# To enhance the impact strength of Acrylic Polymer by retaining it's transparency using Interpenetrating Network (IPN).

## Objective

- **To enhance the Impact Strength of Acrylic Polymer by retaining its transparency, selecting the appropriate co monomer or co blending polymer using Inter Penetration Network. (IPN)**

## Introduction

- Poly (Methyl Methacrylate) (PMMA), which has a glass transition temperature (Tg) of about 100° C, is one of the more brittle amorphous thermoplastic materials.

- The molecular mobility in the glassy state is low, and the Polymer chains are unable to undergo large-scale molecular motions in response to rapidly applied external stresses or impacts.

- Thus although it has relatively good global creep properties at ambient temperature, PMMA is brittle and notch sensitive.

- Owing to its transparency, PMMA is often used in applications that require good optical properties.

- However, its brittleness is a limiting factor in many cases (such as in the Automobiles).

- For high molecular weights, the energy dissipated during the fracture of commercial grades of unmodified PMMA is significantly lower than for Polycarbonate (PC), which is one of its main competitors for optical applications

## Improving Toughness

- The toughness of PMMA can be obtained by combining it with a discrete secondary phase that has sub ambient Tg.

- Since this modifier is rubbery at room temperature it introduces soft, incompressible domains into the matrix.

- The size of these domains should be chosen to maximize their influence to optimize the rate of energy dissipation during crack development.

- This approach is currently used to improve the toughness of a wide range of thermoplastics, ranging from amorphous and semi crystalline thermoplastics to highly cross linked thermoset.
- To maintain good optical properties, the rubbery domains in modified PMMA should be smaller than the wavelength of visible light, and/or the refractive index of the secondary phase should match that of the matrix.

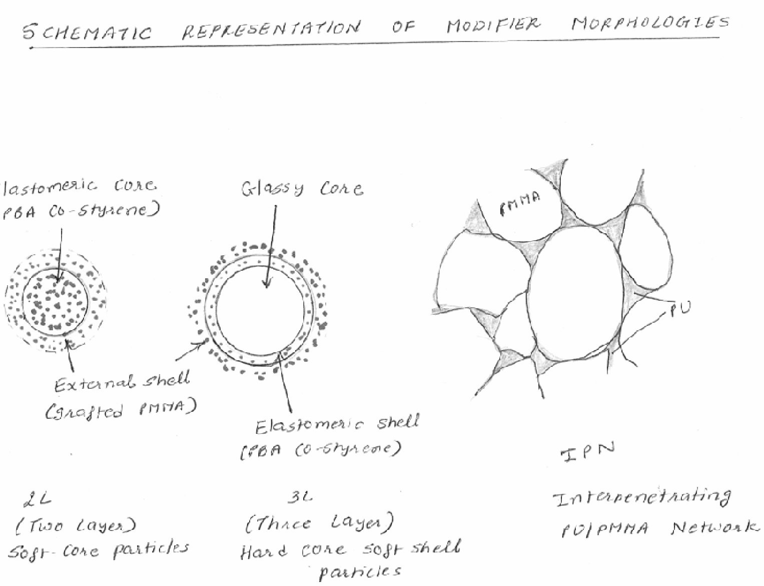
- Thus the size and the nature of the rubbery domains are of primary importance for the mechanical and optical properties.

**Different Morphologies**

- The simplest is two layer morphology (2L) consisting external shell by grafted PMMA covering Elastomeric core.

- Another is three layer (3L) particles consists of glassy PMMA core surrounded by a rubbery inner shell and a grafted PMMA outer shell.

- The third and more advantageous type in IPN (Inter penetrating Network). Here, PMMA is interpenetrated between crosslinked PU.



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- The most obvious distinctions between the 3L-particle-modified PMMAs and the 2L particle-modified PMMAs lie in the nature of the particle cavitation.

- In the case of the 2L particles, cavitations occurs in the particle center, generally giving rise to the formation of a single void.

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- In the 3L particles, cavitation initiates in the polar regions of the elastomeric shell.

- 3L particles may show voiding within the whole of the elastomeric shell. The individual voids are separated by ligaments of rubber, linking the glassy outer shell/matrix to the glass inner core.
- As deformation continues, the particle shell become highly elongated, which suggests that they continue to sustain load bearing at deformations well beyond those at which cavitation takes place.

## PMMA/PU IPN

- The term IPN refers to the permanent interlocking of two or more different Polymers, formed by interstatial Polymerization.

- The synthesis involves mixing all the monomers or prepolymers, together with their corresponding cross-linking agents, either simultaneously [to give “simultaneous interpenetrating networks” (SINs)] or sequentially.

- The damage zone is characterized by intense stress whitening around the crack tip.
- At low speed IPN shows no stress whitening. But at high speed it shows 100% stress whitening without cracking due to ductile behavior.
- In 3L30 stress whitening occurs from 10% to 100%.
- In 3L20 stress whitening occurs below 10% and at high speed it breaks.
- In 2L15 and 2L30, at high speed it shows breaks directly without evidence of stress whitening.

- Here, cavitation occurs in the particle center, generally giving rise to the formation of voids. As deformation continues, there is widespread crazing in the intervening matrix regions, with several narrow crazes being initiated at each rubber particle.
- The PMMA particles are then incorporated within the crazed regions of matrix.

- The final morphology of an IPN generally consists of a fine dispersion of distinct phases.

- The impact properties depend on the fraction of PU and its cross-link density. The Tg of PU phase for significant enhancement of the impact properties, it should remain below -30°C.

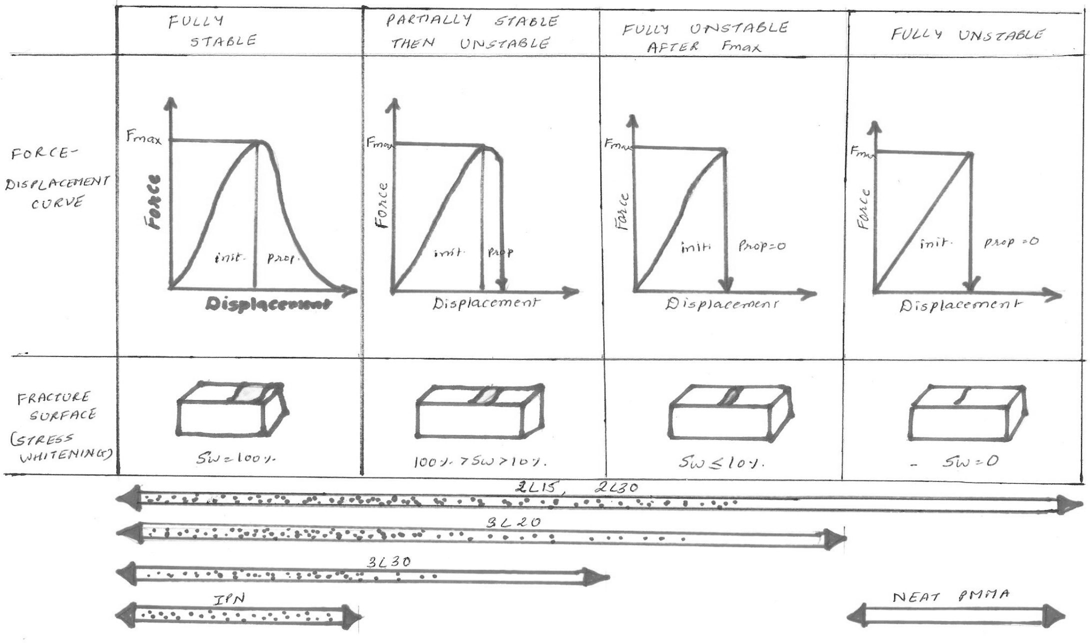
- Increasing PU Content in steps of 5 to 10%, a significant improvement found in impact properties with only 5-6% PU as the secondary phase.

## Fracture Behaviour

- The fracture parameters are obtained from precracked notched specimen deformed over extended range of crosshead speeds using izod test method.
- Specimen thickness ranges from 4.5 mm to 10 mm.
- The result is shown through force-displacement curve.
- The IPN shows stable fracture behavior even at high test speed.

- In 3L30 a transition is seen to semistable crack propagation. Here crack becomes unstable but after initial development of damaged zone.
- Similarly 3L20 and 2L15 shows fully stable crack growth at low speed changes to fully unstable growth at high speed.

STAGES OF EVOLUTION OF FRACTURE BEHAVIOUR WITH TEST SPEED



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## Conclusion

With the help of Interpenetrating Network we can modify PMMA with a ductile behavior even at high speeds of sudden impact loading with retaining its transparency.