# LIST OF FIGURES

1.1 A schematic representation of different types of morphologies of polymer blends.  
1.2 Proposed mechanism for initial morphology development in polymer blends.  
1.3 Pictorial representation of morphology development during dynamic vulcanization.  
1.4 Structure of TPE and TPVs a) block-copolymer b) dynamic vulcanizates.  
1.5 Morphological scales in iPP with indicated size of dimensions for α-crystalline form.  
1.6 Different stages of spherulite growth as a function of time in PP.  
1.7 Optical micrographs of OHB-5, isothermally melt-crystallized at T < 315 K, (a) and (c), and at T > 315 K, (b) and (d). The scaling bar corresponds to 50 µm. AFM micrograph of OHB-5 (oligo[(R)-3-hydroxybutyrate]/PHB), isothermally melt-crystallized at T < 315 K (e). The scan area is 40 x 40 µm².  
1.8 Morphology of PLLA spherulites after direct crystallization at different temperatures (left column) and annealing at 160 °C for 2 h followed by slow cooling to the crystallization temperatures (right column), respectively. The spherulites were obtained via crystallization at 140°C (a) and (b), 130°C (c) and (d), 120°C (e) and (f) and 110°C (g) and (h), respectively.  
1.9 Effect of melting time on the morphology of PLLA spherulites. The spherulites were obtained via crystallization at 120 °C after melted at 240 °C for different periods of time: (a) 2 min; (b) 5 min; (c) 10 min; (d) 15 min.  
1.10 Influence of film thickness on the spherulitic morphology development in In-Situ Hot Stage Atomic Force Microscopy Study of Poly(E-caprolactone) Crystal Growth in Ultrathin Films in Tapping mode AFM height images of a) 200 nm ii) 30nm- thick PCL film crystallized for 24 h at room temperature. The four images were recorded at the same position, for different scanning dimensions: (a) 20 x 20 µm²; (b) 10 x 10 µm²; (c) 5 x 5 µm²; (d) 1 x 1 µm².  
1.11 Spherulites viewed under polarized optical microscopy for PCL with various Mn indicated in the figure (7c) 40 °C. The nucleation density is found to increase with increasing MW.  
1.12 Polarised optical micrographs of PHB after isothermal crystallization at a 105, b 110, c 115 and d 120°C (×100).
1.13 iPS spherulites grown at 220°C after cooling from the melt at 260°C; optical micrographs (crossed polars) obtained after crystallization in (left) and without (right) the magnetic field.

1.14 Spherulite growth rates of isotactic polypropylene in the presence of dispersed particles of different radii PaP : (a) $r = 0.33$ mm; (b) $r = 0.7$ mm.

1.15 a) Spherulite growth rate of iPP in iPP/PaP blends. [ref.100].
b) Spherulite growth rate of iPP in iPP/HOCP blends as a function of composition.

1.16 Spherulite growth rates of PB1 in PB1/HOCP blends.

1.17 Schematic of phase separation phenomena that can accompany spherulite formation in binary blends (grid density shows concentration of the non-crystallizable component). (a) Initial homogeneous melt. (b) Crystallization of one component changes composition of the amorphous phase in the interlamellar regions of the spherulites. (c) Rapid diffusion of the amorphous component produces a homogeneous concentration distribution on an intermediate composition level. (d) Crossing with the binodal curve causes liquid–liquid phase separation in the amorphous parts within the spherulite. (e) When the concentration gradient at the spherulite growth front surpasses the binodal curve, phase separation in the melt near the spherulite surface occurs.

1.18 Morphology of a PCL/aPS (60/40 w/w) blend during isothermal crystallization at 51 °C, after 109 h; bar corresponds to 25 mm.

1.19 Scanning electron micrographs of cryogenically fractured surface of PP/PC blends. Weight ratio of PP/PC: (a) 10/90, (b) 20/80, (c) 40/60, (d) 50/50, (e) 60/40, (f) 80/20, (g) 90/10, (h) 95/5.

1.20 DSC thermographs for PP and PP/PC blends prepared by non-isothermal crystallization at a cooling rate of 10 °C/min.

1.21 DSC cooling curves at 10 K/min for a) PS/PA6 and b) (PPE/PS)/PA6 blend compositions.

1.22 a) DSC cooling curves at 10 K/min of PS/PA6 75/25 and (PPE/PS)/PA6 75/25 blends before and after annealing in the melt for 1 h in the DSC. b) DSC cooling and melting curves at 10 K/min after premelting to the indicated temperatures for the PA6 in (PPE/PS)/PA6 75/25.

1.23 Original WAXD spectra and the corresponding normalized 100% POM WAXD patterns for (a) POM/Ha4 blends and (b) POM/Ha7 blends.

1.24 DSC crystallization curves for different compositions of (a) (PS/SMA2)/PA6 blends. b) DSC crystallization curves of (PS/SMA2)/PA6 75/25 blends with different SMA2 concentrations.
1.25 Schematic representation of various crystallization processes: (a) isothermal; (b) non-isothermal with constant cooling rate; and (c) non-isothermal with varying cooling rates.

1.26 Plots of relative crystallinity versus crystallization time for PES during isothermal crystallization from the amorphous state.

1.27 Avrami plots of PES during isothermal crystallization from the amorphous state.

1.28 Typical relative crystallinity u(t) as a function of crystallization time t, t₀.5 is also shown in the figure. For the syndiotactic PP isothermally crystallized at 70°C. The line shows the Avrami fit form the experimental data.

1.29 Variation of the Avrami exponent n₀ as a function of crystallization temperature Tc: melt-crystallization data measured in this work.

1.30 a) Heat flow rate of iPP/PaP 90/10 blend cooled at various scanning rates. b) Tc of iPP/ Poly(a-pinene) blends as a function of cooling rate.

1.31 Non-isothermal crystallization curves of (a) PTT/PEN 20/80 and (b) PTT/PEN 40/60 blends at different cooling rates.

1.32 Relative crystallinity vs. temperature for non-isothermal crystallization of (a) PTT/PEN 20/80 and (b) PTT/PEN 40/60.

1.33 Ozawa plots of log [-ln(1-Xt)] vs. log D for (a) PTT/PEN 20/80 and (b) PTT/PEN 40/60.

2.1 Torque development during the dynamic vulcanization as a function of time.

2.2 Instrumental setup for the infrared strain measurements.

3.1 SEM micrographs showing how the phase morphology is changing with blend ratio. Micrographs were taken after NR phase etched from cryo cut surfaces with hot benzene and dried under vacuum. Blend morphology had profound influence on the spherulite grown in the blend. a) NR/PP 02/98 b) NR/PP 05/95 c) NR/PP 20/80 d) NR/PP 30/70 and e) NR/PP 50/50.

3.2 Influence of blend ratio on the domain size distribution of NR/PP blends.

3.3 Effect of blend ratio on the number average, weight average and volume average diameters of NR/PP blend.

3.4 Influence of blend ratio on the domain size distribution of NR/PP blends.

3.5 Crystallization behavior of PP/NR blends.
3.6 Micrographs showing spherulite developed in the iPP and its different NR/PP blend at 136°C at a cooling rate of 10°C/min. All micrographs were taken under reflection mode with 100 times magnification where 3.6.a) iPP b) NR/PP 02/98 6.c) NR/PP 05/95 3.6.d) NR/PP 10/90 3.6.e) NR/PP 20/80 3.6.f) NR/PP 30/70 3.6. g) NR/PP 50/50.

3.7 Radial growth of PP spherulite in NR/PP 10/90 blend at Tc 124°C (the melt was brought to the crystallization temperature at cooling rate of 10°C/min).

3.8 The relation between Tc and spherulite growth rate of PP having different weight percentage of natural rubber at cooling rate of 10°C/min.

3.9 The relation between G and blend ratio at different Tc.s

3.10 The influence of cooling rate on the spherulite growth rate of neat PP at different Tc.

4.1 SEM pictures explaining the effect of blend ratio on the cryofractured surfaces of NR/PP Blends.

4.2 Effect of blend ratio on the fractionated crystallization behavior of PP/NR blends.

4.3 Results of different cooling rate on the crystallization of neat PP

4.4 Impact of cooling rate on the confined crystallization behavior of NR/PP 90/10 blend.

4.5 SEM pictures explaining the effects of compatibilization blend ratio on the cryofractured surfaces of PP/NR Blends.

4.6 a) Pictorial representation of three stages of compatibilization and the location of compatibilizer at the interface. b) Location of compatibilizer at the face boundary.

4.7 Influence of the hydroxy terminated natural rubber and maleic modified polypropylene as compatibilizer on the fractionated crystallization behavior of NR/PP blends

4.8 Influence of the epoxydised natural rubber and maleic modified polypropylene as compatibilizer on the fractionated crystallization behavior of NR/PP blends.

4.9 a) Influence of cooling rate on the compatibilized blend of NR/PP with hydroxy terminated natural rubber and maleic modified polypropylene (2wt%). b) Influence of cooling rate on the NR/PP 90/10 blend which is compatibilized using epoxydised natural rubber and maleic modified polypropylene.

4.10 a) DSC scans showing the influence of self-nucleation on PP. b) NR/PP 85/15. c) NR/PP 80/20
4.11 a.) Melting behavior of the fractionately crystallized NR/PP blends b) Influence of the hydroxy terminated natural rubber and maleic modified polypropylene as compatibilizer on the melting behavior of fractionately crystallized NR/PP blends c) Influence of the epoxidised natural rubber natural rubber and maleic modified polypropylene as compatibilizer on the melting behavior of fractionately crystallized NR/PP blends.

5.1 a) Effect of temperature on crystallization isotherms of pure iPP. b) Percentage crystallinity changes in pure iPP crystallised isothermally at different temperatures.

5.2 a) Effect of blend ratio on the isothermal crystallization of PP/NR blends crystallized at 116°C. b) Effect of blend ratio on the isothermal crystallization of PP/NR blends crystallized at 120°C.

5.3 Evolution of the relative crystallinity and predicted data using Avrami model of iPP and its blends with NR isothermally crystallized at various temperatures. The symbols and the lines represent experimental data and calculated data. Where a) 116°C b) 120°C c) 124°C d) 128°C.

5.4 Evolution of the relative crystallinity and predicted data using Tobin model of iPP and its blends with NR isothermally crystallized at different Tc. The symbols and the lines represent experimental data and calculated data. Where a) 116°C b) 120°C c) 124°C d) 128°C.

5.5 Melting behavior of the isothermally crystallized TPEs (50 wt% NR) just after the crystallization at each Tc.s.

5.6 WAXD spectrum of a) neat PP and TPEs having varying rubber content crystallized at 124°C. b) Dynamic vulcanization NR content of 50 wt% crystallized at 124°C.

5.7 Polarised light micrographs with spherulites showing 80 second growth of TPEs having a NR content of 30 wt%. Micrographs were taken in transmission mode with 100 times magnification.

5.8 Polarised light micrographs with spherulites showing 80 second growth of TPEs having a NR content 50 wt%, images were taken in transmission mode with same magnification.

6.1 a) Influence of cooling rate on the crystallization behavior of neat PP. b) Development of relative crystallinity changes with cooling rate for neat PP.

6.2 Influence of blend ratio on the development of relative crystallinity of NR/PP blends with various NR content at 12°C/min.
6.3 Influence of cooling rate on the relative crystallinity development of NR/PP 30/70 blends at various cooling rates. 186
6.4 Schematic representation of morphology development during dynamic vulcanization. 188
6.5 Influence of dynamic vulcanization on the relative crystallinity development behavior of NR/PP 50/50 blend system at 12°C/min as a function of temperature. 189
6.6 a) Typical Ozawa analysis for neat PP. b) Typical Ozawa analysis for PP/NR 50/50 sample at different cooling rate. 191
6.7 Influence of cooling rate on the \( T_c \) of NR/PP blend having varying blend ratio. 192
6.8 Influence of cooling rate on the \( T_{1/2} \) of NR/PP blends and dynamic vulcanizates having diverse blend ratio. 193
6.9 Plots of the effective energy barrier for non-isothermal melt crystallization of PP, NR/PP TPEs and NR/PP 50/50 TPV as a function of the relative melt conversion. 196
7.1 Influence of blend ratio on the stress-strain behavior of the NR/PP TPEs. 204
7.2 Effects of blend ratio on the ultimate tensile strength and elongation at break of NR/PP blends. 205
7.3 Influence of dynamic vulcanization on the stress-strain behavior of NR/PP blends. 207
7.4 Influence of mastication time on the stress-strain behavior of NR/PP TPEs. 208
7.5 Plot of relative tensile strength versus volume fraction of dispersed NR phase using different models. 210
7.6 Dependence of storage modulus on temperature for different NR/PP blends. 212
7.7 Dependence of loss modulus on temperature for different NR/PP blends. 214
7.8 Dependence of tan (\( \delta \)) values on temperature for different NR/PP blends. 214
7.9 a) Effect of dynamic vulcanization on the storage modulus of NR/PP TPEs. b) Influence of dynamic vulcanization on the loss modulus of NR/PP TPEs. c) Effect of dynamic vulcanization on the tan (\( \delta \)) of NR/PP TPEs. 217
7.10 a). Influence of mastication time on the storage modulus of NR/PP TPEs. b). Influence of mastication time on the tan (\( \delta \)) values of NR/PP 50/50 TPEs. 218
7.11 a) Comparison of the experimental and theoretical data of storage modulus of NR/PP blends at $T_g$ of NR. b) Comparison of the experimental and theoretical data of storage modulus of NR/PP blends at $T_g$ of PP. c) Comparison of the experimental and theoretical data of storage modulus of NR/PP blends at room temperature.

7.12 Influence of rubber content on the indentation modulus of NR/PP TPEs.

7.13 Influence of rubber content on the nano-hardness of NR/PP TPEs.

8.1 a-e) Scanning electron micrographs of the fractured surface of the uncompatibilized NBR/PP blends.

8.2 Effect of blend ratio on the number average, weight average and volume average diameters of NBR/PP blend.

8.3 Melting behavior of NBR/PP blend.

8.4 Crystallization behavior of NBR/PP blends.

8.5 Polarized optical photomicrographs of the different stages of spherulite growth in neat PP. (All of these photographs were taken in the transmission mode with cross-polarized light at 200 times magnification.) (a) Taken 1 min after the spherulite growth started. All other micrographs were taken at an interval of 5 min.

8.6 Polarized optical micrographs of blends of polypropylene and acrylonitrile butadiene rubber (all these photographs were taken in the transmission mode with cross polarized light) blends (magnification 200 times) a) 1wt% NBR, b) 2wt% NBR, c) 6wt% NBR, d) 10wt% NBR.

8.7 Spherulite diameter in PP/NBR blends.

8.8 Radial growth of PP spherulite as a function of time.

8.9 Radial growth rate of PP spherulite as a function of rubber addition.

9.1 a-e) Scanning electron micrographs of the uncompatibilized blends a) NBR/PP 02/98 b) NBR/PP 05/95 c) NBR/PP 10/90 d) NBR/PP 15/85 e) NBR/PP 20/80.

9.2 Effects of blend ratio and cooling rate on the fractionated crystallization behavior of neat PP and its blends a) Influence of blend ratio b) Neat PP at various cooling rate c) Effect of different cooling rate on the crystallization activities of NBR/PP 98/02, inset shows the change in $T_c$ as a function of cooling rate d) Result of different cooling rate on the crystallization activities of NBR/PP 90/10, inset shows the change in $T_c$ as a function of cooling rate.
9.3 Showing the scanning electron micrograph of the cryogenically fractured surfaces of compatibilized NBR/PP 90/10 blends with, a) MA-PP 1phr, b) MA-PP 3phr c) MA-PP 5phr. d) 1phr COOH-PP e) 3phr COOH-PP f) 5phr COOH-PP g) 1phr NBR-PP block h) 3phr NBR-PP block i) Schematic representation of the compatibilizer concentration on the dispersed PP domains.

9.4 Emulsifying action of compatibilizers as a function of compatibilizer concentration.

9.5 Effect of compatibilizer concentration the confined crystallization behavior of NBR/PP blends a) Influence of maleic modified polypropylene on the fractionated crystallization behavior of NBR/PP 90/10 b) Influence of carboxylated modified polypropylene on the fractionated crystallization behavior of NBR/PP 90/10 c) Influence of NBR-PP block copolymer on the fractionated crystallization behavior of NBR/PP 90/10 blend.

9.6 Schematic representation of compatibilizer at the interphase and nuclei migration during melt mixing. a) Strengthening of interphase using graft copolymer formed by the reaction between MA-PP and liquid NBR. b) Schematic representation of the impurity migration during melt mixing.

9.7 Effects of self seeding techniques on the confined crystallization behavior of NBR/PP blends a) Outcome of self seeding technique on the crystallization behavior of polypropylene b) End result of self seeding technique on the fractionated crystallization behavior of NBR/PP 90/10.

9.8 WAXS diffraction pattern of pure iPP and fractionated crystallized samples showing the presence of α-spherulites.

10.1 a) SEM images of NBR/PP 30/70 1 b) 50/50 blend, NBR phase was etched using chloroform from the faces of cryogenically cut specimens.

10.2 AFM images of TPVs from NBR and PP. a) NBR/PP 50/50 b) NBR/PP 60/40 c) NBR/PP70/30.

10.3 Effect of blend ratio on the isothermal crystallization of PP/NBR blends crystallized at 120°C.

10.4 a) Effect of compatibilization and dynamic vulcanisation on the isothermal crystallization of PP/NBR blends crystallized at 120°C. b) Isothermal crystallization behaviour of PP and TPVs having various rubber contents. All the samples were crystallized at 120°C.
10.5 Evolution of the relative crystallinity and predicted data using Avrami model of PP and its blend with NBR isothermally crystallized at 120°C. The symbols and the lines represent experimental data and predicted data. a) Effect of blend ratio. b) NBR/PP blend having a blend ratio 60/40, influence of compatibilizer and dynamic vulcanisation c) PP and TPVs of NBR and PP.

10.6 Evolution of the relative crystallinity and predicted data using Tobin model for PP and its blend with NBR isothermally crystallized at 120°C. The symbols and the lines represent experimental data and predicted data. a) Effect of blend ratio. b) Influence of compatibilization and dynamic vulcanization. c) Impact of blend ratio on TPVs.

10.7 Influence of blend ratio on the half time for the crystallization (T_{1/2}) of NBR/PP TPEs.

10.8 Melting behavior of NBR/PP blends. a) Influence of blend ratio on the melting behaviour of PP/NBR blends. b) Influence of compatibilization and dynamic vulcanization on the melting behaviour of NBR/PP 60/40 blend systems. c) Impact of blend ratio on the dynamically vulcanized systems.

10.9 WAXD spectrum of a) neat PP and TPEs having varying NBR content, crystallized at 124°C. b) Neat PP and TPVs having varying rubber content crystallized at 124°C.

11.1 Heat flow versus temperature during nonisothermal crystallization of a) iPP and b) NBR/PP 60/40D at different cooling rate.

11.2 Influence of cooling rate on the T_c values of PP and its TPVs.

11.3 Relative crystallinity versus temperature during nonisothermal crystallization of a) iPP and b) NBR/PP 60/40D at different cooling rate.

11.4 Typical Ozawa analysis for a) PP and b) NBR/PP 60/40D sample at different cooling rates.

11.5 Influence of cooling rate on the t_{1/2} values of PP and its TPVs.

11.6 Influence of various cooling rate on the melting behavior of a) PP b) NBR/PP 60/40 dynamic vulcanizates.

11.7 Plots of the effective energy barrier for non-isothermal melt crystallization of PP, NBR/PP TPVs as a function of the relative melt conversion.

12.1 Scanning electron micrographs of the fracture surfaces of the uncompatibilized NBR/PP blends.

12.2 Effect of blend ratio on the number average, weight average and volume average diameters of NBR/PP blend.
12.3 Influence of blend ratio on the stress-strain behavior of the uncompatibilized NBR/PP TPEs.

12.4 Effects of blend ratio on the ultimate tensile strength and elongation at break of uncompatibilized NR/PP blends.

12.5 Influence of compatibilizer (NBR-g-MAPP) concentration on the stress-strain behavior of NBR/PP blend.

12.6 Influence of curing agent on the stress-strain behavior of NBR/PP 60/40 blends.

12.7 Influence of blend ratio on the stress-strain behavior of NBR/PP dynamic vulcanizates.

12.8 Plot of relative tensile strength versus volume fraction of dispersed NR phase using different models.

12.9 Dependence of storage modulus on temperature in the compatibilized (CUV); dynamically vulcanized (dn); and compatibilized and dynamically Vulcanized (D) NBR/PP blends.

12.10 Dependence of G" on the temperature in the case of 60/40 NBR/PP compatibilized and dynamically vulcanized blends. 
(S stands for blend of NBR and PP, CUV stands for Compatibilized but unvulcanised blend. dn stands for dynamically vulcanized but uncompatibilized, D stands for compatibilized and dynamically vulcanized).

12.11 Effect of blending, compatibilization, dynamic vulcanization and both on the Tan (δ) value of the NBR/PP 60/40 blend system. (S stands for blend of NBR and PP, CUV stands for Compatibilized but unvulcanised blend. DN stands for dynamically vulcanized but uncompatibilized, D stands for compatibilized and dynamically vulcanized).

12.12 Dependence of G' of compatibilized and dynamically vulcanized NBR/PP blends of various blend ratios, on temperature.

12.13 Dependence of Tan (δ) of compatibilized and dynamically vulcanized NBR/PP blends of various blend ratios, on temperature.

12.14 Dependence of a) G' b) G" and c) Tan (δ) on temperature of quenched and unquenched neat PP and NBR/PP 60/40D.

12.15 Experimental and theoretical curves of storage modulus of NBR/PP 60/40 blend in the temperature range -80 to +40°C.

12.16 Static IR spectra of a) PP b) NBR c) NBR/PP 60/40D at room temperature.

12.17 Influence of stretching on the IR peak at different strain level.

12.18 Orientation function for the a) PP b) NBR phase as a function of strain for various dynamic vulcanizates.