CHAPTER - X

SUMMARY AND CONCLUSIONS
Polymer blends and alloys are some of the most dynamic sectors of the polymer industry. The annual growth rate of engineering polymer blends and alloys has been systematically outstripping that of the industry as a whole by a factor of 4 to 5. The main reason for the popularity of polymer blends and alloys is the ever-increasing cost of development of new materials (new polymers). It is estimated that developing a new polymer costs nearly US $15 million for research and development and an additional US $150 million in capital cost for a pilot plant. Blending is quicker and less expensive. The cost of development of a new polymer blend seldom exceeds a few million dollars. With little capital investment for efficient compounding and with the present knowledge and industrial know-how, there are fewer dead-end in the development of polymer blends and alloys than of new resins. The properties of blends can be tuned to satisfy a spectrum of customer demands.
The earliest blends were prepared by exploiting the natural miscibility of components. Good examples are blends of polyvinyl chloride with acrylonitrile rubber or polyphenylene ether with high impact polystyrene. The miscibility is still the main criterion for blending. So it is necessary to identify miscible and immiscible blends. When the blends are miscible, one can make tailor made materials to suit a particular need. When the blends are immiscible one can convert them into polymer alloys by the addition of suitable compatibilizers.

In order to study the miscibility of polymer blends various methods are used. They are spectroscopy, thermal, mechanical, dielectric, and diffraction techniques. Some of these techniques may be expensive, complicated, and time consuming. In the present work the author used low cost, simple, and rapid techniques to study the miscibility of polymer blends in solution. As it is already established that the solution technique yield the same information as the other solid state sophisticated techniques, the author decided to take up the present problem. In the present study the author used viscosity, ultrasonic velocity, density, refractometric and optical polarizing microscope techniques for the study of fourteen different blends. The author selected these simple techniques as these are low cost and rapid techniques and can be used even for routine analysis. The author also used some solid state techniques such as polarized optical microscopy and differential scanning calorimetry in order to confirm the results obtained by solution techniques.
The thesis is divided into ten chapters. In chapter-I a brief introduction to the history of the development of polymer blends is presented. In the same chapter, the literature surveyed by the author relating to the topic on polymer blends is presented. The aim and scope of the work are presented in the same chapter. In this chapter the author also discusses the importance of ionic radiation on polymers and polymer blend films. The limitations of the present work are also included in this chapter.

Chapter -II deals with a brief description of materials used in the present study. The method of preparation of the blend solutions and the measurements of relative viscosity, ultrasonic velocity, density, and refractive index of the polymer blends solution is described in this chapter. The author also explains the optical polarizing microscope technique to probe the miscibility criterion in the polymer blend films and describes the instruments used by him in the present study. A description of the General Purpose Vacuum Chamber and Material Science Vacuum Chamber available with Nuclear Science Centre, New Delhi, is also given in Chapter-II.

From Chapter - III to Chapter - IX the thesis deals with the results obtained by the author on fourteen blends selected by him. Chapter - III reports the miscibility studies on the polymer blends of PMMA with PVC, PC, and CA. The interaction parameter \( \mu \) for the blends of PMMA/PVC, PMMA/PC, and PMMA/CA were found to be 0.4259, 140, and -0.4347 respectively, basing on the criterion proposed by Chee [1]. Using Sun et al [2] criterion the interaction parameter \( (\alpha) \) for the blends of PMMA/PVC, PMMA/PC, and PMMA/CA were found to be 0.12657, 0.15 and -0.31813 respectively. From the optical
polarizing micrograms of the PMMA/PVC blend and PMMA/PC blend, it can noticed that a uniform distribution of the components is present in the blend as the phase agglomeration is minimum, whereas in the case of the PMMA/CA blend the phase agglomeration is maximum and there is no uniform distribution of the components. Basing on the above results, the blends of PMMA/PVC and PMMA/PC were found to be miscible whereas the blend of PMMA/CA was found to be immiscible. Ultrasonic, density, refractometric, and differential scanning calorimetric methods further confirmed these results.

Chapter - IV presents the miscibility studies on the polymer blends of CA with PVC and C-PVC in cyclohexanone at 30 °C. The interaction parameter $\mu$ for the polymer blends of CA/PVC and CA/C-PVC were found to be -0.075 and 1.275 respectively, basing on the criterion proposed by Chee [1]. Using Sun et al. [2] criterion the interaction parameter ($\alpha$) for the blends of CA/PVC and CA/C-PVC were found to be -0.0209 and 146 respectively. From the optical polarizing microgram of the CA/C-PVC blend, it can be noticed that a uniform distribution of the components is present in the blend, as the phase agglomeration is minimum, whereas in the case of the CA/PVC blend the phase agglomeration is maximum and there is no uniform distribution of the components. Basing on the above results, the blend of CA/ C-PVC was found to be miscible whereas the blend of CA/PVC was found to be immiscible. Ultrasonic, density, and refractometric methods further confirmed these results. However, the results of DSC indicated that the CA/C-PVC blend is only partially miscible. This has to be further probed by sophisticated techniques such as scanning electron microscopy, atomic force
Chapter - V describes the miscibility studies on the polymer blends of PC with PS, PVP and PEO in chloroform at 30 °C. The interaction parameter μ for the polymer blends of PC/PS, PC/PVP and PC/PEO were found to be -0.54, -0.2041 and -0.3305 respectively, basing on the criterion proposed by Chee [1]. Using Sun et al [2] criterion the interaction parameter (α) for the blends of PC/PS, PC/PVP, and PC/PEO were found to be -0.13, -1.8959 and -0.3192 respectively. From the optical polarizing micrograms of the polymer blends of PC/PS, PC/PVP, and PC/PEO it can be noticed that a uniform distribution of the components is not present, as the phase agglomeration is maximum. Basing on the above results the blends of PC/PS, PC/PVP, and PC/PEO were found to be immiscible. Ultrasonic, density, refractometric, and differential scanning calorimetric methods further confirmed these results.

Chapter - VI deals with the miscibility studies on the polymer blends of PS with PVC and CA in cyclohexanone at 30 °C. The interaction parameter μ for the polymer blends of PS/PVC and PS/CA were found to be -0.3562 and -0.0451 respectively, basing on the criterion proposed by Chee [1]. Using Sun et al. [2] criterion the interaction parameter (α) for the blends of PS/PVC and PS/CA were found to be -0.0451 and -1.78062 respectively. From the optical polarizing micrograms of PS/PVC and PS/CA, it can be noticed that a uniform distribution of the components is not present in the micrograms of the blends, as the phase agglomeration is maximum. Basing on the above
results the blends of PS/PVC and PS/CA were found to be immiscible. Ultrasonic, density, refractometric and differential scanning calorimetric methods further confirmed these results.

Chapter - VII reports the miscibility studies on the polymer blends of PEO with PMMA and PS in chloroform at 30 °C. The interaction parameter $\mu$ for the polymer blends of PEO/PMMA and PEO/PS were found to be 0.024 and -0.89 respectively, basing on the criterion proposed by Chee [1]. Using Sun et al [2] criterion the interaction parameter ($\alpha$) for the blends of PEO/PMMA and PEO/PS were found to be 0.68 and -0.33 respectively. From the optical polarizing microgram of the PEO/PMMA blend a uniform distribution of the components is observable in the blend, as the phase agglomeration is minimum, whereas in the case of PEO/PS the phase agglomeration is maximum and there is no uniform distribution of the components. Basing on the above results, the blends of PEO/PMMA was found to be miscible whereas the blend of PEO/PS was found to be immiscible. Ultrasonic, density, and refractometric methods further confirmed these results.

Chapter - VIII describes the miscibility studies on the polymer blends of PVP with PS and PMMA in mixed solvent of dimethyl formide +cyclohexanone at 30 °C. The interaction parameter $\mu$ for the polymer blends of PVP/PS and PVP/PMMA were found to be -0.1596 and -0.7344 respectively, basing on the criterion proposed by Chee [1]. Using Sun et al. [2] criterion the interaction parameter ($\alpha$) for the blends of PVP/PS and PVP/PMMA were found to be 0.836 and -0.4828 respectively. From optical
polarizing microgram of the PVP/PS blend a uniform distribution of the components can be seen in the blend, as the phase agglomeration is minimum, whereas in the case of PVP/PMMA the phase agglomeration is maximum and there is no uniform distribution of the components. Basing on the above results the blend of PVP/PS was found to be miscible whereas the blend of PVP/PMMA was found to be immiscible. Ultrasonic, density, and refractometric methods further confirmed these results.

In Chapter – IX the author describes the method of preparation of polymer blend films required for irradiation with a $^{28}$Si ion beam. In the same chapter the author also presents the experimental conditions for the irradiation. The author irradiated the blend films of PMMA/PS by the silicon ion beam of energy 60MeV with a current of 2pna. Optical transmission, solubility and infrared spectral techniques were used to analyze the structural changes in the blend induced by the ionic radiation. It is concluded that the blend PMMA degraded whereas PS cross-linked on ionic irradiation.

The blend films of PMMA/PVC with different composition were irradiated to silicon ion beam of 120 MeV energy with a current of 4 pna for different fluence. The structural changes induced by the ionic beam were analyzed by the infrared spectroscopic technique. Basing on the observations it is concluded that gas evolution, degradation of PMMA, and cross-linking in the case of PVC were the complex phenomena the ionic radiation resulted in. The mechanism of structural changes induced by the ionic radiation is also presented for this blend in the same chapter. At the end of the thesis, the author included the reprints of the papers published in the field of the research and related fields.
To conclude, it is observed that the simple, low cost, and rapid techniques such as viscosity, ultrasonic velocity, density, and refractometric techniques can be effectively used for the miscibility studies of polymer blend in solution. As high energetic ionic beam induces selective damage in the blends of PMMA/PS and PMMA/PVC, these can be utilized for the creation of ionic tracks in them by suitable chemical etching.
REFERENCES
