An Introduction to

Alloys and Blends of Engineering Plastics

One of the fastest growing areas in the field of Engineering Plastics is their Alloys & Blends. This is because Alloys & Blends allow tailor-making of materials with desired properties while keeping the cost under control....

In recent years, there has been a significant progress in Compounding of Engineering Plastics in India. This is mainly driven by special needs of Automotive and Electrical & Appliance industries due to introduction of high-performance applications as well as due to regulatory requirements and to adhere to stringent specifications. Several new applications have been developed as well as material selection has been optimized to meet specific end-use requirements. A classic example and perhaps the first such large scale move to Engineering Plastics in India is the household electrical switch. Traditionally made of thermosetting PF, MF and UF Resin and then from Filled PP all these switches are now made of FR Polycarbonate.

Alloys & Blends are mixtures of two or more polymers. Whether two polymers will mix or not is basically decided by the polarity or solubility parameter. A lot is also decided by the laws of Thermodynamics. To make it simple, let us say that rule-of-thumb is “if the difference in solubility parameter is less than 0.1 then the polymers are expected to be miscible”. If this difference is more than 0.3 then they may be immiscible. However, there are several other factors that affect miscibility and hence it is not easy to predict how a mixture of two polymers will behave. For instance, PP and LDPE are both simple non-polar hydrocarbon polymers and one would expect complete miscibility in all proportions. But this is not the case. Miscibility is also affected by temperature thereby further complicating the issue. This is why polymers seldom give good stable blends.

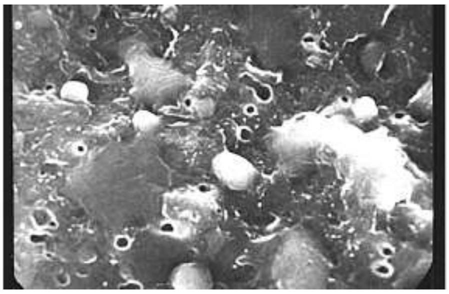
One notable exception is the blend of Polyphenylene Ether with Polystyrene which is a rare example of a completely miscible blend. It was manufactured for the first time in India by GE Plastics under the trade name of Noryl in 1993. PPE and PS are polymers that actually mix completely in all proportions. By itself PPE is difficult – if at all possible – to process due to its high melting point. However, when blended with PS it gives a nice blend that will have the good processing characteristics of PS and the high properties of PPE. This blend finds wide usage in automotive applications. Due to its exceptionally low water absorption, it is also used in making items like water-pump impellers.

It is very unlikely that two polymers will be completely miscible. Usually they are non-miscible, sometimes partially miscible. It may be possible to overcome this issue by using suitable Compatibilizers....

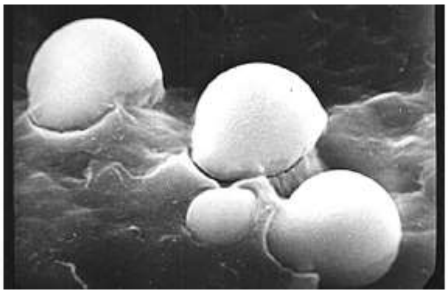
Next is the case of partially miscible polymers. Here the two polymers (or a part of the two polymers) are compatible thereby facilitating the formation of a stable blend. A good example of such a blend is Polycarbonate and ABS. The SAN phase of ABS and PC partially dissolve in each-other thereby making this a compatible blend. Both blends are homogenous and have their own Tgs (thought shifted towards each-other). Due to miscibility of SAN and PC usually no compatibilizer is needed to make this PC/ABS blend.

In case of non-miscible blends, a compatibilizer is needed because the morphology is coarse and adhesion between phases is very poor. Non-reactive compatibilizers have structures which are partially miscible with each component of the blend. This improves the interfacial bonding and facilitates adhesion between the blend components.

Reactive compatibilization on the other hand is an in-situ formation of chemical bonds at the time of melt compounding. The compatibilizer has one or more reactive sites that react chemically with one or more components of the blend generating a structure that makes the blend at least partially miscible. This stabilizes the blend and makes it usable. An example of such a blend is PP+PA6 with PP-MAH as the reactive compatibilizer. PP in the PP-MAH graft which dissolves in the PP phase of the blend while Maleic Anhydride reacts with PA6 phase thereby forming a sort of bridge which stabilizes an otherwise non-miscible blend. Reactive compatibilization changes the morphology drastically as can be seen from the images below.



With Compatibilizer



Without Compatibilizer

Some examples of such blends with reactive compatibilizers are PP+PET, ABS+PA6, PBT+PP, PA6+EPDM, PPE+PA66, PET+ABS and so on. In theory, it is possible to make a compatibilizer for almost any combination of polymers. However, all such blends may not have synergistic properties and commercial viability.

High quality melt compounding of blends requires special machines and designs together with proper process control. It is best done using Co-rotating Twin Screw Extruders....

Alloys and Blends may be made either by melt compounding in an extruder or in solution. Blending in solution is not usually done due to the high cost of solvent removal and recovery as well as associated environmental issues. Blends are best made in Twin Screw Co-rotating Extruders. This affords the simplest and most efficient route to making good blends.

Blends of Biopolymers with conventional polymers is a recent development. It not only is a technology challenge but also involves special materials and processes....

An important recent development is the blending of Biopolymers with conventional polymers. This approach is environmentally beneficial and offers good usable blends that are commercially viable. Though there are few manufacturers who offer these blends commercially, there is a significant amount of research in progress so we should be able to use such blends on a large scale in the future. Polylactic Acid is one of the mainstays of biopolymers and can be blended with polymers like PVA, PP, HIPS, Polyacetals, ABS, etc., to enhance the properties. Blends with PMMA may be transparent. Melt blending is not easy as PLA is sensitive to high melt temperatures. Various compatibilizers including those based on Maleic Anhydride, Epoxy and Isocyanates amongst others have been reported.

Another biopolymer of interest is starch and its derivatives. Low cost and abundantly found in nature, starch is a very good candidate for commercial usage. However, it has poor properties and is very hydrophilic in nature making it difficult to get usable blends. Some compatibilizers that may be used with starch are derived from glycidyl methacrylate, maleic anhydride, peroxides, etc.

One very interesting development is the use of a flame-retardant 50:50 blend of PLA/PC for IT devices. Another example is the reSound range of blends by PolyOne which consist of biopolymers like PLA and others with Engineering Plastics. The company claims that these blends may be used for consumer durable goods, electronic equipment, medical devices, automotive interiors, etc.

In conclusion, alloys and blends of Engineering Plastics have great potential especially with next-generation applications like automotive, aerospace, appliances and medical devices. With more blends of biopolymers on the horizon, it is only a matter of time before these blends become commonplace in applications of daily use.

If you have any other questions or would like to suggest topics for us to write about, please feel free to contact us at info@polymerupdateacademy.com

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