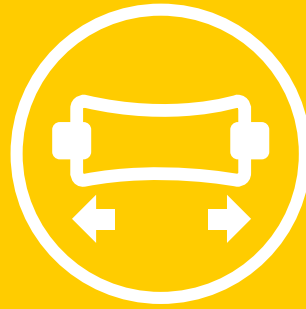


TECHNICAL STUDY



**Improved
dispersion**



**Mechanical
properties**



**Reduced
costs**



**Friction
reduction**



**THE EFFECT OF CEVO® 3400
ON THE MATERIAL PROPERTIES OF CARBON FIBRE
REINFORCED POLYCARBONATE (PC)**

Polycarbonates (PC) are a group of thermoplastic with a diverse range of applications. They are used in electronics, car headlights, medical devices, sports equipment, and numerous other applications. Carbon fibres are common-

ly used for the mechanical reinforcement of materials in composite manufacturing due to their high specific modulus, strength, stiffness, and low density.

Introduction

The mechanical properties of carbon fibre composites derive largely from the mechanical properties of the carbon fibre, the fibre/matrix adhesion, and the dispersion of the fibre. CEVO® 3400 is an excellent release agent for thermoplastic polymers. A concentration of 0.3 % is recommended in unfilled polymers. In the case of filled materi-

als, depending on the filler content, higher concentrations can be beneficial. This study analysed the effect of CEVO® 3400 on material properties when used as an additive in carbon fibre filled polycarbonate compounds. In particular, mechanical properties were analysed.

Matrix	Recipe #	CEVO® 3400 [phr]	Carbon fibre [phr]
Makrolon® 2405 MVR (300 °C/1.2 kg) 19 cm ³ /10 min; general purpose; low viscosity; easy release	1	0.3	9.7
	2	0.4	17.2
	3	0.5	28.5

Table 1: Dosage of CEVO® 3400 and carbon fibre concentrations

To determine the mechanical properties, multi-purpose test specimens 1A (in accordance with DIN EN ISO 3167), were produced using an Arburg injection molding machine in accordance with recipes 1-3 (Table 1), and wax-free references.



Results

Improvement of the modulus of elasticity

It was possible to improve the tensile modulus of elasticity for each of the three carbon fibre concentrations by adding CEVO® 3400 to the formulation.

The improvements compared to the wax-free references are listed below:

Recipe 1: with 0.3% by weight CEVO® 3400, it was possible to increase the modulus of elasticity of the PC-CF 9.7 recipe by 10.7%.

Recipe 2: with 0.4% by weight of CEVO® 3400, it was possible to increase the modulus of elasticity of the PC-CF 17.2 recipe by 9.8%.

Recipe 3: with 0.5% by weight of CEVO® 3400, it was possible to increase the modulus of elasticity of the PC-CF 28.5 recipe by 9.7%.

Improvement of the tensile strength

It was possible to improve the tensile strength for each of the three carbon fibre concentrations by adding CEVO® 3400 to the formulation.

The improvements compared to the wax-free references are listed below:

Recipe 1: with 0.3 wt.% CEVO® 3400, it was possible to increase the tensile strength of the PC-CF 9.7 recipe by 18.6%

Recipe 2: with 0.4 wt.% CEVO® 3400, it was possible to increase the tensile strength of the PC-CF 17.2 recipe by 17.0%

Recipe 3: with 0.5% by weight CEVO® 3400, it was possible to increase the tensile strength of the PC-CF 28.5 formulation by 9.0%.

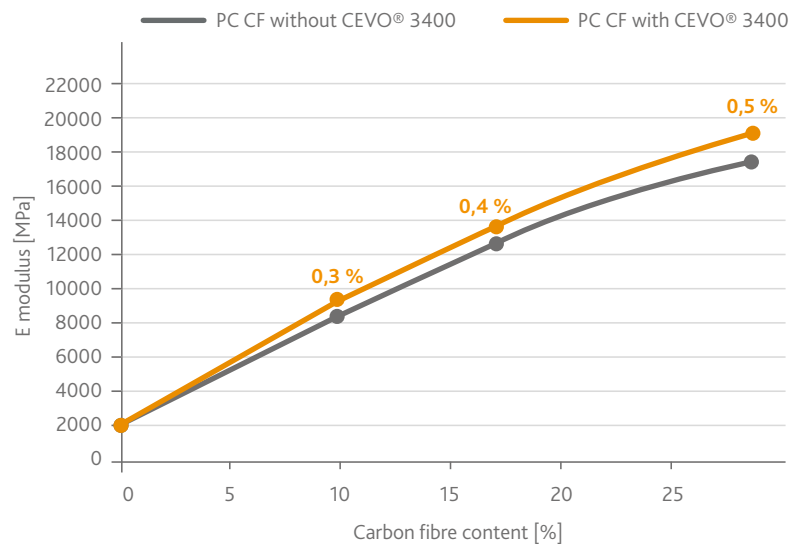


Fig. 1: The tensile modulus of elasticity could be significantly improved by the addition of CEVO® 3400

CF [w %]	E-modulus [Mpa] without CEVO® 3400	E-modulus [Mpa] with CEVO® 3400 [%]	Improvement [%]
9.7	8236	9118 with 0,3	10.7
17.2	12652	13900 with 0,4	9.8
28.5	17822	19551 with 0,5	9.7

Table 2: Percentage improvement in the modulus of elasticity compared to the wax-free reference.

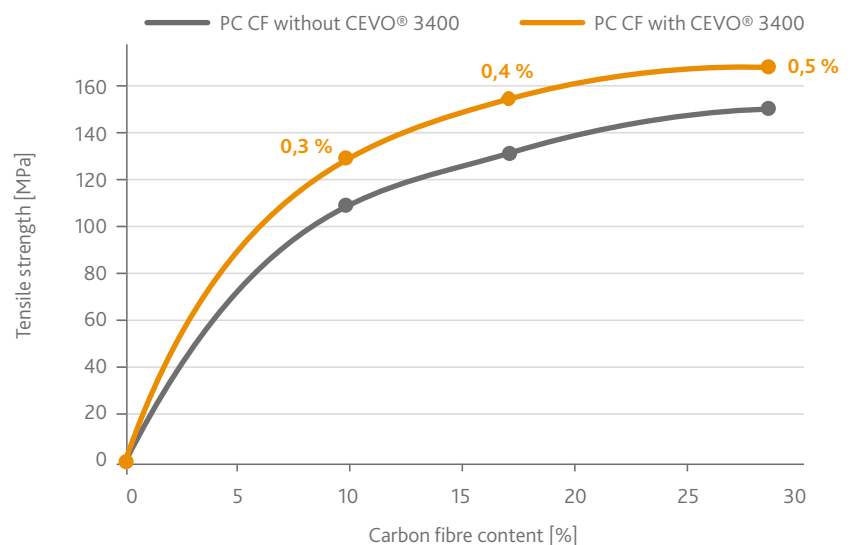


Fig. 2: The tensile strength could be significantly improved by the addition of CEVO® 3400

Carbon fibre [w %]	Tensile strenght [Mpa] without CEVO® 3400	Tensile strength [Mpa] with CEVO® 3400 [%]	Improvement [%]
9.7	107	128 with 0,3	18.6
17.2	129	152 with 0,4	17.0
28.5	150	167 with 0,5	9.0

Table 3: Percentage improvement in the tensile strength compared to the wax-free reference

Various cost-saving effects in polycarbonate at the same time:

By using CEVO® 3400 in PC, improved tensile strength (up to > 18 %) can be achieved while maintaining the same carbon fibre dosage (Fig. 3).

Alternatively, up to 44 % carbon fibres can be saved if only an existing tensile strength level is to be maintained: For example, a tensile strength of 150 Mpa, which is achieved with 28.5 % carbon fibres, can already be achieved with 17.2 % carbon fibres, if 0.4 % CEVO® 3400 is added. The improved distribution of the carbon fibres makes it possible to reduce the carbon fibre content, which leads to lower raw material costs. CEVO® 3400 is available as a coarse powder and as compacted, dust-free granules.

Bio-based structural twins complement the proven CEVO® range

CEVO® 3400-R is the 'bio-based twin' of CEVO® 3400, which is structurally very similar to the existing CEVO® 3400 described above and behaves identically. The CEVO® R series combines the technical advantages typical of montan wax with the requirement for renewable raw materials. CEVO® 3400-R is therefore the material of choice for applications where sustainable raw materials are important.

Conclusion

This study demonstrated that using CEVO® 3400 can significantly improve both tensile modulu and tensile strength. Previous studies have already shown that there is a significant correlation between the dispersing effect of this additive on filler materials and the improvement in mechanical properties. As expected, the distribution of the carbon fibers plays

a subordinate role in the elongation at break test. Therefore a significant change in the length at break was not found. Improved carbon fibre distribution allows a reduction in carbon fibre content, thus leading to lower raw material costs. CEVO® 3400 is available as powder and as compacted, dust-free pellets.



About VOELPKER

Backed by 120 years of expertise in the production of montan waxes and specialty waxes, VOELPKER® is one of the most well-established wax producers in Europe and is appreciated as a manufacturer of high-quality specialty waxes around the world. Due to the unique multi-functionality of our montan wax types,

they can be put to use in virtually every sector of industry. Our wax additives are predominantly used as high-performance additives for process optimisation in the plastics industry. In addition, our wax brands WARADUR® and CEVO® have proven themselves worldwide in a multitude of other applications.



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