Analysis of Recycled Glass-fiber Reinforced Nylon 6

～ What factors decreases the tensile strength? ～

When the recycled glass-fiber reinforced nylon 6 was used, the tensile strength decreased. Several kind of analyses (e.g. nano-indentation, X-ray CT, OM and SEM) were carried out to find out the cause of the decrease in strength.

Samples

■ **Glass-fiber (GF) Reinforced Nylon6**

Sample Name	Composition rate (%)	Tensile strength
Virgin Material	Virgin Nylon: 70 Recycled Nylon: 0 GF: 30	187 MPa
Recycled Material A	Virgin Nylon: 19 Recycled Nylon: 51 GF: 30	137 MPa

Theoretical formula of tensile strength prediction

■ **Fukuda-Chou formula**

$$\sigma_c = \underbrace{\sigma_f \left(\frac{l}{2lc}\right) v_f \eta_\theta}_{\text{Factor from fiber}} + \underbrace{\sigma_m (1 - v_f)}_{\text{Factor from polymer}} \quad (l \leqq lc) \qquad l_c = \left(\frac{d\sigma_f}{2\tau_i}\right)$$

σ_c : FRP tensile strength, σ_f : Fiber strength,
v_f : Fiber volume fraction, η_θ : Fiber orientation coefficient,
σ_m :Polymer strength, l : Fiber length、d : Fiber diameter,
τ_i :Interfacial strength

Investigate which factor caused the decrease in tensile strength by using dumbbell test pieces

Strength of fiber and resin

■ **Nano indentation**

Calculate the average elastic modulus using the data from multiple locations

Sample Name	Average elastic modulus	
	Fiber	Resin
Virgin Material	55.7 GPa (8.5)	2.7 GPa (0.4)
Recycled Material A	56.0 (8.8)	2.8 (0.6)

( ): standard deviation

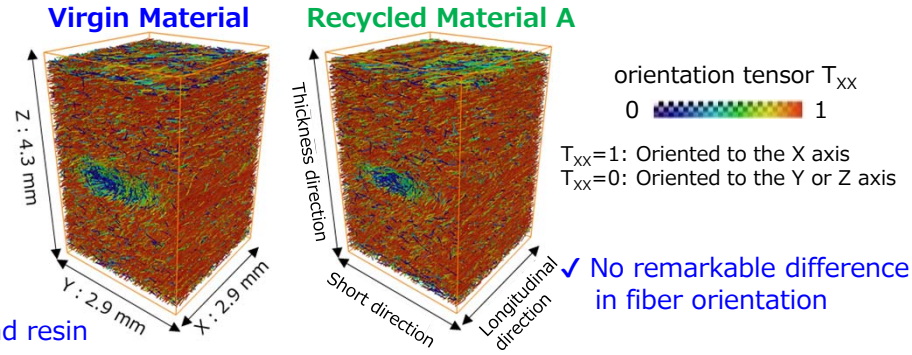
✓ No remarkable difference in strength of fiber and resin

Fiber orientation

■ **X-ray CT**

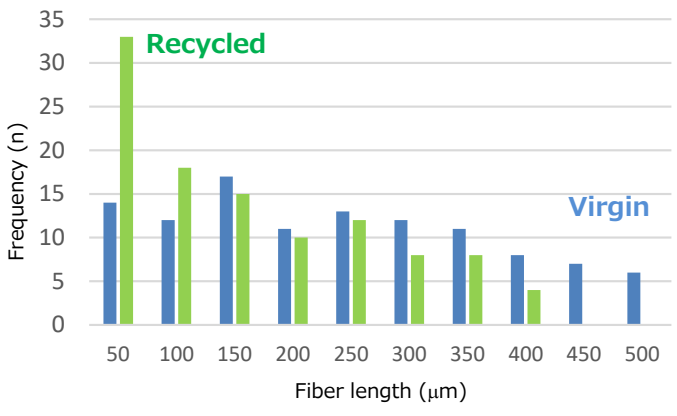
Calculate the orientation tensor* of each GF and display it as a stereoscopic image.

* Calculate by regarding one GF as an aggregate considering the curvature



✓ No remarkable difference in fiber orientation

Fiber length

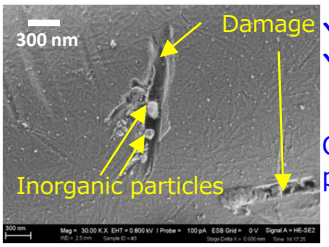


✓ Recycled material A has a higher proportion of short fibers than virgin material

Observation of GF surface

■ **SEM**

SEM observation of shortened fiber surface (Recycled Material A)



✓ Small damage on surface
✓ Inorganic particle in damage

GFs were damaged by inorganic particles and shortened.

It was suggested that shortening of fibers due to inorganic particle was the cause of the decrease in tensile strength

→ By understanding the cause, it is possible to take appropriate htzsyjwuqfsx%j313changing the initial fiber length of pellets and reducing inorganic impurities ..

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