

MARKETS FOR INHANCE™ PRODUCTS

INHANCE™ products represent a new dimension in material engineering. This family of materials offers a way to manufacture end products that have new and superior performance.

To understanding the value that INHANCE™ products bring to many applications, it is important to understand that these products are not what are typically referred to as fillers or additives. According to the *American Heritage Dictionary of the English Language*, filler and additive have the following definitions:

- Fill•er 2. Something added in order to augment weight or size or to fill space.
- Ad•di•tive -n. A substance added in small amounts to something else to improve, strengthen, or otherwise alter it.

INHANCE™ particles are performance-oriented polymer materials that have specially modified to make them able to be combined with other types of polymer systems. The combination of INHANCE™ particles with other polymers creates novel composite materials, which have beneficial properties and performance. INHANCE™ particles are not fillers; they are not added to take up space or to reduce the cost of a material. INHANCE™ particles are not simply additives; they are generally used in fairly high percentages because one is forming a new composite.

INHANCE™ particles and fibers have found commercial use in a broad spectrum of applications, and new uses continue to be developed. Specific combinations of INHANCE™ particles with other polymers that we are aware of are listed below. In the following section, details concerning specific types of applications these combinations are used in will be discussed.

POLYMER COMPOSITES MADE WITH INHANCE™ PRODUCTS

PU, cast	Polyphenylene sulfide thermoplastic
PU coatings/linings	Nylon, thermoset
PU RIM	Nylon, thermoplastic
TPU	EPDM rubber
Acrylic latex coatings	SBR rubber
Epoxy coatings/linings	Thermoplastic polyolefins
Epoxy adhesives	Polysulfide coating
Amodel thermoplastic	Unsaturated polyester

Cast PU

Cast polyurethanes are rather expensive high performance elastomers that are used in demanding applications that utilize their toughness, durability, and low cost of molding. Composites of INHANCE UH, HD, and Ti particles in cast PU are used to make end products that perform better, primarily greater durability and lower coefficient of friction, than do those made in just PU. Almost all of these applications use the UH or the HD grades of INHANCE™. While INHANCE™ Ti-9000 will perform well in many of these, they cannot bear the high cost of that material.

Concerning roll coats, we have been told that one important reason for using INHANCE UH-1250 particles is that they inhibit the migration of water through the coating which greatly slows delamination of roll coat from the metal roll. The particles increase moisture barrier through tortuous path mechanism.

The Examples of specific end products include:

- Roll coats (such as used in paper making)
- Wiper blades, used on conveyor belts and other mining applications
- Screens used in mining
- Gears used in machinery
- Pulleys used in ski lift equipment
- Throwing wheels, for dispersing salt & sand
- Drive wheels for escalator grab rails
- Belts, cogged and V-belts for timing, drive, etc.

❖ Note attached brochure from customer Plan Tech, Inc. promoting their ARMORGLIDE™, which is made with INHANCE™ UH particles in cast PU.

PU Coatings

Polyurethane coatings are used where durability, toughness, and flexibility are required. In general, polyurethanes have better uv resistance than do epoxies. For retention of colors in external applications, aliphatic polyurethanes are used. Specific coatings using INHANCE™ UH and HD grades include:

- Automotive (believed to be rocker panels)
- Truck bed liners
- Rail car liners
- Industrial coatings
- Coatings for silos and storage bins
- Material handling systems

PU RIM

PU components molded via Reaction Injection Molding are prized for their toughness and abrasion resistance. INHANCE™ UH and HD grades are used in the manufacture of:

- Buckets for bucket conveyors
- Mechanical components

TPU

Thermoplastic polyurethanes combine the physical property attributes of polyurethanes with the high volume productivity associated with thermoplastics. INHANCE™ UH particles are compounded into TPUs to give greater abrasion resistance, increased toughness, and reduced coefficient of friction. Dow Chemical has experimented with use of INHANCE™ Ti-9113 in TPU and reported remarkable increase in abrasion resistance, but none are commercial at this time. One TPU product made with INHANCE UH particles that we know of is:

- Mechanical seals

Epoxy Coatings

Epoxy coatings are widely used in industrial coatings applications because of their outstanding toughness, chemical resistance, and durability. Incorporation of INHANCE™ UH, HD or Ti-9000 in epoxy coatings makes the performance even greater. Also, incorporation of INHANCE™ particles in coatings gives better adhesion to substrates.

We have seen a sample of an epoxy coating that incorporated about 20% INHANCE™ UH-1700, which was claimed by the paint manufacturer to have the greatest mar resistance they have ever seen. To demonstrate, they instructed us to scratch it with a coin and then wipe it with our fingers. The scratch disappeared!

Specific examples of epoxy coatings formulated with INHANCE™ particles include:

- Abrasion resistant lining for pneumatic conveying piping
- Material handling systems
- Coatings for silos and storage bins
- Industrial coatings
- Coatings for appliance/office machine

Acrylic Latex Paint & Coatings

Acrylic latex paints are primarily used in trade sales – paint sold to consumers for painting inside and outside of houses. These coatings give very good performance and are easy to work with, especially compared with 2-part systems. In general, acrylic latex paints do not have the toughness and abrasion resistance of 2-part epoxy or PU systems, and thus the latter two are used instead of acrylic latex in high performance industrial coating applications.

It has been found that when INHANCE™ UH particles are incorporated in acrylic latex paint, the abrasion resistance and toughness increase considerably. It has also been found that use of INHANCE™ particles increases the adhesion strength to substrates. A number of paint companies in North America have developed (and still are developing) new acrylic latex paints based in INHANCE particles, which are targeting higher performance and industrial coating markets. Two such products that we know of include:

- Maintenance paints
- Floor paints

Epoxy Adhesives

The majority of structural and other high performance, industrial adhesives are based on epoxies. It has been found that incorporation of approximately 20% INHANCE™ UH or HD particles increases the tensile and lap shear strength by as much as 50%. It has also been found that incorporation of INHANCE™ particles increases adhesion to substrates. At least two customers have developed epoxy adhesives based on INHANCE™ UH particles.

- Two part, high performance structural adhesive

Amodel® (polyphthalamide thermoplastic made by Amoco Plastics)

Approximately 23% (by weight) INHANCE™ Ti-9113 is combined with an Amodel resin to manufacture rod guides for the oil industry. These guides have very high abrasion resistance.

- Rod guides for oil wells.

Polyphenylene sulfide (PPS)

PolyPhenylene Sulfide (PPS) offers the broadest resistance to chemicals of any advanced engineering plastic. They have no known solvents below 392°F (200°C) and are inert to steam, strong bases, fuels and acids. Minimal moisture absorption and a very low coefficient of linear thermal expansion, combined with stress-relieving manufacturing, make PPS ideally suited for precise tolerance machined components. PPS is used in bushings as well as numerous other applications. PPS is sold under trade names Ryton® and Fortron®. Incorporation of INHANCE™ Ti-9113 in PPS significantly increases its abrasion resistance even further. At this time, we are aware of one commercial use of INHANCE™ Ti-9113 in PPS:

- Rod guides for oil wells

Nylon, thermoset (NYRIM)

Thermoset polyamide is made by catalytic ring opening polymerization of caprolactam. This process, promoted under the name NYRIM, creates a very tough form of nylon. We have one customer who incorporates INHANCE™ UH-1080 in NYRIM to make:

- Wear plates for rail road application

Nylon, thermoplastic

A number of compounders incorporate INHANCE™ UH materials in thermoplastic nylon to create special nylon compounds:

- Nylon compounds designed to have low coefficient of friction and high abrasion resistance

EPDM rubber

INHANCE™ UH and HD grades are combined with peroxide-cured EPDM rubber to make:

- Roll coat, such as for paper making rolls

SBR rubber

INHANCE™ UH and HD grades are combined with SBR rubber to form compounds with good abrasion resistance and low coefficient of friction. These compounds are used to make:

- O-Rings
- Seals

Thermoplastic Polyolefins

- Inhance HD-1035 is reportedly used as a compatibilizer in a custom compound

Polysulfide Coating

Polysulfides have very high barrier to permeation of organics. One coatings manufacturer has developed a specialty coating based on INHANCE™ UH-1250:

- Chemical barrier coating with good abrasion resistance, tear resistance, and toughness

Unsaturated polyester

We have seen prototypes of INHANCE™ UH-1250 combined with unsaturated polyester, reportedly good for:

- Kitchen countertop material that is light weight, crack resistant, and stain resistant

Cast PU and epoxy applications can probably be commercialized fastest.

Paints & coatings applications probably represent the largest potential market identified thus far.