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13th Mediterranean Conference on Calorimetry and Thermal Analysis

BOOK OF ABSTRACTS

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13th Mediterranean Conference on Calorimetry and Thermal Analysis

Medicta 2017

AICAT
Associazione Italiana di Calorimetria e Analisi Termica
(Italy)

GICAT
Gruppo Interdivisionale di Calorimetria e Analisi Termica della Società Chimica Italiana
(Italy)

GECAT
Grupo Especializado de Calorimetria y Analysis Termico
(Spain)

CATPOR
Grupos de Calorimetria e Analise Termica do Porto
(Portugal)

AFCAT
Association Française de Calorimétrie et d'Analyse Thermique
(France)

HSTA
Hellenic Society for Thermal Analysis
(Greece)

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Use of Spirulina in the synthesis of PF resins for plywood panels

Evangelia Tarani[a], Electra Papadopoulou[b], Dimitra Patsiaoura[a], Konstantinos Chrissafis[a]*

[a]Physics Department, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
[b]CHIMAR HELLAS S.A., Sofouli 88, 55131 Thessaloniki, Greece
*corresponding author: hrisafis@physics.auth.gr

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Microalgae are a promising feedstock for the sustainable supply of commodities. In recent years interest has focused on the development and integration of mild cell disruption and environmentally-friendly extraction and fractionation processes, including functionality testing and product formulation based on established industrial algal strains [1]. Spirulina is a microalga, or more specifically, a cyanobacteria, typically found in high-alkaline freshwater conditions. It is a natural source of a high variety of essential nutrients, such as provitamins, minerals, proteins and polyunsaturated fatty acids [2]. In this work, Spirulina (*Arthrospira platensis*) was studied as raw-material in the synthesis of thermosetting polymers suitable to be used as adhesives for the production of wood based panels like particleboards, MDF, plywood, etc. Spirulina was provided by the Spanish Bank of Algae (BEA) at the University of Las Palmas de Gran Canaria (ULPGC) at Canary Islands. The synthesis of polymers was carried out by CHIMAR HELLAS SA in Greece while their thermochemical properties were studied by the Physics department of the Aristotle University of Thessaloniki (AUTH), Greece.
CHIMAR developed thermosetting polymers of phenolic type (phenol-formaldehyde resins) with a 20w.t.% replacement of phenol by Spirulina. AUTH evaluated the creation of chemical bonds among the raw-materials with Fourier transform infrared spectroscopy (FTIR) and studied their thermal properties with thermogravimetric analysis (TGA). The curing performance of the resins was monitored via Differential Scanning Calorimetry (DSC) measurements. The bonding ability of the new resins was evaluated via their application in the production of plywood panels by CHIMAR HELLAS SA. The panels were prepared at lab scale following a simulation of the industrial practice and were tested according to the European standards in force (EN 314-1:2004 and EN 314-2:1993). For comparison reasons a typical phenol-formaldehyde (PF) resin was also included in this study. It was found that the resins were successfully prepared and that the maximum curing temperature of the experimental resins was slightly shifted to higher values than the control. Also, according to the TGA results, the Spirulina-based resins seem to lose mass with a lower rate, which denotes that they are more thermally stable than a typical PF. Regarding their bonding ability the use of Spirulina-based resins gave plywood panels with somewhat higher shear strength and wood failure than the ones prepared with a typical PF resin. The above testing results show that Spirulina 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. Of course in reality, instead of Spiroulina, protein containing residues is recommended to be used.

[1] http://miraclesproject.eu/index.php
[2] Miranda, J.M., Mendes Victor, L.A., Simoes, J., Luis, J., Matias, H., Shimamura, H., Shiobara, H., Nemoto H., Mochizuki, H., Him,, A., Lepine, J., Mar. Geophys. Res. **1998**, *20*, 171.

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[a] Physics Department, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
[b]CHIMAR HELLAS S.A., Sofouli 88, 55131 Thessaloniki, Greece

Indroduction

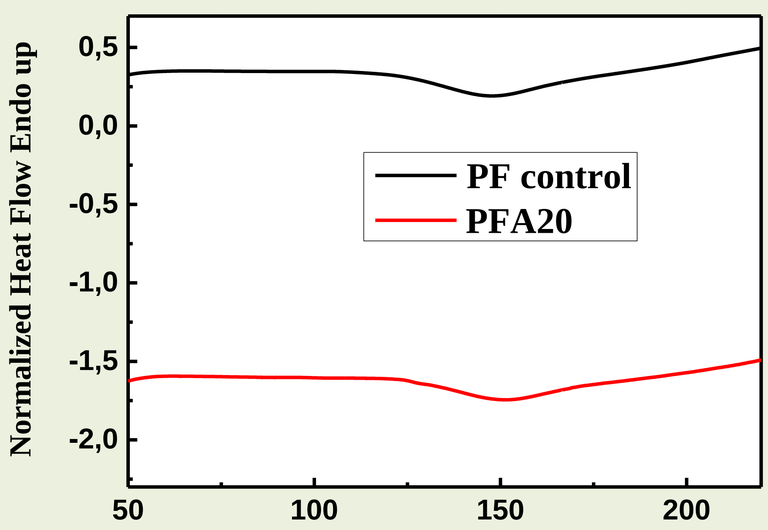
Microalgae are a promising feedstock for the sustainable supply of commodities. Spirulina is a microalga, or more specifically, cyanobacteria, typically found in high-alkaline freshwater conditions. It is a natural source of a high variety of essential nutrients, such as provitamins, minerals, proteins and polyunsaturated fatty acids.

Materials- Examination Methods

In this work, Spirulina (*Arthrospira platensis*) was studied as raw-material (20w.t.%) in the synthesis of thermosetting polymers of phenolic type (phenol-formaldehyde resins) suitable to be used as adhesives for the production of wood based panels. Spirulina was provided by the Spanish Bank of Algae (BEA) at the University of Las Palmas de Gran Canaria (ULPGC) at Canary Islands. The development and testing of polymers were carried out by *CHIMAR HELLAS SA*, while their thermochemical properties were studied by the Physics department of the *Aristotle University of Thessaloniki*.

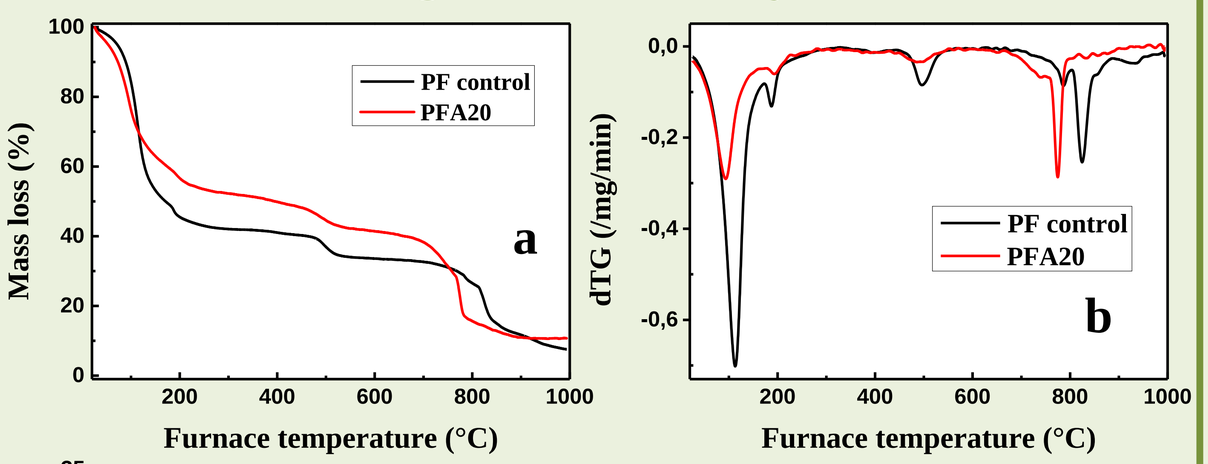
The bonding ability of the new resins was evaluated via their application in the production of plywood panels by *CHIMAR HELLAS SA*. The panels were prepared at lab scale following a simulation of the industrial practice and were tested for their mechanical properties according to the European standards in force *(EN 314-1:2004 and EN 314-2:1993)* and as per the *JIS A 1460 for* their formaldehyde emissions.

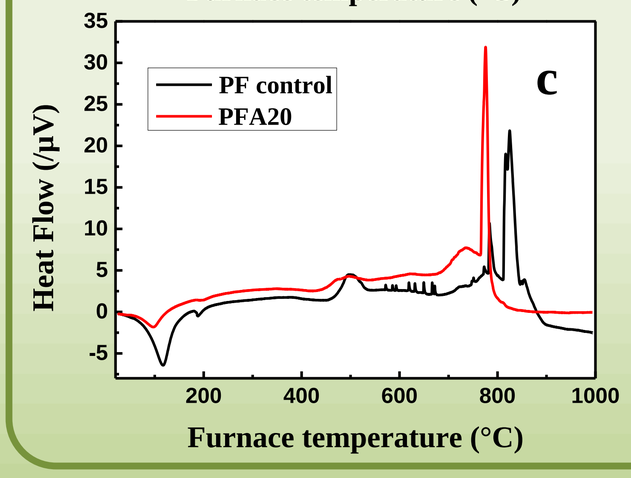
Differential Scanning Calorimetry



DSC thermograms of PF control and PF with a 20w.t.% replacement of phenol by Spirulina heated at 2.5 Kmin^{-1} in N_2 flow

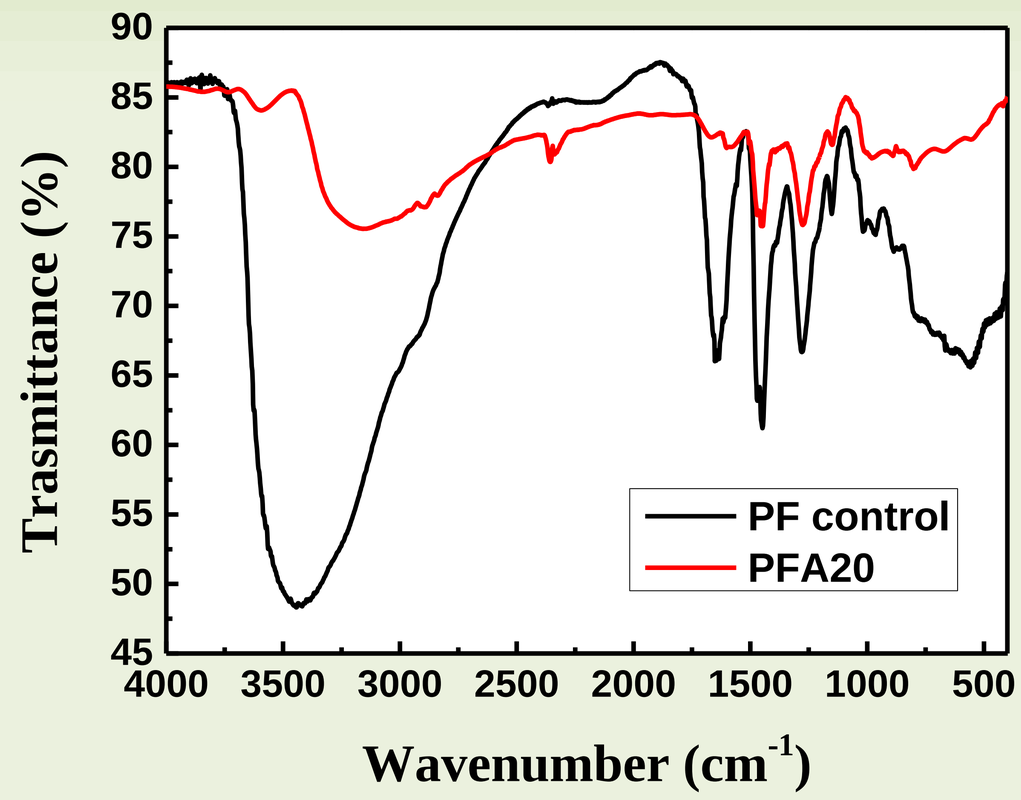
Thermogravimetric analysis- TGA





α) Mass loss curves, b)* the first derivative (dTG) *and c) measurements of Heat Flow versus temperature for the PF control and PF with a 20w.t.% replacement of phenol by Spirulina heated at 20 °Cmin^{-1}

Fourier Transform Infrared Spectroscopy- FTIR



FTIR transmittance spectra of PF control and PF with a 20w.t.% replacement of phenol by Spirulina recorded in the region 4000 -400cm^{-1}

Table: Plywood testing results

Resins:	**PF**	**PFA20**
	control	PF-Spirulina with 20% phenol sub.
Substrate wood type	*Birch*	*Birch*
EN314-1:2004		
Pre-treatment:	**Immersion in water of 20°C for 24h**	
Shear Strength (N/mm^2)	1.95	1.98
Wood Failure (%)	65	80
Pre-treatment:	**4h in boiling water-16h drying at 60°C- 4h in boiling water-1h in cool water**	
Shear Strength (N/mm^2)	1.71	1.84
Wood Failure (%)	65	95
JIS A 1460		
Desiccator (mg/l)	0.389	0.374

Discussion

- **The resins were successfully prepared and the respective plywood panels had better performance than the ones prepared with the control resin.**
- **The maximum curing temperature of the experimental resins was slightly shifted to higher values than the PF control.**
- **The Spirulina-based resins seem to lose mass with a lower rate, which denotes that they are more thermally stable than a typical PF.**

Conclusion

Spirulina, as a model algae can effectively replace part of the petrochemical phenol in the synthesis of PF resins, increasing so the bio-content of these products and making them more friendly to people and the environment. In this study, Spirulina was used as a model algae paving the way of exploiting protein-containing residues.

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