Electroplating of Polyamide (Nylon) for Automotive Applications

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Plated polyamide (nylon) has recently become of interest to the automotive industry. Polyamide has many of the physical properties that are ideal for vehicle applications: impact strength with some elasticity, vibration reduction and others. Plated polyamide parts are being used in decorative applications while maintaining these physical properties. Appearances ranging from bright nickel/chromium, satin nickel/chromium, to dark deposits using alloys and chromium are being utilized for their decorative appeal.

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Producing decorative parts for the automotive industry is one of the most challenging and interesting activities for the plating industry. Automotive designers and engineers are continuously modifying the appearance and construction of decorative parts while maintaining or improving their physical properties. Weight reduction, cost, design flexibility and appearance are driving forces for change. In the 1960s, most decorative automotive parts were constructed from copper/nickel/chromium plated steel. Between 1968 and 2002, the amount of decorative steel parts was reduced by 65% and was replaced primarily with aluminum and plastic (ABS and ABS/PC). Zinc (extruded and die-cast) and brass were also used but with reducing amounts. Plated magnesium is being reviewed for automotive applications. Its fate will depend partly upon its availability and its physical properties (corrosion, etc.) after plating.

Plastic is one of the fastest growing substrate for the automotive industry. For example, Saturn uses an extensive amount for body siding and other parts (although not much of it is plated). This trend is now moving into the higher-end vehicles. BMW has announced that by 2009, they expect 18% of their standard vehicle to be constructed from plastic. This compares to 13% today and 5% in the 1970s. Some of the decorative parts are being plated. ABS and ABS/PC constitute the majority of the plated plastic on automobiles and all other applications. However, their use is restricted because of the limited strength and the narrow temperature range in which it can be utilized.

In order to increase the use of decorative plated plastics, the automotive industry, in conjunction with plastic and plating suppliers, is investigating high performance and specially plastics such as PA (polyamide, nylon), GTX (nylon blend), RRIM (rigid rapid injection molding), and SMC (sheet molding compound). PA (mineral filled) has already developed a commercial automotive niche primarily with plated interior door handles but also with other applications. The use of decorative plated PA is increasing because a successful plating sequence has been commercially available for several years, starting in Europe.

Polyamide in the Automotive Industry

The automotive industry developed an interest in mineral filled polyamide because of its physical properties. It is lightweight but is stronger and more rigid than ABS and ABS/PC. When impacted, it has some memory because of its slight degree of elasticity. It also is abrasion resistant, vibration dampening and has a low coefficient of friction. PA has an outstanding resistance to chemicals. It has excellent temperature stability from negative 30 C to about plus 130 C giving it a wider usable temperature range than ABS or ABS/PC. For example, it can withstand the temperature extremes that wheel covers experience (cold weather to the high heat from the brakes), and under hood and interior applications. And, for decorative applications, it has good thermal expansion characteristics making it an excellent substrate for copper/nickel/chromium plating.

Molding of Mineral Filled Polyamide

For the molder, mineral filled polyamide is an excellent low manufacturing cost plastic to work with. Once the molding parameters have been established, it is simple to process partly due to its high lubricity and dimensional stability with a low tendency to creep or warp which produces a smooth surface part. However, PA easily absorbs moisture making proper drying important. The maximum permissible moisture content for injection molding is reported to be 0.15%.

Mold temperatures of 35, 65 or 125 C are common. A 35 C molded part has a slight but uniform amount of surface pitting after plating. These parts are used where they are not directly in view. The plated 65 C molded parts are comparable in appearance to ABS and ABS/PC plated parts and are used were they are in direct view. Parts molded at 125 C are typically not plated. As with ABS and ABS/PC, some PA material is easier to plate than others. Modification of the pre-plate conditions might be necessary when trying to plate different types of PA.

Plating of Mineral Filler Polyamide

Historically, the majority of plastics have been plated by one of the plating sequences outlined in Figure 1. Depending upon the type of plastic being plated and the plating process being used, the surface of the part is either etched by a mixture of chromic and sulfuric acids (Fig. 1, line 1A) or by processes that first swell and then etch the plastic surface (line 1B). The objective of both processes is to roughen the plastic surface to increase the adhesion between the plastic and plated metal. Usually etching is followed by the adsorption of a colloidal catalyst onto the surface (line 2B). Some plating processes and plastics are able to use a lower cost and more stable ionic catalyst (line 2A). The catalyzed plastic surface is then placed into an electroless nickel or copper process to produce a conductive metallic coating over the surface (lines 3A and 3B).

Some specialty plastics are conductive enough making it unnecessary to deposit the conductive surface (line 2C). Another alternative process is to produce a conductive coating without an electroless step (line 2D). Once the plastic is etched and made conductive (lines 4A and 3C/4B), the plastic part can be further processed by methods used for parts made from platable metallic substrates. These final decorative deposits give a plastic part the appearance of metallic parts but can be much lighter in weight and more intricate in design.

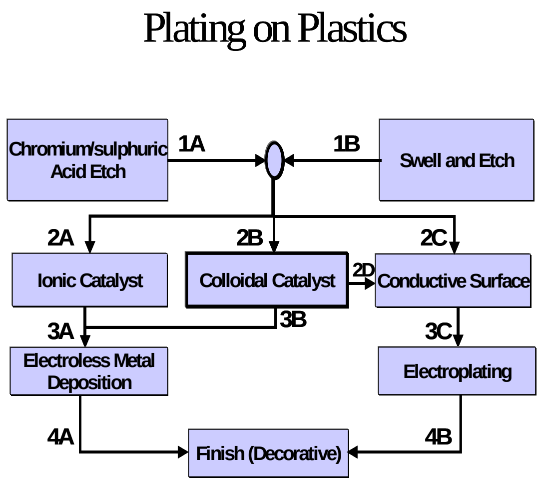


Figure 1 – *Sequence for plating on plastics*

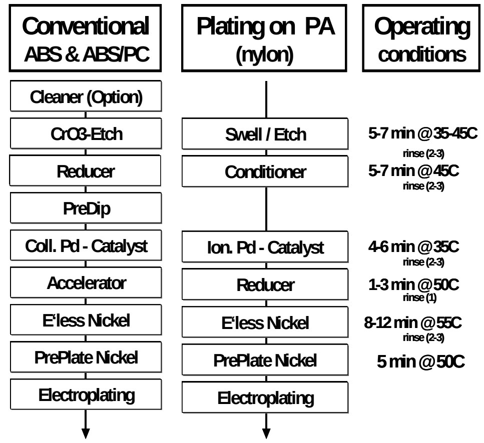


Figure 2 – *Plating sequences for Conventional and PA (mineral filled nylon)*

One way to take advantage of the physical properties of PA is to mold a thin layer of ABS or ABS/PC over the PA part. The part would then be plate as if it was constructed from ABS or ABS/PC. A newer approach is to directly plate PA following the plating sequence of lines 1B, 2B, 3B, and 4A in Figure 1. Figure 2 compares conventional ABS and ABS/PC plating with directly plated miner filled PA (nylon). The plating times and temperatures are similar to the conventional sequence but there are some important differences. No chromic acid etch is used which makes the plating sequence more environmentally friendly. The Sweller and Conditioner processes replace the conventional Etch, Reducer, and Pre-dip steps. The Conditioner process also makes the PA surface much more receptive to the adsorption of palladium catalysts.

Since no chromic acid is used, no chromium reduction step is required. No PreDip prior to the catalyst is used because ionic palladium catalysts are very stable. A Reducer step after the catalysts converts the palladium ions to palladium metal similar to the Accelerator step in a conventional system.

A lower level of adsorbed palladium is utilized in the PA plating sequence than in ABS and ABS/PC processes. In the PA plating process, the electroless nickel requires no ammonia, giving the sequence an additional environmentally friendly step. Also, rack plating has been eliminated under most conditions. Once the part is coated with electroless nickel, it can be further electroplated to meet automotive specifications. This usually includes acid copper, semi-bright and bright nickels, particle nickel and chromium. Decorative trivalent chromium and alloys are used to replace electroplated decorative hexavalent chromium to make the process entirely hexavalent chromium free and to offer different appearances.

Figure 3 shows electron microscope views of correctly molded, mineral filled, PA and ABS. Figure 4 shows the difference in appearance between etched PA and ABS.

The rectangular inclusion in the etched PA is one of the minerals used to fill PA. Properly etched and plated, the peal strength (adhesion) of the plated metal being pulled from the PA surface is equal to or greater than that obtained from ABS or ABS/PC.

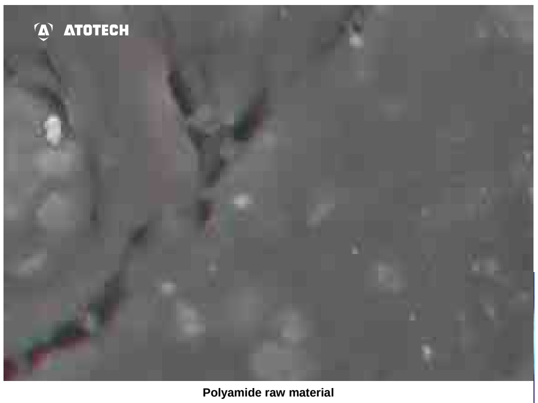


Figure 3A - *SEM view of molded PA*

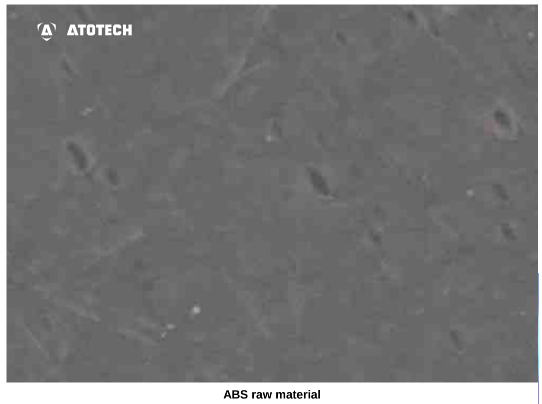


Figure 3B - *SEM view of molded ABS*

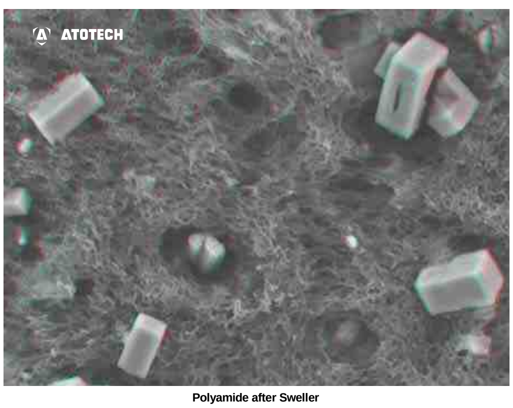


Figure 4A - *SEM view of etched PA surface*

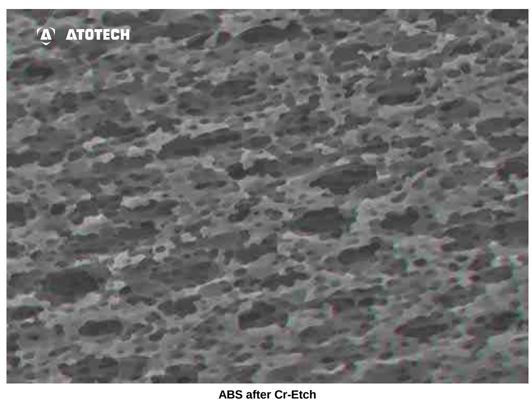


Figure 4B - *SEM view of etched ABS surface*

Automotive Consumers Desire Different Appearances

One of the major driving forces for the use of specialty plastics such as PA on vehicles is its ability to be made into intricately shaped parts with a variety of final appearances. Even though other plastics can be given the same appearances, PA is desired because of the wider variety of applications PA plastic parts can be utilized due to its physical properties.

The traditional finish for decorative plated parts is the white color of hexavalent chromium with its very slight blue hue. This is commonly referred to as “chrome plated”. Figure 5 shows commercial “chrome plated” PA door handles used inside the vehicle. Because of their strength and lower cost, plated PA has replaced plated zinc die cast door handles. Directly plated PA has also replaced PA parts with plated ABS skins (double shot molding).

Dark chromium deposits are available to designers to give their vehicle a unique appearance. There are several trivalent chromium processes with different appearances than “chrome plate”. A photograph is not included because even though the eye can easily tell the difference, the camera cannot. For example, one version of trivalent chromium gives the appearance of depth to the deposit.

Black deposits are used on automobiles because they do not reflect light while have a striking appearance. Figure 6 shows PA plated door handles with black trivalent chromium. The deposit is very pleasing because it is not as jet-black as black hexavalent chromium but has a pleasant gray/black appearance. Both of these deposits, plated over copper, duplex nickel, particle nickel and chromium, could be used for exterior automotive applications because they can pass 44 to 66 hours of CASS testing.

Figure 5 *– Commercially “chrome plated” PA door handles with decorative hexavalent chromium*

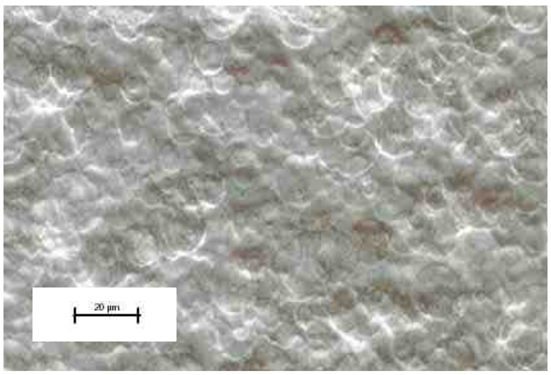
Figure 6 *- PA door handles plated with black trivalent chromium*

Black deposits are also available without using chromium. Black tin-nickel offers a shinny black appearance that is different than either hexavalent or trivalent black chromium deposits. Black tin-nickel can be barrel plated while the chromium deposits cannot. Figure 7 demonstrates some rack plated black tin-nickel PA door handles

A satin appearance is now very popular for the interior and exterior of vehicles. This appearance is usually achieved by electroplating a satin nickel deposit prior to chromium or another topcoat. Figure 8 demonstrates a satin appearance on PA plated door handles. Processes are available that produce satin nickel deposits with appearances ranging from an almost bright reflective normal-nickel/chromium appearance to very satin without any reflectivity. Figure 9 shows a SEM top view of a satin nickel deposit. This “rough” appearance can be varied to produce a wide variety of satin appearances. This is the magnified appearance of most commercially available satin nickel deposits. At essentially the same magnification as Figure 9, Figure 10 shows a highly magnified top view of a unique satin nickel deposit. The “roughness” is more pronounced which reduces fingerprinting and further reduces the reflectivity and gives some depth to the satin appearance. By using both processes, a wider range of satin appearances is available than obtainable from the traditional deposits shown in Figures 8 and 9.

Figure 7 *– Black tin-nickel plated PA door handles*

Figure 8 *– Satin nickel plated PA door handles*



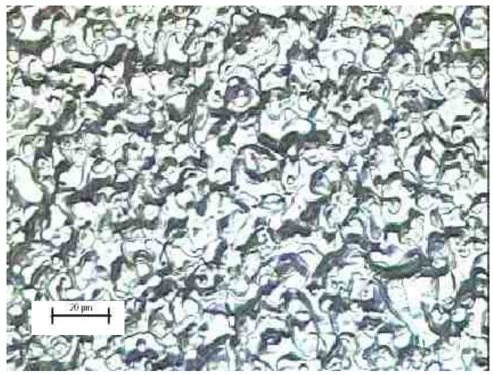


Figure 9 *– SEM magnification of the top view of a traditional satin nickel deposit*

Figure 10 *– SEM magnification of the top view of a unique satin nickel deposit*

Flexibility for the Automotive Industry

Many of the physical properties of mineral filled PA are superior to ABS and ABS/PC. With the availability of a commercial process for directly plating PA, the automotive industry has more flexibility in the number of locations a decorative plated plastic part can be located on a vehicle. PA and other plastic parts can be plated to give the “chrome plate” appearance that many consumers associate with quality and prestige. Also, with the wide verity of different appearances available from plating processes, platable plastic offers the designer a method to produce unique designs.