

Novel bio-based multi-component plastic additives in the form of granulate

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Materials and methods

Materials

- **Beech wood flour (BF)**, particle size <200 μm,
- **Ammonium polyphosphate (APP)**, Addforce FR APP201, >31% P, >12% N,
- **Tannic acid (TA)**, >93%,
- **Chitosan (CH)**, 3000-6500 cps, >90%,
- **Poly(ε-caprolactone) (PCL)**, Capa 6500.

Table 1. Compositions applied in the presented study.

Material	Sample			
	1	2	3	4
	Content, wt%			
BF	60	60	60	60
APP	20	20	20	10
TA	20	-	10	15
CH	-	20	10	15

Additives manufacturing

Homogenization and densification – IdeaPro Intensive Mixer with star-belt type stirrer (dry mixing: 30 s, stirrer speed 1200 rpm, pan speed 60 rpm; wet mixing: addition of water - 50 pbw, 5 min) followed by the granulation in a pan granulator.

Compounding

Injection molding with Engel e-mac 50 machine at 100-110 °C (samples PCL-1, PCL-2, PCL-3, and PCL-4), eventually preceded by melt blending with Zamak 16/40 EHD co-rotating twin-screw extruder at 100-130 °C (sample PCL-4X). PCL:additives mass ratio 1:1.

Properties of developed multi-component granulates

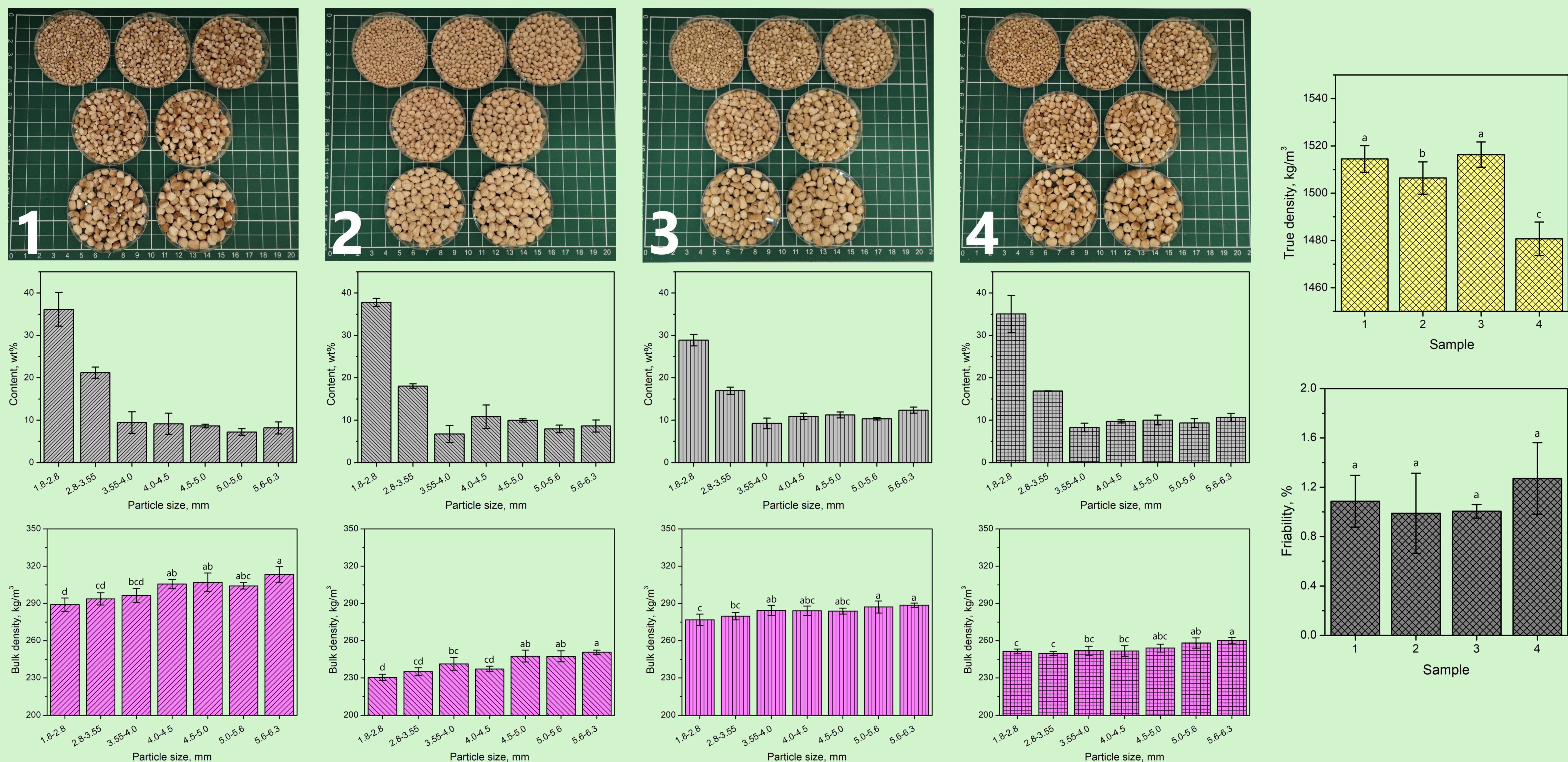


Fig. 1. The appearance, particle size distribution, bulk and true density, as well as friability of developed multi-component granulates.

Properties of developed polymer composites

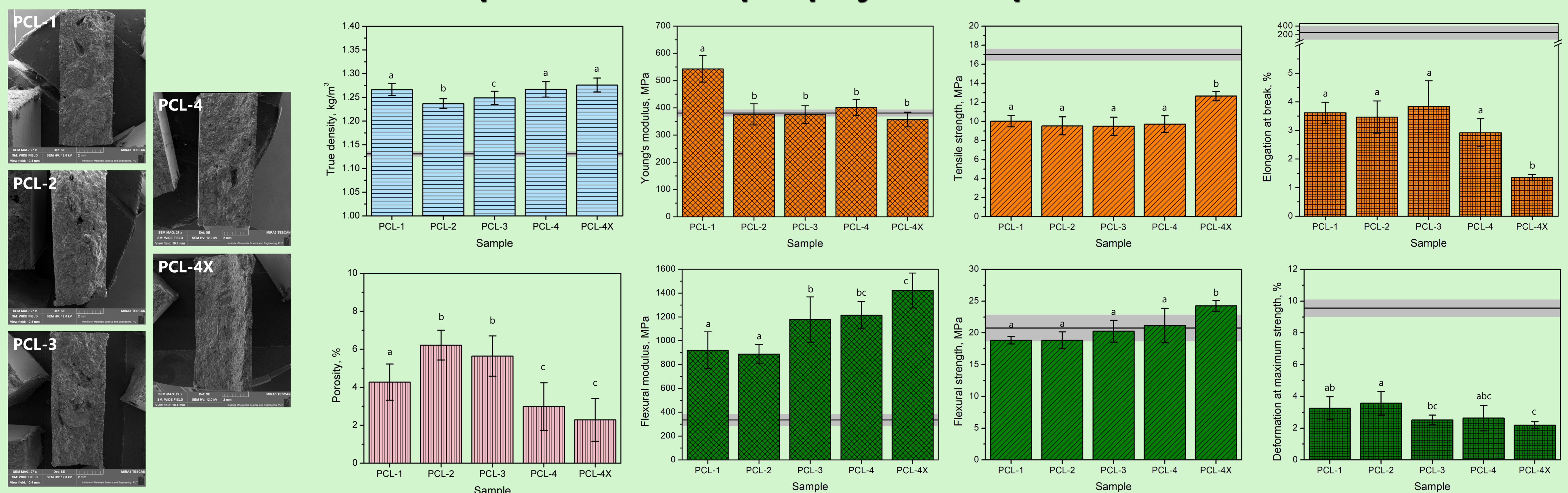


Fig. 2. The impact of introduced multi-component additives on the morphology and resulting physico-mechanical properties of PCL-based composites (black and grey lines indicate values for unfilled PCL).

- Novel multi-component plastic additives, based on beech wood flour and sustainable flame retardants, with granulometric properties similar to those of polymer granulates, have been developed.
- Developed additives can be efficiently introduced into the polymer matrix via injection molding alone, without prior melt blending, thereby simplifying the manufacturing process.
- Additional melt blending can be applied to enhance the dispersion of components, which may affect the performance; however, proper adjustment of the injection molding process may mitigate dispersion limitations.
- The impact of applied additives on the fire retardancy of developed composites is under ongoing investigation; however, preliminary studies indicated significantly reduced dripping of material, which limits the potential fire spread.

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