Denka

Styrenic Copolymers having Maleic Anhydride Units as Reactive Compatibilizer for ABS and Engineering Plastic Alloys

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The 3rd International Summit of Polymer Compatibilization Technology
Shanghai China, Sep 1, 2015

Denka's Company Profile

● Name	DENKI KAGAKU KOGYO K.K.
● Established	May 1, 1915
● Net Sales（Fiscal Year 2014）	USD 3,494 Million*
● Net Income（Fiscal Year 2014）	USD 172 Million*
● Employees	5,309

* Exchange rate : 109.9 Yen/USD

Denka's Business

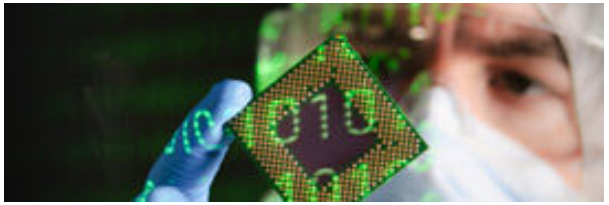
Denka

Elastomers & Performance Plastics

- Elastomers
- Acetylene Black
- Styrenic Polymers
- Styrene & Acetyl Chemicals

Infrastructure & Inorganic Materials

- Cement
- Special Cement Additives
- Inorganic Chemicals
- Agri-Products



Electronics & Innovative Products

- Functional Films
- Advanced Specialty Materials
- Electronic Products
- Adhesives & Solutions

Life Science & Environment Products

- Housing Materials
- Industrial Materials
- Household Packaging
- Medical Science

Denka Styrenic polymers

DENKA STYROL（GPPS）

- Ultra high impact strength（MW-1）
- Easy Processing

DENKA TX Polymer（MS）

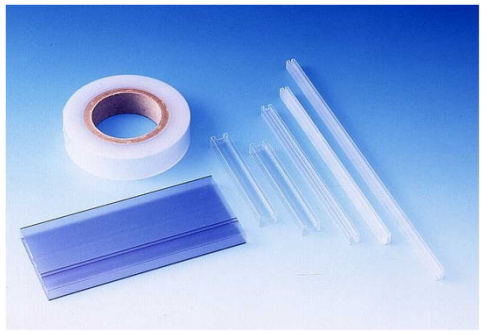
- Excellent transparency
- Good weather resistance

DENKA MABS (Transparent ABS)

- Excellent clarity and toughness

DENKA MBS

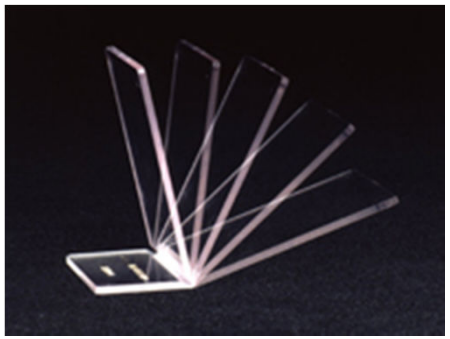
- High impact and Easy Processing



Denka Styrenic polymers

CLEAREN（SBC）

- Good Flexibility
- Miscible with standard PS



* SBC is Styrene Butadiene block copolymer.

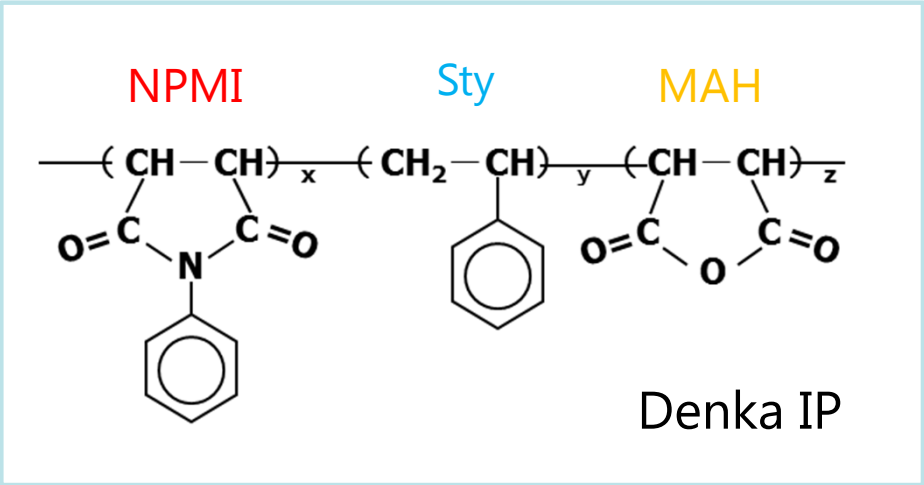
DENKA IP

- Heat resistant modifier for ABS, ASA
- Compatibilizer for PA6/ABS

DENKA is the global styrenic supplier. We offer the portfolio of styrenic specialties. We can provide various styrenic with transparence, high heat resistance and so on.

Denka IP

Denka IP is the copolymer developed by Denka's unique technology.



- Major characteristics

  Miscible with SAN, ABS, ASA …

  High heat resistance （Tg : 196℃） and good thermal stability

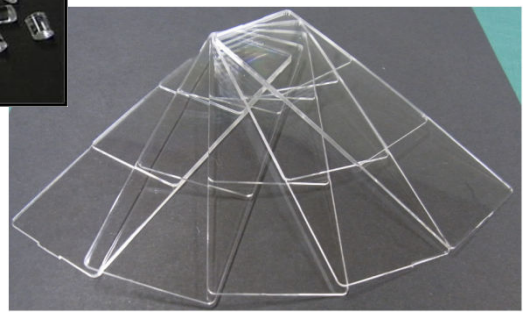
- Main application

  Heat resistant modifier for ABS, ASA ⇒ High heat ABS

  Compatibilizer for ABS and Engineering Plasitic alloys（e.g. PA6/ABS）

Denka “RESISFY”

RESISFY is a specialty styrenic copolymer developed by Denka’s technology.



＜Characteristics＞

- Miscible with PMMA, ABS
- High Heat Resistance
- High Transparency

＜Application＞

- Heat Resistant Modifier of PMMA
- Touch Panel
- Polarizer Protective Film
- Optical Lenses
- Automotive Meter Panel
- Piano-Black Resin
- Compatibilizer

Outline

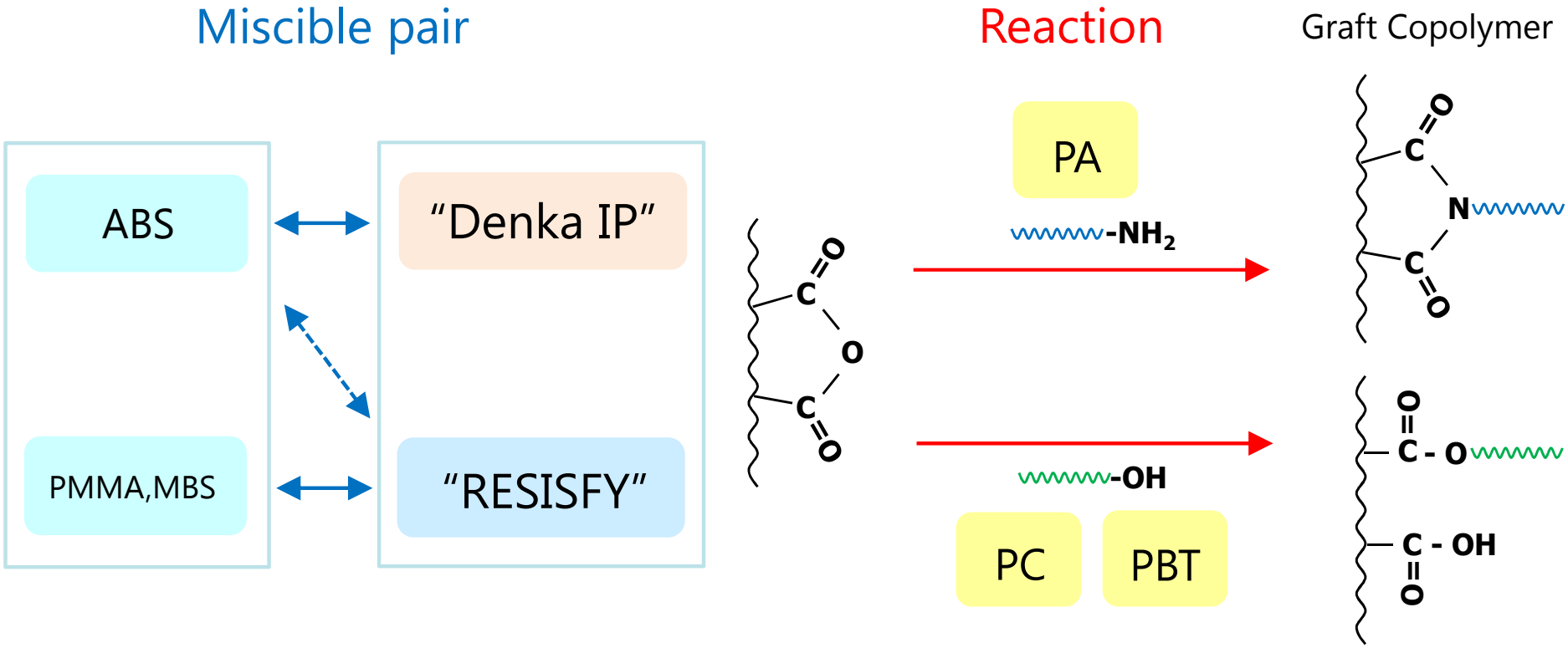
- Background
- Denka IP as Reactive Compatibilizer
- Experimental
- Properties of PA6 / ABS Alloy modified with Denka IP
- Summary

Background

- ABS resin has been widely used for engineering plastic alloys such as PC/ABS, PA/ABS, and PBT/ABS for improving deficient characteristics of a particular material.
- Crystalline plastics such as PA and PBT are immiscible with ABS. However, compatible alloys can be achieved with reactive compatibilizers which have functional groups such as cyclic anhydride and epoxide.
- To obtain industrially useful alloys, the selection of optimal reactive compatibilizer and reaction control are important.

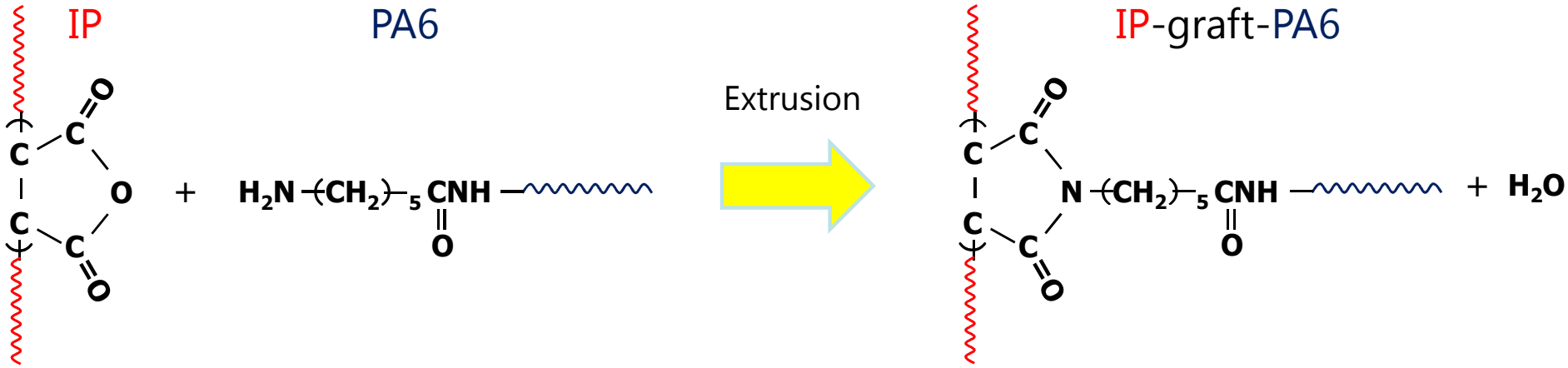
Denka IP as Reactive Compatibilizer

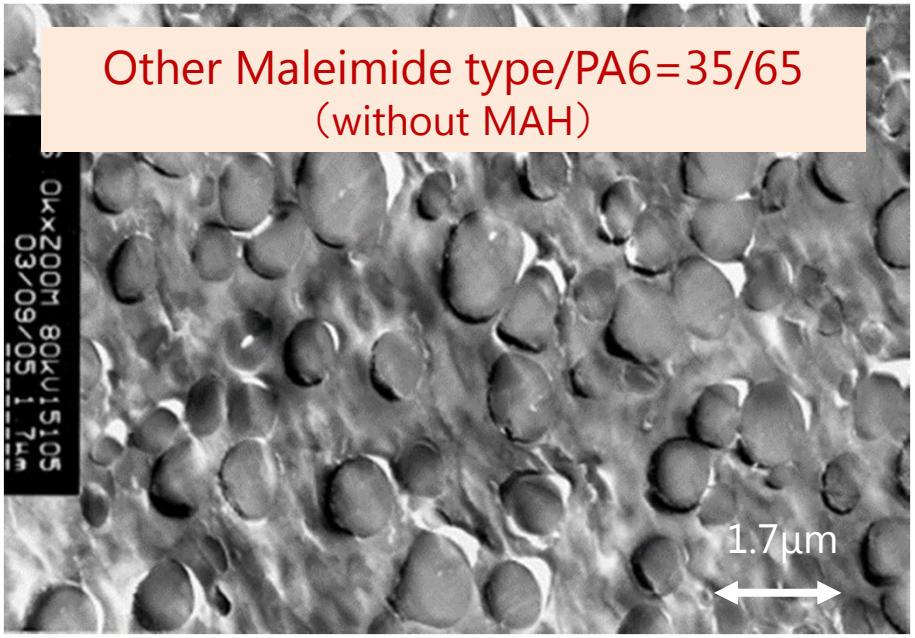
- Reactive Compatibilizer for immiscible polymer blend

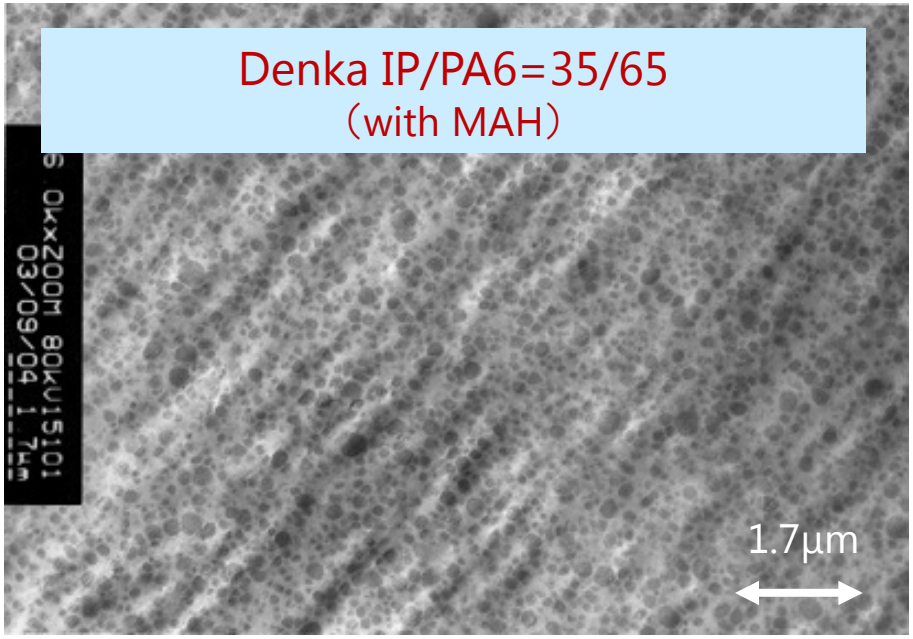


- Graft copolymer can be formed in situ during extrusion process.
- As the results, compatibility of immiscible polymer blend can be improved.

● Formation of IP-graft-PA6 copolymer







Denka IP is well dispersed into PA6 matrix because of reaction between IP and PA6.

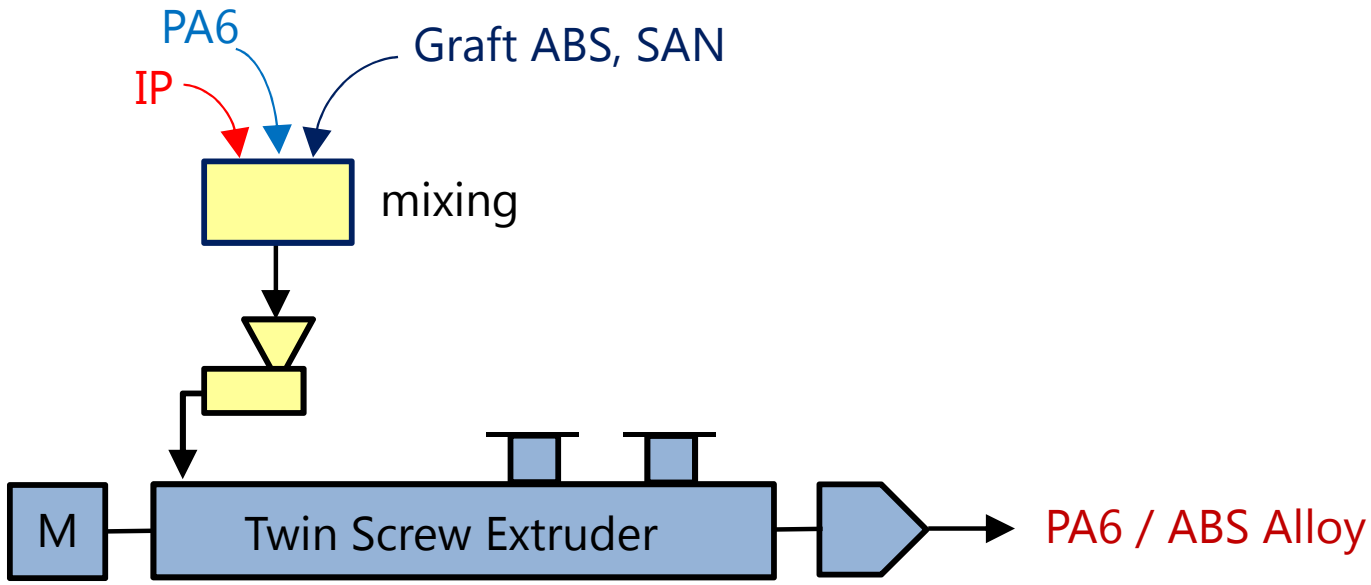
Experimental

Materials

- Denka IP : Standard, High Flow
- PA6 : Standard, High Flow
- ABS : Graft-ABS （PBd > 50%）
- SAN : Standard

Compounding

- Extruder : 35mm Twin Screw
- Cylinder Temperature : 270℃
- Screw Speed : 250 rpm
- Discharge Rate : 25kg /h



Injection Molding

- Cylinder Temperature : 250℃ or 260℃
- Mold Temperature : 60℃

Evaluations

- Mechanical and Thermal Properties : ISO method
- Conditioning : 16h at 23℃ / 50% relative humidity

Properties of PA6 / ABS Alloy

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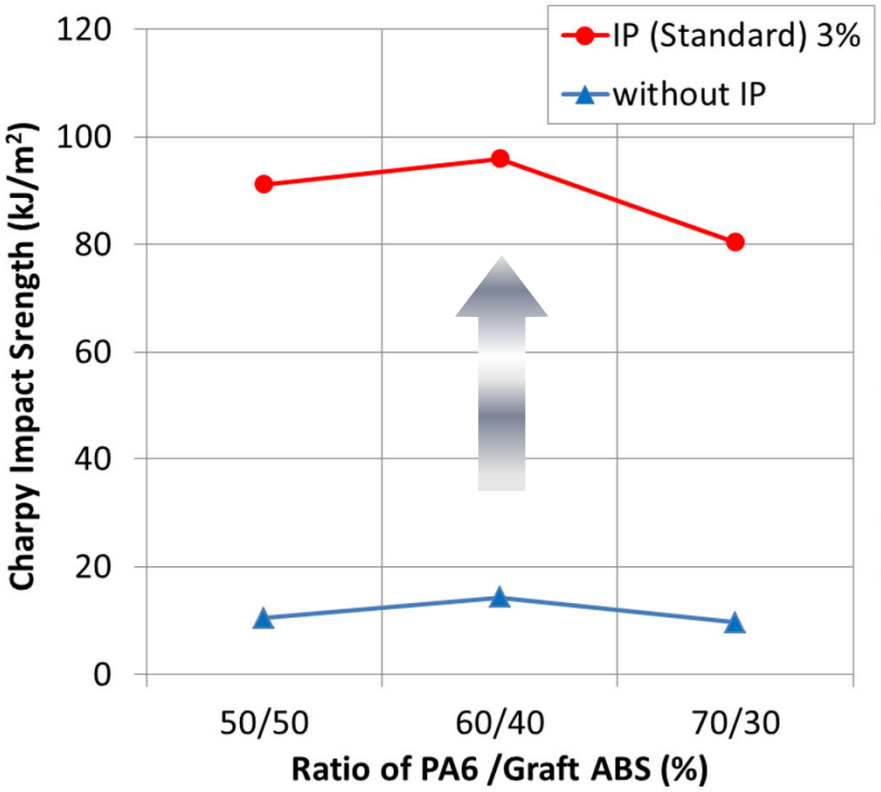
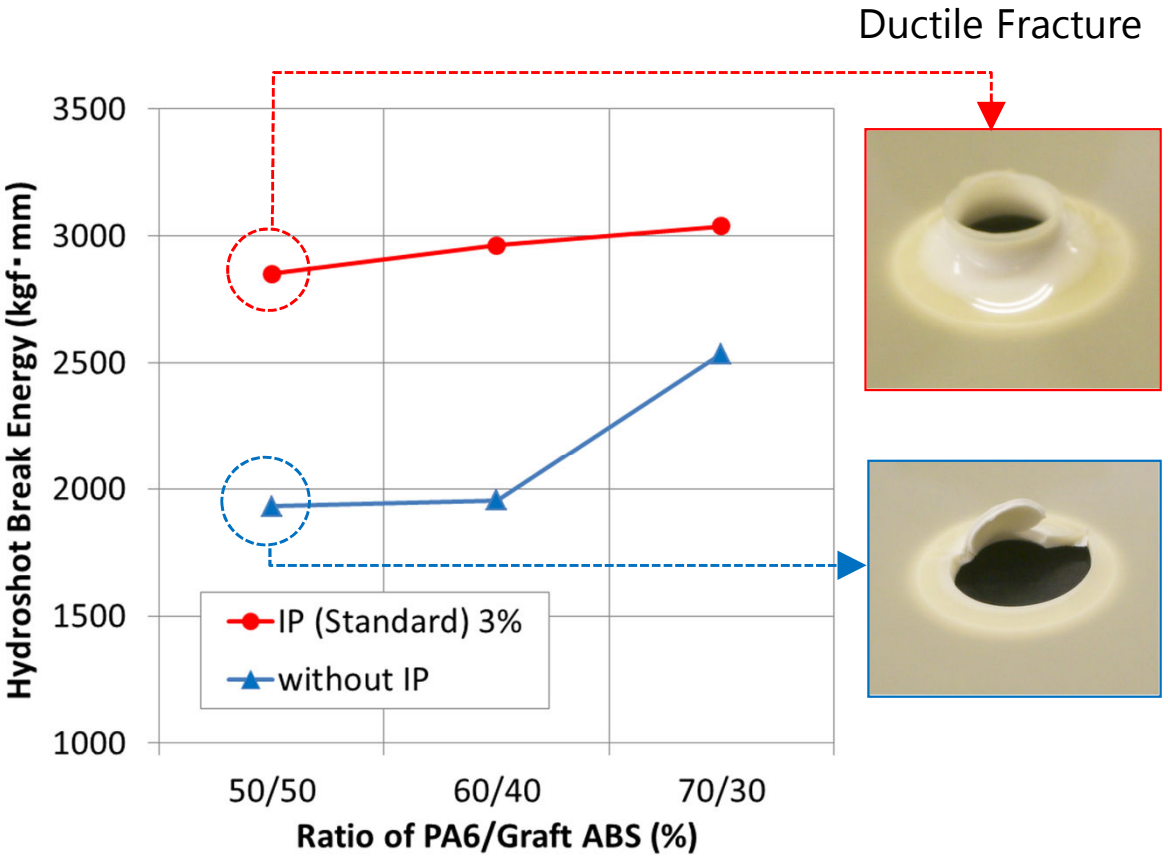
- Impact Properties





Ratio PA/Graft ABS	Unit	50/50		60/40		70/30	
Content of IP	%	0	3	0	3	0	3
Tensile Strength	MPa	22	29	28	35	35	40
Flexural Modulus	MPa	900	1,110	1,060	1,180	1,360	1,530
HDT 0.45MPa (without annealing)	℃	77	83	80	87	86	107

* PA6 : Standard Grade

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- Effect of Denka IP concentration

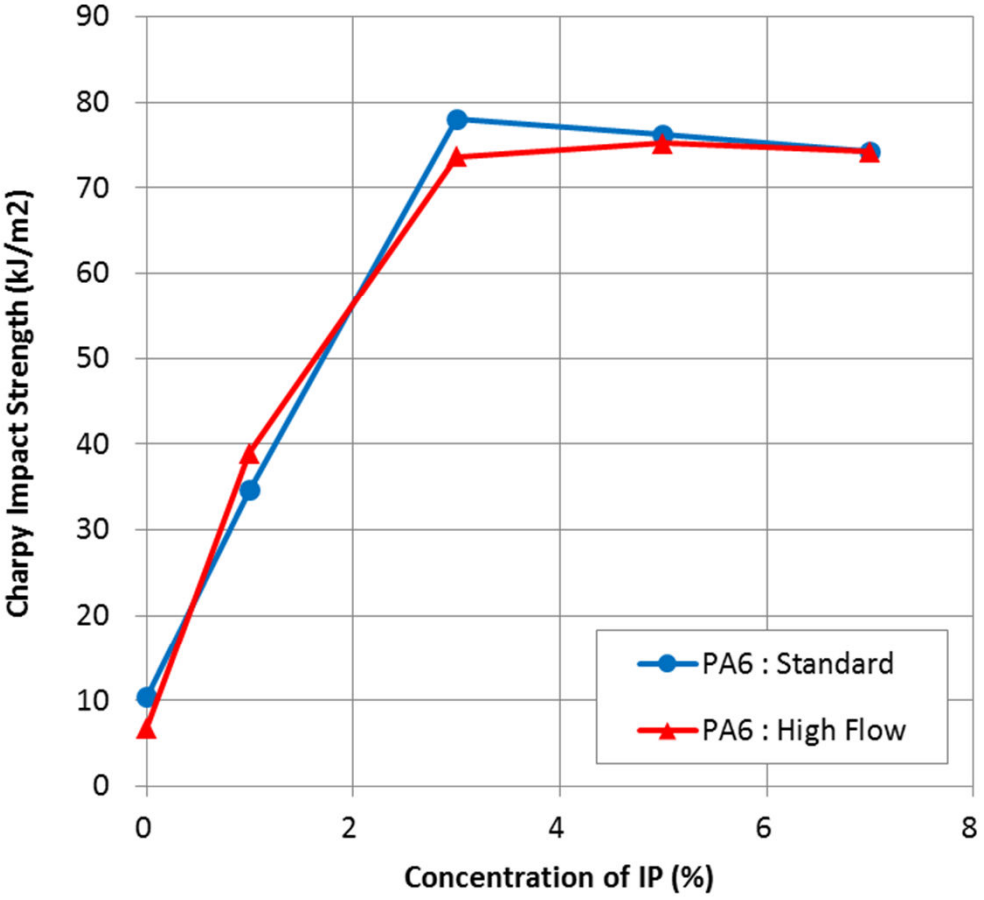

Figure Impact strength of PA6/ABS Blend

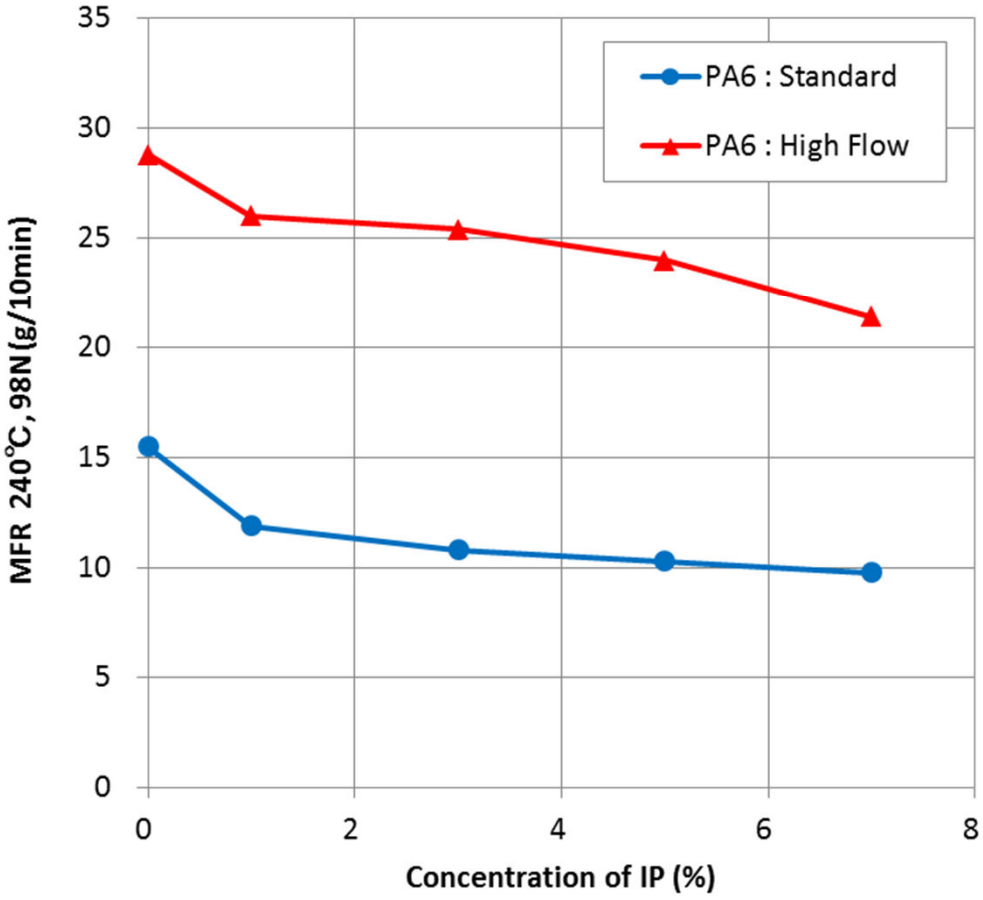

Figure MFR of PA6/ABS Blend

* Denka IP : High Flow , ABS : Graft ABS , PA6/ABS=50/50

Examples of PA6/ABS Alloy modified with IP

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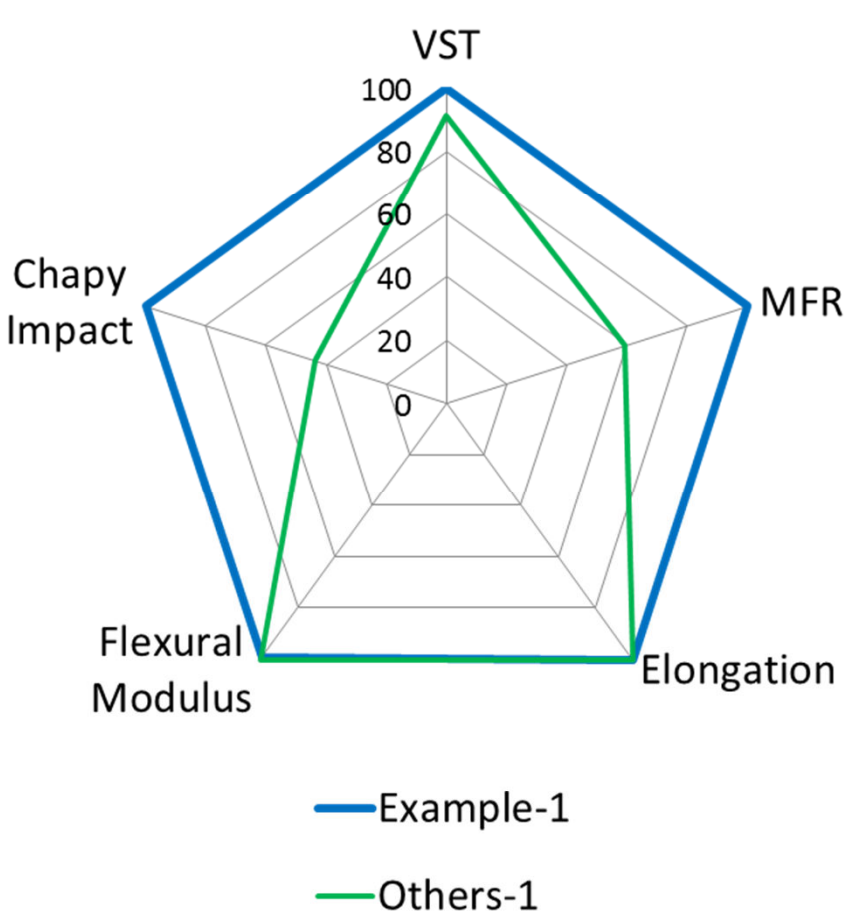
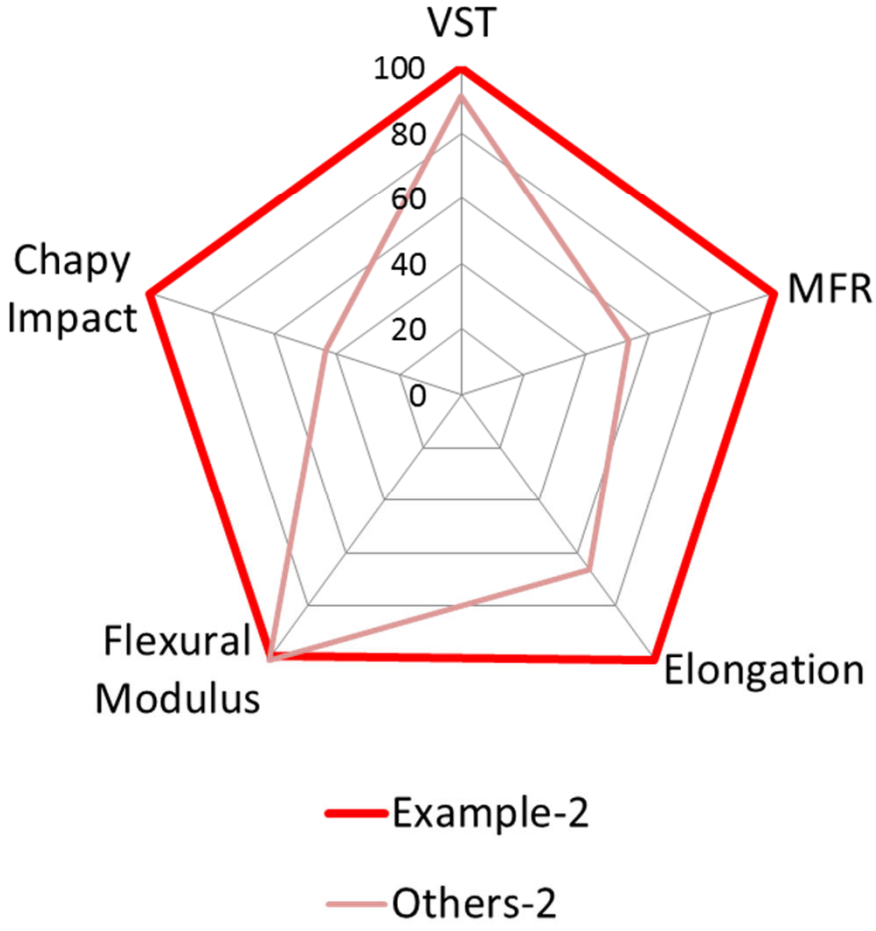
			Standard		High Stiffness	
		unit	Example-1	Others-1	Example-2	Others-2
IP	High Flow	wt%	5		5	
PA6	High Flow	wt%	48		48	
ABS	Graft-ABS (PBd >50%)	wt%	35		30	
SAN	Standard	wt%	12		17	
MFR 240℃, 98N		g/10min	54	32	67	36
Tensile Stress at Yield		MPa	38	37	41	43
Elongation at Break		%	>200	>200	112	74
Flexural Modulus		MPa	1,520	1,530	1,660	1,680
Notched Charpy Impact Strength		kJ/m^2	73	32	64	28
Vicat Softening Temp, 50N		℃	113	103	116	106

※Values are typical and not guaranteed.

Denka IP allows well-balanced properties of PA6/ABS





Summary

- Denka IP has been widely used as reactive compatibilizer for PA6/ABS alloy.
- IP-graft-PA6 copolymer can be formed in situ during the extrusion processing of PA6/ABS alloy because of maleic anhydride groups of IP.
- As the results, ABS domains in alloy become smaller and super-tough PA6/ABS alloy can be obtained.

Thank you for your attention !

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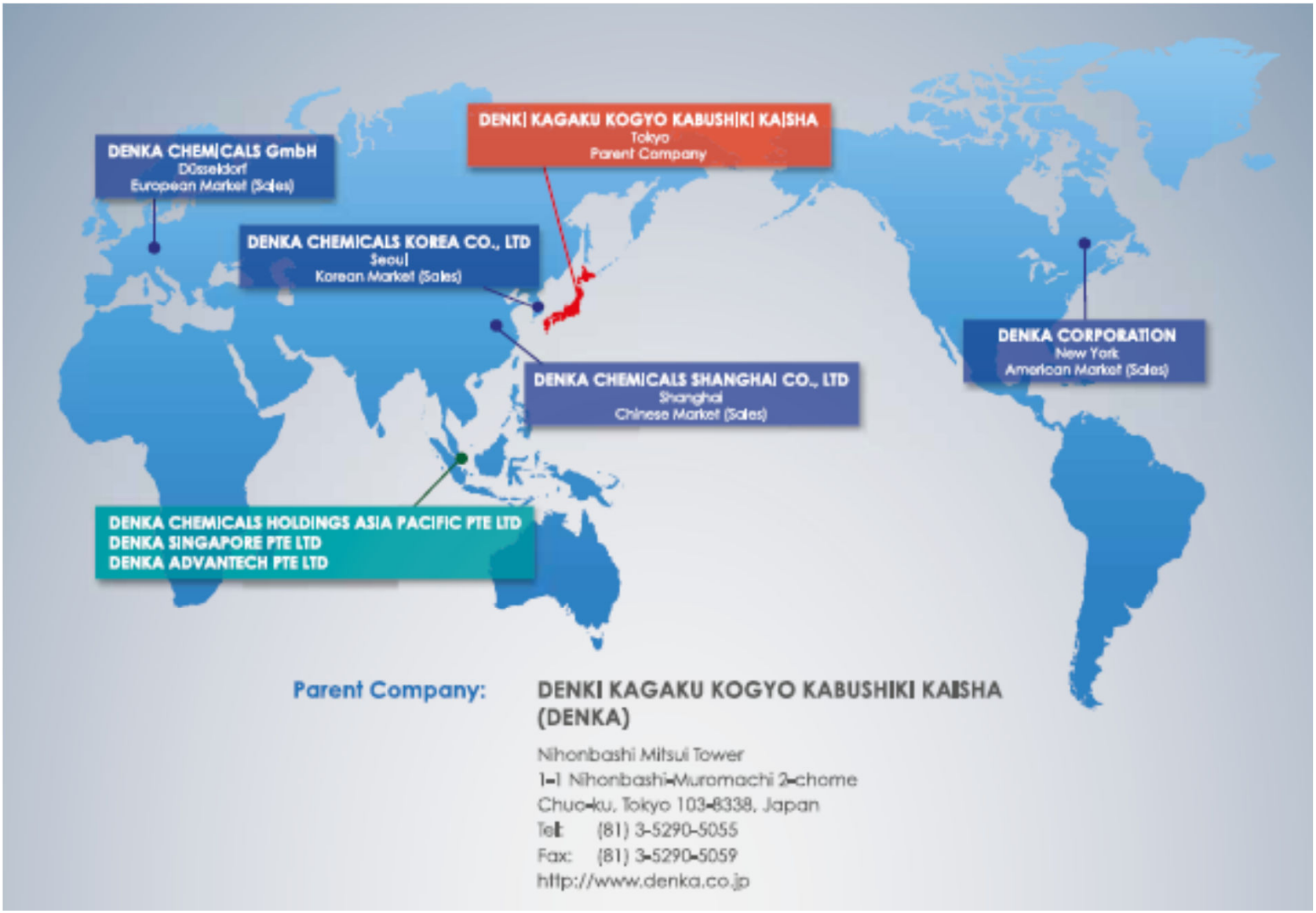

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