COLOR • CONDUCTIVE • FILM/SHEET • FLAME RETARDANT
STRUCTURAL • THERMOPLASTIC ELASTOMERS • WEAR

Tough or Strong? Short or Long? Dialing in Mechanical Performance

Karl Hoppe
Senior Product Development Engineer - Structural

rtpcompany.com • rtp@rtpcompany.com

STRENGTH

STIFFNESS

IMPACT

THE FORMULA

Resin + Additives = Change in Properties

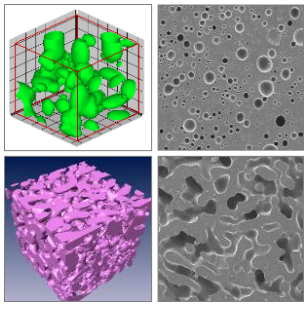
THE FOUNDATION

THE ADDITIVES TOOLBOX

MODIFIERS

Polymer blends

Impact modifiers



POLYMER BLENDS

PC/ABS → **ABS brings**
- Improved flow
- Chemical resistance
- Cost reduction

Nylon/PP → **PP brings**
- Improved flow
- Chemical resistance
- Cost reduction

PC/PBT → **PBT brings**
- Improved flow
- Chemical Resistance

POLYMER BLENDS

ABS/PC → **PC brings**
- Toughness
- Strength

PP/Nylon → **Nylon brings**
- Strength
- Stiffness
- Higher heat performance

PBT/PC → **PC brings**
- Toughness
- Dimensional stability

POLYMER BLENDS

	PC	PC/ABS (RTP 2500 A)	ABS
Specific Gravity	1.19	1.15	1.06
Tensile Strength (MPa)	60	60	45
Notched Izod Impact (J/m)	800	700	270

POLYMER BLENDS

Housing for Hearing Tester

Problem:	Toughness and chemical resistance
Solution:	Polycarbonate/ABS Alloy
Benefits:	Strength and toughness of PC with the added chemical resistance of ABS

MODIFIERS

Impact properties

Impact Modifiers

Strength/stiffness

IMPACT MODIFIERS

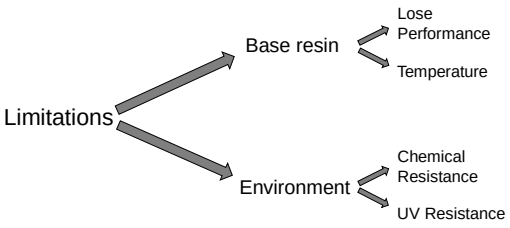
	PA 6/6	Impact Modified PA 6/6
Specific Gravity	1.14	1.08
Notched Izod Impact (J/m)	55	900
Tensile Strength (MPa)	80	52
Flexural Modulus (GPa) (Stiffness)	2.8	2.1

IMPACT MODIFIERS

ATV Wheel Bead Lock Ring

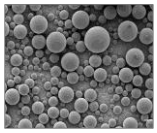
Problem:	Low ductility
Solution:	Impact Modified Nylon 6/6 with fiber reinforcement
Benefits:	• Retain some stiffness of reinforced Nylon • Improved ductility for high strain rate loads

IMPACT MODIFIERS

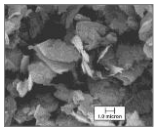


THE ADDITIVES TOOLBOX

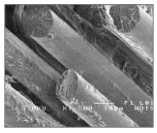
FILLERS



Beads
(Glass)



Minerals
(Talc)



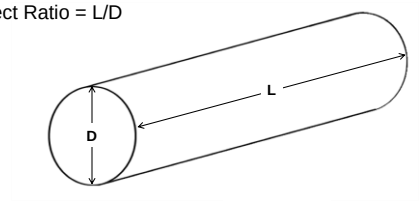
Fibers
(Glass)

Photo: Potters, Inc.

ASPECT RATIO

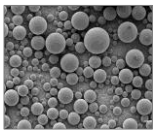
Property change determined by:

Aspect Ratio = L/D



Aspect Ratio Reinforcing

LOW ASPECT RATIO



Beads
(Glass)

Photo: Potters, Inc.

Aspect Ratio = 1

	PC	PC + 10% Glass Beads	PC + 30% Glass Beads
Specific Gravity	1.19	1.27	1.42
Tensile Strength (MPa)	60	55	48
Notched Izod Impact (J/m)	800	100	80
Flexural Modulus (GPa)	2.3	2.6	3.4

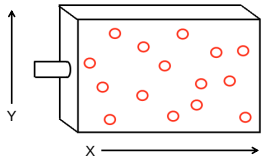
LOW ASPECT RATIO

Minerals
(Talc)

Aspect Ratio = 2 - 50

	PP	PP + 20% Talc	PP + 40% Talc
Specific Gravity	0.91	1.05	1.25
Tensile Strength (MPa)	32	32	30
Notched Izod Impact (J/m)	53	53	43
Flexural Modulus (GPa)	1.4	2.6	3.9

LOW ASPECT RATIO

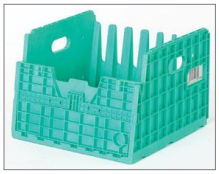


Shrink Rate X = Shrink Rate Y ⟹ Flat Part

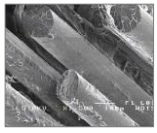
LOW ASPECT RATIO

Reusable Handling Container

Problem:	Warpage prevented smooth operation
Solution:	Mineral filled Polypropylene
Benefits:	• Reduced warpage • Improved functionality



HIGH ASPECT RATIO

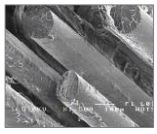


Fibers
(Glass)

Aspect Ratio = 50 - 250

	PC	PC + 30% Glass Beads	PC + 30% Glass Fiber
Specific Gravity	1.19	1.42	1.42
Tensile Strength (MPa)	60	48	124
Notched Izod Impact (J/m)	800	80	160
Flexural Modulus (GPa)	2.4	3.4	7.6

HIGH ASPECT RATIO



Fibers
(Glass)

Aspect Ratio = 50 - 250

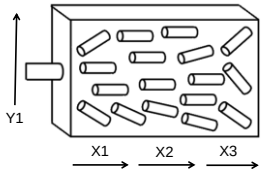
	PP	PP + 40% Talc	PP + 40% Fiber
Specific Gravity	0.91	1.25	1.21
Tensile Strength (MPa)	32	30	82
Notched Izod Impact (J/m)	53	43	120
Flexural Modulus (GPa)	1.4	3.9	6.5

HIGH ASPECT RATIO

Surgery Drill Guide

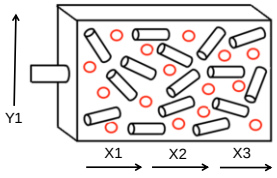
Problem:	Stiffness and dimensional stability
Solution:	Glass fiber reinforced Polycarbonate
Benefits:	• Rigidity • Tight tolerances

HIGH ASPECT RATIO - WARP



Shrinkage X1 & X2 ≠ X3 ⟹ Warp

HIGH ASPECT RATIO - FLAT



Shrinkage X1 = X2 = X3 ⟹ Flat Part

HIGH ASPECT RATIO

Carbon Fibers

Aspect Ratio = 50 - 250

	PEEK	PEEK + 40% Glass Fiber	PEEK + 40% Carbon Fiber
Specific Gravity	1.30	1.61	1.45
Tensile Strength (MPa)	93	186	265
Notched Izod Impact (J/m)	53	133	91
Flexural Modulus (GPa)	3.8	13.8	30.3

FIBER COMPARISON- PP

	PP 40% GF	PP 40% VLF	PP 20% CF
Flexural Modulus (GPa)	6.5	8.5	8.9
Tensile Strength (MPa)	82	124	93
Notched Izod Impact (kJ/m^2)	12.1	22.6	5
Specific Gravity	1.21	1.21	1.00

FIBER COMPARISON – PA 6/6

	PA 6/6 60% VLF (Long Fiber)	PA 6/6 30% Carbon Fiber
Flexural Modulus (GPa)	20.0	19.0
Tensile Strength (MPa)	262	248
Tensile Elongation (%)	2.0	2.5
Specific Gravity	1.71	1.27

FIBER COMPARISON – PPS

	PPS 40% Glass	PPS 15% Carbon
Flexural Modulus (GPa)	15.2	15.9
Tensile Strength (MPa)	169	172
Tensile Elongation (%)	1.5	1.1
Specific Gravity	1.68	1.40

CARBON FIBER APPLICATION

Brake Rotor Measuring Probe

Problem:	Casting replacement
Solution:	Carbon fiber reinforced PPA
Benefits:	• High strength • High stiffness

EXTREME ASPECT RATIO -VLF

Long Glass Fiber

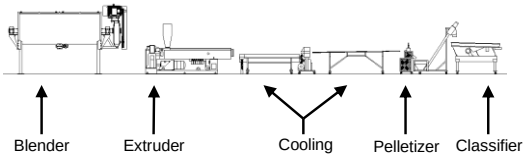
Aspect Ratio = 300+

	PP + 40% Short Glass	PP + 40% Long Glass
Specific Gravity	1.21	1.21
Tensile Strength (MPa)	82	124
Notched Izod Impact (J/m)	120	228
Flexural Modulus (GPa)	6.5	8.5

STANDARD COMPOUNDING PROCESS

Raw Materials

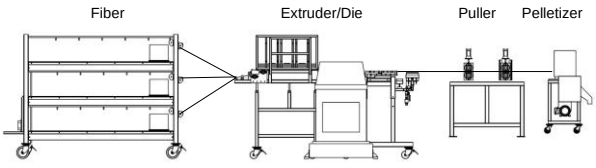
Finished Product



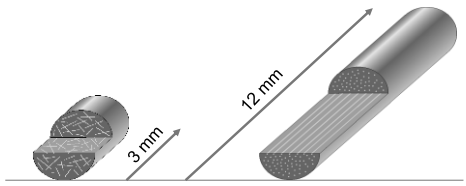
VLF PULTRUSION PROCESS

Raw Materials

Finished Product



EXTREME ASPECT RATIO - VLF



Short Fiber
Fiber length: ~ 1-2 mm

Long Fiber
Fiber length: 12 mm

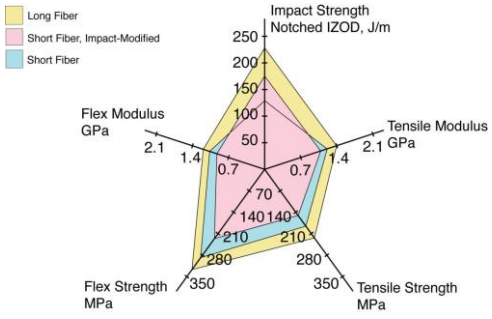
EXTREME ASPECT RATIO - VLF

Secret to success: *the fiber skeleton*

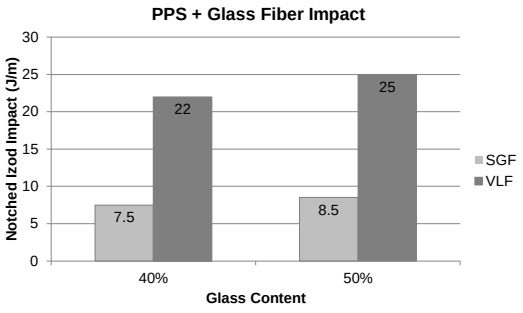
PA 66 + 60% VLF
Seat Belt Tension Housing

IMPACT PERFORMANCE

Nylon 6/6, 40% Glass Fiber



IMPACT PERFORMANCE



METAL REPLACEMENT

Metal vs. VLF shifter comparison

METAL REPLACEMENT

Metal vs. VLF shifter comparison

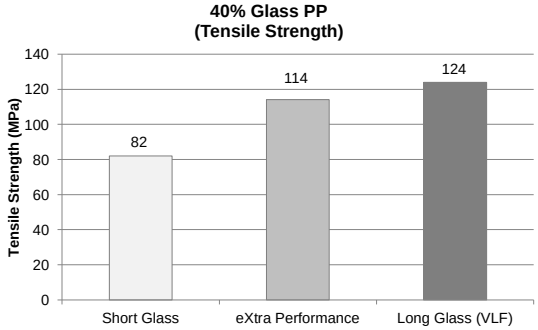
SHORT GLASS REPLACEMENT

	30% Short Glass PA 6/6		40% VLF PP
	(Dry as Molded)	(50% RH)	
Tensile Strength (MPa)	185	125	124
Flexural Modulus (GPa)	8.4	5.9	8.5
Izod Impact (J/m)	120	135	228
Specific Gravity	1.36		1.21
HDT (ºC)	250		155

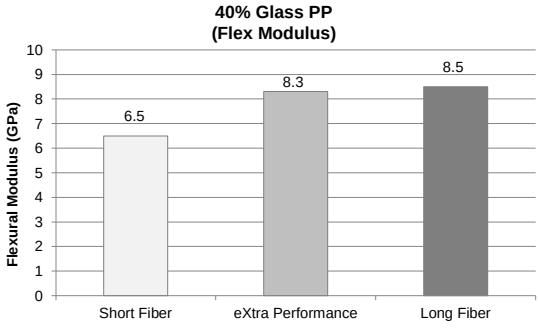
NEW TECHNOLOGIES

- Improvements in Short Glass Fiber PP (XP Series)
- New “Light and Tough” materials for lightweighting (LT Series)

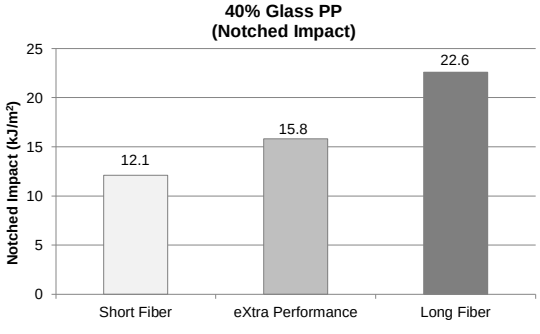
IMPROVEMENTS IN SGF PP



IMPROVEMENTS IN SGF PP



IMPROVEMENTS IN SGF PP

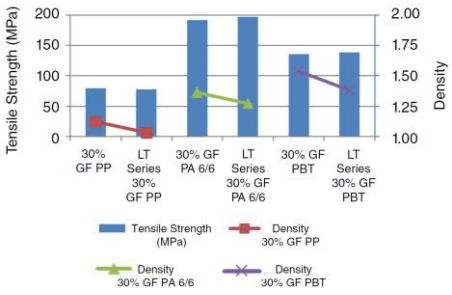


LIGHT AND TOUGH (L&T) COMPOUNDS

- The LT Series is the fastest, easiest, and most cost effective drop-in solution for customers who want to lightweight existing GF compound parts.
  - Benefits:
    - Up to 10% reduction in density while maintaining mechanical properties
    - Weight savings are not wall thickness dependent
    - Drop-in solution for existing tools
  - Side Benefits:
    - Improved surface finish vs. foaming
    - Reduced warp

DENSITY VS. STRENGTH COMPARISON

TENSILE STRENGTH WITH DENSITY OVERLAY



LIGHT AND TOUGH VLF PP

TECHNOLOGY	30% SGF	30% VLF	L&T VLF
DENSITY, g/cm3 (ISO 1183)	1.12	1.13	1.02
TENSILE STRENGTH, MPa (23 deg C, ISO 527)	75	110	101
FLEXURAL MODULUS, GPa (23 deg C, ISO 178)	5,000	6,500	6,800
IZOD NOTCHED, KJ/m^2 (ISO 180/1A)	11	21	21

SUMMARY

Modifiers
- Polymer Blends - overcome morphology deficiencies
- Impact Modifiers - increase impact but reduction in strength/stiffness

Fillers
- Performance driven by aspect ratio

VLF
- Excellent metal replacement high end polymer replacement technology

Overall: Combinations of technologies result in balancing of properties and requirements