



**ACRYLITE® acrylic polymers  
& ACRYLITE PLUS® impact acrylic polymers**

NTAA – Design and Processing Recommendations

# ACRYLITE® acrylic polymers & ACRYLITE PLUS® impact acrylic polymers

for injection molding of automotive exterior trim parts

## Non-Transparent Automotive Acrylics (NTAA)

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ACRYLITE® acrylic polymers and ACRYLITE PLUS® impact acrylic polymers are highly suitable molding compounds for manufacturing exterior high gloss automotive appliqué parts due to their specific characteristics. Their excellent weather resistance, strength, outstanding gloss and ease of processing make them the best choice for these applications. Class-A surfaces can be produced in high-gloss polished molds without any additional coatings. Compared with coated systems, parts using ACRYLITE® and ACRYLITE PLUS® polymers can offer an enormous reduction in component costs – for example, by up to 40% for B-pillar covers compared to coated systems.

For many years, our PMMA molding compounds have withstood the test in a multitude of series applications in numerous vehicles for many renowned OEMs. Until now, the main applications have been: A-, B-, and C-pillar covers, rear panels and trim parts in the roof area. Development is turning increasingly toward applications in the vehicle interior as well as large-surface parts – in the passenger vehicle roof area or as decorative panels for commercial vehicles.

In this brochure, you will find basic technical information on mold design, injection molding machines, pretreatment and processing of molding compounds, among other topics.

## Mold Configuration and Design

### Steel grades

The current steel grades used in tool making can be used to manufacture injection molds. Good polishing behavior is essential. For this reason, very pure, vacuum-melted steels containing chromium are normally used.

Below are a few examples:

#### Examples of Steel Grades

Material-no.	Designation	Remarks
1.2379	X155CrVMo121	Good strength, highest wear resistance
1.2343	X38CrMoV5-1	Good polishability
1.2344	X40CrMoV5-1	Good polishability
1.2738	40CrMnNiMo8-6-4	Good polishability
1.2767	X45NiCrMo4	For highly stressed plastic molds
1.2316	X38CrMo16	Stainless, good polishability

### Surface quality

A completely smooth, polished surface of the mold cavity is a prerequisite for producing molded parts with high surface quality (Class-A surface). Mold Surface requirement: mirror finish, free from minor scratches and grooves, (SPI #1 finish or better).

ACRYLITE and ACRYLITE Plus polymers can attain gloss levels from a highly polished tool. Alternatively, very fine appearance low-gloss parts can also be

obtained by texturing, or etching the tool surface. Despite the intentional lower gloss, ACRYLITE polymers still achieve a very desirable “deep” color appearance.

### Minimum wall thickness

Wall thicknesses below 0.039” (1 mm) are not recommended. Extremely thin-walled parts tend to have a high degree of molecular orientation due to excessively fast injection and cooling. This can lead to deformation, even below the indicated heat deflection temperature.

### Draft angle

Undercuts should be avoided when injection molding thermoplastics with a high modulus of elasticity, such as acrylics. Drafts angles of 5° are recommended for ACRYLITE polymers, however, in some cases draft angles can be as low as 1 - 2°.



### Mold venting

Sufficient venting in the parting line must be provided to enable quick displacement of air from the cavity during filling. Trapped air can prevent complete cavity filling and can lead to burning of the melt (diesel effect) due to strong compression combined with a temperature increase.

Recommended dimensions for vents:

- Width: 0.6" – 0.8" (15-20 mm)
- Opening: 0.0015" to 0.002" (0.04 mm to 0.05 mm)

The surface of the venting channels should be polished. To prevent the formation of deposits in the mold, we recommend regular cleaning of the venting channels.

### Feed systems

Full round runners are best for ACRYLITE and ACRYLITE PLUS polymers. Successful designs usually start with a main runner diameter 1.5 times the thickest section of the part. Main runner diameters are often 0.250" (6.3 mm). The ACRYLITE and

ACRYLITE PLUS polymer's melt is not highly oriented in the runners, therefore the pressure drop in the runners is much greater than normally anticipated.

Vents on the runners should be 0.002" (0.05mm) deep.

The gate must be centered on the runners to eliminate excessive shear.

### Gates

Fan and tab gates are the most successful designs for ACRYLITE and ACRYLITE PLUS polymers. Valve gates with low shear designs and proximity cooling have also been successful.

Do not ignore the pressure drop in the annular flow around the valve gate pins. The pressure drop may be sufficiently high due to the annular flow width and length that ACRYLITE and ACRYLITE PLUS polymers may not be successfully molded.

Fan and tab gate openings must be a minimum of 75% of the wall thickness and the width about 50% wider than its depth. The gate's land should be one-half the gate depth but should never exceed 0.050" (1.3mm).

Minimum recommended subgates for small parts are: 0.020" (0.5mm) for ACRYLITE polymer high flow grades such as L40 and M30, 0.035" (0.89mm) for ACRYLITE H12, H15 and FT8 polymer grades and 0.035" (0.89mm) for all the ACRYLITE PLUS NTA impact acrylic grades.

Hot runner technology: An essential advantage of this technology is the low-waste production. To prevent thermal damage to the melt, special attention needs to be paid to design and dimensioning.

Additional advantages are:

- Low pressure loss, which enables the realization of longer flow paths
- Trouble-free production of multiple-cavity molds
- Gate systems without subsequent sprue removal
- High automation of the production process
- High degree of freedom for the gate location



### Material shrinkage

Dimensional differences between the molded part and the mold cavity due to shrinkage must be considered during design.

The total shrinkage consists of:

- Demolding shrinkage, which can be measured directly after ejection of the part
- Processing shrinkage, measured after storage for 16 hours in a standard conditioning atmosphere
- Post-molding shrinkage

Shrinkage of 0.3 to 0.7% along the flow direction can be assumed as typical for ACRYLITE and ACRYLITE PLUS polymers. The values are lower for dimensions perpendicular to the flow direction. The longitudinal shrinkage depends on the specific holding pressure level over the flow length.

It is difficult to predict the processing shrinkage with any degree of accuracy since it is determined by a number of factors, such as material, processing conditions, component design and mold technology.

### Overmolding design considerations

Each material's cavities must have its own gate and runner system tailored to that specific material. The wall thickness of the substrate and overmold should be uniform for best cycle times. Wall thickness of 0.039" - 0.118" (1-3 mm) will ensure good bonding. Wall thickness changes should be gradual to reduce melt flow problems such as back fills and gas traps. Minimum radii of 0.020" (0.5 mm) in sharp corners help reduce localized stress.

## Injection Molding Machine

### Clamping unit

The clamping unit is exposed to the greatest stress during the manufacture of large-surface moldings. The required closing forces are 2.5 tons/in<sup>2</sup> (250 bar) of projected area for flow length/wall thickness < 100/1 and 5 tons/in<sup>2</sup> (500 bar) of projected area for flow length/wall thickness > 100/1.

### Nozzle and nozzle point

ACRYLITE and ACRYLITE PLUS polymers are usually processed with open nozzles. Since the melt viscosity can be adjusted by a suitable nozzle temperature at the nozzle aperture, processing with open nozzles does not present any problems.

The diameter of the aperture should, however, be ample. It is also important that the nozzle aperture is slightly conical so that the cold slug is pulled out with the sprue.

### Cylinders and screws

ACRYLITE and ACRYLITE PLUS polymers can be processed on commercially available injection molding machines with general purpose screws, provided that the compression ratio is below 2.5:1. To maintain reasonable residence times and minimize shear degradation, the shot size should range from 40 to 60% of the barrel capacity. Standard screws and cylinders suitable for other thermoplastics (e.g. PC, ABS, etc.) can also be used.

### Suggested screw geometry for processing PMMA

Our proposed zone divisions are consistent with standard screw recommendations. For processing PMMA, a reduction of the compression zone to 3 x D can additionally decrease the danger of air intake. In general, we recommend consulting the machine manufacturer regarding screws that are specially developed for PMMA.

	Material-no.	Designation
<b>Common steel types for cylinders</b>		
	1.8519	31CrMoV9
	1.8550	34CrAlNi7
<b>Common steel types for screws</b>		
	1.4122	X35CrMo17
	1.4057	X22CrNi17

Screw geometry without venting	Screw length = 20D
Feed zone	L = 12 x D (60%)
Flight depth in the feed zone	h = 0.15 x D
Compression zone	L = 4 x D (20%) (better 3D) (core progressive)
Metering zone	L = 4 x D (20%)
Flight depth in the metering zone	h = 0.07 x D
Compression	2.1
Pitch	1D



ACRYLITE and ACRYLITE PLUS polymers: High depth of color and classy look-and-feel

### Conveying

Owing to their high surface hardness, ACRYLITE and ACRYLITE PLUS polymers can cause abrasion in feed pipes. For this reason, feed pipes should be made of stainless steel. Polyurethane is suitable for short, flexible connections. Pipes made of PVC are not recommended due to their low wear resistance.



## Pretreatment and Processing

### Predrying

Acrylics are hygroscopic, i.e. they absorb ambient moisture. If the moisture content is too high when processing the molding compounds, it can lead to streaks on the molded parts. For optimal processing, we generally recommend predrying our molding compounds in a desiccant-type dryer. As a general rule: dry at the hottest temperature possible so that the highest moisture removal is achieved in the shortest time.

Owing to the different softening temperatures, the drying temperatures are also different for the individual molding compound grades.

Standard values for the optimum drying temperature: 20°F (7°C) below the Vicat softening temperature of the respective compound.

Molding compound grade	Drying temperature – maximum	Starting point
ACRYLITE® FT8	194°F (90°C)	180°F (82°C)
ACRYLITE® FT15	212°F (100°C)	180°F (82°C)
ACRYLITE PLUS® NTA-1	200°F (95°C)	180°F (82°C)
ACRYLITE PLUS® NTA-3	212°F (100°C)	180°F (82°C)

If the drying temperature falls substantially below the temperatures indicated, the drying times are lengthened, and in unfavorable cases (environmental conditions, relative humidity) a high residual level of moisture remains even after drying for several hours. The duration of drying depends on the degree of moisture and lies between 2 and 6 hours. The more difficult the production of the molded parts (long flow paths, high melt temperatures), the more care should be taken with predrying. Aside from a low dewpoint recommended temperature of -20°F (-28°C), it is important that sufficient airflow is available to actually dry the material.

The permissible water content for flawless processing lies at < 0.05% depending on the processing conditions and the complexity of the molded part.



### Screw speed

Dependent on the screw diameter: the larger the diameter, the lower the rotational speed (circumferential speed < 0.3 m/s).

Recommendations:

Screw diameter	Maximum screw speed
1.5" (30 mm)	120 rpm
1.8" (45 mm)	90 rpm
2.4" (60 mm)	70 rpm
3.5" (90 mm)	50 rpm
4.7" (120 mm)	30 rpm

At increasing rotational speeds, the shear increases in the melt and the compound temperature rises.

Note: At temperatures that are too high, there is a danger of thermal damage (visible in the form of streaks on the molding surface or yellow appearance).

### Back pressure

We typically recommend 100 psi gauge pressure, however, up to 290 psi (20 bar) can be used to lower the viscosity of the melt. This corresponds to a pressure on the molding compound of approximately 1000 to 2900 psi (100 to 200 bar). At increasing back pressures, the compound temperature and mixing effect increase and the plasticizing capacity drops.

### Injection speed

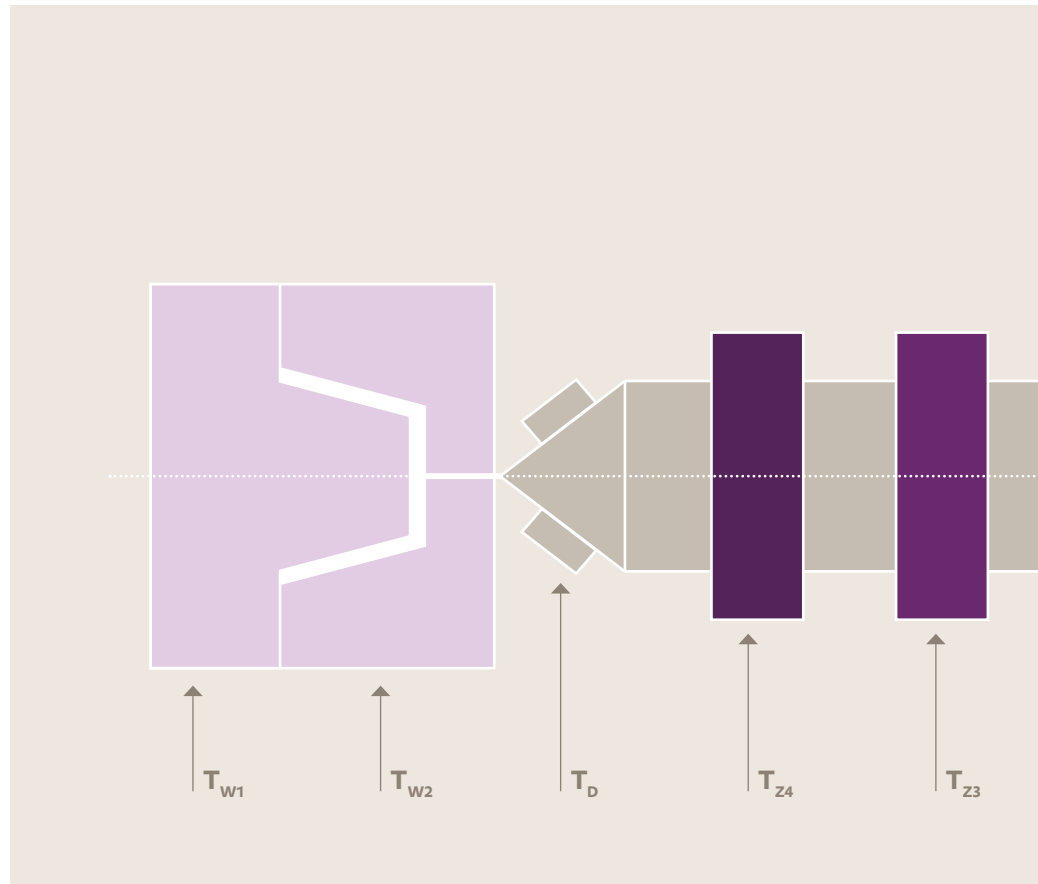
Fill the cavities to 98% full at a medium-to-fast injection speed to maintain constant viscosity. Some mold designs require extremely slow filling speeds. Slow speeds result in difficult filling and packing control. Mold and gate designs should allow fast filling speeds.

### Injection pressure (specific)

Keep injection pressure low at the beginning of production and increase until the mold cavity is completely filled. This will allow you to avoid unnecessarily high injection pressure.

### Holding pressure

The constant pressure head (approx. 60% of the injection pressure) and the duration should be selected in such a way that the mold is well filled and no sink marks are visible.



## Pretreatment and Processing

### Temperature control – mold & cylinder

The influence of the mold temperature on the processing and the characteristics of the finished part is often underestimated. Injecting ACRYLITE or ACRYLITE PLUS melt into a cold mold makes filling more difficult and often leads to high cooling stress, warpage, strong orientation, sub-optimal surfaces, and sink marks in the molded part. Therefore it is necessary to guarantee a constant mold temperature by using a connected temperature control unit.

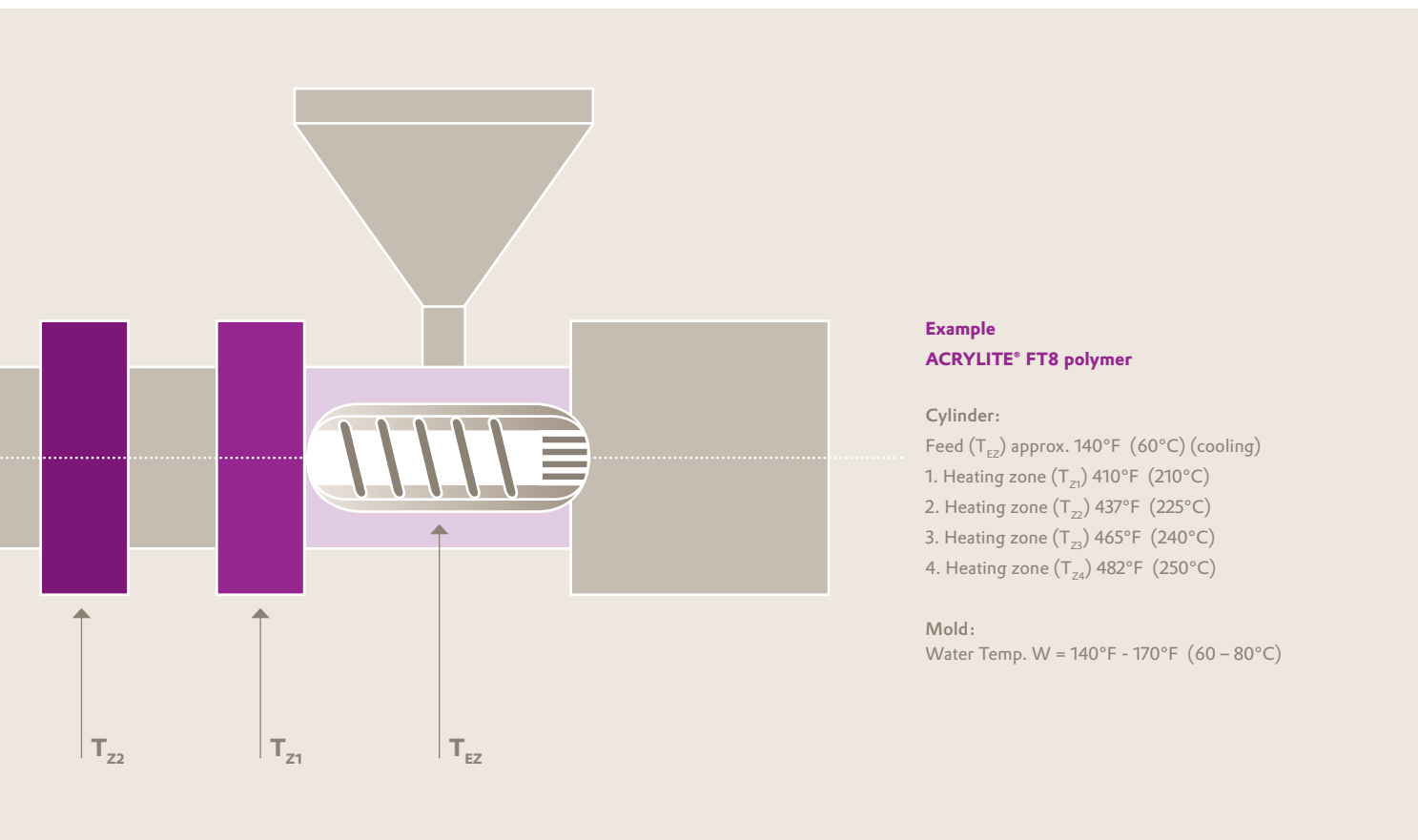
Water thermostats are almost always sufficient, because a mold temperature higher than 194°F (90°C) is seldom required. We advise against cooling purely with uncontrolled water (without thermostat).

The heating-cooling channels in the mold should be distributed in such a way that all zones of the molded part are cooled more or less simultaneously; that means that more heat can be dissipated in thick areas than in thin ones.

The closer the channels are to the mold surface, the more effective the temperature control. For molded parts with large thickness differences or for molded parts with unequal surfaces (one surface smooth, another surface textured), warpage can be compensated by separate temperature control of the two mold halves.

The influence of the mold temperature on processing and properties of the finished part is significant. Cooling around gates is critical; the polymer melt must sufficiently solidify to prevent drooling. Excessive heat surrounding the gates will be exhibited as a haze, splay or artifacts of melt degradation. Too often the mold's cooling water system cannot sufficiently cool the mold. Calculate the tons of cooling required with ACRYLITE and ACRYLITE PLUS polymer's specific heat of 0.49 Btu/lb., Heat content of 236 Btu/Lb., and ejection temperature of 197°F (92°C).

Install pressure, flow and temperature indicators on the water lines. Sufficient cooling water velocity must exist to maintain turbulent flow.



### Barrel temperatures

To guarantee stable feed, the first zone should be adjusted to a lower temperature. Set barrel temperatures according to molding compound grade. For example: heats should be profiled from 410°F (210°C) at the feed section to 482°F (250°C) in the compression section to obtain a melt temperature of 482°F (250°C) for ACRYLITE FT8 polymer.

Molding compound grade	Recommended melt temperatures
ACRYLITE® FT8	428° - 500°F (220° - 260°C)
ACRYLITE® FT15	428° - 482°F (220° - 250°C)
ACRYLITE PLUS® NTA-1	450° - 480°F (232° - 250°C)
ACRYLITE PLUS® NTA-3	428° - 482°F (220° - 250°C)

### Treatment after injection molding

Released molded parts are statically charged and will attract ambient dirt and dust. Therefore the greatest possible cleanliness should be maintained when producing moldings requiring Class-A surfaces.

After injection molding, the surface of the molded part is especially vulnerable to scratches. We recommend that anyone handling freshly molded Class A parts wear cotton or soft cloth gloves, or that a protective film be applied to the parts immediately after removing them from the mold. The scratch resistance of the parts increases with cooling and long storage times due to the absorption of moisture.

Any possible testing of the scratch resistance should, therefore, only be performed 48 hours after production of the molded part is completed.



## Typical values

	Units	Standard	ACRYLITE®		ACRYLITE PLUS®	
			FT8	FT15	NTA 1	NTA 3
<b>Mechanical values</b>						
Tensile modulus (1 mm/min)	MPa	ISO 527	3300	3500	2700	2900
Yield stress (50 mm/min)	MPa	ISO 527	77 (1)	50 (1)	68	60
Elongation at yield (50 mm/min)	%	ISO 527	-	-	5	0
Nominal elongation at break	%	ISO 527	5.5 (2)	3.1 (2)	10	2.6
Charpy impact strength (23°C)	kJ/m <sup>2</sup>	ISO 179	20	18	33	16
<b>Thermal values</b>						
Vicat softening temperature (B/50)	°C	ISO 306	108	115	110	116
Glass transition temperature	°C	IEC 10006	117	121	120	126
Heat deflection temperature under load (1.8 MPa)	°C	ISO 75	98	105	102	106
Fire Rating	-	DIN 4102	B2	B2	B2	B2
Flammability UL 94 at nom. 1.6 mm	Class	IEC 707	HB	HB	HB	HB
<b>Rheological values</b>						
Melt volume-flow rate MVR (230/3.8)	cm <sup>3</sup> /10 min	ISO 1133	3	4.5	3	2
<b>Other values</b>						
Density	g/cm <sup>3</sup>	ISO 1183	1.19	1.19	1.18	1.18
Water absorption in water	%	ISO 62	-	-	> 3 %	> 3 %
(1) Fracture stress (5 mm/min)    (2) Elongation at break (5 mm/min)						

## Products



The various ACRYLITE and ACRYLITE PLUS® polymer grades have specific property profiles designed to meet the full range of requirements for various add-on automotive body parts.



Polishing  
Example

## Polishing

Polishing moldings made of  
black **ACRYLITE** and **ACRYLITE PLUS®**  
polymers

Initial state

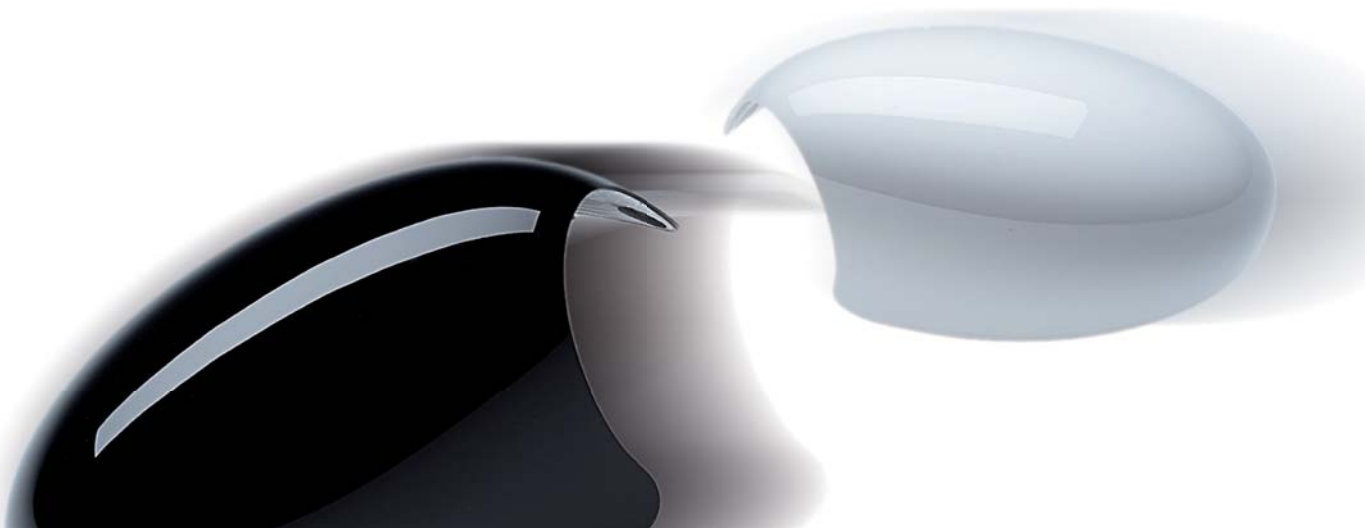
Surface treated  
with sandpaper up to  
the upper right edge

Subsequent  
high gloss polishing  
of the surface

ACRYLITE and ACRYLITE PLUS® polymers have the highest surface hardness of all thermoplastics. Therefore, scratches seldom occur. Any scratches that do occur and are particularly noticeable on high-gloss black surfaces can be removed by polishing.

Detailed information on this subject is available on request.

→ [www.acrylite-polymers.com](http://www.acrylite-polymers.com)



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