Bio-based fire-retardant thermoplastic composites reinforced with natural fibers

THERMOFIRE (GA101112370)

Elvira Villaro Ábalos

The project is supported by the Circular Bio-based Europe Joint Undertaking and its members.

Circular Bio-based Europe Joint Undertaking

Bio-based Industries Consortium

Co-funded by the European Union

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THERMOFIRE

Bio-based fire-retardant thermoplastic composites reinforced with natural fibres

Design, develop and validate novel, lightweight and low-cost bio-based and recyclable thermoplastic composites with enhanced mechanical properties and fire resistance by the incorporation of natural fiber reinforcements and bio-based halogen-free flame retardants.

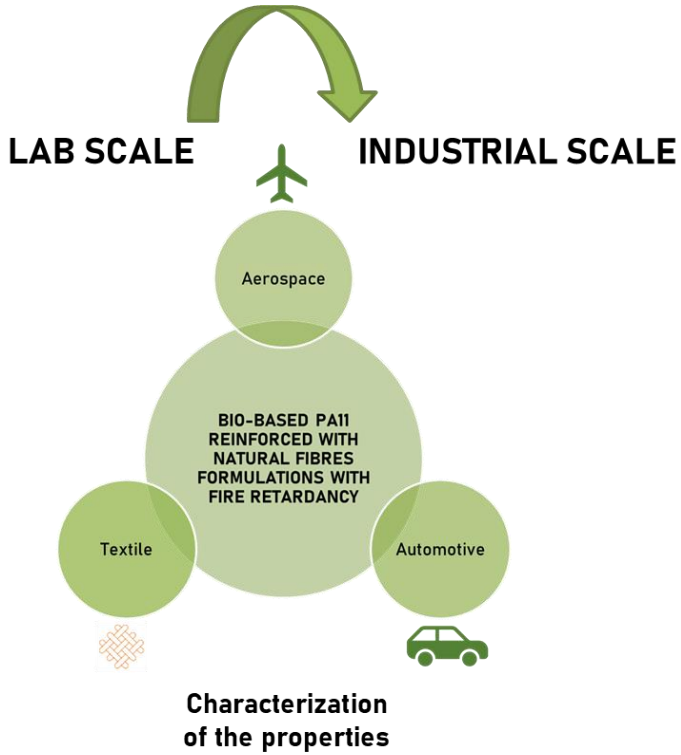
Consortium of 12 partners led by Avanzare Innovacion Tecnologica SL

Use of biobased materials as a feedstock

100% biobased PA11, Biobased flame retardant and biobased fibers

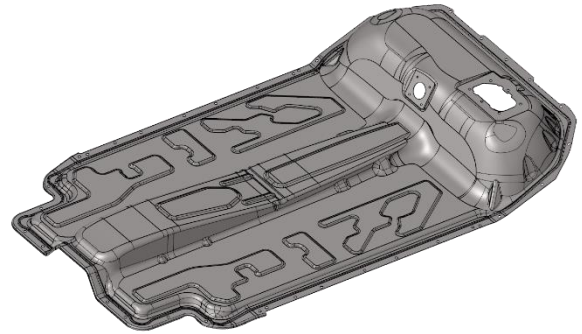
3 prototypes (TRL5) in automotive (housing for electrical batteries), aerospace (aircraft interior seats) and textile (non-woven fabrics).

Remove the EU's dependence on fossil-based polymers and increases the sustainability of the composites, addressing new methods for bio-polymer preparation with low environmental impact.



THERMOFIRE

Bio-based fire-retardant thermoplastic composites reinforced with natural fibres

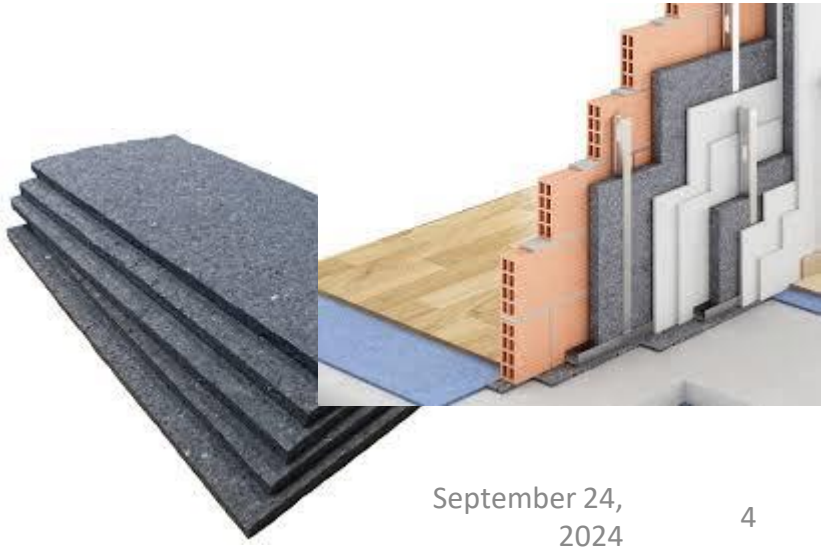


CBE JU contribution: € 4.47 million

Duration: June 2023 – May 2027

Feedstock: [natural fibers, 100% biobased PA11, biobased flame retardant]

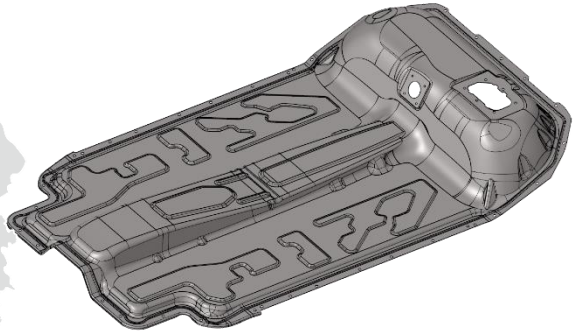
Main products: [aircraft interior seats, battery houses for electrical vehicle made in 100% biobased materials]



THERMOFIRE

Bio-based fire-retardant thermoplastic composites reinforced with natural fibres

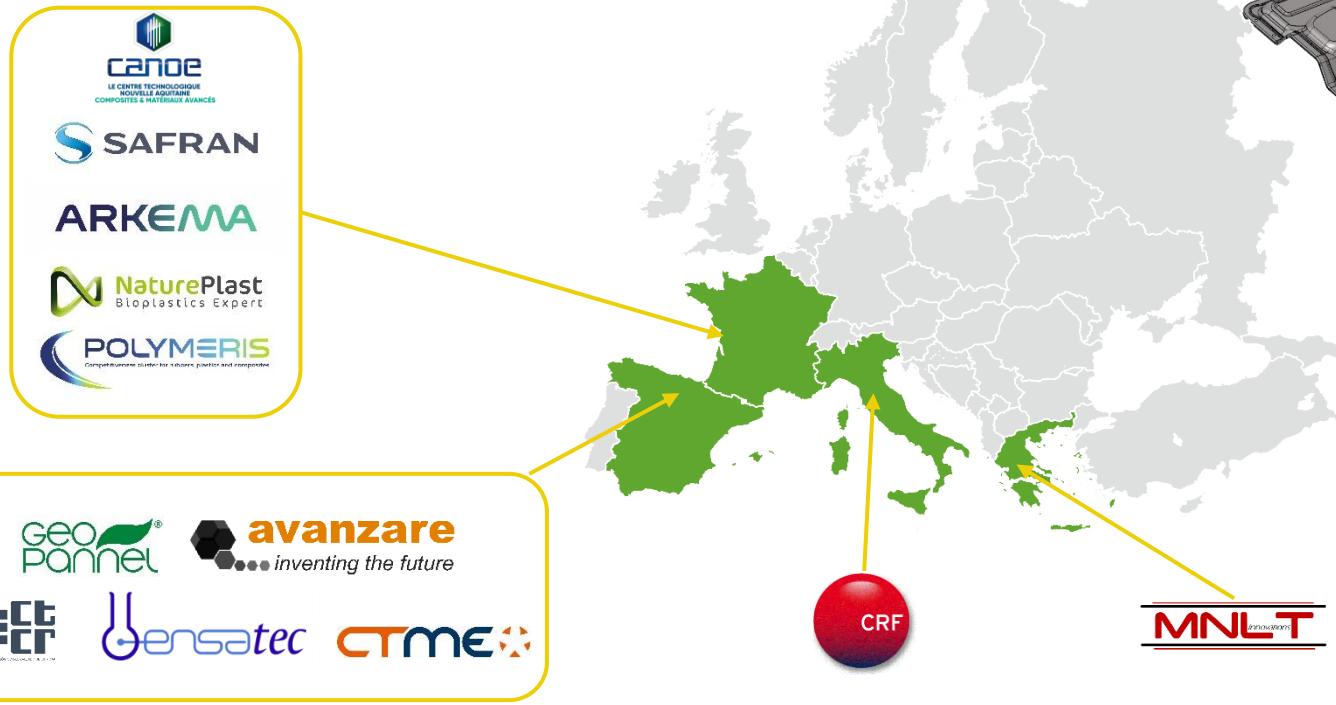
Project lead: Avanzare Innovacion Tecnologica SL (Spain)



2 RTOs

6 SMEs

4 Large Companies



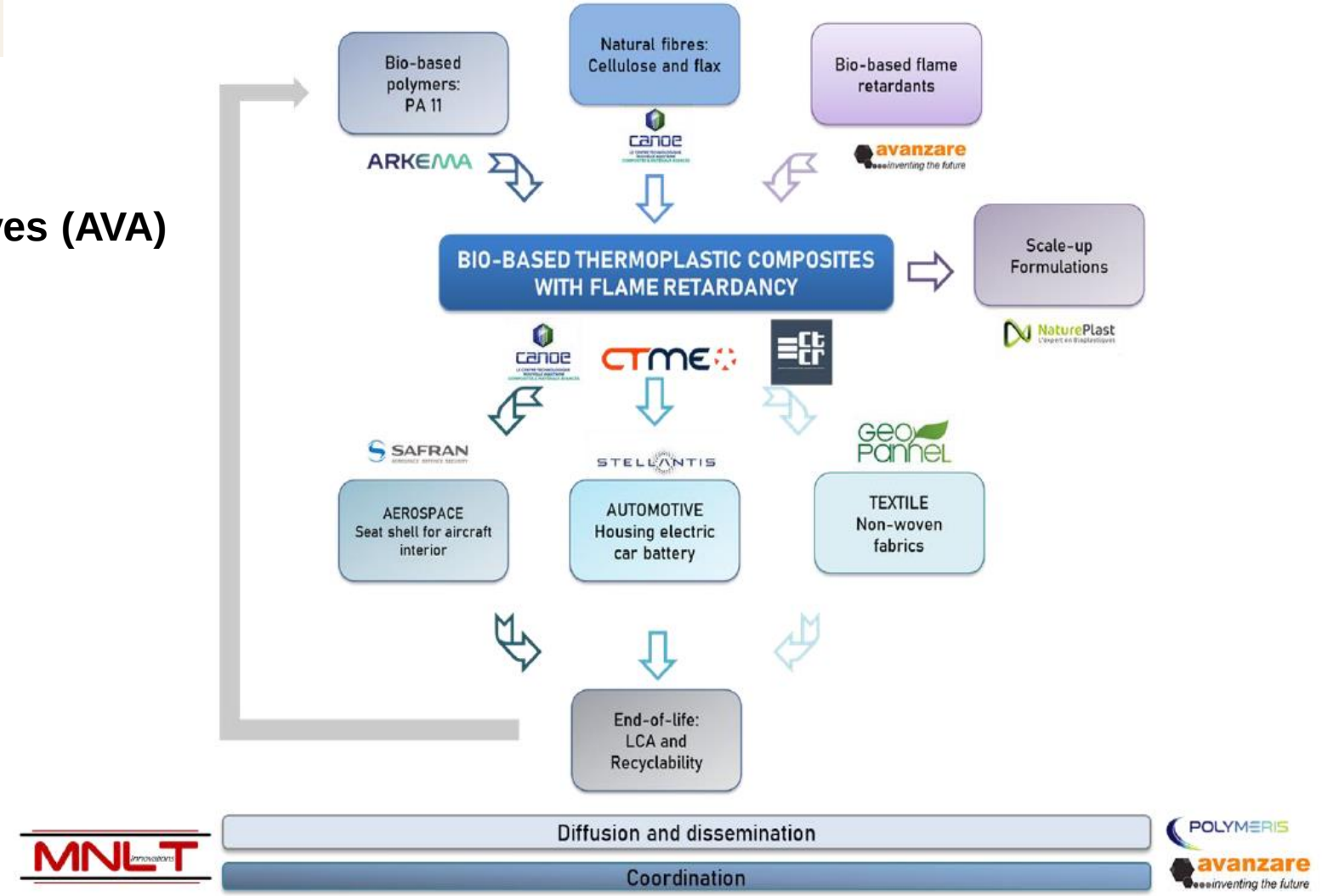
General Objectives

The THERMOFIRE project has the objective to develop **novel bio-based and recyclable composites** with enhanced mechanical properties and fire resistance by using **natural fiber reinforcements** and **bio-based halogen-free flame retardants.** The production of these novel composite materials will be scaled up and **3 types of demonstrators** will be developed: aerospace, automotive and textile applications.

- Up to 100% bio-based polymers will be reinforced with different natural fibers (e.g., regenerated cellulose from wood and commercial flax) and bio-based flame retardants aiming at giving excellent flame retardancy to the final bio-based thermoplastic (TP) composites. The innovation of THERMOFIRE relies on the development of high-performance composites with a **20% reduction in weight and 30% in cost while maintaining the required levels of safety** suitable for applications under stringent operating conditions.
- New halogen-FREE and bio-based flame retardants with low toxicity compared to commercial ones.
- Environmentally friendly and low-cost biobased cellulose fibers as reinforcement with CO2 neutrality directly extracted from nature without further processing.
- Development of up to 100% bio-based TP composites with improved fire-resisting properties by using bio-based additives and/or by developing a new intrinsic bio-based polyamide 11 by introducing fire retardant monomer in its molecular chain.
- Verify the reusability and recyclability of the produced materials.
- Development of three prototypes adapted to the application requirements of the aerospace, automotive and textile sectors.
- Development of validation test of prototypes (TRL 5)

Developed Materials

3.1. **Biobased Flame Retardant Additives (AVA)**
3.2. **Biobased FST PA-11 (ARK)**
3.3. **Biobased Fibers (CANOE)**
3.4. **Integration & Use cases:**
- **CRF**
- **SAFRAN**
- **GEOPANNEL**



3.1. Flame Retardant Additives (AVANZARE)

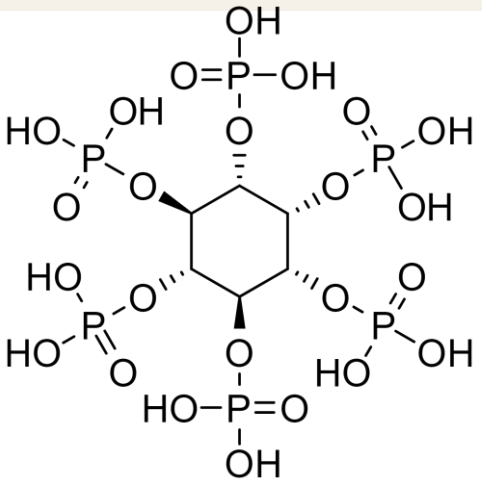
Study of the bio-based flame retardants

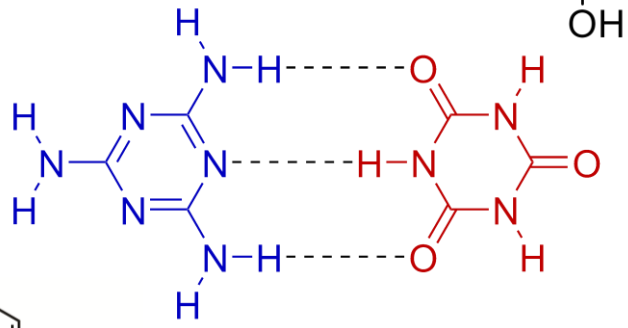
Phosphorus-based Bio-based Flame Retardants:

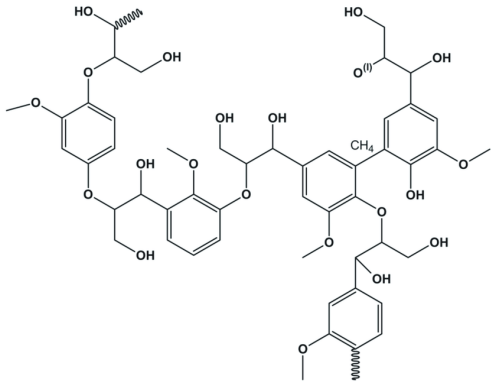
Nitrogen-based Bio-based Flame Retardants:

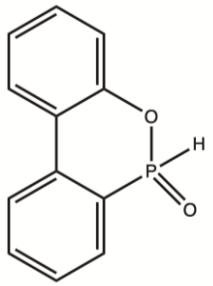
Bio-based Intumescent Flame Retardants:

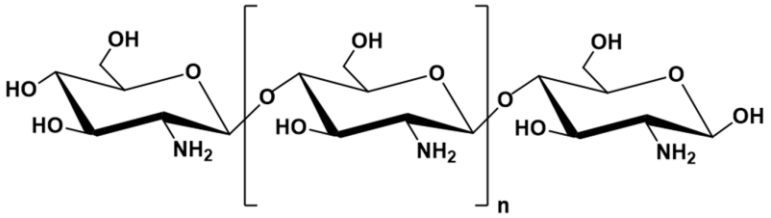
Lignin-based Flame Retardants:











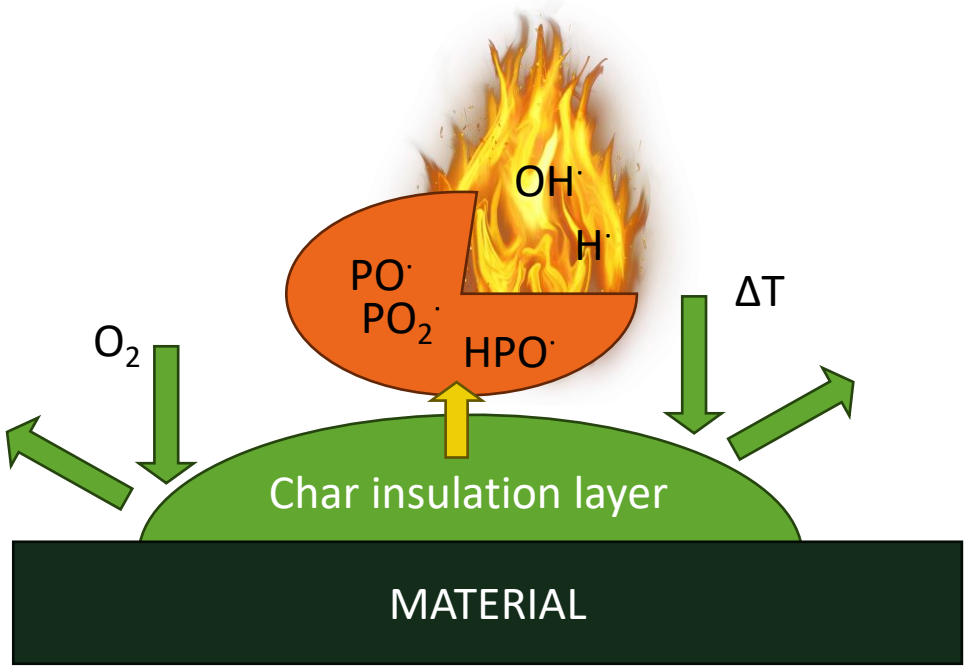
Study of the bio-based flame retardants

Phosphorus-based Bio-based Flame Retardants:

- Phytic Acid (Plant sources)

Nitrogen-based Bio-based Flame Retardants:

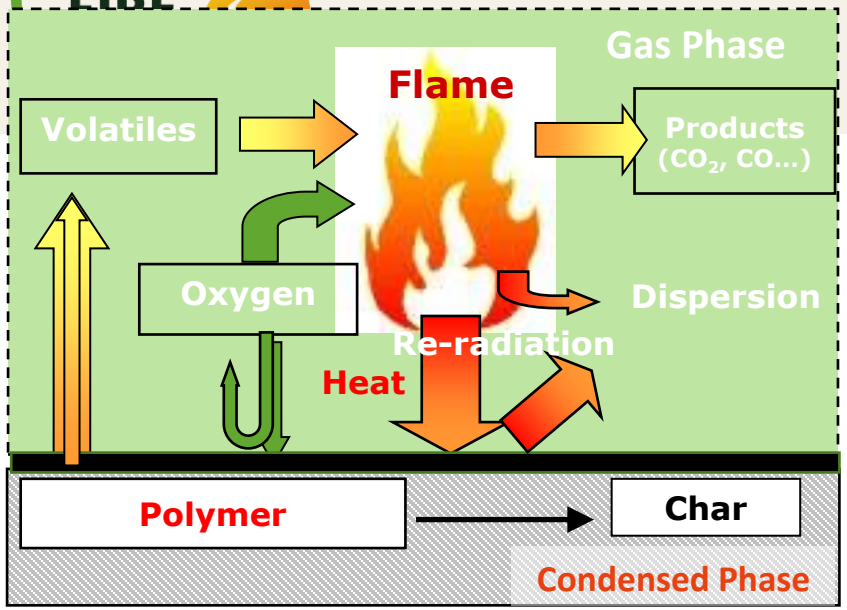
- Lignin and Tannin-based Flame Retardants:



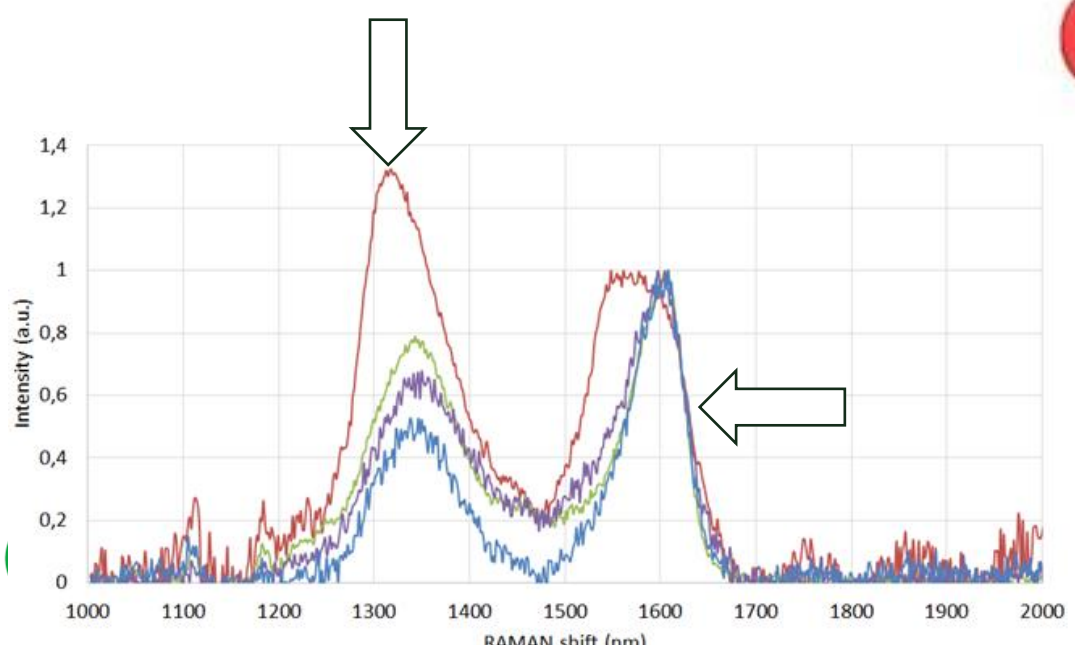
Study of the carbonous materials

- GO
- Nanoplatelets

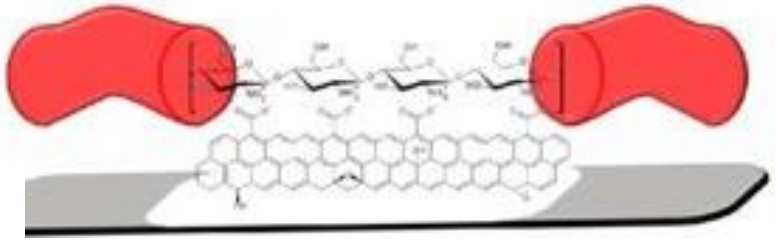
Char Effect: Char is a residue left behind after a material undergoes combustion. In the context of flame retardancy, the formation of a stable and protective char layer is desirable as it can act as a barrier, limiting the access of oxygen and slowing down the combustion process.

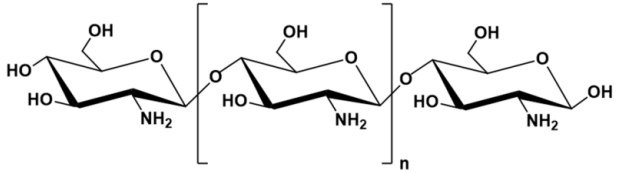


Classification	Description
V0	No complete ignition, and the flame duration is less than 10 seconds after each series of five flame applications
V1	No complete ignition, and the flame duration is less than 30 seconds after each series of five flame applications.
V2	No complete ignition, and the flame duration is less than 30 seconds after each series of five flame applications. With flame propagation and the formation of drops or particles
NC	The flame duration is higher than 30 seconds after each individual flame application.



GO-Chitosan





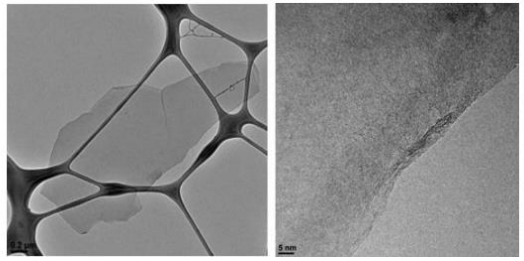
Induce Char graphitization

3.1. Flame Retardant Additives (AVANZARE)

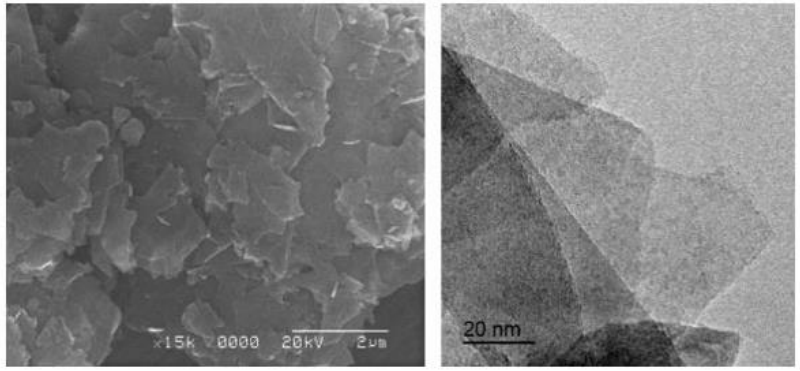
Study of the carbonous materials

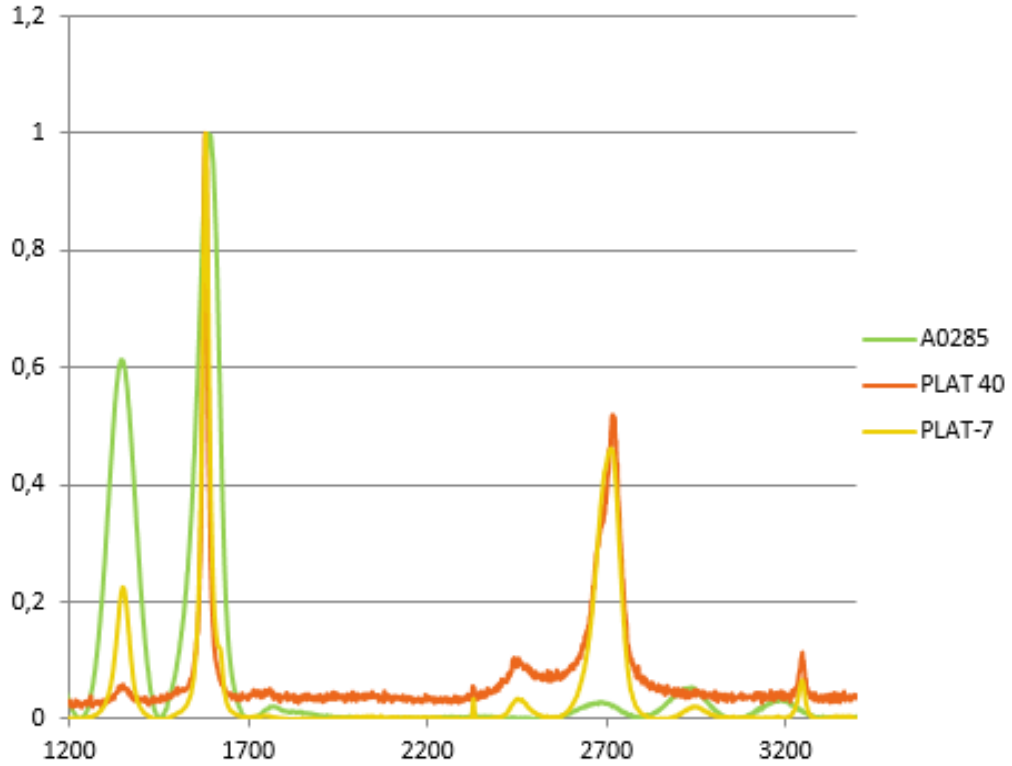
- **GOx**
- **PLAT 7**
- **PLAT 40**

GOx SEM



Nanoplatelets SEM





3.2. PA-11 (ARKEMA)

Study with PA-11 to FST-PA11

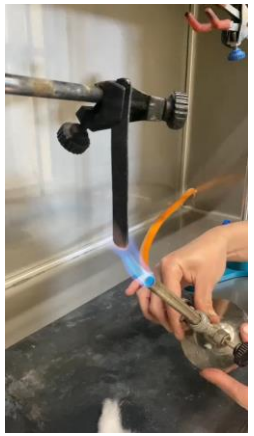
Produced from a renewable source (castor oil), PA11 is used in a large number of applications thanks to its outstanding properties, including excellent chemical resistance, easy processing, high and low-temperature performance (-40°C / +130°C), high dimensional stability, and low density.

Many industries around the world (e.g. automotive, textile, oil & gas, wire & cables, electronics)

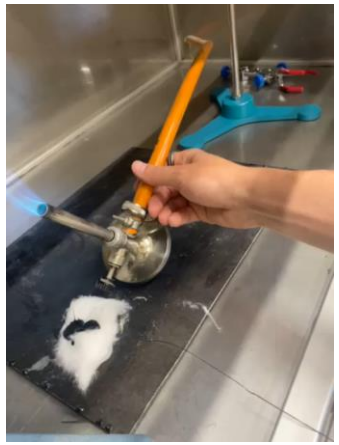
PA11 is easy to process using most processing technologies (extrusion, extrusion-blow molding, injection molding, rotomolding, and 3D printing).

ARKEMA FST-PA11

Work Package WP2- Raw materials: development of bio-based TP polymers, natural fibers and bio-based flam retardants

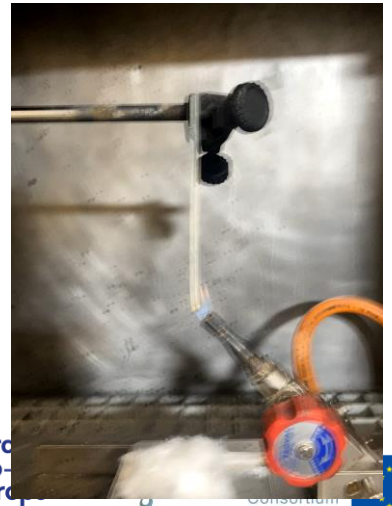


VP2238



VP2242

VP2245

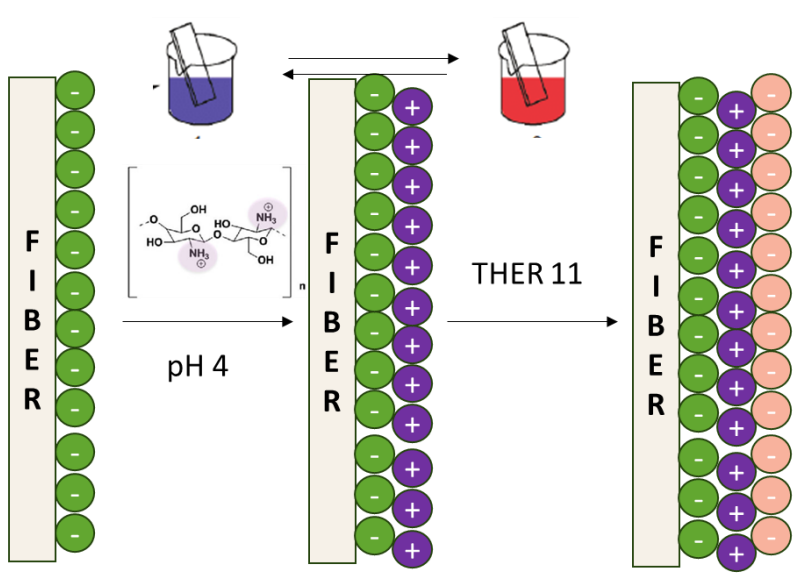


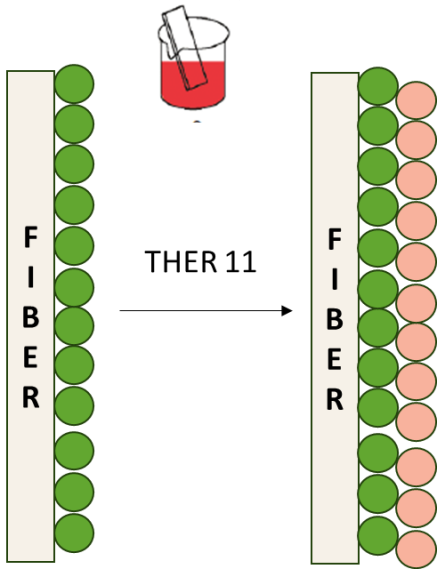
Non treated

Internal reference	PA	Carbonous material	Biobased FR		Other (rheologhy adapters…)	
VP	PA11	Nanoplats	TANIN	CHITOSAN		
2233						
2234						
2236						
2237						
2238						
2239						
2240						
2241						
2242						
2243						
2244						
2245						
2246						
2247						
2248						
2249						
2250						
2251						
2261						
2262						
2263						
2264						
2265						

3.3. Fibers (Cellulose by CANOE + comercial ones; jute or hemp)

- 2 layers of suspensión with FR
- Drying temperature below 100ºC for 1 hour
- Increase the charge of bio-additives





3.3. Cellulose fibers (CANOE)

Next steps

- Sinergy between carbonous materials to modify reology and MFIs.
- Sinergy with different biobased FRs to increase the performance.
- Preparation of composites with additives and fibbers and testing the properties.
- LCC and LCA analysis.