



**Facoltà di Ingegneria Civile e Industriale**

*Dottorato di ricerca in Ingegneria Elettrica, dei Materiali e delle Nanotecnologie (EMNE)*

**PhD in electrical, materials, raw materials and nanotechnology engineering**

<b>Relazione annuale A.Y.:</b>	
<b>1st Year 2023/2024</b>	
<b>Ph.D. cycle:</b>  <b>XXXVIII</b>	<b>Curriculum:</b>  <b>B: Materials and Raw Materials Engineering</b>
<b>PhD student:</b>  <b>Alessia Pantaleoni</b>	<b>Supervisor:</b>  <b>Prof. Fabrizio Sarasini</b>

**TITLE OF RESEARCH PROJECT**

Phosphorus-based coatings for natural fibers: an eco-sustainable approach for the production of biocomposite materials with improved durability and fire resistance.

**Summary of the research lines carried out (max 200 words)**

Natural fiber-reinforced composites (NFRCs) turn out to be a sustainable alternative to traditional fiber-reinforced composites (FRCs), however, they are characterized by weak fire resistance and low thermal stability. The PhD research project involves the development of phosphorus (P)-based flame retardant (FR) coatings for natural fibers as alternatives to halogenated FRs (highly effective but toxic to humans and the environment). A bioderived and bioinspired FR coating was developed within the first year. Flax and basalt fibers were chosen as a model. The coating involves gallic acid (GA) units (phenolic acid derivable from plant biomass) covalently immobilized on the fiber surface. Immobilization occurs by reaction with the fiber surface's -OH groups, increased by pretreatment with ozone (proposed as a safer alternative to classical oxidizing agents). GA units are exploited for the complexation of iron phenyl phosphonates via a mechanism bioinspired to the bacterial process of iron acquisition from the surrounding environment. The effectiveness of the coating process was demonstrated by FT-IR, SEM-EDS, MP-AES and TGA analysis. The treated fibers will

be used as reinforcement in the manufacturing of green biocomposites, and their flame retardance efficiencies will be evaluated.

### **Seminars, Classes, Workshops and Schools**

**ADVANCED COMPOSITE MATERIALS** - Chemical and materials engineering - 6 CFU - Prof. Jacopo Tirillò

**STATISTICAL INFERENCE** - Statistics, Economics, Finance and Insurance - SEFA - 9 CFU - Prof. Fulvio de Santis

### **Periods spent abroad**

### **National and International Conference Participation**

**ICNF 2023** - 6th International Conference on Natural Fibers – Funchal, Madeira (PT).  
Oral presentation: Facile and bioinspired development of a novel bio-based coating from gallic acid of natural fibers for composite applications.

### **Publications**

**Journal:** ACS Omega; **Title:** A facile and bioinspired approach from gallic acid for the synthesis of bio-based flame retardant coating of basalt fibers; **Author(s):** Pantaleoni, Alessia; Sarasini, Fabrizio; Bavasso, Irene; Santarelli, Maria Laura; Petrucci, Elisabetta; Valentini, Federica; Bracciale, Maria Paola; Marrocchi, Assunta

(Status: under review)