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Innovation by Chemistry

TOYOLAC$_{TM}$ SAN Resin
Styrene Acrylonitrile Resin

TECHNICAL GUIDE

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1. INTRODUCTION

TOYOLAC$_{TM}$ SAN Resin is a styrene acrylonitrile resin, which is a copolymer plastic consisting of styrene and acrylonitrile. It is high clarity, good in tensile strength, hardness and good dimensional ability. Besides, it offers excellent chemical and thermal resistance properties. Hence, it is widely used to replace polystyrene in the plastic industry. It is also excellent compatibility with grafted ABS powder in the compounding process.

2. APPLICATIONS OF TOYOLAC$_{TM}$ SAN RESIN

Industry	Typical Applications
Electrical and Electronic	Parts of computer's, printer, dust cover for audio, electric fan propeller and etc.
Automotive	Car battery case, bicycle reflector and etc.
Other	Cosmetics container, gas lighter, handles for brushes and tooth-brushes, cooling tower, merchandise and etc.

Table 1: Typical Applications of TOYOLAC$_{TM}$ SAN Resin

3. TYPICAL PHYSICAL PROPERTIES OF TOYOLAC™ SAN RESIN

SAN Resin							
Property 代表物性	Test Method 试验法	Test Condition 试验条件	Units 单位	Good Colorability 着色性	SAN Standard 一般	SAN Standard Good Colorability 着色性	SAN Chemical Resistance 耐药性
			Type 型号	A11C	A20C	A21C	A37C
			Suffix 区分字符	333	333	333	333
ISO STANDARD							
Melt Flow Rate 流动系数	ISO 1133	220°C / 10 kg	g/10min	29	26	26	10
Charpy Impact Strength (notched) 缺口冲击强度	ISO 179/1eA	23°C / 50 %RH	kJ/m^2	1.5	1.2	1.2	1.7
Deflection Temperature Under Load 热变形温度	ISO 75	1.8 MPa / 120°C/hr	°C	86	90	90	90
Tensile Strength 引张强度;降伏点	ISO 527	50 mm/min	MPa	70	76	76	82
Tensile Elongation at Break 拉伸伸长率			%	-	-	-	-
Tensile Modulus 拉伸模数		1 mm/min	MPa	3800	3700	3700	3800
Flexural Strength 弯曲强度	ISO 178	2 mm/min	MPa	120	125	125	125
Flexural Modulus 弯曲模数				3700	3600	3600	3500
Density 比重	ISO 1183	23°C	kg/m^3	1070	1070	1070	1070
Light Transmittance 光線透過率	ASTM D1003	3 mmt	%	90	90	90	90
Haze 模糊系数	ASTM D1003	3 mmt	%	2	2	2	2
Flammability 燃烧性	UL94 File No. E41797			HB	HB	HB	HB

Note: 1. The above values are typical data for the products under specific test conditions and not intended for use as limiting specifications.

2. TOYOLAC™ A37C 333 resin for Lighter application is added with external lubricant.

Table 2: Typical Physical Properties of TOYOLAC™ SAN Resin

4. ENVIRONMENTAL STRESS CRACKING AND CRAZING

SAN, like most polymers will undergo stress cracking and crazing when subjected to exposure to certain chemical environments under high stress for given periods of time. This cracking and crazing will occur even though some chemicals will have no effect on unstressed (relaxed) parts, and therefore simple immersion of test pieces is an inadequate measure of chemical resistance of the polymer. There are two cases of stress generation. One is caused by external force (external stress), another is the stress that remains in moulded parts (residual stress). Residual stress in moulding parts is generated by uneven cooling speed and fluctuation of melt flow during moulding. Residual stress relaxes gradually with time. However, degradation is accelerated by having contact with a chemical agent. It may cause cracking and crazing trouble. These phenomena are so called "Environmental Stress Cracking and Crazing (ESC)".

Cracking phenomenon is observed on moulding surface when it is soaked in a chemical agent under applied stress. Nevertheless, cracking and crazing may not occur lower than certain stress or strain. These stress and strain are referred to as "Critical Stress" and "Critical Strain" under contacted with certain chemical agent. However, occurrence mechanism is complicated and yet to be clarified. General mechanism is shown as follows:

Main Occurrence Mechanism

A. First Stage : Penetration of environmental chemical occurs by expansion stress (tensile stress).

B. Second Stage : Expansion pressure occurs from penetration of environmental material causing penetration of environmental material to be accelerated. This causes transformation of polymer chain to be accelerated causing cracking and crazing.

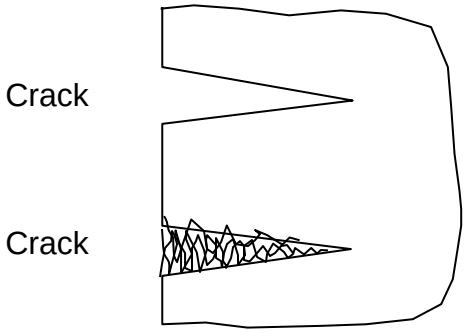


Figure 1: Schematic demonstration of the difference between a crack and a craze

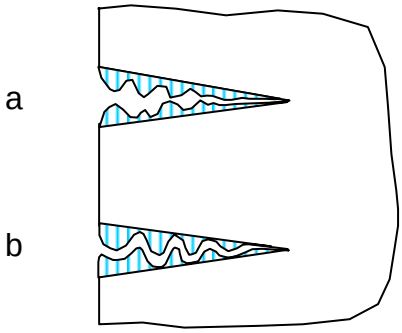


Figure 2: Two mechanism of crack propagation through a craze

When stress is applied to moulded parts of SAN resin, strain may occur, and crazing may occur in matrix phase. Crazing is stretched in a highly orientated or slipped polymer chain. Density in this crazing area is 50～60% of normal area. This is because it consists of orientated polymer and microscopic voids.

Cracking may be caused by exposure to a chemical agent while the part is under stress. This phenomenon is related to interaction between a chemical agent and polymer surface. Namely, it is affected by wetting property (contact angle θ) of a chemical agent. And also this interaction is related to mole volume of a chemical agent. There is a linear relationship between "Critical Strain ε_c and $V^{1/3}/\cos\theta$as shown in *Figure 3*. This figure shows that stress cracking is accelerated by higher mole volume of chemicals.

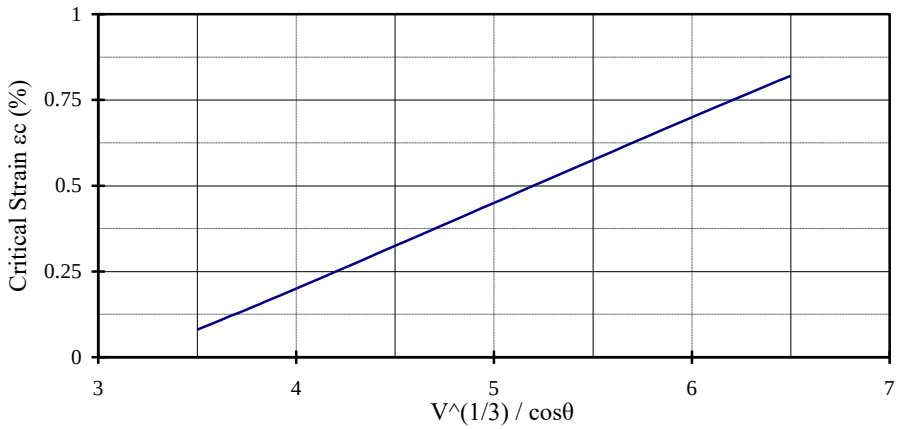
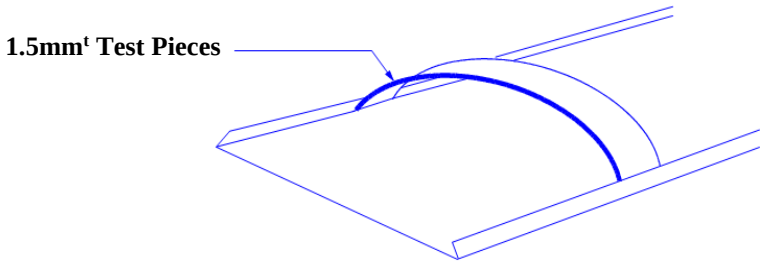


Figure 3: Critical Strain versus Mass Volume

Test Method of ESC in Toray

ESC Evaluation Method



$$\delta(\%) = \frac{\pi^2 2\sqrt{l' \times (l - l')}}{l'^2 \times \pi} \times \frac{t}{2} \times 100$$

l : *Test Pieces Length = 127 mm*

l' : *Test Pieces Length = 98 mm*

δ : *Strain = 3%*

t : *Test Pieces Thickness = 1.5 mm*

Test Condition

A. Treatment time: 1 week (basically)

B. Treatment temperature & humidity: 23°C/ 50%RH

C. Calculation formula of critical strain

Chemicals	TOYOLAC™ A20C 333	TOYOLAC™ A37C 333
Distilled Water	A	A
10% Sulfuric acid	A	A
90% Sulfuric acid	A	A
10% Acetic acid	A	A
90% Acetic acid	B	B
98% Ethyl alcohol	C	B
98% Methyl alcohol	A	B
10% Sodium hydroxide	B	A
Silicon oil	A	A
LABOUR Dishwashing Liquid	A	A

Table 3: ESC Test Evaluation for TOYOLAC™ A20C 333

Judgment:

A- No Defect
B- Craze
C- Crack
D- Break

5. Processing

(a) Drying

Pre-drying is necessary. The recommended pre-drying condition is as below.

Hot air drying oven:-

Drying Temperature	:	80 ~ 90 °C
Drying Time	:	3 ~ 5 hour

Longer drying time is required when initial moisture content is high.

(b) Molding Condition

Recommended molding condition is as below:

Polymer Temperature (°C)	190 ~ 240
Injection Pressure (MPa)	70 ~ 140
Mold Temperature (°C)	40 ~ 80

(c) Precaution During Molding

Please ensure to wash or flush barrel with normal SAN resin whenever stop molding in order to protect injection molding machine and to prevent burnt material formation.

(d) Safety Precaution

Before using the material, please read information concerning safety on Material Safety Data Sheet (MSDS).

6. Mould Shrinkage

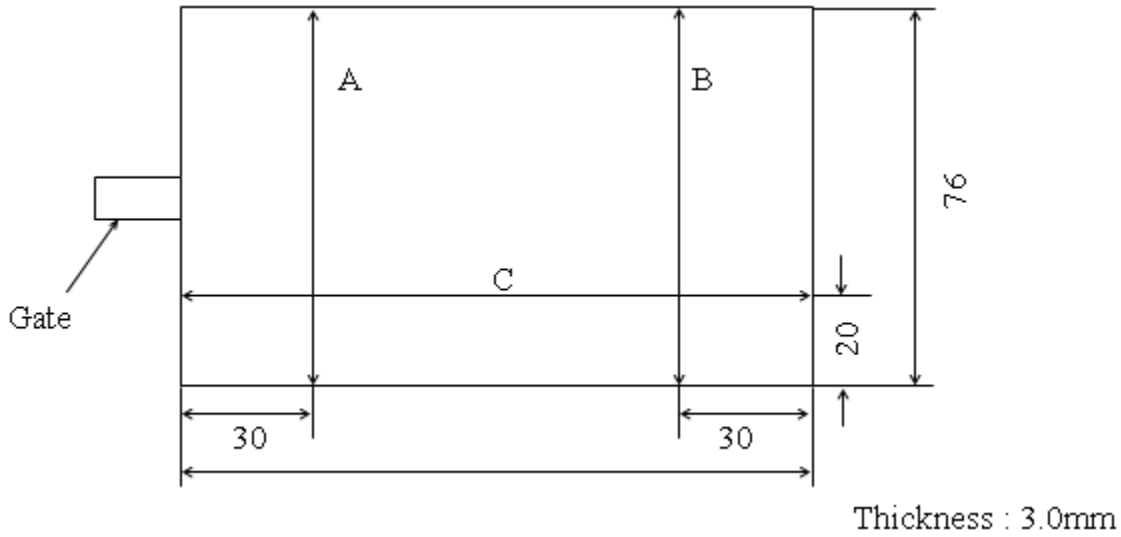


Figure 4: Dimension Measurement for Test Pieces after left 24 hours

Grade	Holding Pressure	Shrinkage Rate, %		
		Transverse Direction		Mold Direction
		A – A (near gate)	B – B (far gate)	C - C
TOYOLAC$_{TM}$ A20C 333	+ 5 MPa	0.03	0.03	0.08
	+ 10 MPa	0.01	0.03	0.09

Table 4: Mould Shrinkage Data for TOYOLAC$_{TM}$ A20C 333 SAN Resin

Moulding Condition:

1. Moulding Machine : Toshiba Machinery, IS50A
2. Moulding Temperature : 230°C
3. Mould Temperature : 60°C
4. Injection Speed : Medium (FCV B-0 : fill-in time 2 sec.)
5. Injection Pressure : Minimum injection pressure +0.98MPa
6. Holding Time : 13 sec.
7. Cooling Time : 30 sec.
8. Test Piece Dimension : 127 x 76 x 3t mm
9. Measure Method : Measure test piece dimension after 24 hours conditioning at 23°C, 50% RH

7. Spiral Flow Length

Spiral flow test is a method to determine the flow properties of a thermoplastic or thermosetting resin. Based on the distance it will flow, under controlled conditions of pressure and temperature, along a spiral runner of constant cross section. In the figure below show a function of the injection temperature with injection pressure as parameter. It is useful for comparing the flow ability of products under the same conditions even if this test has not been standardized.

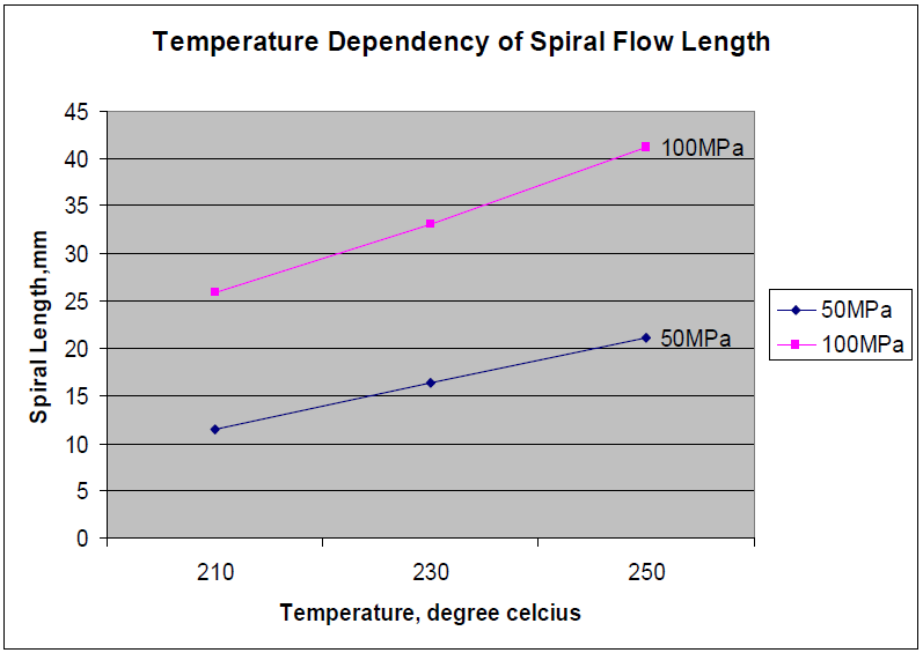


Figure 5: Spiral Flow Length of TOYOLAC$_{TM}$ A20C 333 SAN Resin

Moulding Condition:

1.	Moulding Machine	: Toshiba Machinery, IS50A
2.	Moulding Temperature	: 210, 230, 250°C
3.	Mould Temperature	: 60°C
4.	Injection Speed	: Medium (FCV B-0 : fill-in time 2 sec.)
5.	Holding Time	: 13 sec.
6.	Cooling Time	: 30 sec.
7.	Mould Dimension	: 10Wx2mmt (Spiral Flow)

8. Injection Moulding

Injection Temperature

The barrel temperature of injection moulding machine should increase from the hopper to the nozzle gradually. TOYOLAC$_{TM}$ SAN resin start softening generally around 90 ~ 110°C although it depends on grades.

Nozzle (°C)	Zone 4 (°C)	Zone 3 (°C)	Zone 2 (°C)	Zone 1 (°C)	Hopper (°C)
200 ~ 240	200 ~ 240	200 ~ 240	190 ~ 230	190 ~ 230	190 ~ 230

Table 5: Recommended Barrel Setting Temperature

It should be properly controlled according to the injection moulding machines, the shapes and size of the products, and the mould structure. Temperature in excess of above recommended could result of discoloration or burn marks troubles. Those troubles are a sign of damage to the material. Melt temperature of resin should be between 230^{o}C and 250^{o}C. It should be checked frequently and maintained within above recommended range to prevent defect of appearance and mechanical properties. If shutdown is required, remove the material from the machine and purge out completely to avoid burning trouble.

Mould Temperature

The mould temperature affects the surface quality and the level of residual stress in the moulded products. To provide moulded product having excellent surface finish and less residual stress, the mould temperature should be controlled as high as possible, ranging between 40^{o}C ~ 80^{o}C. However, higher mould temperature may cause longer cycle time and warpage problem. It should be taken attention excessive mould temperature.

Injection Speed & Pressure

Injection speeds will be depending on products shape, gate structure and runner dimensions. Moderate injection speed is preferable in order to prevent orientation of rubber particles due to excessive sheer. Injection pressure should be controlled to mould full parts consistently with acceptable appearance. Many parameters affects injection pressure, such as injection temperature, products shape, nozzle and gate size, runner dimensions and mould temperature. Typical injection pressure range is 70 ~ 140MPa for TOYOLAC$_{TM}$ SAN resin. It is important that injection pressure should drop off to holding pressure after fill-up immediately.

Purging

General maintenance and equipment cleaning should include frequent purging with SAN resin. If prolonged shut-down is required, reduce barrel temperature less than 150^{o}C, remove the material from the injection machine and purge with SAN resin. Continue this operation until hopper is empty throughout and confirm barrel temperature has been dropped less than 150^{o}C.

Regrind

Runners, sprues and shot-shots of TOYOLAC$_{TM}$ SAN resin moulded under proper moulding conditions can be used for recycle materials. Those non-degraded regrind up to a 20% can be reprocessed with fresh pellets of the same grade. Please do not mix it up with other grades of TOYOLAC$_{TM}$ resin or other plastics. And dry it up before reprocessing.

9. Troubleshooting

Typical moulding problems and problem solutions are shown as following table. Most cause of moulding troubles is the tangle of any kind of factors such as improper moulding conditions, imperfect design of mould and mouldings. Any one of the suggested remedies may solve a particular problem. However some problems may require a combination of suggested remedies.

Problems / Remedy	Short Shots	Flash	Sink Marks	Burn Marks	Poor Weld Line	Low Gloss	Jetting	Excessive Warpage	Scratches	Air Marks	Silver Streaking	Crack, Whitening
Increase Injection Speed	✓		✓		✓	✓		✓				✓
Decrease Injection Speed				✓			✓			✓	✓	
Increase Injection Pressure	✓		✓		✓				✓			
Decrease Injection Pressure		✓		✓				✓			✓	✓
Increase Mould Temperature	✓				✓	✓	✓				✓	✓
Decrease Mould Temperature			✓					✓	✓			
Increase Barrel Temperature	✓				✓	✓	✓	✓				✓
Decrease Barrel Temperature		✓	✓	✓					✓		✓	
Decrease Nozzle Temperature				✓								
Increase Nozzle Temperature					✓	✓						
Check Nozzle, Sprue, Runner & Gate Size	✓		✓	✓			✓		✓		✓	✓
Check Gate Position & Number	✓				✓		✓		✓		✓	
Improve Venting	✓			✓	✓	✓				✓	✓	
Increase Filling Quantity	✓		✓						✓			
Decrease Filling Quantity		✓										
Check Clamping Force		✓										
Increase Holding Pressure						✓						
Decrease Holding Pressure		✓						✓				✓
Increase Holding Pressure Time			✓			✓						
Decrease Holding Pressure Time		✓						✓				✓
Increase Cooling Time			✓						✓			
Decrease Screw r.p.m.											✓	
Check Pellet Drying											✓	

Table 6: Troubleshooting Guide for TOYOLAC™ SAN Resin

Important Notes:

1. In as much as Toray Plastics (Malaysia) Sdn. Bhd. has no control over the use to which other may put this material, it does not guarantee that the same result as those described herein will be obtained. Nor does Toray Plastics (Malaysia) Sdn. Bhd. guarantee the effectiveness or safety of any possible or suggested design for articles of manufacturer as illustrated herein by any photographs, technical drawing and the like. Each user of the material or design or both should make his own tests to determine the suitability of the material or any material for the design, as well as suitability or suggested uses of the material or design described herein are not to be construed as constituting a license under any Toray Plastics (Malaysia) Sdn. Bhd. patent covering such use or as recommendations for use of such material or design in infringement of any patent.

2. The material described here is not recommended for medical application involving any implantation inside the human body. Material Safety Data Sheet (MSDS) for the materials concerned should be referred to before any use.