



Healthcare Team



**Plastic Technologies**  
For Safe & Effective Medical Devices



**THERMOPLASTIC ELASTOMERS • STRUCTURAL • WEAR**  
**CONDUCTIVE • COLOR • FLAME RETARDANT**



**New Medical Plastic Technologies**

*Dr. Joel Bell*  
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## **Independent Specialty Compounder**

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **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



## **Agenda**

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Define Compounding**
- **Plastic Resin Selection Process**
- **Compounds for Healthcare**



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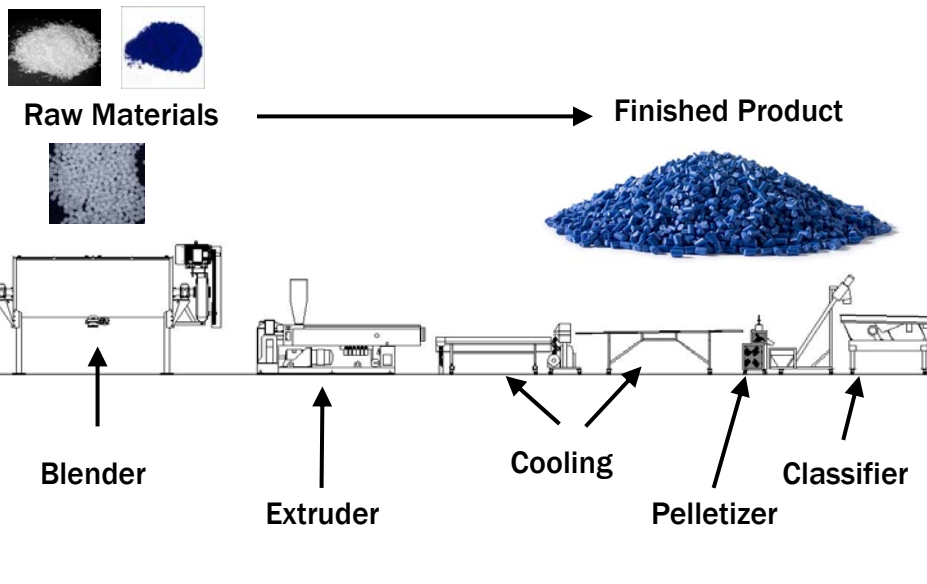



# Defining Compounding



## Compounding Process

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS



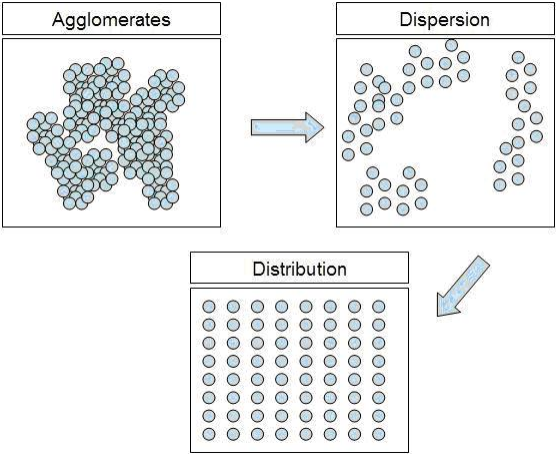



## Compounding Objectives

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Mixing**
  - Dispersive
  - Distributive







## Compounding Extruders

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

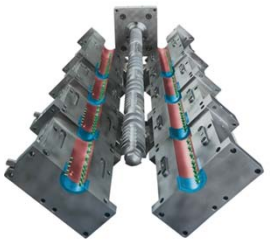
  



**Single Screw**



**Twin Screw**

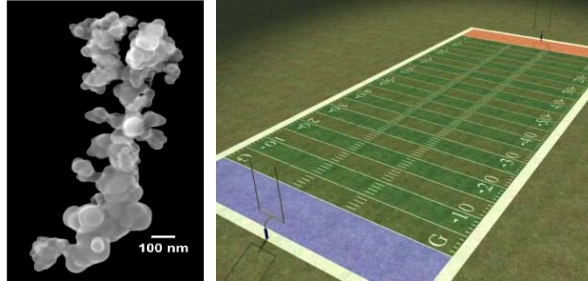


**Co-Kneader**



## Putting Compounding Into Perspective

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS




- Conductive carbon black surface area = 130 m<sup>2</sup>/gram
- 34 grams carbon black = surface area of football field (4460m<sup>2</sup>)
- Dispersing a 20% carbon black compound is similar to evenly coating a football field with 136 grams of plastic!





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## Resin Selection


 **The Dilemma**  
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- 60 Thermoplastic Resins + 100 Additives = 1000's of Potential Compounds

? ? ? ?

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

 **Plastic Selection Process**  
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- Step 1: Use Resin Morphology
- Step 2: Use Thermal & Cost Requirements
- Step 3: Fine Tune & Special Features



## Plastic Selection Process

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### — Step 1: Use Resin Morphology —

Step 2: Use Thermal & Cost Requirements

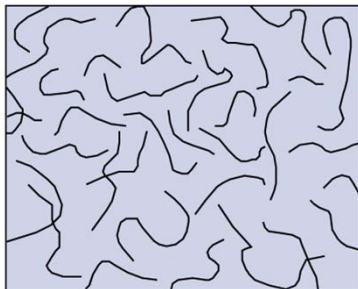
Step 3: Fine Tune & Special Features



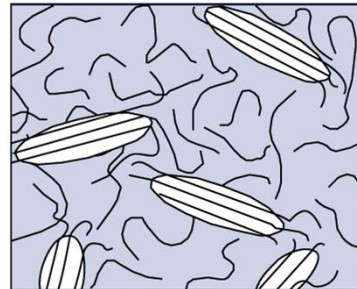
## Morphology

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS


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



Amorphous

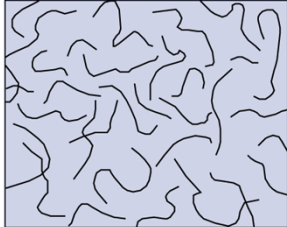


Semi-Crystalline

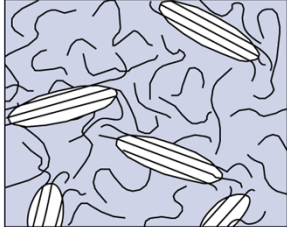


## Morphology

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS




Amorphous



Semi-Crystalline

**Compare**

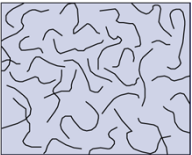
- Molecular Packing (Shrinkage)
- Resistance to Molecular Disentanglement (Chemical/Abrasion Resistance)
- Light Refraction (Opacity)
- Melting Characteristics (Flow)

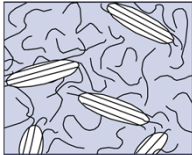


## Morphology Characteristics

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

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









## Morphology Of Thermoplastics

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### Amorphous

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

### Semi-Crystalline

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



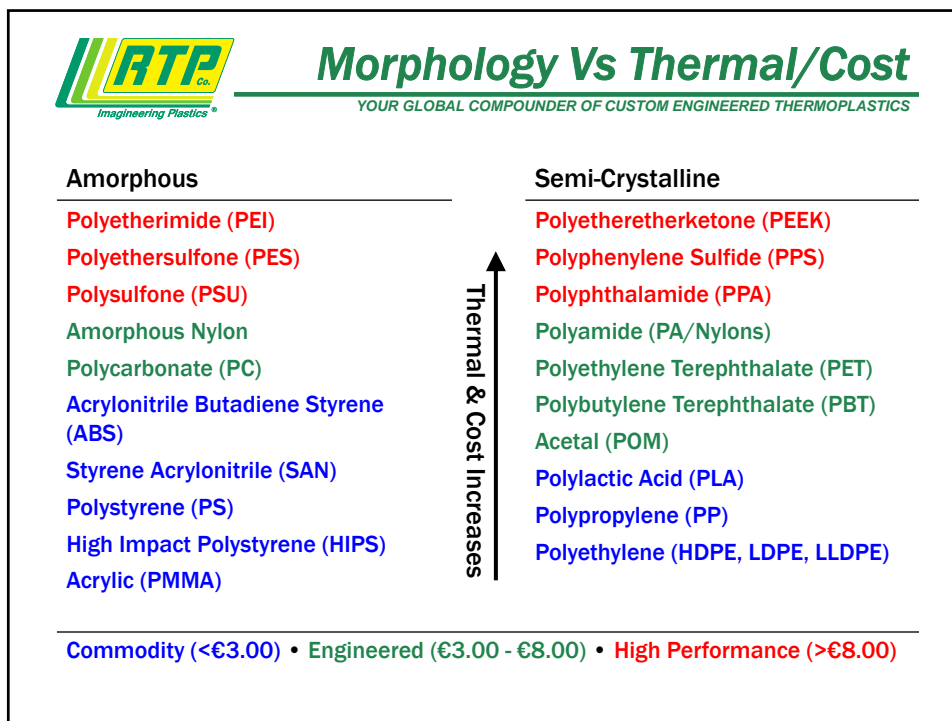
## Plastic Selection Process

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

**Step 1: Use Resin Morphology**

**— Step 2: Use Thermal & Cost Requirements —**

**Step 3: Fine Tune & Special Features**





## Plastic Selection Process

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### Compare:

- **PC**
  - Impact
- **Nylon**
  - Strength, fuel resistance
- **Acetal**
  - Wear and friction

### Vs.:

- **PMMA**
  - Cost, UV
- **PP**
  - Cost, stable properties
- **Nylon**
  - Wear and friction + mechanical properties



## PEI Replacement

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### • Topic of the day: PEI Replacement

- Tight supply
- Long lead times
- One supplier



- **Several alternatives, none are one-to-one replacements**



## PEI Replacement

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- Which resin depends on:

- Temperature performance
- Mechanical properties
- Chemical resistance

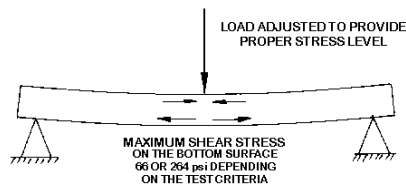


## PEI Replacement


YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### Temperature Properties


HDT @ 1.8 MPa	Unfilled	30 glass
Amorphous		
PEI	200 C	207 C
PPSU	207	213
PES	203	215
PSU	175	185
Semicrystalline		
PPS	N/A	265
PPA	137	260
PEEK	156	315




HDT can be improved through compounding fillers.  
Also need to understand peak and continuous temperatures to select the right product.



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## **Compounds for Healthcare**



**Application Requirements**  
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- **Environmental requirements**
  - *What conditions must the material survive?*
  - *What must survive around the material?*
- **Property requirements**
  - *What other properties does the material bring to the table?*


“Typical” vs. “Medical”



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## **Environmental Requirements**



## **Environmental Exposure**

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- **Typical requirements, resistance to:**
  - Chemicals
  - Temperature
  - Humidity
- **Medical requirements**
  - Sterilization
  - Tissue/Fluid contact
  - Drug flow path




## Sterilization

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Radiation**
  - Gamma
  - E-beam
- **Damages polymers via chain scission or crosslinking**
- **Cumulative damage**





## Sterilization

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Radiation resistant**
  - ABS
  - Sulfones (PSUL, PES, PPSU)
  - PC
    - Typically yellows with radiation exposure
    - Maintains mechanical properties
  - Polypropylene
    - Requires stabilization to survive multiple exposures
- **Not resistant**
  - Polyethylene
  - POM



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## Sterilization

- **Ethylene Oxide (EtO)**
  - Toxic gas
  - Polymers require chemical resistance
  - Most polymers OK for use with EtO
  - Some ABS grades exhibit stress cracking



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## Sterilization

- **Steam (Autoclave)**
- **Commonly used in healthcare facilities**
- **Temps from 120°C to 135°C with humidity exposure**
- **Exposure time from 3 to 15 minutes**
- **Stress relaxation (annealing) can occur**







YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

## Sterilization

### Resistance to autoclave

- **Best**
  - PEEK
  - PPSU
- **Good**
  - PP
  - PA
  - PSUL
  - PC

### Not recommended for autoclave

- Styrenics
  - ABS
  - Polystyrene
- Polyesters
  - PBT
  - PET
- Materials with poor resistance to heat/humidity



## Internal Fluid/Tissue Contact

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Suitability often determined by biocompatibility testing**
  - ISO 10993
  - USP Class VI
- **Testing best performed on part, not just material**
- **Specialty medical compounder material selection:**
  - Biocompatible resins
  - FDA compliant additives



## Formulating for Body Contact

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Resins**
  - ISO 10993
  - USP Class VI
- **Fillers/additives**
  - FDA Compliant
  - Have history of passing previous bio tests
- **“No Subs” formulation**



## Drug Flow Path

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Biocompatibility**
- **Chemical resistance of polymer**
  - Resist degradation from drug exposure
- **Drug potency**
  - Extractables
  - Material-drug interaction





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## Property Requirements

**Compounding in Performance**

**Focus:**

**Metal Replacement**

**Conductive/Antistatic**

**Laser Direct Structuring**

**TPEs**



## Metal Replacement

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- Generally focused on fiber reinforced compounds



- **Questions to ask:**

- Might the metal part be overspecified?
- Are there secondary operations that can be eliminated with a switch to plastic?
- Could performance be enhanced with a switch to plastic?



## Surgical Head Restraint

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

**Application:**

Surgical Head Restraint System

**Problem:**

MR/CT scans unrecognizable due to magnetic material.

**Current Material:**

Titanium

**Solution:**

PEEK reinforced with carbon fiber.

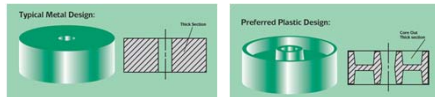


## Metal Replacement

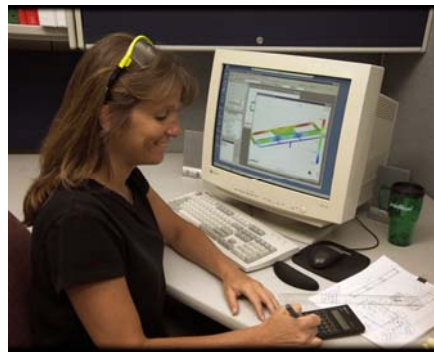
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

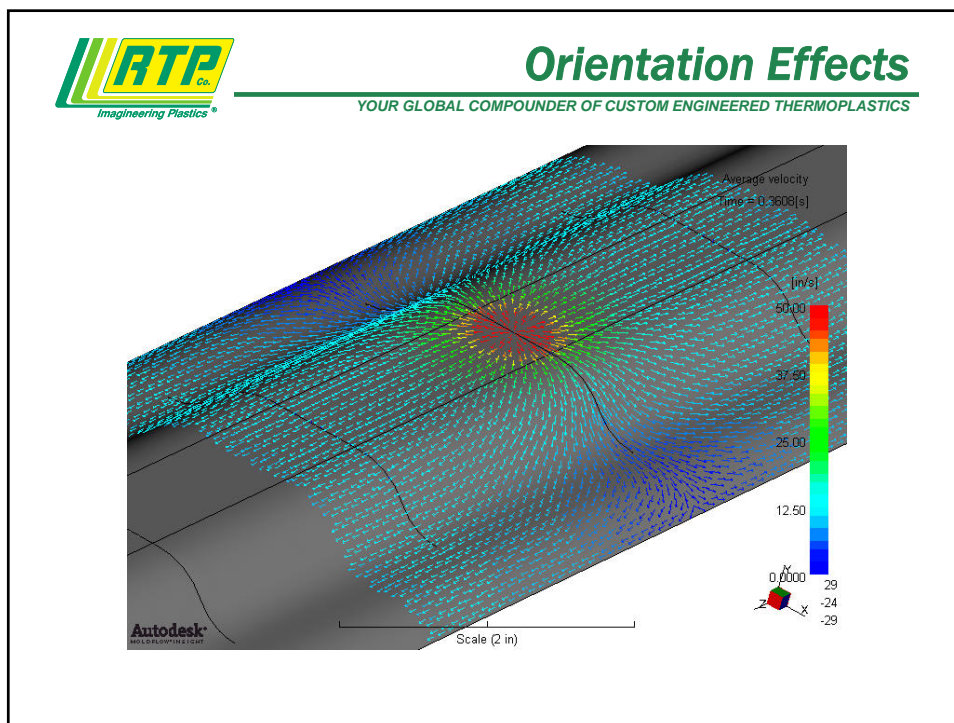
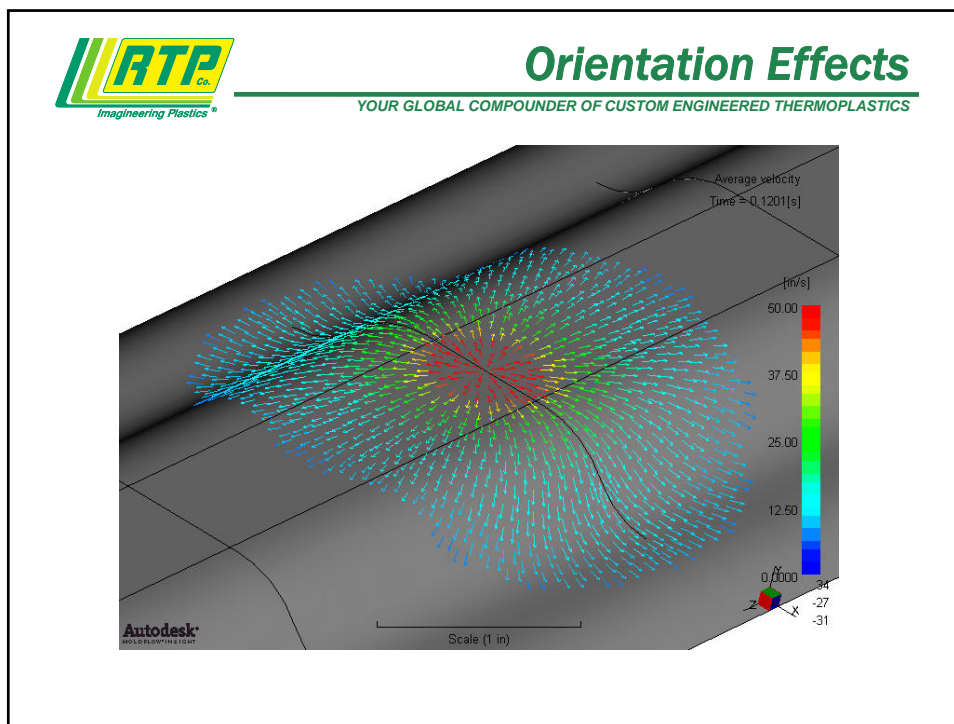
• **Items to note:**

- Consult with plastics experts on proper plastic design principles.



- Consider mold design and gating as carefully as part design and material selection.







## Surgery Drill Guide

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

**Application:**

Surgery Drill Guide

**Problem:**

Needed a disposable product at a disposable price.

**Current Material:**

Metal

**Solution:**

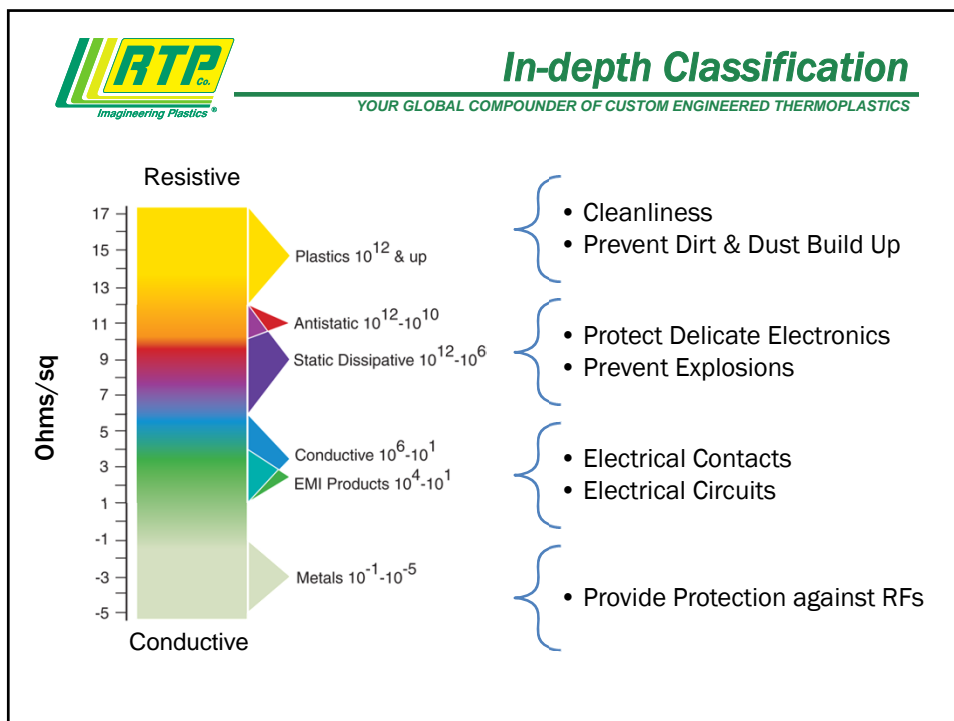
Glass fiber reinforced PC



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## Conductivity in Thermoplastics



**Antistatic - Drug Delivery**  
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

**Application:**

Dry Powder Inhalers

**Problem:**


Drugs stick to surfaces causing dosage inconsistencies

**Current Material:**

Polycarbonate/ABS

**Solution:**

PermaStat ABS



**Imagining Plastics®**

## PermaStat® Overview

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

**All-polymeric**

**Based on Inherently dissipative polymers**

- Typically consist of polyethylene oxide block copolymers
- Other block dictates compatibility
- Forms a co-continuous morphology with the base resin
- 1E8 - 1E12 ohm/sq capable

**Fully Colorable**

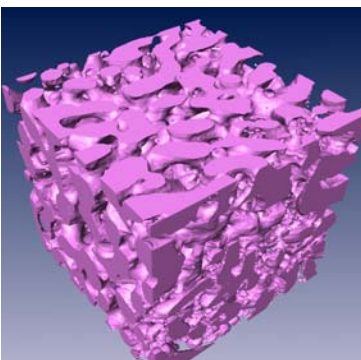
- Only conductive technology with this capability


**Transparent Grades**

- ABS, PMMA, PP
- Amorphous Nylon

**MD Grades**

- Pretested for ISO 10993
- ABS, PMMA, PP





**Imagining Plastics®**

## Conductive – Current Carrying

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

**Application:**

Pipette Tips

**Problem:**


Need to measure fluid level and have high hydrophobicity

**Current Material:**


Polypropylene

**Solution:**

Conductive carbon black polypropylene







## Carbon Black Overview

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

**Defined by:**

- Structure
- Size of Particles
- Porosity
- Surface Chemistry

**Many Types**

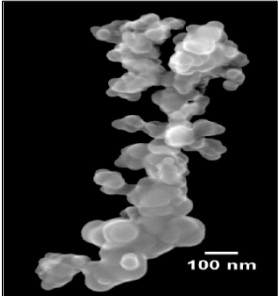

- Greater than 10 available


**Black Color Only**

**Economical**

**Dissipative or Conductive**

- Surface: 1E3 - 1E9 ohm/sq
- Volume: 1E0 - 1E6 ohm-cm

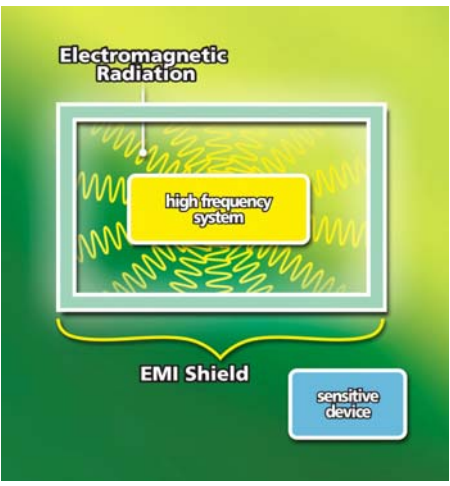



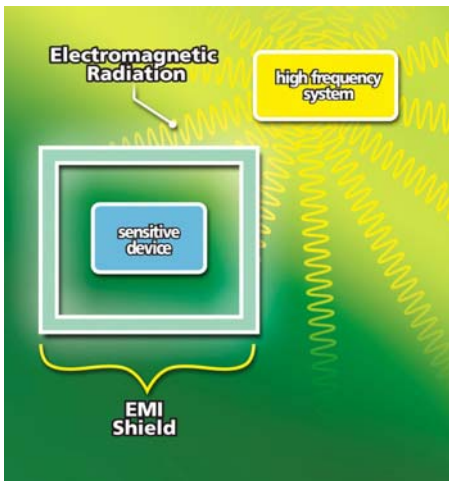


## Shielding -EMI in Action

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EMI shields protect sensitive devices







## EMI Shielding Methods

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### Metals

- Metallic paint/metal coatings
- Metal foil/screen
- Actual metal housing

### Polymer Compound

- Increase design freedom
  - Part consolidation
- Eliminate time-consuming secondary operations
  - Reduce part cost
  - Shorter time to market



## Additive Comparison

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS



### Stainless Steel Fiber

- Non-Reinforcing
- Equivalent shrinkage to neat resin
- Moderate shielding performance
- Colorable

### Nickel-Coated Carbon Fiber

- Reinforcing
- High shielding performance
- Higher cost
- Less colorable





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## **Laser Direct Structuring**

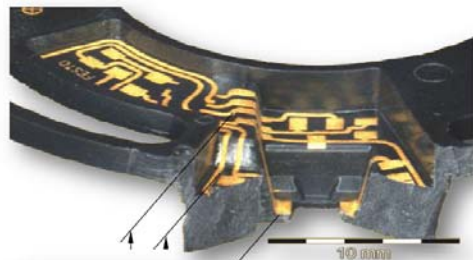


### **Selective Plating Laser Direct Structuring**

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

#### **Advantages**

- Specialized formulations
- Limited number of platers
- Standard single shot tooling
- Great design flexibility





## Selective Plating Laser Direct Structuring

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### Additive Process

Selective metallization of thermoplastic injection molded parts by Laser Direct Structuring

#### 3 Step Process

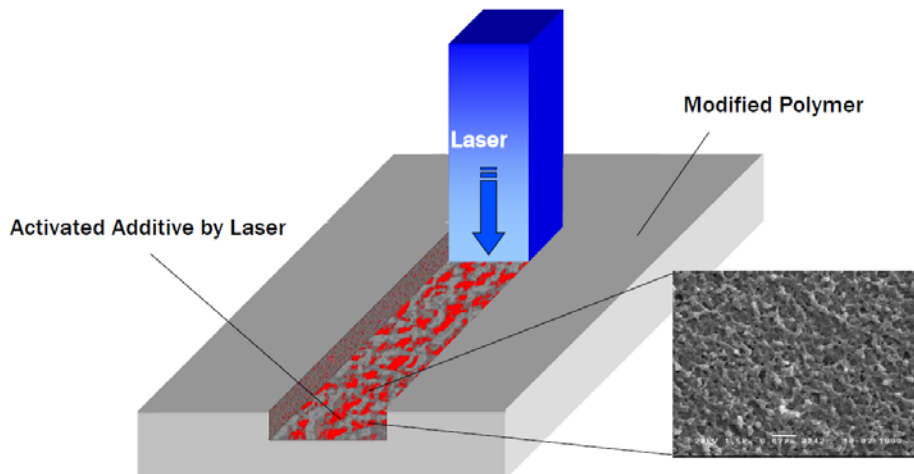
1. Injection Molding
2. Laser Activation
3. Selective Metallization



## Overview of LDS Technology

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### Generation of a micro-etched surface





## Applications

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Connectors**
- **Sensors**
- **Antennas for handheld devices**
  - Phones
  - Cameras
  - GPS
- **Security Covers**
- **Various components for part consolidation**




## Materials Available


YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **PC**
- **ABS**
- **PC/ABS**
- **Nylon 6/6 with glass and mineral**
- **LCP with glass and mineral**
- **PPA with glass and mineral**
- **PEI with glass and mineral**
- **PEEK with glass and mineral**





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# Thermoplastic Elastomers



**Styrenic Based TPEs**  
 YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

**2700 S & 2740 S Standard Products**

- **RTP 2700 S Series** - 30A to 80A unfilled
  - Translucent to clear, low gravity, excellent elasticity
  - **Medical and FDA compliant grades available (MD and Z)**
- **RTP 2740S Series** - 30A to 80A filled SEBS
  - Opaque, higher gravity, FDA compliant grades available

**Attributes**

- *Highly Elastic*
- *Highly Customizable*
- *Design Flexibility*
- *Broad Cost Spectrum*
- *Great RT Compression Set*

**2799 S X Design Flexibility**

- Water clear
- Increased Elasticity
- Low Hardness + Strength
- EU food contact compliant
- Processing Tweaks
- Haptics (Touchy-Feely)






**RTP Co.**  
Imagineering Plastics®

**Bondable TPE Technology**  
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

		Rigid Substrate Material										
		RTP 600 ABS	RTP 200 A PA 6	RTP 1000 PBT	RTP 300 PC	RTP 2500 PC/ABS	RTP 2000 PBT/PC	RTP 2000 PET/PC	RTP 1800 A PC/PMMA	RTP 100 PP	RTP 400 PS	RTP 2300 RTPU
Overmolding Material	RTP 2700 S											
	RTP 2740 S											
	RTP 2800 B											
	RTP 2800 D											
	RTP 6003											
	RTP 6004											
	RTP 6035											
	RTP 6042			**								

■ Indicates combinations exhibiting very good peel strength (15 pli or greater)  
 \*\* Not tested

- Typical hardness range is from 45 - 75 Shore A but can be customized for each application.
- Substrate and elastomer overmold can be modified to improve adhesion.
- Matching the elastomer chemistry with the substrate dramatically improves adhesion.



## Bonding to Polar Substrates

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS


**RTP 6042 Series: ABS, PC, and PC/ABS Bondable SEBS Alloys**

- Excellent Bonding due to unique technology
- Great grip and feel, very durable
- Good aging properties relative to competitors
- Excellent processability and aesthetics
- Specialty versions available for unique applications
- MD / ISO 10993 grades available

**Typical Applications**

- Consumer Electronics
- Hand Tools
- Soft-Touch Home Goods
- Medical Devices
- Knobs and Controls
- Personal Grooming Products
- Fitness Equipment
- Phone and Tablet Cases





## Wrap-Up

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Defined Compounding**
- **Plastic Resin Selection Process**
  - Basics
  - Medical Specific Considerations
- **Compounds for Healthcare**
  - Metal Replacement
  - Conductive Thermoplastics
  - LDS
  - TPEs



