Introduction to Coloring Plastics for Special Decorative Effects

SPECIAL EFFECT COLORANTS & SECONDARY PROCESSES

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The second of a four-part series on the coloring and decorating of plastics, this article focuses on special effects colors and compares their appearance with what can be achieved by secondary processes.

Decorators use a variety of secondary processes to create eye-catching effects for containers and other plastic parts. In addition, special effects colorants can be molded into plastic parts to yield an attractive appearance in their own right. Better yet, we can combine these colorants with secondary processes, such as spray painting, pad printing, hydrographics, laser marking and metallizing to yield unique visual and tactile special effects.

Types of Special Effects Colorants

Table 1 lists six major classes of special effects pigments and dyes. All are available as heavy metal free, and some are compliant with FDA plastics regulations. Pricing varies with the type of effect sought.

Pearlescent Pigments. The primary type of pearlescent pigments used in paint, inks, and plastic are based on mica flakes coated with titanium dioxide[1]. As the coating thickness increases, the color varies from silvery white to yellow, red, blue, and green. Different colors can be achieved by adding a second coating of iron oxide (gold and beige) or chrome oxide (green); and a range of metallic colors (bronze and copper) is achieved by replacing the titanium dioxide with iron oxide.

What makes these pigments special is not so much their color, but their pearl-like appearance, which can be "tuned" by adjusting the size of the flakes. Small flakes (about 5 microns) give rise to a satiny appearance with good opacity. Larger flakes (about 25 microns) give a lustrous effect with lower hiding power. Typically you would blend different particle sizes to achieve a desired combination of luster and opacity. Color stylists typically combine pearlescent pigments with transparent pigments and dyes[2] to add luster to the base color. Many automotive finishes include pearlescent pigments. They not only make the finish more attractive but they also protect it by reflecting harmful rays from the sun. Because the size and shape of these particles are so important to the resulting appearance, special care has to be taken when processing the pigments in plastics. High shear forces can fracture the flakes and reduce the luster effect.

As noted above, the surface of the pearlescent flakes reflect light. In contrast, the edges scatter the light in all directions and are comparatively darker. This can lead to an undesired effect in injection molded parts. When flow fronts come together they may form a weld line. If pearlescent pigments are used, the flakes tend to flop over at the weld line exposing their edges. The result is a dark line accentuating the weld. Proper mold design places the gates in such a way that the weld lines are in less visible locations.

Pearlescent Pigments and Secondary Processing. These pigments also can be formulated into inks and coatings that can be applied to plastics by well-known secondary decoration processes, such as hydrographics, pad printing and screen printing. One advantage is that pearlescent pigments are less prone to "flop" when used in an ink or coating, and a uniform appearance is more easily obtained. In addition, certain mica based pigments enhance laser marks. They are designed to enhance the interaction of the laser

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Table 1

Type of Effect	Pearlescent	Metallic	Fluorescent	Phosphorescent	Thermochromic	Photochromic
Cost	Low	Low	Low-High	Medium	High	High
Polymer Compatibility	All	All	Dyes: PMMA, PS, PET, PC, ABS, SAN *Pigments: PE, PP, PVC*	*PE, PP, PS, PMMA, Elastomers*	All	All
Durability	Excellent	Excellent	Fair	Good	Fair	Fair
FDA Status	21CFR178.3297		Non-heavy metal	Non-heavy metal	Non-heavy metal	Non-heavy metal

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energy with such plastics as polyethylene and polypropylene, and some are designed to undergo color changes in their own right. In Part 4 of this series we will discuss these points further.

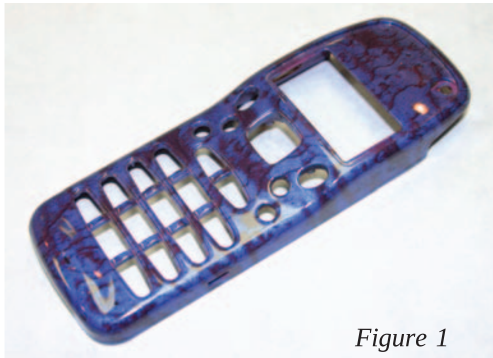

Figure 1

Metallic Pigments. Metallic pigments are made from copper alloys and aluminum, and are available in a variety of colors and particle shapes. The copper versions vary in color from bright greenish gold to red gold. Aluminum versions are silver and silver-gray in color. Originally, the vast majority of offerings were in flake form to maximize luster. As with pearlescents, the plastics processor has to care to minimize shear forces to preserve the particle shape, and typically the colorist blends pigments of different particle size to impart the desired balance of luster and opacity. Smaller particles provide opacity; larger particles provide luster. Because metallic pigments conduct heat and electricity, they often are used to impart other functional properties aside from decoration. Examples include the following:

- Antistatic properties and electromagnetic shielding
- Microwave absorption to promote heating
- Thermal management (conducting and radiating heat)

Metallic Pigments and Secondary Processing. As in the case with pearlescents, metallic pigments can be formulated into inks and coatings. Higher loadings are possible, and the resultant designs or coatings have a true metal-like appearance. *Figure 1* illustrates a mobile phone face plate decorated with metallic pigments in conjunction with more traditional pigments via hydrographics. For comparison, the figure shows other metallic effects that can be achieved by foil transfer, including holographic designs.

Fluorescent Dyes and Pigments. Sometimes called "glow-in-daylight" colors, fluorescent colors work by "robbing Peter to pay Paul". Daylight is composed of ultra-violet, visible, and infrared radiation. In the case of conventional pigments, the color we see is due to reflection of particular wavelengths of the visible light hitting the object. Fluorescent pigments and dyes make use of the ultraviolet as well as the visible rays. Their chemical make up allows them to emit some of the UV rays they absorb as visible radiation. This emitted light is added to the reflected visible light resulting in a far brighter color that appears to glow. A similar effect happens with commercial fluorescent lighting. Consumer products ranging from bubble gum to laundry detergent have been packaged in fluorescent containers in an effort to attract the buyer's eye.

Fluorescent colorants are available as dyes and pigments. The pure *dyes* are suitable for many widely used resins, with the exception of polyethylene (PE) and polypropylene (PP). They work exceptionally well in transparent plastics such as Acrylics (PMMA), polycarbonate (PC), and polyester (PET), in which they exhibit an "edge glow" effect, and are used in translucent and opaque resins, such as ABS, to brighten up the color. Pure fluorescent dyes have a high unit cost, but they are effective at very low levels (less than 0.1% by weight) and provide good value. The most commonly available fluorescent *pigments* are composed of fluorescent dyes bonded to a polymer matrix that is selected to be compatible with PE, PP, PVC, and related polymers and alloys. These pigments have a low unit cost but need to be added at about 1% by weight. If the plastic contains a high level of lubricant or plasticizers, it is a good practice to test the fluorescent pigment in the application before going into production. Some of these additives can dissolve the dye and promote plate out. In addition, one manufacturer offers true fluorescent

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pigments designed to yield an outstanding edge glow effect in transparent resins. The unit price is very high, but the coloring cost is warranted in some applications.

Fluorescent Pigments in Secondary Processing. Fluorescent pigments are widely used in the printing industry. The specific types of pigments chosen have a polymer matrix designed for compatibility with the ink in question. When used in a coating, fluorescent pigments can be combined with a variety of other special effect colorants to create some eye-catching effects. *Figure 2* shows a striking red frost coating achieved by combining a red fluorescent pigment with a flattening agent.

Phosphorescent Pigments. Also called "glow-in-the-dark" pigments, phosphorescent pigments are finding their way into a wide variety of applications including: light switches, dials, buttons on TV remotes, and toys, to name just a few. Whereas conventional pigments emit light as quickly as they absorb it, the phosphorescents interact differently with light sources. These pigments readily absorb light over a broad range of wavelengths, but reemit it very slowly over time. Originally, these pigments relied on a cadmium sulfide chemistry. But today several companies are offering heavy metal free versions. You "charge" the article colored with such pigments by exposing it to a visible light source – an ordinary incandescent bulb will suffice – and the article will glow for several hours after being removed from the light source.

Figure 2

Phosphorescent Pigments and Secondary Processing. Figure 3 illustrates the long lasting bright glow achievable from the latest generation of heavy metal free phosphorescent pigments. In this example, the phosphorescent pigment is molded into the plastic article and then decorated with inks via pad printing. Phosphorescent pigments can also be formulated in inks and coatings to yield similar glow-in-the-dark effects.

Thermochromic and Photochromic Colorants. These colorants provide striking color change effects. As the name suggests, *thermochromic* colorants change color in response to a temperature change.

They are complex colorants that consist of a dye, an activator, and a solvent. The melting point of the solvent determines the temperature at the color change takes place, whereas the dye determines the color. Thermochromics work best in "soft plastics". For example they are more effective in PE, impact polystyrene, and flexible PVC, than they are in PP, crystal polystyrene, or rigid PVC. This is because the softer plastics have more free volume available to accommodate all 3 required components. Commercially available thermochromics vary widely in price, but all have to be used at fairly high levels to get a dramatic color change effect. *Photochromic* colorants are based on dyes that change their molecular shape when exposed to sunlight. The photochromics can be used at low levels (about 0.5% and lower) and work well for transparent plastics.

Figure 3

Thermo- and Photochromics in Secondary Processing. Both photochromic and thermochromic colorants can be formulated into inks and coatings. Drinking cups and mugs decorated with thermochromic inks are a popular novelty. Specially formulated photochromic coatings are used on eye-glass lenses to turn dark in the sun. ■

References

[1] Robert A. Charvat, Editor, "Coloring of Plastics, Fundamentals", 2^{nd} Edition, John Wiley and Sons Inc., Hoboken, 2003, Chapter 15.

[2] Scott Sabreen, "Introduction to Coloring Plastics for Special Decorative Effects, Part 1", Plastics Decorating, January/February, 2004.

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