

ENGINEERED PLASTICS WORKSHOP

Learn About Thermoplastics | Connect with Experts

2017

**WESTBOROUGH / MASSACHUSETTS
(BOSTON AREA)**

**YOUR GLOBAL COMPOUNDER OF
CUSTOM ENGINEERED THERMOPLASTICS**





Introduction to Engineered Thermoplastics



Steve Maki | VP of Technology
smaki@rtpcompany.com
(507) 474-5371

8:15 a.m.

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

Introduction to Engineered Thermoplastics

Steve Maki
Vice President of Technology

rtpcompany.com • rtp@rtpcompany.com

Copyright 2017 RTP Company

AP POLYMER, INC. ESP Hueforia Wiman

RTP AGENDA

1. Define Compounding
2. Plastic Resin Selection Process
3. Application Case Studies
4. Compounding To Enhance Performance
5. New RTP Company Technologies

RTP INDEPENDENT SPECIALTY COMPOUNDER

Compounder → We blend thermoplastic resins with fillers, additives, and modifiers

Specialty → We create engineered formulations

Independent → We are unbiased in our selection of raw materials

RTP COMPOUNDING PROCESS

Raw Materials → Finished Product

Blender Extruder Cooling Pelletizer Classifier

COMPOUNDING OBJECTIVES

Mixing

- Dispersive
- Distributive

COMPOUNDING EXTRUDERS

Single Screw Twin Screw Co-Kneader

PUTTING COMPOUNDING INTO PERSPECTIVE

- Conductive carbon black surface area = 130 m²/gram
- 34 grams carbon black = surface area of football field (4460m²)
- Dispersing a 20% carbon black compound is similar to evenly coating a football field with 136 grams of plastic!

Resin Selection

RTP THE DILEMMA

60 thermoplastic resins + 100 additives
= 1000's of potential compounds

Which **ONE** Do I Choose For My Application???

RTP PLASTIC SELECTION PROCESS

Step 1: Use Resin Morphology

Step 2: Use Thermal & Cost Requirements

Step 3: Fine Tune & Special Features

RTP PLASTIC SELECTION PROCESS

Step 1: Use Resin Morphology

Step 2: Use Thermal & Cost Requirements

Step 3: Fine Tune & Special Features

RTP MORPHOLOGY

The form and structure the molecules of a polymer take upon solidification

Amorphous Semi-Crystalline

RTP MORPHOLOGY

Amorphous

Semi-Crystalline

Compare

- Molecular packing (shrinkage)
- Resistance to molecular disentanglement (chemical/abrasion resistance)
- Melting characteristics (flow)
- Light refraction (opacity)

RTP MORPHOLOGY CHARACTERISTICS

	Amorphous	Semi-Crystalline
Low Shrinkage	X	
Low Warpage	X	
Tight Tolerances	X	
Transparency	X	
Mold Flow Ease		X
Chemical Resistance		X
Wear Resistance		X

RTP MORPHOLOGY CHARACTERISTICS

Lens?
Fuel Float?
Precision Printer Chassis?
Tool Housing?
Multiple Pin Connector?
Pulley?
Grease Fitting?
Laptop Cover?

	Amorphous	Semi-Crystalline
Low Shrinkage	X	
Low Warpage	X	
Tight Tolerances	X	
Transparency	X	
Mold Flow Ease		X
Chemical Resistance		X
Wear Resistance		X

RTP MORPHOLOGY OF THERMOPLASTICS

Amorphous

- Polyetherimide (PEI)
- Polyethersulfone (PES)
- Polysulfone (PSU)
- Amorphous Nylon
- Polycarbonate (PC)
- Acrylic (PMMA)
- Acrylonitrile Butadiene Styrene (ABS)
- Styrene Acrylonitrile (SAN)
- High Impact Polystyrene (HIPS)
- Polystyrene (PS)

Semi-Crystalline

- Polyetheretherketone (PEEK)
- Polyphenylene Sulfide (PPS)
- Polyphthalamide (PPA)
- Polyamide (PA/Nylons)
- Polybutylene Terephthalate (PBT)
- Polyethylene Terephthalate (PET)
- Acetal (POM)
- Polylactic Acid (PLA)
- Polypropylene (PP)
- Polyethylene (HDPE, LDPE, LLDPE)




RTP PLASTIC SELECTION PROCESS

Step 1: Use Resin Morphology

Step 2: Use Thermal & Cost Requirements

Step 3: Fine Tune & Special Features

RTP MORPHOLOGY VS. THERMAL/COST

	
Amorphous	Semi-Crystalline
<ul style="list-style-type: none"> Polyetherimide (PEI) Polyethersulfone (PES) Polysulfone (PSU) Amorphous Nylon Polycarbonate (PC) Acrylic (PMMA) Acrylonitrile Butadiene Styrene (ABS) Styrene Acrylonitrile (SAN) High Impact Polystyrene (HIPS) Polystyrene (PS) 	<div style="display: flex; align-items: center; justify-content: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg); font-size: small; margin-right: 5px;">Thermal & Cost Increases</div>  </div> <ul style="list-style-type: none"> Polyetheretherketone (PEEK) Polyphenylene Sulfide (PPS) Polyphthalamide (PPA) Polyamide (PA/Nylons) Polybutylene Terephthalate (PBT) Polyethylene Terephthalate (PET) Acetal (POM) Polylactic Acid (PLA) Polypropylene (PP) Polyethylene (HDPE, LDPE, LLDPE)
Commodity (<\$1.50) • Engineered (\$1.50-\$4.00) • High Performance (>\$4.00)	



RTP PLASTIC SELECTION PROCESS

Step 1: Use Resin Morphology


Step 2: Use Thermal & Cost Requirements

Step 3: Fine Tune & Special Features

RTP ENGINEERED & COMMODITY RESINS

	
Amorphous	Semi-Crystalline
<ul style="list-style-type: none"> Amorphous Nylon Polycarbonate (PC) Acrylic (PMMA) Acrylonitrile Butadiene Styrene (ABS) Styrene Acrylonitrile (SAN) High Impact Polystyrene (HIPS) Polystyrene (PS) 	<ul style="list-style-type: none"> Polyamide (PA/Nylons) Polybutylene Terephthalate (PBT) Polyethylene Terephthalate (PET) Acetal (POM) Polylactic Acid (PLA) Polypropylene (PP) Polyethylene (HDPE, LDPE, LLDPE)
Commodity (<\$1.50) • Engineering (\$1.50-\$4.00)	


RTP AMORPHOUS RESINS

 **Morphology Features** -- Low Shrink, Low Warp, Tight Dimensional Tolerances, Transparent (except HIPS & ABS), Poor Chemical & Abrasion, Poor Flow in Thin Mold Sections

Amorphous	Special Features
Amorphous Nylon	Transparent/good chem. resistance
Polycarbonate (PC)	Optical transparency/high impact
Acrylic (PMMA)	Optical transparency/UV stable
Acrylonitrile Butadiene Styrene (ABS)	High impact/high gloss/opaque
Styrene Acrylonitrile (SAN)	Transparent/mod. chem. resistance
High Impact Polystyrene (HIPS)	Moderate impact/opaque
Polystyrene (PS)	Transparent/brittle

Commodity (<\$1.50) • Engineering (\$1.50-\$4.00)

RTP SEMI-CRYSTALLINE RESIN

 **Morphology Features** -- Excellent Chemical Resistance, Excellent Abrasion Resistance, Good Flow in Thin Mold Sections, Poor Dimensions, Opaque

Semi-Crystalline	Special Features
Nylon 6/12	Less Sensitive to humidity vs. 6&6/6
Nylon 6/6	Better thermal vs. 6/humidity Dep
Nylon 6	Hides GF/strong but humidity Dep
Polybutylene Terephthalate (PBT)	Good electricals/easier to mold
Polyethylene Terephthalate (PET)	Good electricals/difficult to mold
Acetal (POM)	Low wear & friction/high fatigue
Polylactic Acid (PLA)	Green/Low impact & thermal
Polypropylene (PP)	Poor low temp impact/mod thermal
Polyethylene (HDPE, LDPE, LLDPE)	Good low temp impact

Commodity (<\$1.50) • Engineering (\$1.50-\$4.00)

RTP PUTTING IT ALL TOGETHER

Step 1: Use Resin Morphology

Step 2: Use Thermal & Cost Requirements


Step 3: Fine Tune & Special Features

Test Your Knowledge With Application Examples

RTP CASE STUDY

CD Jewel Case

- Transparent
- Flat & Dimensionally Stable
- Low Cost



RTP CASE STUDY

Gas Tank


- Good chemical resistance
- Good low temperature impact
- Low cost



RTP CASE STUDY

Auto Tail Lamp Cover

- Transparent Colors
- Dimensionally Stable
- Excellent UV
- Low Cost



RTP CASE STUDY

Plastic Glass Tumblers

- Transparent
- Reasonable Thermal & Chemical Resistance (Dishwasher Cycles)
- Low Cost



RTP CASE STUDY

Sump Pump Housing

- Chemical resistance
- Reasonable thermal resistance
- Low cost



RTP CASE STUDY

Safety Glasses

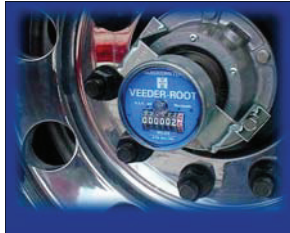
- Optical transparency
- High impact
- Moderate cost OK



RTP CASE STUDY

Hub Odometer Lens

- Transparent
- Good Chemical Resistance
- Moderate-High Cost OK



RTP CASE STUDY

Chemical Beakers

- Excellent chemical resistance
- Low Cost
- Transparent



RTP CASE STUDY

Nail Gun Housing

- Good chemical resistance
- Excellent strength, stiffness & impact
- Good surface finish when reinforced
- Moderate cost OK



RTP CASE STUDY

Automotive Intake Manifold


- Chemical resistance
- Excellent strength, stiffness & impact
- Moderate heat resistance
- Moderate cost OK



RTP CASE STUDY

Oil Pan

- Chemical resistance
- Excellent strength, stiffness & impact
- Moderate heat resistance
- Moderate cost OK
- Extremely tight dimensions & flat



RTP CASE STUDY

Electrical Connectors

- Good flow in thin walls
- Excellent electrical properties
- Dimensionally stable in humidity
- Moderate cost OK



RTP CASE STUDY

Conveyor Rollers

- Good abrasion resistance
- Low wear & friction
- Moderate cost OK



RTP CASE STUDY




Printer Gears

- Extremely tight dimensions
- Moderate cost OK
- Good abrasion resistance
- Low wear & friction

RTP CASE STUDY

Lawn Tractor Hood

- Tight dimensions & low warp
- Moderate cost OK
- Chemical resistance
- Good mold flow

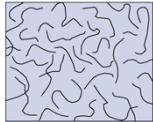
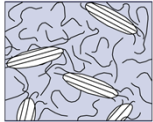


RTP

Overcoming Resin Deficiencies Via Compounding

RTP MORPHOLOGY DEFICIENCIES

	Amorphous	Semi-Crystalline
Low Shrinkage	X	D
Low Warpage	X	D
Tight Tolerances	X	D
Transparency	X	D
Mold Flow Ease	D	X
Chemical Resistance	D	X
Wear Resistance	D	X

RTP DIMENSIONAL STABILITY

Can We Reduce Shrink Rate & Improve Dimensional Stability of Semi-Crystalline Resins?

Autodesk

RTP FIBER REDUCES SHRINK

Shrink Rate X \neq Shrink Rate Y \rightarrow Warp

RTP WARP CONTROL

Shrink Rate X = Shrink Rate Y \rightarrow Flat Part
But Low Strength!


RTP STRENGTH & WARP CONTROL

Common Loading = 15% Glass Fiber & 25% Mineral or Beads

RTP CASE STUDY

Oil Pan

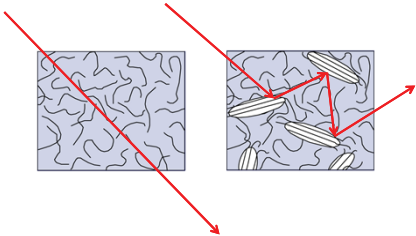
- Chemical resistance
- Excellent strength, stiffness & impact
- Moderate heat resistance
- Moderate cost OK
- Extremely tight dimensions & flat



Nylon 66 + 15% GF + 25% Mineral



RTP TRANSPARENCY

Can We Make A Semi-Crystalline Resin Transparent?



RTP NUCLEATION/CLARIFICATION


Compounding nucleator into PP or PE controls crystal size to less than wavelength of light = Transparency

Melt Phase	Nucleation Phase	Semi-Crystalline Phase
Normal PP		Opaque PP
PP + Nucleator		Clarified PP

RTP CASE STUDY

Chemical Beakers

- Excellent chemical resistance
- Low Cost
- Transparent



RTP CHEMICAL RESISTANCE/MOLD FLOW

Can We Improve Chemical Resistance & Mold Flow of Amorphous Resins?



RTP ALLOYING

Alloy PC with ABS RTP 2500 A Series

	PC	PC/ABS
Tensile Strength, psi	9000	8900
Flexural Mod, E6 psi	0.34	0.40
Izod Impact, ft lb/in	15	13
HDT @ 264 psi, °F	270	210
Fuel Resistance	Poor	Poor
Melt Flow, gm/10 min	10	15
Clarity	Transparent	Opaque

RTP ALLOYING

Alloy PC With Polyester (PBT or PET) RTP 2099 X 63578 B

	PC	PC/PBT
Tensile Strength, psi	9000	8700
Flexural Mod, E6 psi	0.34	0.35
Izod Impact, ft lb/in	15	15
HDT @ 264 psi, °F	270	250
Fuel Resistance	Poor	Fair
Melt Flow, gm/10 min	10	20
Clarity	Transparent	Opaque

RTP CASE STUDY

Lawn Tractor Hood

- Tight dimensions & low warp
- Moderate cost OK
- Chemical resistance
- Good mold flow



RTP WEAR RESISTANCE

Can We Make An Amorphous Resin Wear Resistant?



RTP PTFE LUBRICATED

Compound PTFE Into PC
RTP 300 TFE 15

	PC	PC/15 PTFE	Acetal
Wear Factor	560	130	90
Dynamic Coef. of Friction	0.60	0.33	0.40

RTP CASE STUDY



Printer Gears

- Extremely tight dimensions
- Moderate cost OK
- Good abrasion resistance
- Low wear & friction

RTP WHAT'S NEW?

New Technologies

RTP NEW TECH (HEALTHCARE)

RTP 2000 HC Series

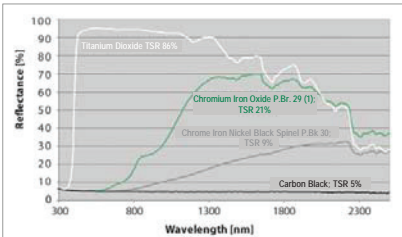


- Increased chemical resistance to healthcare cleaners vs PC, ABS, PC/ABS
- Good dimensional stability with shrinkage similar to above resins
- Flame retardant grade for electronic housings
 - RTP 2000 HC FR A

RTP NEW TECHNOLOGIES (COLOR)

IR Reflecting Colors

Allows Dark Colored Plastics To Remain Cool When Exposed To Sunlight



- Patio Furniture
- Decking/Pavers
- Roofs/Siding
- Auto Interiors

RTP NEW TECHNOLOGIES (FR)

FR Compounds for Plenum Applications (UL 2043)

Low Heat/Smoke Release Grades

- FR PP Grades (Glass Fiber, Mineral, Unfilled)
- FR Nylon (Glass Fiber)

Opportunities

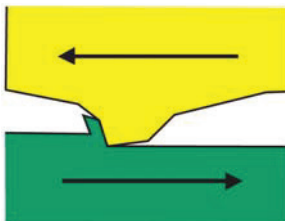
- Wireless Access Points
- Speaker Housings
- Vent Diffusers
- Cable Racks
- Light Housings



RTP NEW TECHNOLOGIES (WEAR)

Abrasion Resistant Compounds

To Compete With UHMWPE (Not Moldable)




- Injection Moldable Polyolefin Alloy
- Similar Abrasion Resistance To UHMWPE
 - Gears
 - Cams
 - Slides
 - Wear Liners

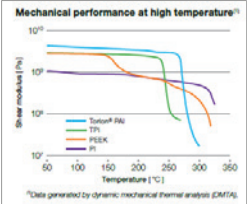
RTP NEW TECH (HIGH TEMPERATURE)

Specialty Torlon Compounds

RTP Company has a license agreement with Solvay Specialty Polymers to manufacture specialty compounds based on Torlon polyamide-imide



- Custom Fiber Reinforced
- Custom Wear Formulas
 - Automotive
 - Aerospace
 - Industrial



*Data generated by dynamic mechanical thermal analysis (DMTA)

RTP REVIEW

- Intro To Compounding**
- The Dilemma**
- Resin Selection Procedure**
 - Resin Morphology
 - Resin Cost & Thermal Performance
 - Unique Resin Features
- Application Case Studies**
- Compounding in Performance**
 - Overcoming Resin Deficiencies
- Introduction To New Technologies**

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

Thank You!

Steve Maki
smaki@rtpcompany.com
(507) 474-5371

rtpcompany.com • rtp@rtpcompany.com



Copyright 2017 RTP Company