PLUSS®

POLYMER BLENDS AND ALLOYS

Part-II NYLON ALLOYS.

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First article in the series (1) had mentioned the improvements that can be obtained in the properties of nylon when alloyed with polyolefins. In the present article we shall discuss some further details on applications of the materials and how those properties are achieved.

Nylon has a number of useful properties as an engineering plastics. However, some of its properties suffer when the ambient conditions change. For example, the impact strength is low in dry state and high in humid conditions. Dimensional stability is badly affected when a nylon moulded part moves from dry to humid atmosphere or vice versa. To improve upon these and other drawbacks the polymer manufacturers have developed a range of alloys based on nylon.

It was Du Pont's introduction of Zylel Supertough Nylons in 1975 and the understanding that small amounts of polyolefins or rubbers dramatically change the fracture behaviour of polyamides that led to improvements in impact properties of not only this but other engineering plastics as well.

Properties

Property enhancement obtainable in major nylon alloys may be summarised as follows:

Base	Modifier	Property
Nylon 6	PE	Dimensional stability, toughness
Nylon 6	PP	Dimensional stability & higher HDT
Nylon 6	EPDM	Very high toughness
Nylon 6,6	PE/PP	Dimensional stability, toughness & higher HDT than corresponding Nylon 6 alloys.
Nylon 6,6	EPDM	Very high toughness.

Improved dimensional stability results from lowered water absorption in those alloys. Filling with glass fibre raises the stiffness and continuous service temperature of the corresponding unfilled nylon alloy.

Presence of acid group compatibiliser also aids dispersion and bonding of glass fibres to the nylon matrix and the resultant alloy has better impact strength than the filled alloy without the compatibiliser. Lower water absorption means less drop in stiffness in higher humidity environment. This in practice means that same stiffness may be obtained with lesser glass content, providing savings in part weight and volume cost. (2) Nylon/PP alloys have higher stiffness than the corresponding Nylon/PE ones. One specific application for this class is listed as castor wheels. Other Nylon blends in commercial usage include Nylon 6 or 66 with ABS/SAN - reported advantages are increased deflection temperature under load, distinctly improved impact strength and lower water absorption. A nylon/aromatic polyester/modifier blend is said to be highly heat resistant, low temperature impact resistant, chemical resistant and has low water absorption. (3) Specific properties range available in commercial products is listed in table below. This table is abstracted from a comprehensive table presented by Utracki in his excellent book Polymer Alloys and Blends (1989) (4). No attempt is made to give details of any preferred grade from any manufacturer since the purpose of this series of articles is to introduce materials. Selection of material for any particular application would mean requirement of much more data than can be presented in this article.

Resin or Blend	Commercial Name	Elong %	Flex Mod (GPa)	Tens. Str. (MPa)	Notched Impact Str (J/m)23°C	HDT (1.82MPA°C)
PA-6,6	Zytel	60	2.83	83	53	90
PA/PO	Zytel-ST	60	1.72	52	907	71
PA/PPS	US Pat. 4,292,416	90	2.18	65	186	88
PA/Ionomer	US Pat 4,404,325	252	1.80	45	955	-
PA-6,6/PPO	Noryl-6TX	60	2.14	60	215	143
HIPS	"	8	7.66	159	105	235
PA-6,6/Elast	Bexicy	120	2.07	62	1030	115
PA-6/ABS	Elemid	-	2.07	48	998	200

PA = nylon
PO = polyolefins
PPS = polyphenylene sulphide
PPO = polyphenylene ether
HIPS = high impact polystyrene
ABS = acrlonitrile butadiene styrene copolymer

Applications

Based on the above considerations Nylon alloys find use in following areas:

Tool handles, housing for motors and hand tools, motor vehicle spoilers, hubcaps and covers, door fittings, panels, handles, automotive cooling fans, motorcycle levers, & helmets.

The applications listed show that these materials are useful where thermal, mechanical and chemical stresses are involved. It is also possible to get excellent surface furnish in these mouldings.

(4) Allied signal have reportedly an alloy of Nylon 6 which effectively competes with Nylon 11 and 12 for heat and chemical resistance but at one-third the cost. The proprietary alloy is designed for automotive brake liners, cable jacketing and hydraulic tubing which must endure exposure to zinc chloride and road salts.

(5) GE's Noryl GTX is a blend of PPE with Nylon. By contrast all other PPE blends are with Polystyrene. A small proportion of a modifier is used. The blend in most cases has a matrix of nylon with PPE acting as compatibilised low density filler.

(6) Nylon/PPE alloys are also available from Mobay (BAYER) BASF, Monsanto and Allied Signal. These alloys provides excellent impact strength even at low temperatures plus excellent stiffness and surface finish.

(7) Shell have reported Nylon blends with functionalised styrenic block copolymers (maleic anhydride grafted on their Kraton rubber) and a new modified block copolymer. The latter is said to give low temperature toughness superior to that obtained with the former or maleated EPR even at -40*C. Compatibilising efficiency of these new materials was tested in nylon/PP blends.

(8) Akzo range has alloys based on functionlised polyolefins. These are said to fit the cost/performance gap between PP and reinforced nylon.

Continuous improvement is being made by various companies to achieve better weatherability, high gloss retention and colour stability.

Modification of Nylon

For Nylon to form alloys with any other polymer the added polymer must have functionality that is compatible with nylon. Thus the ester, acid or anhydride group containing polymers may be reacted with ammonia or other aminating agents to give groups compatible with nylon. Such polymers having acrylates, acrylic acid, anhydride groups may be part of copolymer macromolecule, e.g., SMA grafted on to polyolefins.

Nylon may then be blended with another incompatible polymer using a compatibiliser derived from any of the above imidized material or the amine end group from the nylon molecule itself may be reacted with the reactive group on the added polymer to form an alloy.

(9) Rohm and Haas offer a number of modifiers for nylons. These include acrylic imide copolymers that are compatible with nylons and do not dimnish chemical resistance or barrier properties of the nylons. The modifiers are effective in increasing the melt viscosity of the low molecular weight nylons thus improving film extrusion, blow moulding and thermoforming. Their use in higher molecular weight nylons is limited since the melt viscosity becomes too high. A reactive butyl acrylate based toughner is recommended to improve toughness of normal nylons.

Manufacture / Production

The majority of commercially important polymers are immiscible with one another. When mixed and extruded to make a blend, one polymer will form a dispersed phase in a continuous matrix of the other polymer. Generally, the more viscous polymer forms the dispersed phase. When subjected to further processing the dispersed phase will usually agglomerate into larger domains.

Such a problem also occurs in Nylon blends with polyolefin and other polymers. Phase agglomeration is prevented by bonding the dispersed phase to the matrix by chemical or physical means as indicated above.

For toughening of nylons maleic anhydride / Acrylic acid grafted polymers are used to lower interfacial tensions between the two phases and achieve stabilisation of the blend. The Anhydride/Acid react with $-NH_2$ end groups of the nylon to form a block copolymer. This block copolymer then provides stabilisation of the morphology of the bulk of the two polymers in the blend. To further get a good blend following points need to be borne in mind:

1. Mixing machine used must provide efficient mixing to get desired morphology of one phase in another.
2. Residence time in the machine should be greater than that required for completion of the reaction.

Due to the above requirements, twin screw extruders rather than single screw extruders are often more efficient for blend formation. Internal mixers will generally not provide high enough temperatures required for chemical reaction. Problems may also result due to poor thermal stability of the nylon in presence of air. For non reactive blends these are a strong contender as a suitable machine for the purpose.

Availability and Prices

A range of alloys are imported into the country. Processors like to hold the information confidential. It is difficult to say what is being imported. Some nylon alloys are currently available in India from SRF and PLUSS™. Both are based on Nylon 6 and grafted polyethylene. Pluss also have plans to shortly introduce Nylon 6/PP, Nylon 6,6/PE and Nylon/EPDM alloys to provide a fuller range of materials. The demand for such materials is now beginning to appear in the country.

Prices of toughened material tend to be approx. 20-30% higher than the corresponding straight nylons whether filled or unfilled. PLUSS™ ADNYL® range of Nylon Alloys start at Rs.180/- per kg.

Future in India

Although super tough nylon alloys have been available and manufactured also in India for several years but the user confidence is still low and applications very few. We expect this situation to improve as more companies enter the field. Work will have to be done in application development. Also required is an increase in the technical knowledge dissemination within the industry to understand the newer materials now appearing in India.

References

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