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INJECTION MOLDING THERMOPLASTICS FOR ELECTROPLATING
There are a number of different thermoplastics that have been successfully electroplated. These include ABS, PC, PC/ABS blends, polysulfone, PPOm (PPE), and nylon. However, ABS and PC/ABS blends are by far the most common and widely accepted thermoplastics that are electroplated. The largest volume applications for electroplated thermoplastics are automotive and plumbing but they are also used in the appliance and electronics industries.

The electroplating process involves a pre-treatment step (electroless plating) followed by the electroplating step. The purpose of the pre-treating step is to make the molded parts conductive. The pre-treating step (see Figure 1) involves the following:

- Cleaning the molded part surface (removes any surface contamination, oil, fingerprints)
- Etching the part surface (removes rubber particles to provide for adhesion)
- Neutralizing the part surface
- Applying the catalyst
- Applying the accelerator
- Applying the electroless nickel layer (makes the part conductive)

![FIGURE 1: Pre-Treating Process](image-url)
The electroplating process (see Figure 2) involves the following:

- Sulfuric / chromic acid etch
- Applying semi-bright nickel or copper
- Sulfuric acid bath
- Applying bright acid copper layer (provides leveling)
- Applying bright nickel layer (provides a highly reflective surface)
- Applying Chrome layer (protects the nickel layer and provides the final surface finish)

The typical conditions for electroplating ABS can be found in Figure 3. These include the composition of the sulfuric / chromic acid etching bath, the temperature of the etching bath and the time spent in the etching bath. These conditions are critical as under-etching or over-etching will result in problems with electroplate adhesion to the ABS substrate.
In order to successfully electroplate thermoplastics, one must understand how part design, the injection molding process and the electroplating process all interact to affect the final quality of the electroplated part, especially in regards to the electroplate adhesion.

Part design is more critical for thermoplastic materials that are going to be electroplated. The following items should be considered when designing a thermoplastic part to be electroplated:

- Avoid deep cavities
- Ensure there are no sharp corners
- Provide plenty of generous radii
- Locate the gate away from show surface
- Ensure uniform wall thickness
- Minimize the number of holes and projections
- Ensure good design practices for ribs, bosses, projections and other features

While the above design considerations are, in general, recommended for all thermoplastic parts, they are more critical for parts being electroplated as any surface defects or residual stresses in the part can cause visual defects in the electroplated part surface as well as non-uniform plating or poor electroplate adhesion.

Injection molding of thermoplastics for electroplating is very different from standard injection molding and is critical for electroplate adhesion. In general, the material must be well dried prior to molding as any moisture present can lead to splay marks on the molded part surface which will show up as defects in the electroplated part surface. For ABS the moisture content should be a maximum of 0.02%. The use of regrind should be avoided if possible. If regrind must be used, it should be well dried and limited to a maximum of 10%. The melt temperature and mold temperature should be on the high side of the suggested range. This helps the material to flow easier into the mold which results in lower orientation and molded-in stresses. Injection speed should be very slow, typically below 0.75 inch/second. Slow injection speed is necessary to minimize surface orientation and surface stresses which leads to poor electroplate adhesion. The injection speed determines where in the part cross-section the orientation is located (see Figures 4 and 5). Figure 6 shows the effects of orientation on the quality of the etching which in turn will affect the electroplate adhesion.
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**FIGURE 4: Effect of Injection Speed on Orientation**

- **Shear Thinning Layer**
- **Plug Flow**
- **Fast Fill**
- **Low Orientation**
- **Slow Fill**

**FIGURE 5: Effect of Injection Speed on Location of Orientation**

- **Surface Highly Orientated**
- **Core Orientation From Bulk Shear**
- **Subsurface Orientation From High Shear Near Wall**

**FIGURE 6: SEM Photographs Showing Effects of Orientation on Etching Quality**

- **Good Etch Quality**
- **Poor Etch Due To High Orientation**
One method that is used to test for excessive stress and surface orientation in ABS parts is the Glacial Acetic Acid test (ASTM D1939). In this test the molded part is immersed in glacial acetic acid for 30 seconds, then removed, rinsed and examined. If no cracks or surface whitening is noticed, parts are re-immersed for an additional 90 seconds, removed, rinsed and examined. If parts crack during the acetic acid test this indicates high levels of molded in stress, and is likely due to unfavorable processing conditions. If parts develop a whitening on the surface, especially a non-uniform whitening, this is an indication of surface orientation and this can also be improved by changes to the processing conditions, most notably the injection speed. See Figures 7 and 8 for photographs showing cracking and non-uniform whitening after immersion in acetic acid.

In summary, molding parts for electroplating is not the same as 'shoot-and-ship' injection molding. Care must be taken to ensure the material is properly dried and to minimize the amount of regrind used. Melt and mold temperatures should be set on the high side of the recommended processing range and injection speed should be very slow. Hold and pack pressures should be kept to a minimum to minimize over-packing and high residual stresses. For ABS parts, the glacial acetic acid test is very effective at determining if parts were properly molded. If the test indicates excessive molded-in stresses or surface orientation the molding process should be modified prior to sending parts through the electroplating process. This will prevent defective parts from be electroplated and experiencing quality issues with cracking or poor electroplate adhesion.