Solvent Resistance and Mechanical Properties in Thermoplastic Elastomer Blends Prepared by Dynamic Vulcanization

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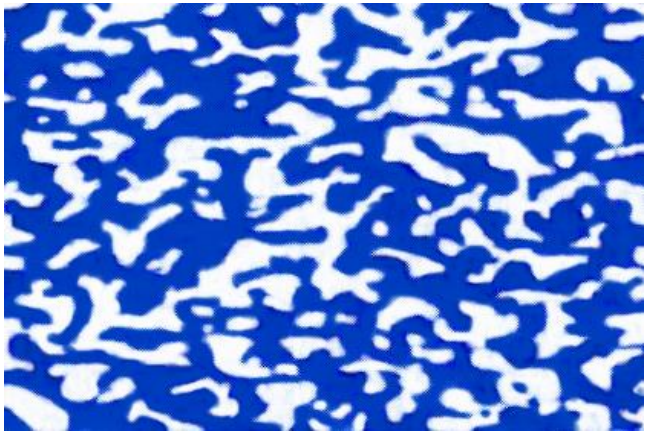
Mixing Methods

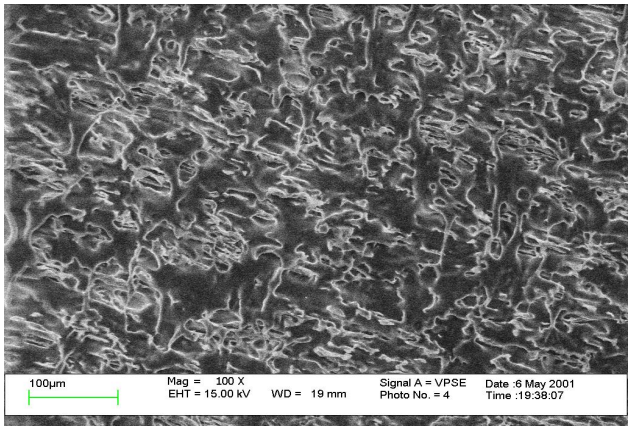
High shear melt mixing

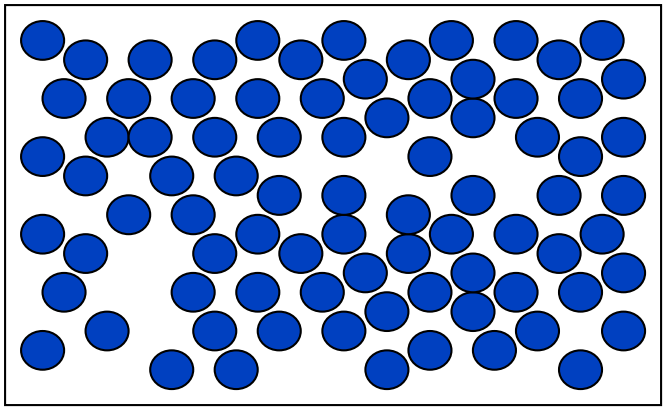
- Without curing agents → *non-vulcanized blends*
  - Continuous phase dependent on proportions in the blend

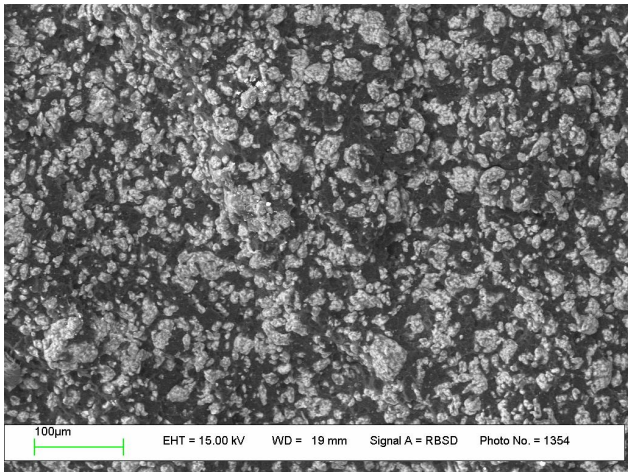
- With curing agents → *dynamic vulcanization*
  - Non-vulcanized component becomes continuous phase, almost independent of proportion in blend

Non-Vulcanization vs. Dynamic Vulcanization





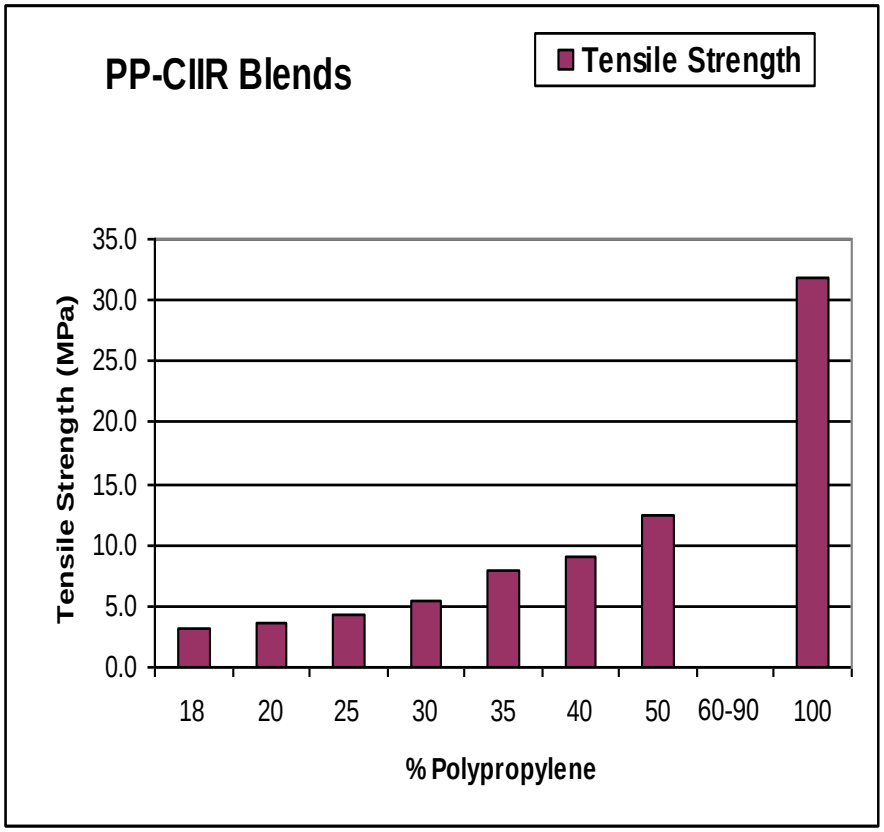


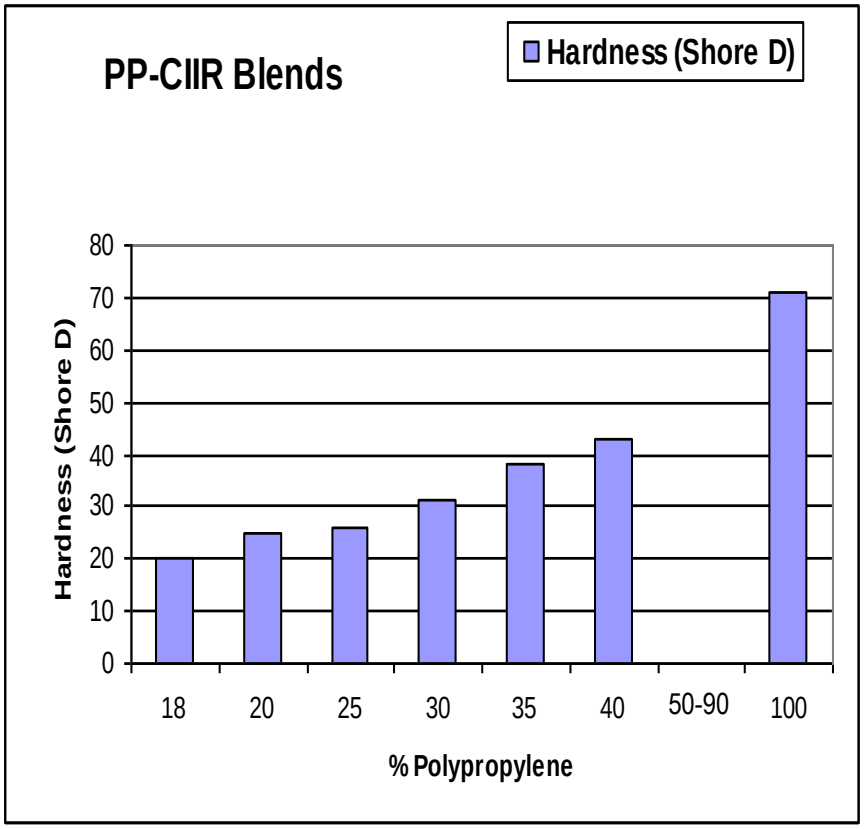


Objective of Present Work

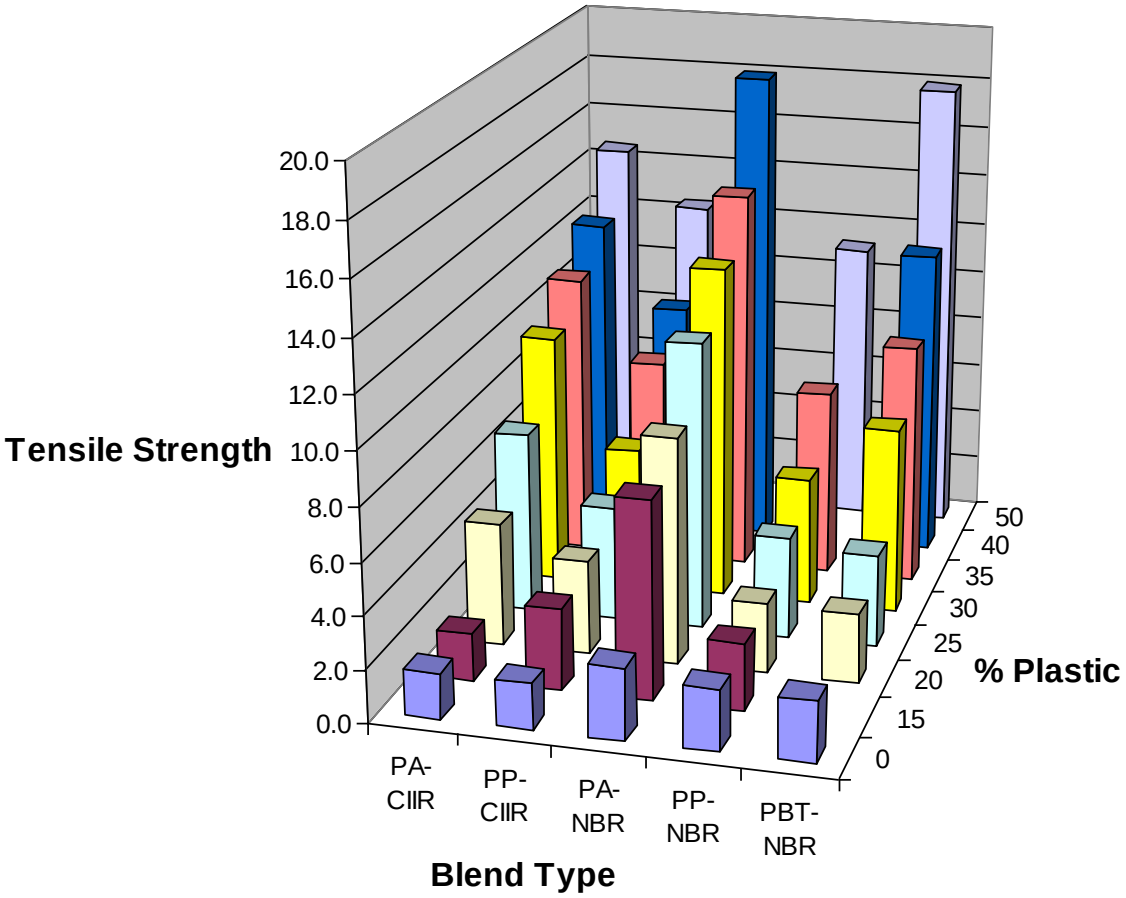
- Dynamic Vulcanization on a Variety of Thermoplastic / Rubber Combinations
  - Thermoplastics (PA, PP, and PBT)
  - Rubber (CIIR, NBR)
- Measure
  - Mechanical properties
  - Exposure to solvents (hexane and $CHCl_3$)
    - % insolubility, swelling index
  - DSC and SEM

Effect of % Thermoplastic on Properties





Tensile Strength Comparison in Blends

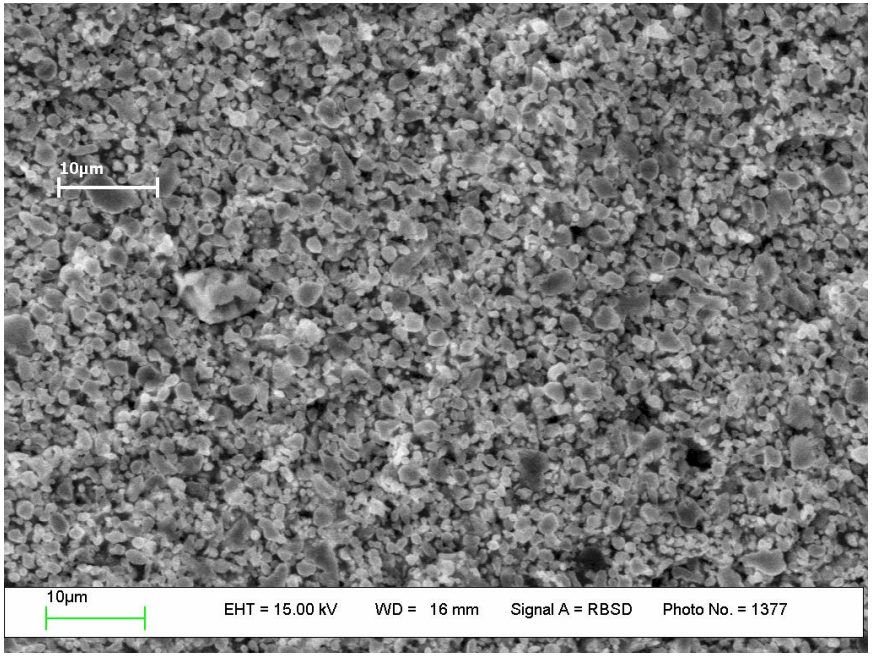


DSC Results – Thermoplastic Phase

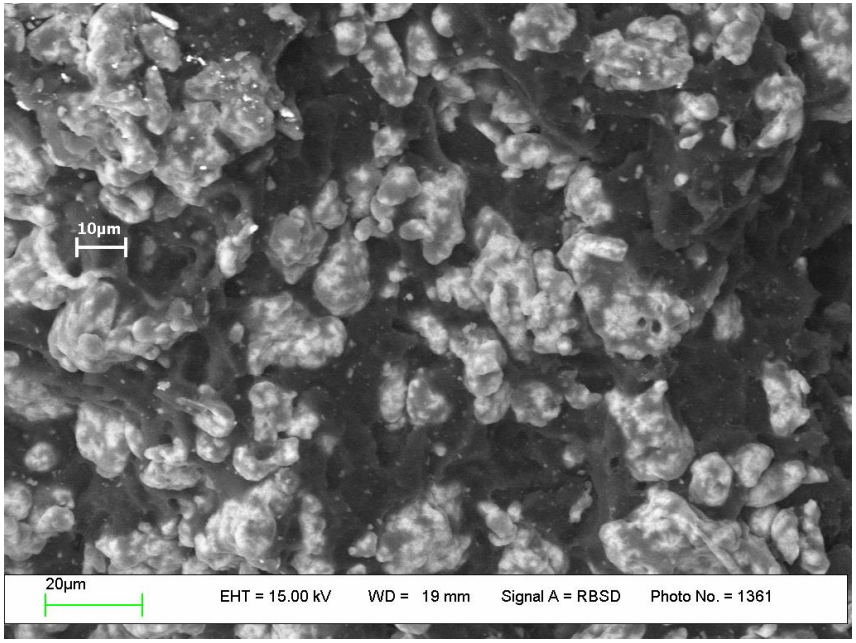
	Tm (°C)	ΔH_f (J/g plastic)
PA	178.7	60.6
PA/CIIR	175.6	58.1
PA/NBR	176.5	58.5
PP	163.3	80.9
PP/CIIR	161.6	83.1
PP/NBR	161.5	80.6
PBT	223.0	38.1
PBT/NBR	222.6	46.0

- Phase separation
- Dynamic vulcanization effects
  - rubber phase (curing, particle formation)
  - thermoplastic phase (MW reduction, graft formation, crystallization effects)

SEM OF PA/NBR BLEND



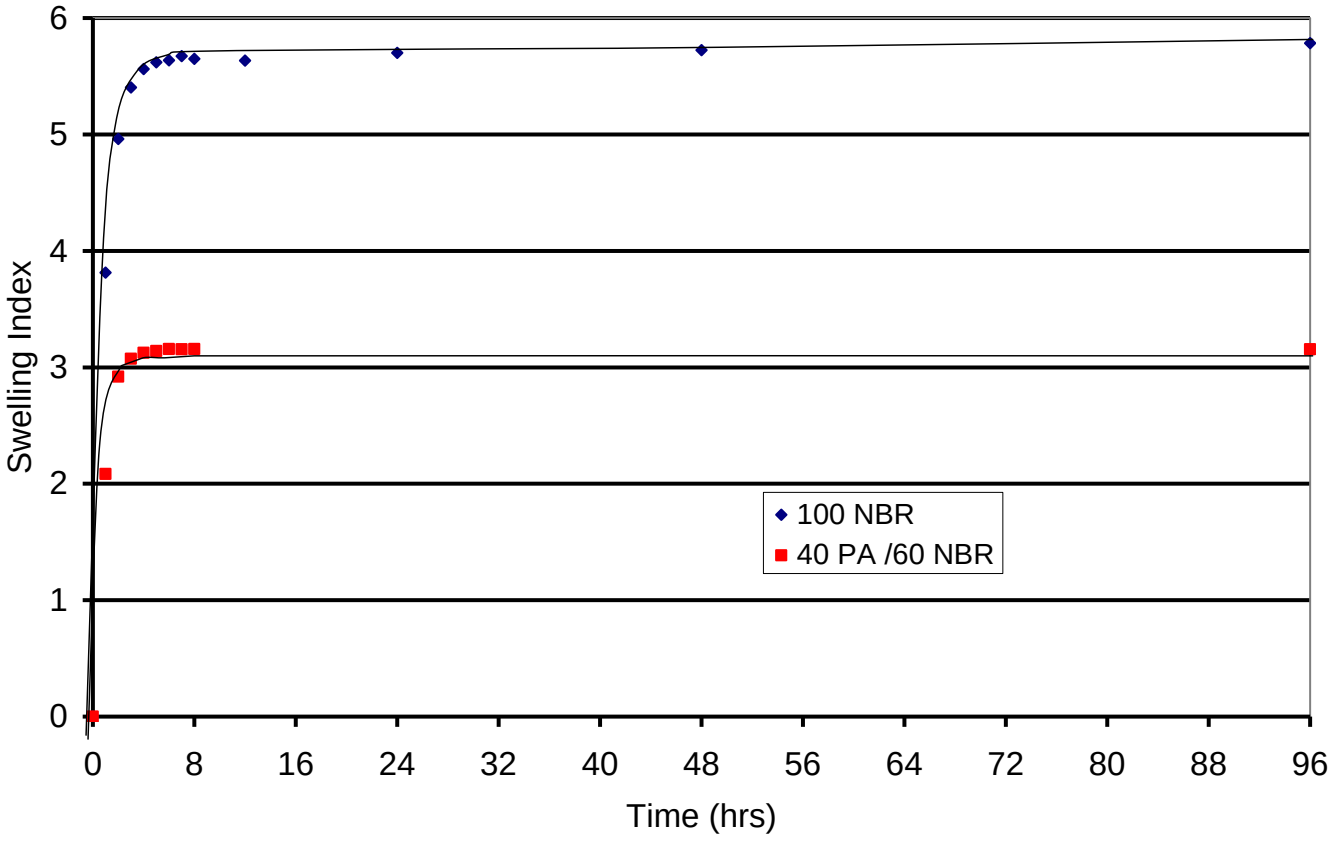
PA-NBR Blend



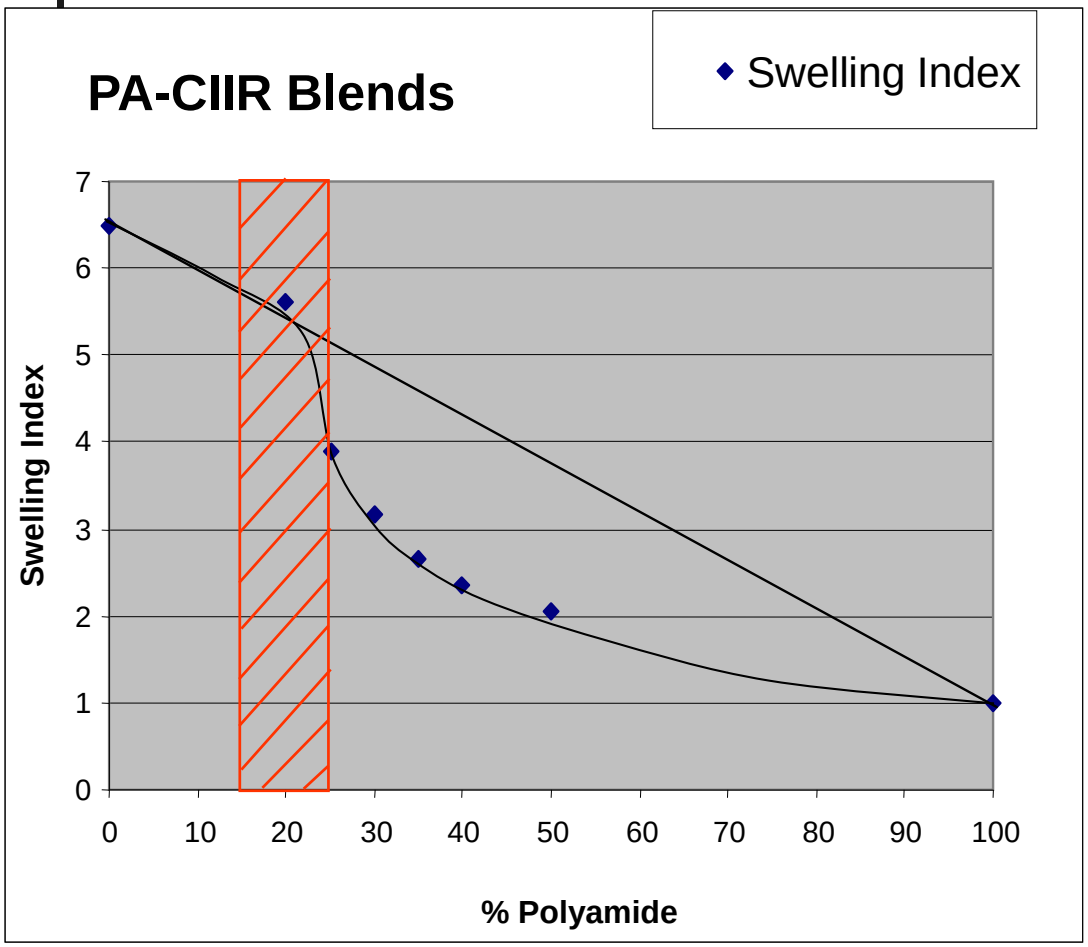
PP-NBR Blend

Solvent Uptake – Kinetic Studies

- Rate of solvent uptake determined on rubber and blend samples
- Blends achieve equilibrium relatively quickly
- Example of 100 NBR and 40 PA/60 NBR

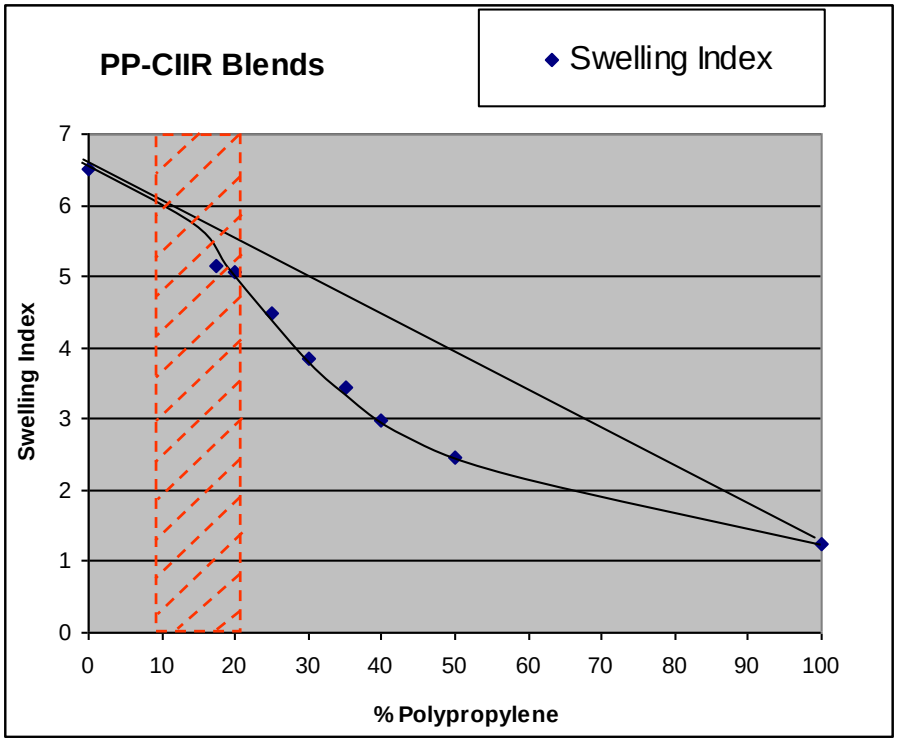


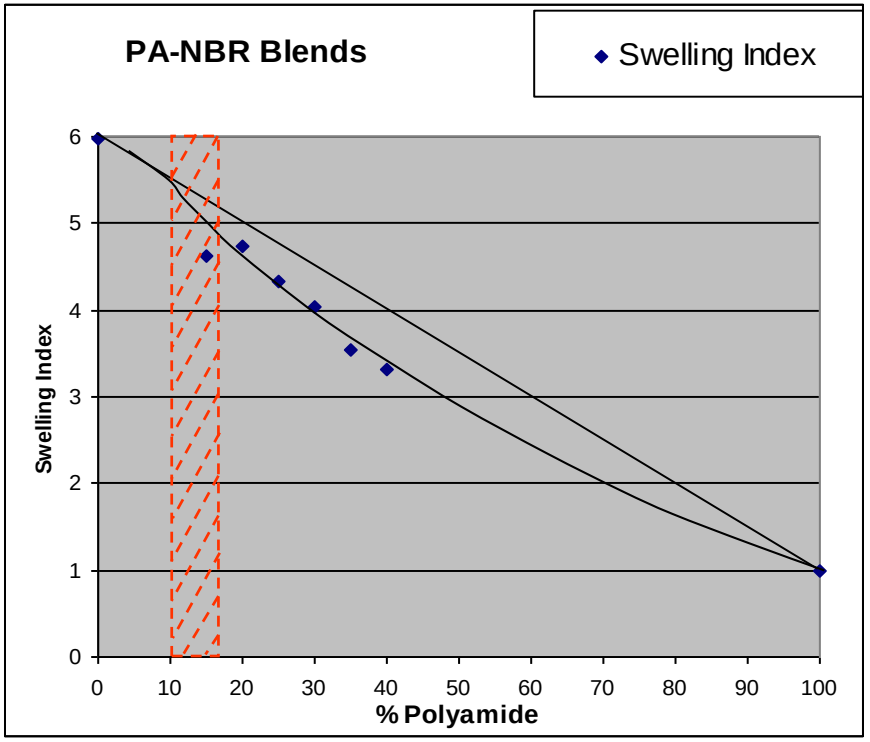
Swelling Index: PA – CIIR Blend at Different Compositions



- S.I. Values consistently below theoretical line (physical mixture)
- Continuous thermoplastic phase prevents solvent expansion of cured rubber phase

Swelling Index Values for Other Blends





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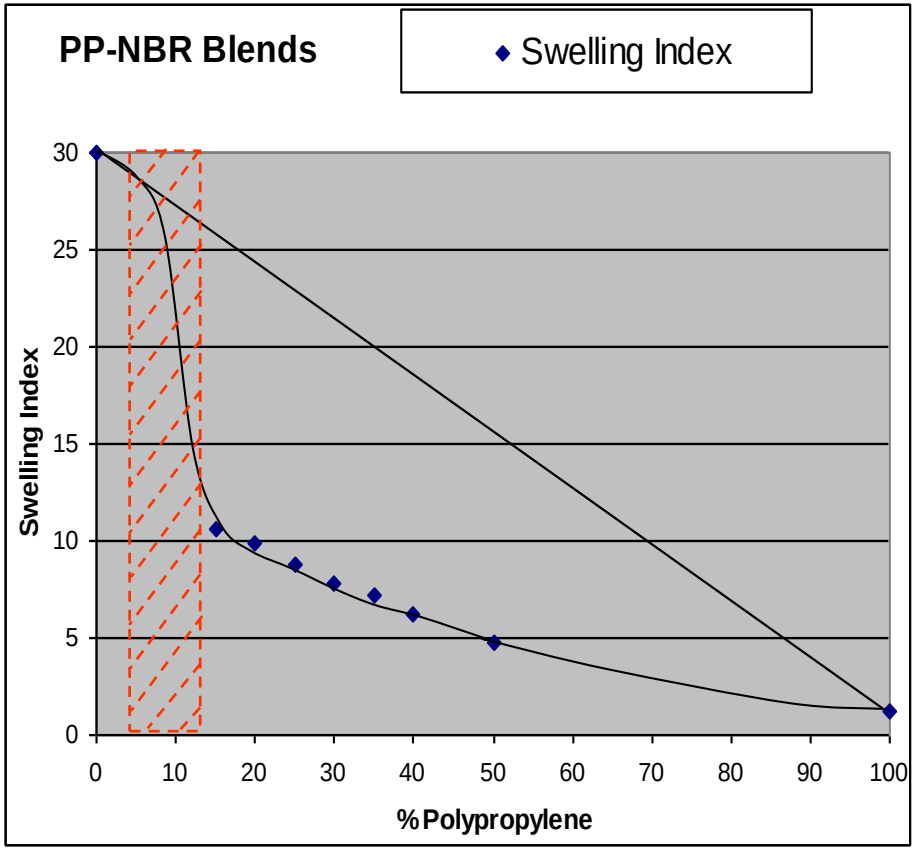
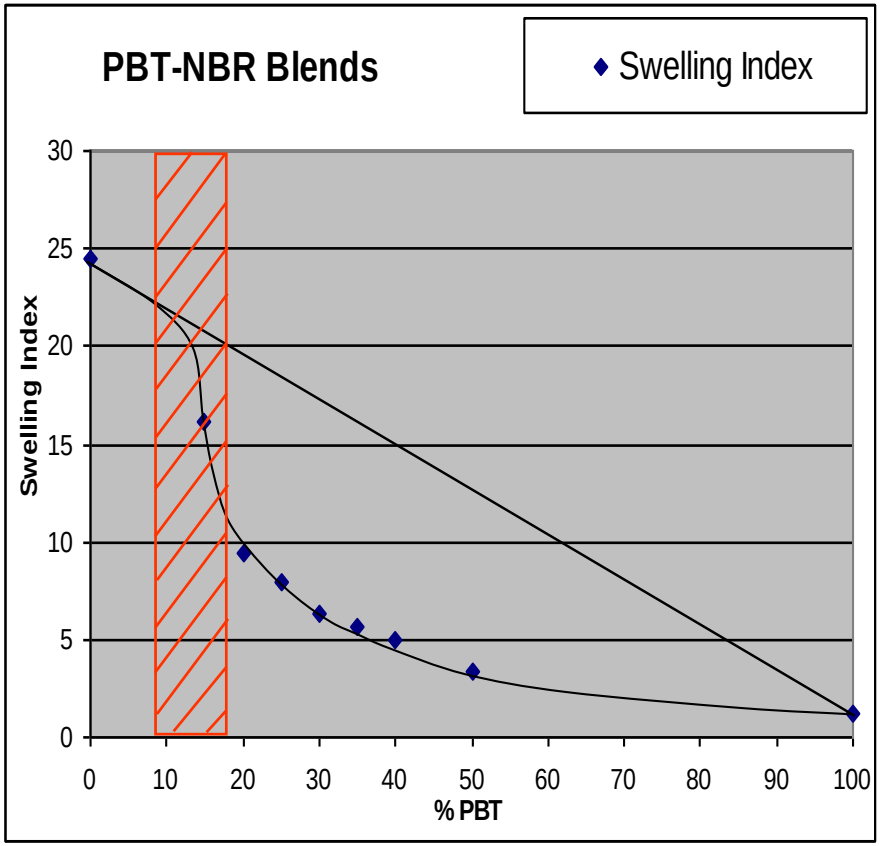
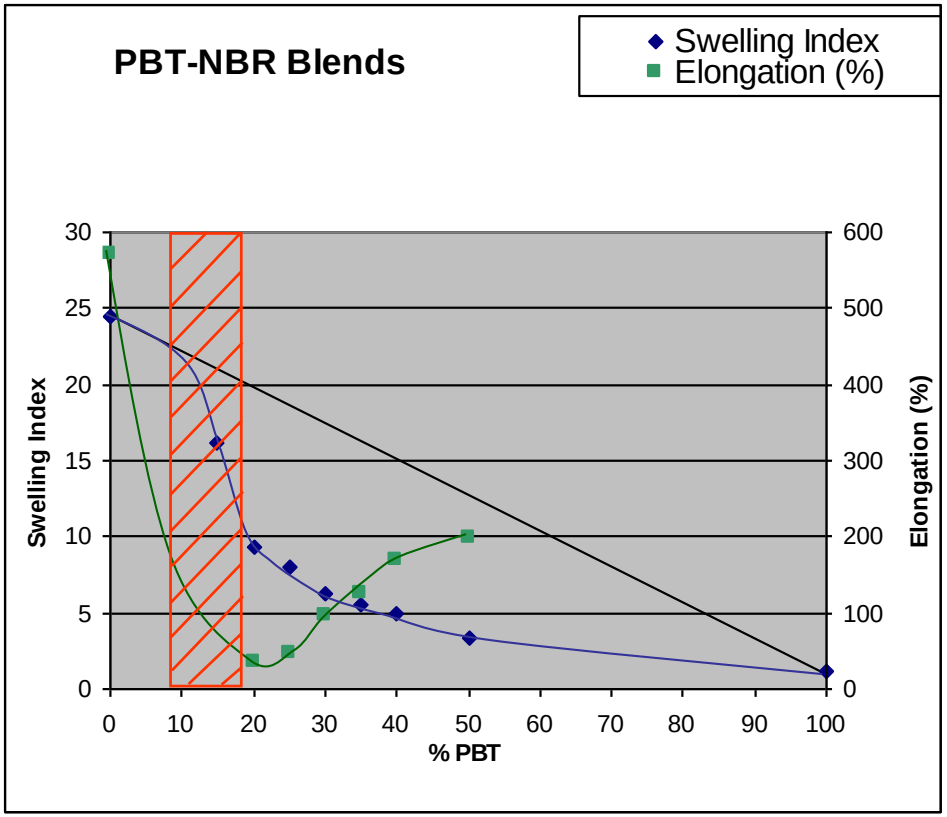




Relationship Between Swelling Index and % Elongation



- Minimum elongation reached at similar composition as change in S.I. Curve
  - Phase inversion
- Similar results for all blends studied.

Conclusions

1. Dynamic vulcanization – variety of rubber plastic blends, many with elastomeric properties.
   - Elastomeric properties seen between 20-40% thermoplastic
2. Both rubber and plastic phases affected during the dynamic vulcanization process.
3. Solvent exposure – rapid swelling upon exposure to solvent (tested on hexane and $CHCl_3$). Similar performance expected with other solvents.

Conclusions (continued)

4. S.I. values of blends are significantly less than expected "theoretical" values.
   - "caging effect" at higher thermoplastic compositions.
5. Minimum elongation values reached at phase inversion.
6. Increased compatibility in blends
   - reduced particle size (discrete phase)
   - frequently produces less caging effect on the rubber phase

Acknowledgements

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