New Thermo-opaque Smart Plastics
Introduction

- Who are Phantom Plastics?
- Our history of new smart materials
- Introduction to styrenic polymers
- What is this new polymer?
- What effects does it display?
- How does it work?
- Is it a viable material?
- Production and supply
- Summary
Phantom Plastics™:

- New plastic materials and formulations (fillers, antioxidants and specialty additives)
- Problem solving
- Training seminars, webinars, documents and video downloads
- Smart materials creation

Smart materials history

- Developed a new water-soluble, self-doped polyaniline with new green to red colour switching with pH change
- At BASF developed and patented new Smart Salts technology to solve a long-standing and serious product quality issue with ABS, ASA and MABS (BASF had spent 30 years and several million Euros and failed to solve the problem)
- Developed, patented and marketing ThermoShift™ opacity changing thermoplastic
- Working with Fortune 100 company to develop a new type of smart packaging
Commodity Styrenic Polymers

General Purpose Polystyrene (GPPS) + butadiene rubber

High Impact Polystyrene (HIPS) + acrylonitrile

SAN + butadiene rubber

ABS + acrylonitrile

Transparent

Opaque
Phantom Plastics™

Specialty Styrenic Polymers

- **SAN**: Chemical resistance, High modulus, Low impact resistance
- **ABS**: + butadiene rubber, + acrylate rubber, + nylon 6, special compatibilizer
- **ASA**: Excellent UV / Heat stability
- **MABS**: Excellent transparency & impact resistance

**ABS/PA**
- Excellent impact resistance
The Mechanism

MABS (transparent ABS)

![Graph showing the relationship between refractive index and temperature. The graph includes two lines, one labeled 'Thermoplastic matrix' and another labeled 'Impact modifier.' The x-axis represents temperature (°C) ranging from 15 to 75, and the y-axis represents refractive index ranging from 25 to 85. A point is marked at 25 °C on the x-axis, showing the intersection of both lines.]

Phantom Plastics™
The Mechanism

ThermoShift™

Phantom Plastics™

Refractive Index

Temperature (°C)

ThermoShift™ Matrix

15 25 35 45 55 65 75

65
Optimised for 40°C (ASTM D1003)
Phantom Plastics™

Optimised for 55°C (ASTM D1003)
Optimised for 65°C (ASTM D1003)
Optimised for 80°C (ASTM D1003)
Haze Overview (ASTM D1003)
Transmission Overview (ASTM D1003)
## Indicative Mechanical Properties

Not to be used as a specification

<table>
<thead>
<tr>
<th>Property</th>
<th>Approximate Value</th>
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<tbody>
<tr>
<td>Modulus (MPa)</td>
<td>2000</td>
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<tr>
<td>Yield Strength (MPa)</td>
<td>35</td>
</tr>
<tr>
<td>Elongation to Break</td>
<td>12 %</td>
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<tr>
<td>Unnotched Charpy (kJm⁻²)</td>
<td>90</td>
</tr>
<tr>
<td>Notched Charpy (kJm⁻²)</td>
<td>10-15</td>
</tr>
<tr>
<td>Puncture test (J)</td>
<td>15-25</td>
</tr>
<tr>
<td>Vicat B (°C)</td>
<td>91</td>
</tr>
<tr>
<td>MVR (ml/10 min)</td>
<td>10-15</td>
</tr>
</tbody>
</table>
The initial application was for Electrolux dishwasher doors to show the machine in action but hide dirty dishes.

Fridge and freezer manufacturers are interested to show whether temperature status at a glance without thermocouples.

Designers are investigating the ability to use the effect for novel lighting applications, e.g. harsh to soft transitions.

Car manufacturers are interested for example in sunroof use to shield against extreme sunlight.

Greenhouses could be built to protect plants from extreme sun.

Can be used to simulate fog / poor visibility for example firefighter training exercises.

Many more applications in novelty items, etc.
Sample material and parts are supplied in partnership with Norner Innovation AS, Norway
Samples provided to interested parties under NDA
Production can be handled in multiple ways:
  • Smaller volumes from Norner Innovation
  • Larger volumes through Phantom Plastics tolling partners locally
  • Production through OEM compounders via licensing
The material is safe with no extractibles, food contact is not in place but could be obtained
Pricing depends on volume and exact material ordered, but is in the region of $ 5-10 / lb
ThermoShift can be developed based on other plastic materials
We present a new, unique material with a reversible thermo-opaque switching behavior.

The material can be made in different grades to provide optimal transparency at temperatures anywhere from -20°C to +85°C.

The material shows an excellent balance of mechanical properties such as modulus, yield strength, and impact resistance.

The material is amorphous, allowing use in any standard injection mold made for amorphous materials.

The limitations are unsuitability for outdoor use or continuous use at high temperatures.

Several Fortune 500 companies are working with Phantom Plastics (exclusivity available on first come, first served basis).