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Flax as structural reinforcement for innovative ecomaterials: the secret is in milling !

Read more

Mayer-Laigle C, Bourmaud A, Shah D-U, Follain N, Beaugrand J

Unravelling the consequences of ultra-fine milling on physical and chemical characteristics of flax fibres.

Powder Technology . 2019

Badouard C, Traon F, Denoual C, Mayer-Laigle C, Paës G, Bourmaud A

Exploring mechanical properties of fully compostable flax reinforced composite filaments for 3D printing applications.

Industrial Crops and Products . 2019

Collaboration

This research created the opportunity to launch new 3D printing-driven collaborations between INRAE and the IRDL in France and SCION Institute in New Zealand.

Contacts

Claire Mayer, Gabriel Paës, Johnny Beaugrand

UMR IATE, UMR FARE, UR BIA

claire.mayer@inrae.fr

gabriel.paes@inrae.fr

johnny.beaugrand@inrae.fr

Context

Plant fibre and agricultural bioproducts and coproducts are increasingly being employed as reinforcement additives in agro-based composites to minimize their environmental footprint. This is where 3D printing opens up a vast array of new architecture opportunities with a minimum of start-material feedstock.
Whatever the shaping process used, plant-based reinforcements need to be prepped either by cutting the long fibres or by milling, and both processes affect their subsequent workability. Our research sets out to get a clear picture of the relationship between the starting properties of plant particles and the functional properties of the end-materials in which they are incorporated.

Results

Our efforts have focused on the processability of powder-form plant particles and on the mechanical properties of 3D-printed and injection-moulded materials, and accommodating the specific constraints tied to each of these processes.
Our work revealed that processed flax-powder particle sizes influenced the properties of the thermoplastic polymer. Sizes greater than 200 µm were found to maximize the elongation ratio (length-to-diameter) and are amenable to injection processes. Sizes less than 100 µm were found to prove better for fused deposition modelling 3D printing processes, as they help resolve process issues like (i) nozzle clogging, (ii) fault zones in the manufactured object, and (iii) in-printing filament breaks.
Advanced comminution processes developed at the IATE joint research unit's PLANET platform ('PLANt Processing with Emergent Technologies') served to yield these target sizes.
Advanced developments in the extrusion and 3D printing processes then managed to incorporate up to 30% flax plant biomass into the composite matrix.

Future Outlook

This research articulating the potential of 3D printing with the responsiveness of ultrafine flax powders now paves the way to creating smart materials that are able to self-sense or responsively adapt to changing environmental conditions (temperature, humidity, pH, and so on), thus heralding '4D materials'. We are now looking at extending this research to encompass other plant-biomass feedstocks.