Researchers from ICMA San Giorgio and the Politecnico di Milano are optimising the production of natural-fibre-filled PLA using a twin-screw extruder

Natural progress

Italian researchers are compounding recycled PLA with kenaf natural fibres with the aim of developing a high-performance, cost-competitive bioplastic composite produced from renewable resources. ICMA San Giorgio is working with Politecnico di Milano on the project.

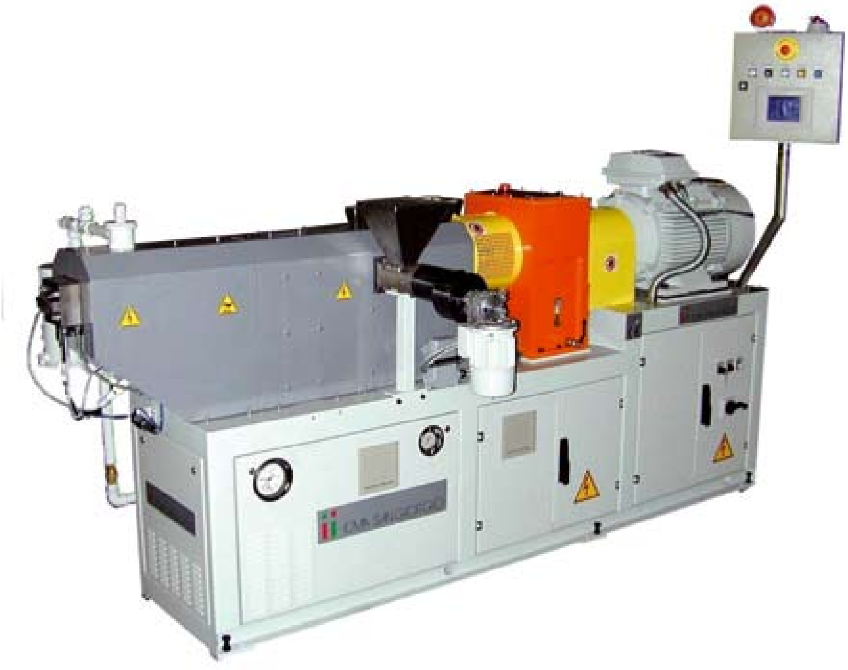
The materials are being produced on an ICMA San Giorgio twin-screw co-rotating extruder and the samples are made by compression moulding. Tests have been carried out to evaluate the effects of different formulations and processing conditions.

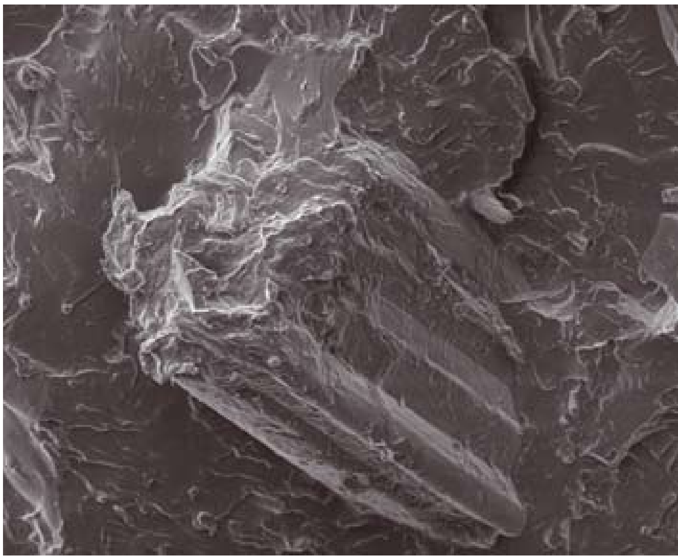
The recycled PLA comes from food packaging, while the kenaf filler is supplied in powder form by Kenaf Eco Fibers Italia (KEFI). Prior to processing, the PLA and kenaf are dried in a vacuum oven at 100°C for eight hours.

Compounding is carried out using an ICMA San Giorgio MCM 25 HT 44D lab-scale extruder with different screw configurations, temperature profiles and screw speeds. Gel permeation chromatography (GPC) has been used to assess polymer degradation levels for different compounding configurations. No excessive degradation was found for any of the different processing conditions tested.

Samples have been produced with kenaf filler loadings of 10, 20, 30 and 40%. These were analysed using differential scanning calorimetry. The addition of kenaf decreases the glass transition temperature and by 2-5°C, while the cold crystallisation temperature

The kenaf plant is extensively cultivated for its fibres which are similar to jute





The trials are being carried out using an ICMA San Giorgio MCM 25 HT 44D lab-scale extruder

falls by 17-20°C depending on the loading level. According to the researchers, this shows that the kenaf acts as a plasticiser and as a nucleating agent.

As expected, the tensile modulus of the composite was found to increase with kenaf filler content (4.9 MPa with 30% filler compared to 3.5 MPa for pure PLA). However the tensile strength declined as filler loadings were increased. This can be attributed to the poor interfacial adhesion between the kenaf and the PLA. The researchers are now looking at different compatibilisers/coupling agents that can increase adhesion between the filler and the matrix. They have already found that changing the configuration of the dispersive mixing portion of the screw improves the tensile strength of the kenaf-filled compound to levels comparable with pure PLA. The tensile modulus was also improved by 11%

Tests on the impact of processing conditions showed that increasing the screw speed from 150 to 200 rpm delivered a material with a higher modulus due to the better dispersion of the natural filler. In addition, increasing the barrel temperature improved deformation properties and tensile strength due to better wetting of the fillers.

The introduction of polyethylene glycol with a molecular weight of 1,000 as a plasticiser did not deliver the expected increase in mechanical properties. This was probably because of the use of recycled PLA.

A scanning electron microscope was used to take a closer look at the morphology of the composite. It showed the poor adhesion between the kenaf fibres and the PLA matrix, confirming the reason for the reduced toughness of the filled polymer. It also confirmed the improved distribution and dispersion that was achieved by optimising the screw configuration.

Fine tuning the screw configuration and processing parameters has already led to improvements of 60% for the modulus, 130% for deformation properties and 65% for tensile strength. On-going work is focusing on compatibilisers and coupling agents to further improve the strength and toughness of the kenaf-PLA composites.

- **www.icmasangiorgio.it**
- **www.polimi.it**
- **www.kenaf-fiber.com**

Results of tests on mechanical properties

Kenaf loading (%)	Temperature (°C)	Screw speed (rpm)	Modulus (MPa)	Deformation	Tensile strength (MPa)
0	180-170	150	3.47 ± 0.06	1.9 ± 0.07	50.42 ± 0.87
10	180-170	150	3.84 ± 0.05	1.28 ± 0.05	40.73 ± 0.32
10	190-180	150	3.73 ± 0.07	1.64 ± 0.2	43.75 ± 0.97
10	180-170	200	3.95 ± 0.04	1.09 ± 0.09	39.04 ± 0.92
30	200-190	150	4.89 ± 0.03	0.93 ± 0.1	35.77 ± 0.75