CGPM 2020
The First International Conference on "Green" Polymer Materials
05–25 NOVEMBER 2020 | ONLINE

# A new textile economy: Synthesis and characterization of phenolic type resin with protein from waste textiles suitable for wood-based panels

Chaired by PROF. DR. ANTONIO PIZZI and PROF. DR. FRANK WIESBROCK

polymers MDPI

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**Abstract:** The population growth and the limited reservoir of fossil resources have ignited the attention of scientific communities and entrepreneurs to produce alternative products with raw-materials from renewable sources. In this work, proteins derived from the recycling of waste textiles were studied as raw-material in the synthesis of thermosetting polymers of a phenolic type suitable for use as adhesives in the production of wood-based panels. The chemical bonds between raw-materials and phenol-formaldehyde (PF) resins were verified with Fourier Transform Infrared spectroscopy. The curing performance and thermal stability of the thermosetting PF resins were studied with Differential Scanning Calorimetry and Thermogravimetric Analysis, respectively. Wood-based panels were prepared and tested at a lab scale following simulation of the industrial practice. Optical Microscope and Scanning Electron Microscopy were applied for the study of the interaction between PF resins and woodchips at the lab scale. It was found that the resins were successfully prepared. The maximum curing temperature of the experimental resins was shifted to higher values than the control PF. The protein-based resins seem to lose mass at a lower rate, which denotes that they are more thermally stable than a typical PF resin.

**Keywords: PF resin; waste textiles; renewable sources; particleboards; thermal properties.**

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## *Aim of the research*

In this work, proteins derived from the recycling of waste textiles were studied as a raw material in the synthesis of thermosetting polymers suitable to be used as adhesives for the production of wood-based panels. The synthesis of ***Phenol-formaldehyde (PF) resin in which 20 wt.%*** of the phenol has been replaced by ***protein*** **(PFP20),** was carried out by CHIMAR HELLAS SA in Greece. The bonding ability of the new resins was evaluated at lab scale following simulation of the industrial practice and was tested for their thermal and morphological properties at the Physics department of the Aristotle University of Thessaloniki (AUTH), Greece.

## *Examination methods*

- **FTIR:** FTIR Spectrum 1000, Perkin-Elmer
- **SEM:** 20 kV JSM 6390 LV
- **Optical Microscope**: ZEISS STEMI DV4
- **DSC:** Setaram DSC 141
- **TGA:** Setaram Setsys TG-DTA 16/18


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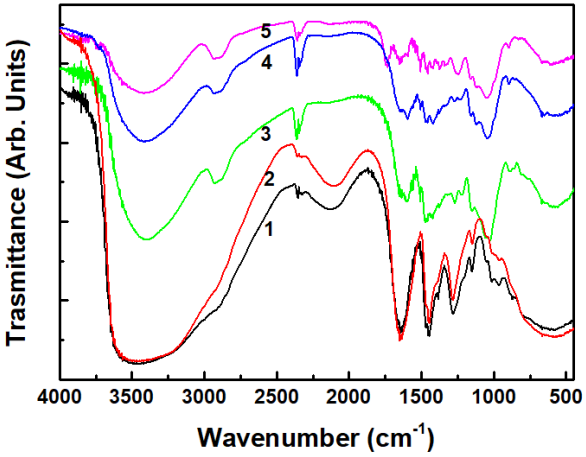
# Results and Discussion

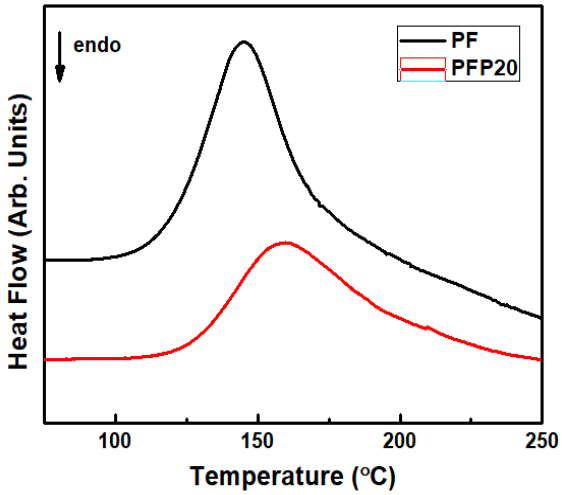
## *Fourier Transform Infrared Spectroscopy- (FTIR)*

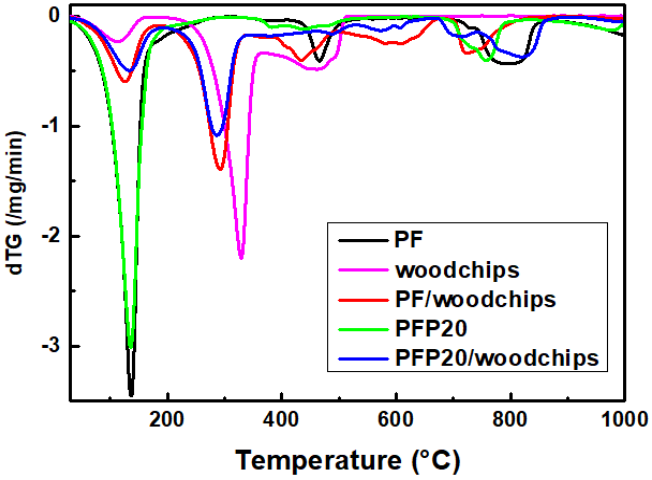


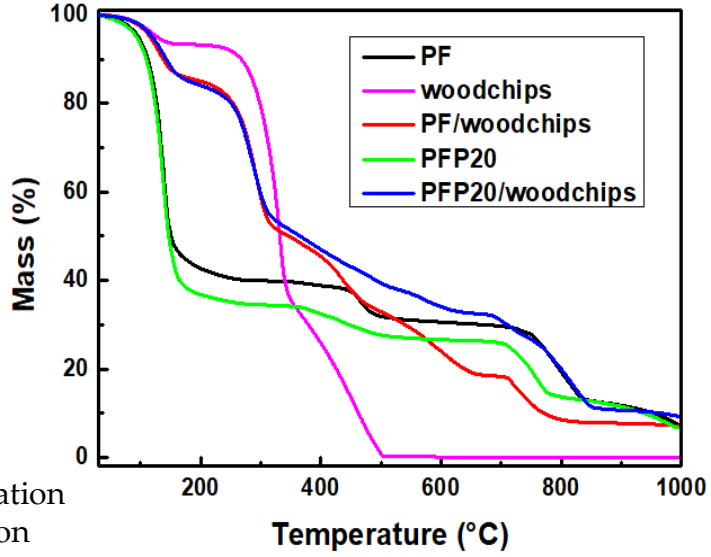

*FTIR transmittance spectra of 1:PF, 2: PF with a 20w.t.% replacement of phenol by protein, 3: the corresponding lab-scale samples PF/Woodchips and 4: PFP20/Woodchips recorded in the region 4000 -400cm$^{-1}$*

3300 cm$^{-1}$: Phenolic O-H stretch
3300-3100 cm$^{-1}$: Aromatic C-H stretch
1680-1650 cm$^{-1}$: Carbonyl C=O stretch
1480-1450 cm$^{-1}$: $CH_2$ deformation
1260 cm$^{-1}$: Biphenyl ether C-O stretch
1060 cm$^{-1}$: Dimethylene ether C-O deformation
1010 cm$^{-1}$: Hydroxymethyl C-O deformation

## *Differential Scanning Calorimetry & Thermogravimetric Analysis results- (DSC &TGA)*




*α) DSC thermograms, b) Mass (%) curves, and c)* **the first derivative (DTG)** *versus temperature for the typical PF, PF with a 20w.t.% replacement of phenol by protein and the corresponding lab-scale samples PF/Woodchips and PFP20/Woodchips*

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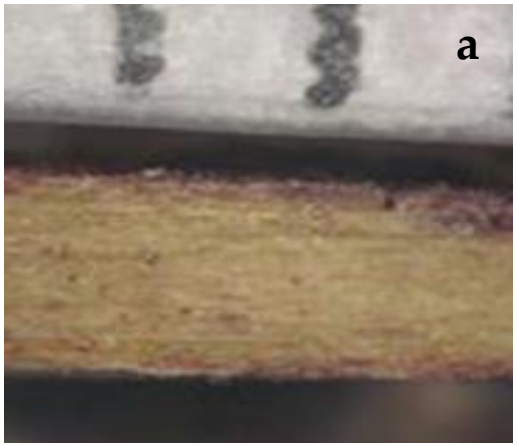
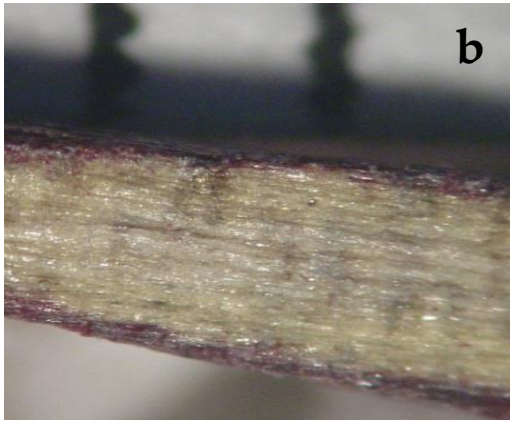
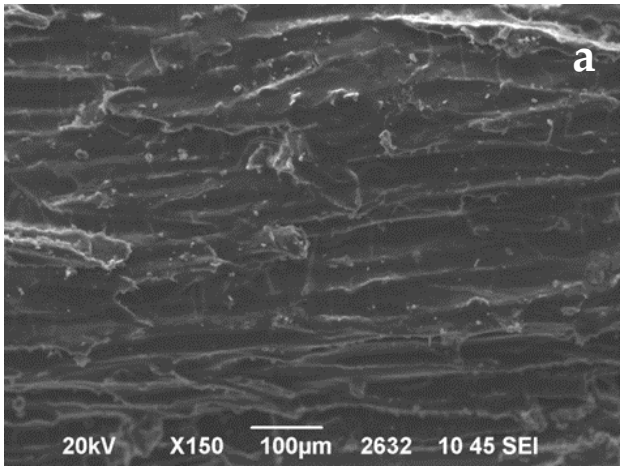
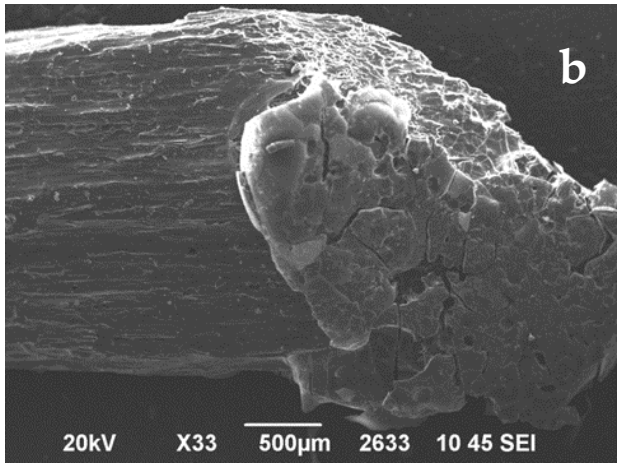
# *Optical Microscope &Scanning Electron Microscopy images*

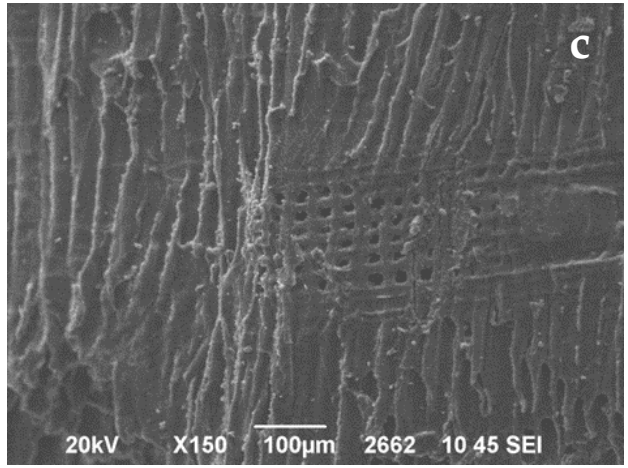


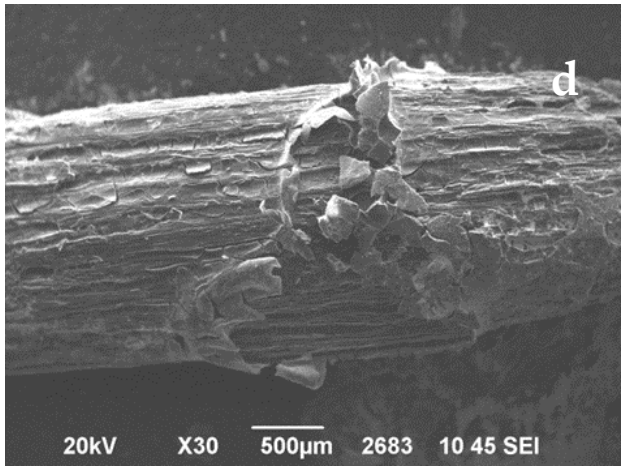




*Optical Microscope images of the a) PF/Woodchips and b) PFP20/Woodchips samples*




*SEM images of the a, b) PF/Woodchips and c, d) PFP20/Woodchips samples*

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# Conclusions

- The resins were successfully prepared.
- According to the IR analysis, the resins blended with woodchips, beyond the characteristic peaks of the resins, show peaks of the functional groups of woodchips.
- The mass degradation of the woodchips impregnated with resins is ended at the same temperature with the PFP20/woodchips sample to present higher solid residue compared to PF/woodchips.
- The maximum curing temperature of the experimental resins was slightly shifted to higher values than the typical PF.
- Optical Microscope analysis and SEM micrographs confirm the resin's penetration into the wood structure
- The protein can effectively replace part of the petrochemical phenol in the synthesis of PF resins, increasing so the bio-content of these resins and making them more friendly to people and the environment.

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# Acknowledgments

This research was carried out within the project “A new circular economy concept: from textile waste towards chemical and textile industries feedstock-RESYNTEX” that was funded by the European Union’s Horizon 2020 research and innovation programme under grant agreement No 641942.


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