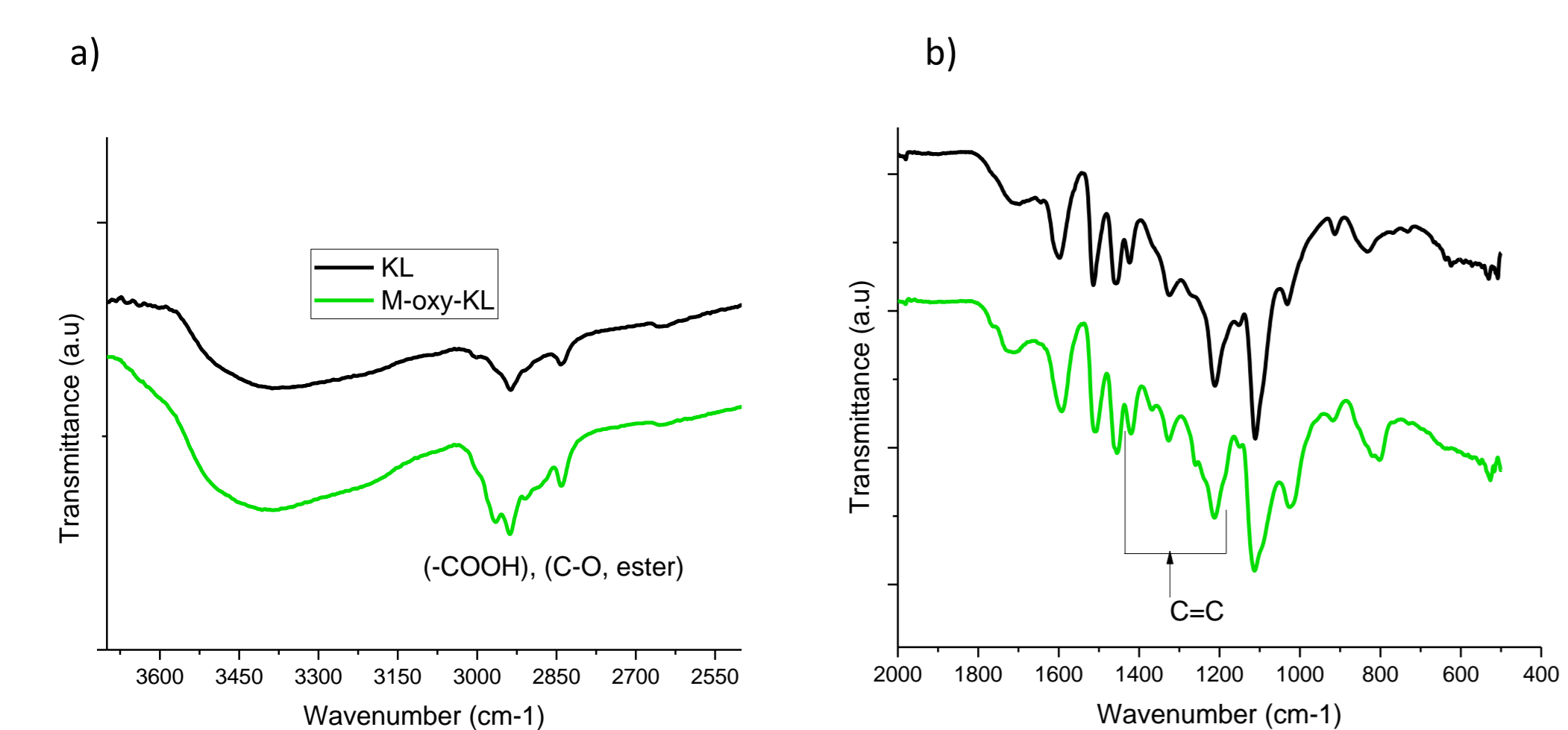


Fig. 1. (a) and (b) FT-IR spectra M-oxy-KL details of the 1150-1450 and 2775-3200 cm<sup>-1</sup> ranges.

Fig. 3. DSC curves of KL, A-oxy-KL and M-oxy-KL

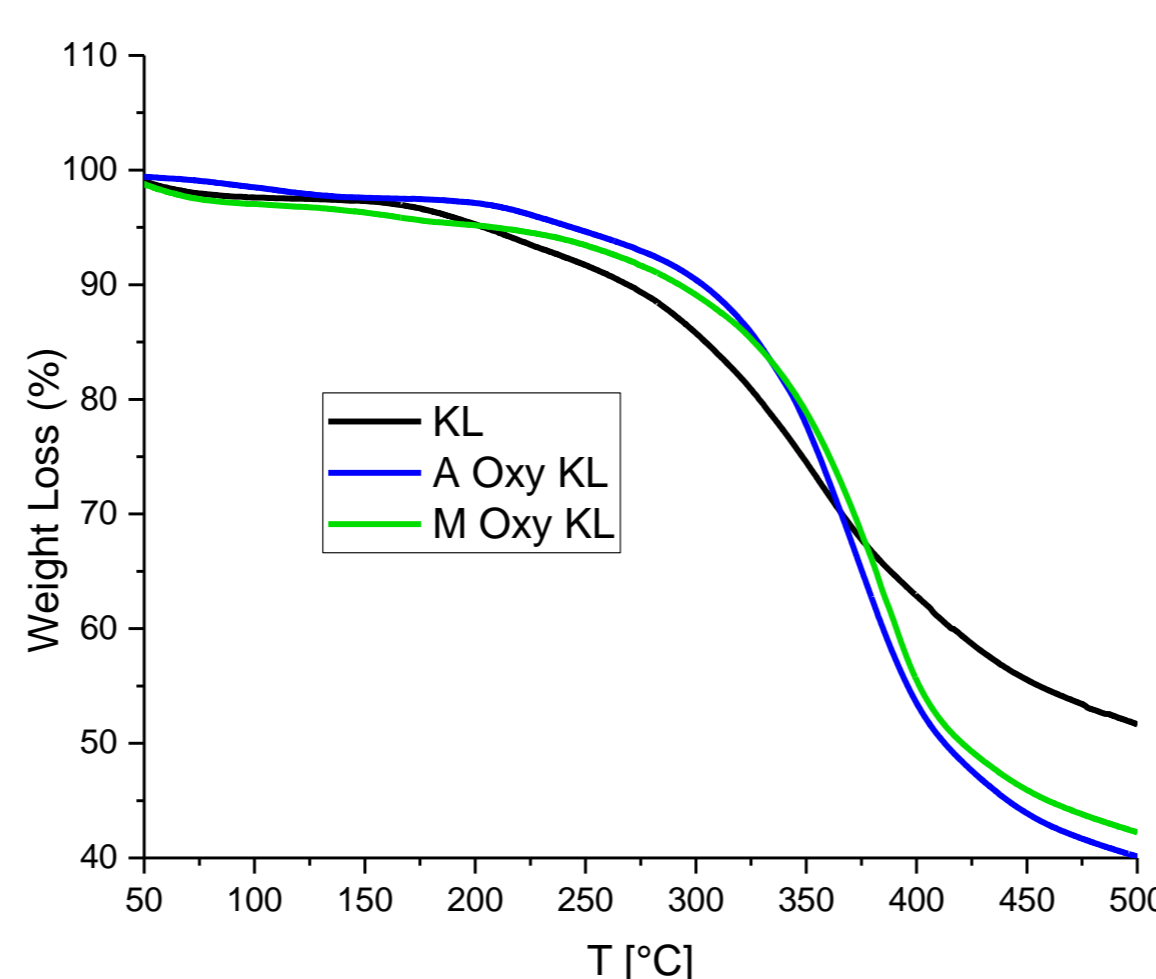
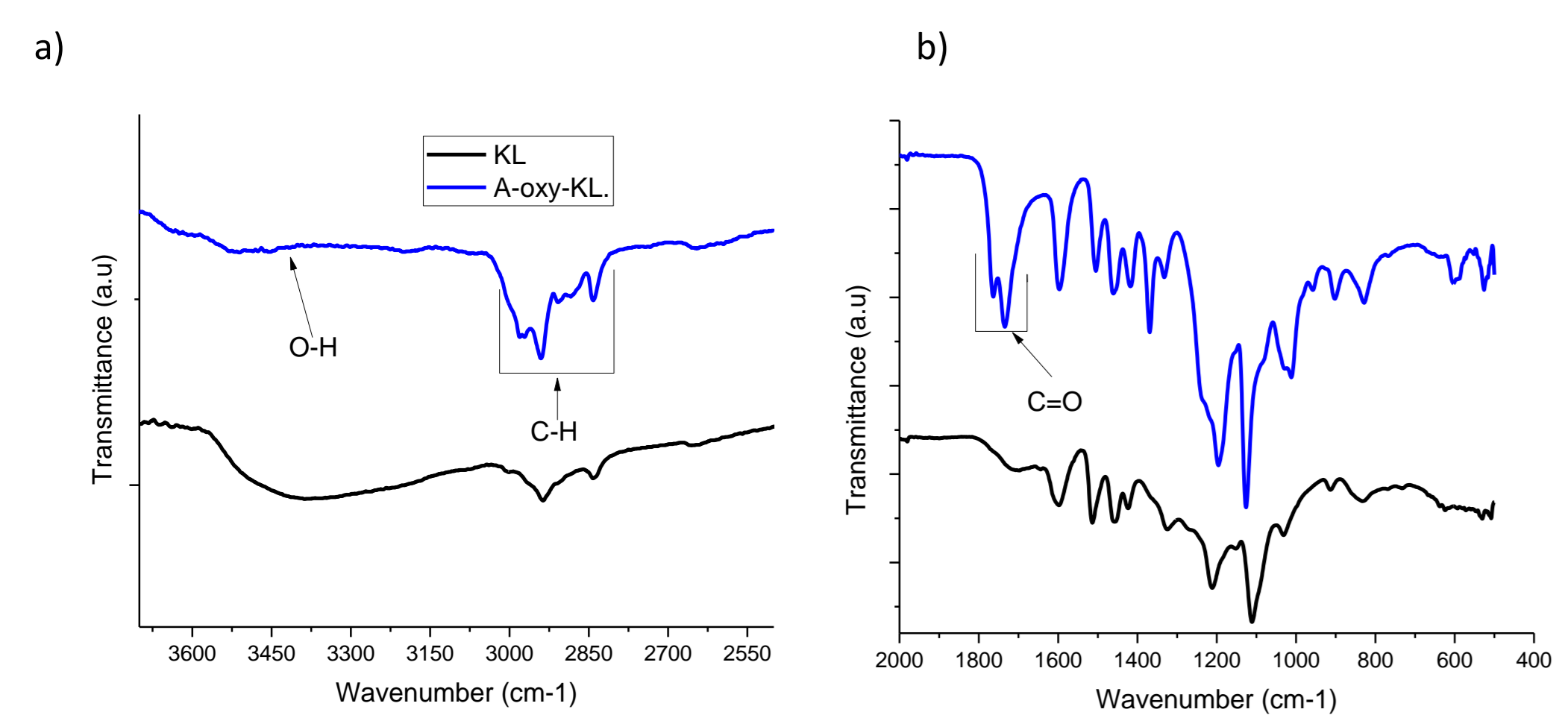


Fig. 2. (a) and (b) FT-IR spectra A-OXY-KL details of the 1600-1900 cm<sup>-1</sup> and 2775-3200 cm<sup>-1</sup> ranges.

Fig. 4. TGA curves of KL, A-oxy-KL and M-oxy-KL

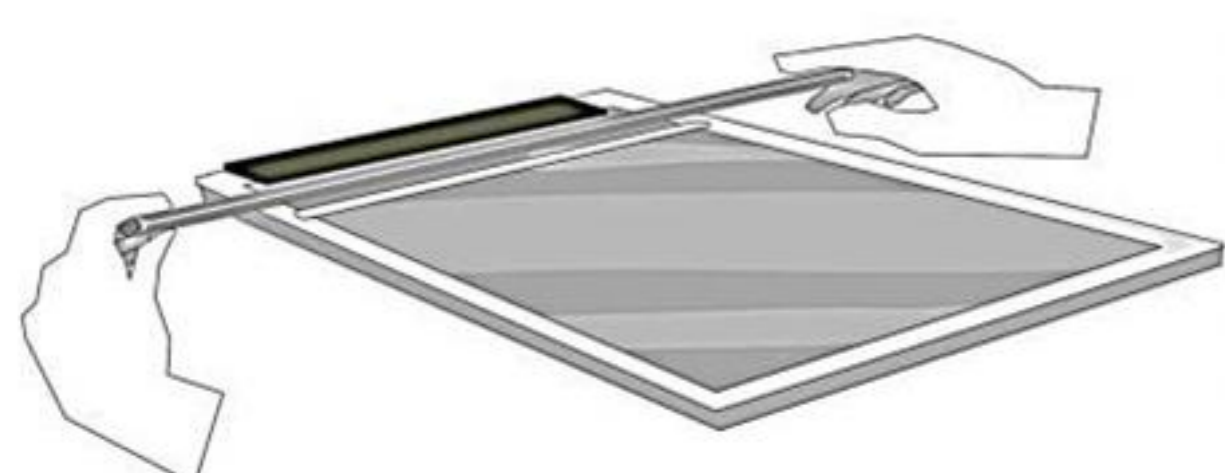


Fig. 5 lamination scheme

## Results

Changes of wettability and surface energy were assessed by contact angle measurement. The effect of modified lignin on thermal properties and microstructure of the composites by DSC. Practical adhesion was evaluated by the peel test and presented in Table 01.

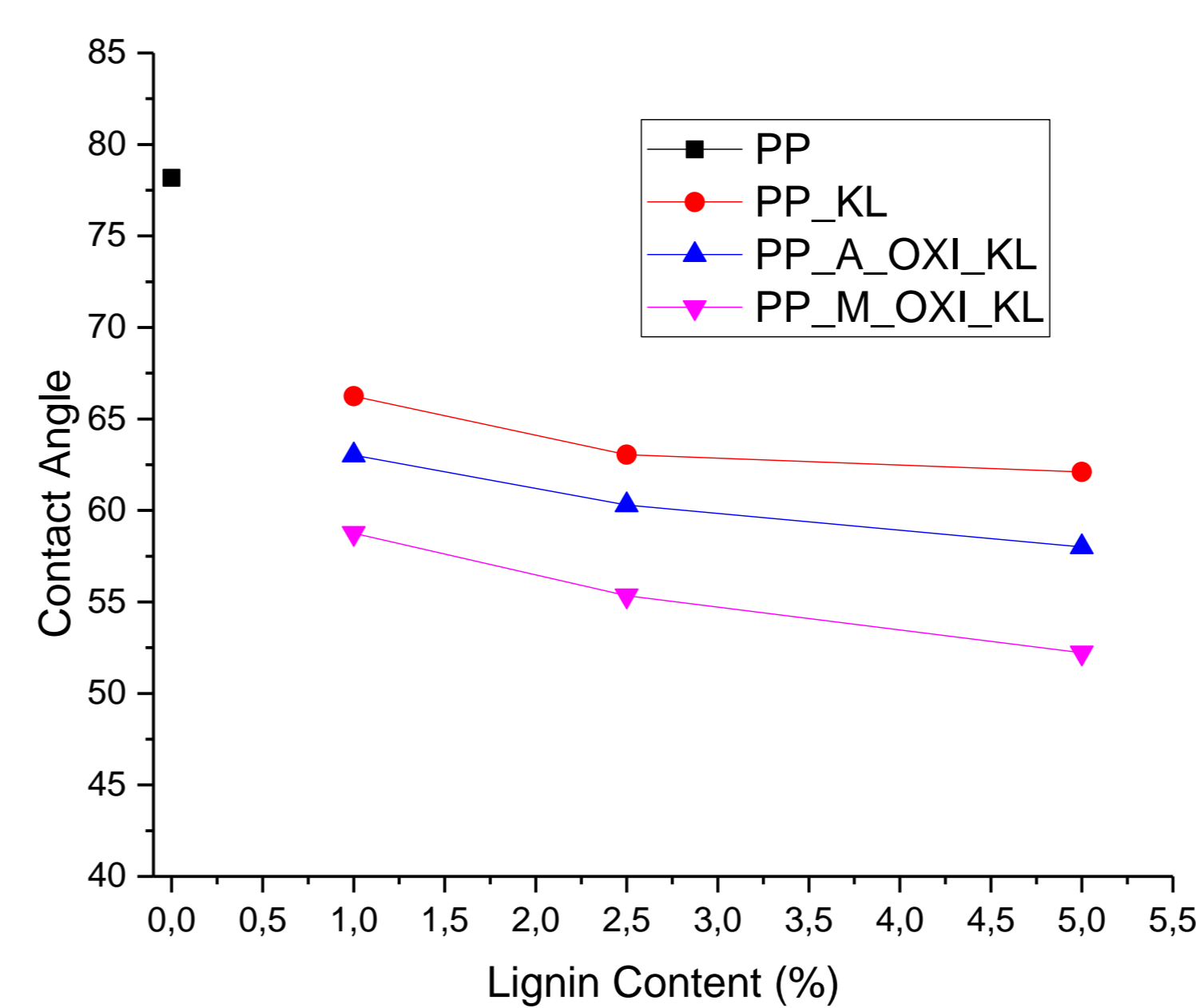


Fig. 7 Contact angle as a function of lignin concentration

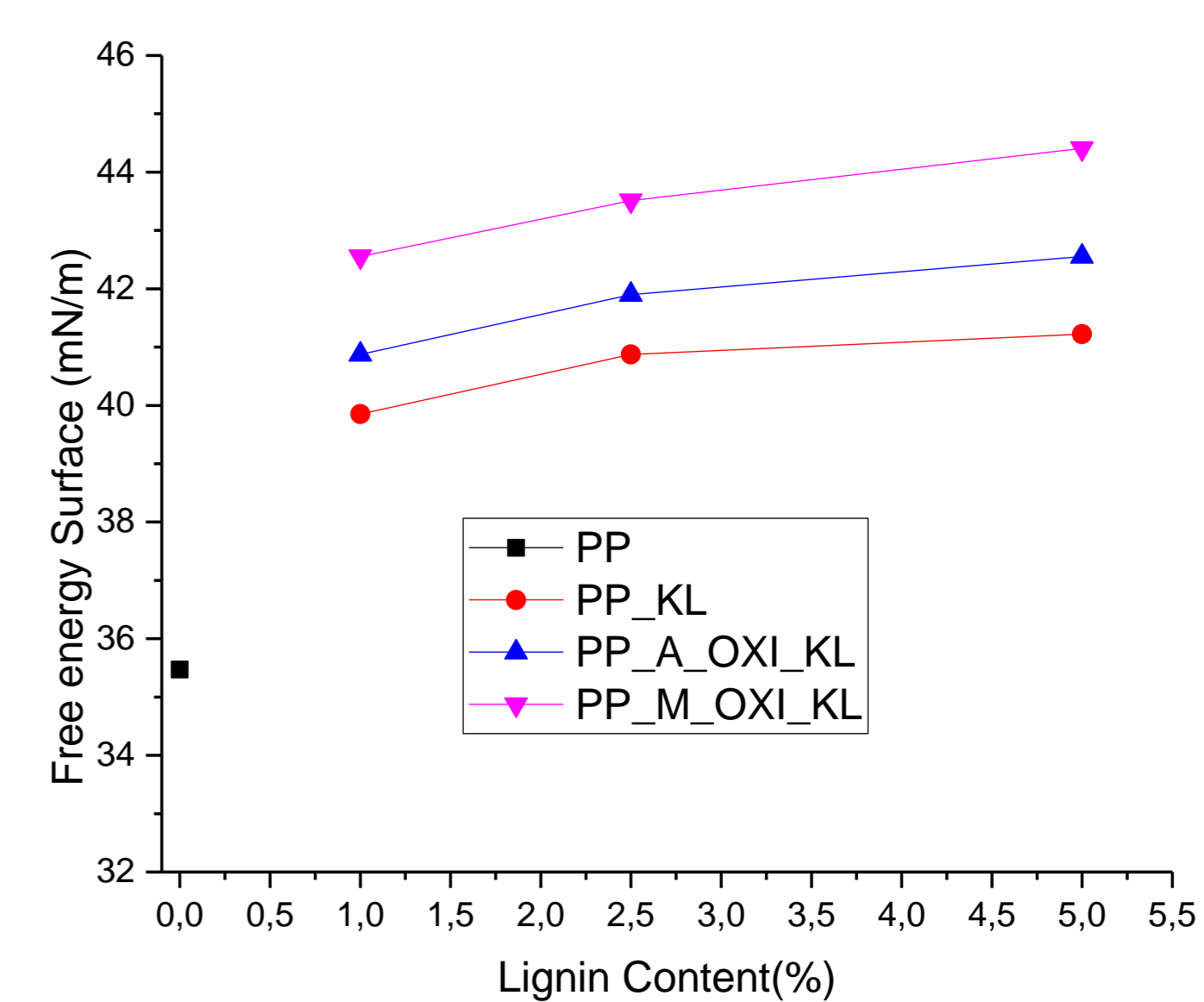


Fig. 7 Surface free energy as a function of lignin concentration

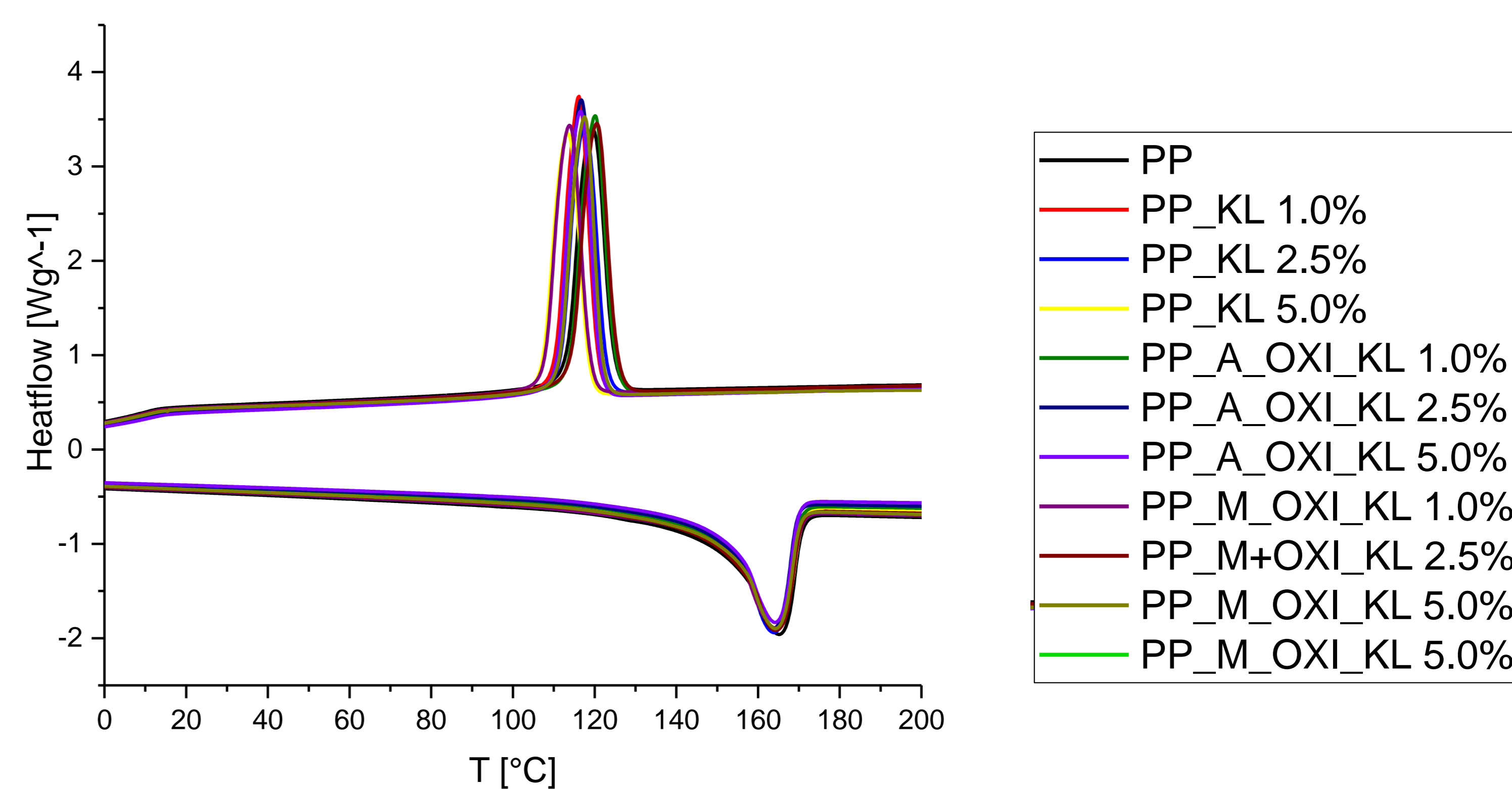


Figure 8. DSC of PP and PP composite films.

Table 1. Peel strength values for PP and PP composite films.

	Average Strength (N/m)	Average Strength (N/m)	Average Strength (N/m)
PP	27.20 ± 0.84		
PP KL 1.0 %	28.72 ± 0.32	PP A KL 1.0%	35.26 ± 0.66
PP KL 2.5%	29.15 ± 0.55	PP A KL 2.5%	37.68 ± 0.91
PP KL 5.0%	30.78 ± 0.43	PP A KL 5.0%	39.58 ± 0.13
		PP M KL 1.0%	39.74 ± 0.89
		PP M KL 2.5%	42.80 ± 1.02
		PP M KL 5.0%	45.15 ± 1.28

## Conclusions

Results revealed that lignin chemical modification increased the surface energy of PP-composites, compared to pristine PP and PP-KL. DSC results showed that the glass transition and melting temperature were not significantly affected by lignin incorporation. Composites with M-oxy-KL showed the highest practical adhesion, confirming the lignin functionalization is a promising approach to improve the practical adhesion of PP films.

## References

- [1] R.R. de Sousa Junior, J.R. Gouveia, D.J. dos Santos, Mater. Res. 22 (2019).
- [2] Wu, L. C. F; Glasser, W. G. *J. Appl. Polym. Sci.*, v. 29, n° 4, p. 1111-1123, 1984
- [3] Jeong, Heonyoung, et al. "Use of acetylated softwood kraft lignin as filler in synthetic polymers." *Fibers and Polymers* 13.10 (2012): 1310-1318.
- [4] Chen, Yao, et al. "Chemical modification of kraft lignin: effect on chemical and thermal properties." *BioResources* 9.3 (2014): 5488-5500.
- [5] Tejado, Ayo, et al. "Physico-chemical characterization of lignins from different sources for use in phenol-formaldehyde resin synthesis." *Bioresource technology* 98.8 (2007): 1655-1663.

## Acknowledgments: