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# THERMAL BEHAVIOUR OF POLYETHERIMIDE PEEK BLENDS

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## Abstract

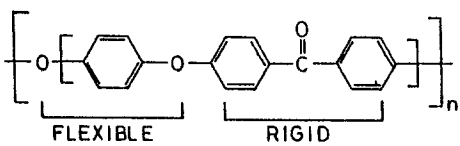
PEEK is characterised by high impact and fatigue resistance and $T_g$ of 145°C. Blends of PEEK and PEI have been made and scanning electron micro-graphs of the broken specimen show that the two polymers are completely miscible in all proportions. The study also shows that PEEK: PEI 50:50 blend, can be used as matrix for composite applications with appreciable enhancement of $T_g$ to 177°C.

**Keywords:** polyetherimide peek blends

## Introduction

High performance engineering polymers having semicrystallinity afford a range of advantages over polymer composites due to complete cohesion between the reinforcement and the matrix. This is so characterized because both the reinforcing crystalline phase and the mesophase are of the same material. In polymer composites the reinforcement and matrix adhesion is brought with the help of interphasing agents which act through Van der Waal's interaction. These forces are by no means as strong as the cohesive forces which interact in a semicrystalline polymer.

Poly(aryletherether) ketone has many typical molecular features which characterize it as the most saught after engineering material. To summarise, these features are derived from the ether bonds with which rigid phenyl rings are attached and these are interposed with a planar carbonyl which doubles the length of the rigid structure. The overall impact is a molecular composite.




Crystallinity of PEEK can be increased with annealing time and the result is appreciably enhanced strength.

There are certain applications of polymer composites where we want to extend the applications of PEEK material to higher temperature such as in aircraft and missile

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structures without sacrificing fracture resistance property. GE PEI (Ultem) has been found to blend with PEEK in all proportion. Its $T_g$ is appreciably higher than PEEK. This polymer has been used to enhance the temperature capability of PEEK material.

## Experimental

Polyether imide from general electric viz., Ultem 1000 was used for blending with PEEK. It has a relative viscosity of 0.5 dl/g as measured at 0.2% solution in chloroform at 25°C. PEEK of 1.1 dl/g intrinsic viscosity was used for blending with PEI. The various proportions of 70:30, 50:50, PEEK:PEI were blended using Minimax extruder (Custom Scientific Instrument Inc., USA) at 300°C and at a screw speed of 40 rpm. The extruded chord was granulated by chopping and compression moulding in a 250 Tons hydraulic press. The temperature, pressure and time profile used was 250°C, 500 psi for one hour and it was gradually raised to 300°C, 1500 psi and one hour. The heating was switched off and was allowed to cool to room temperature before reducing pressure. The mouldings obtained in this manner were tested using DSC, Rheovibron (DDV III) & SEM techniques.

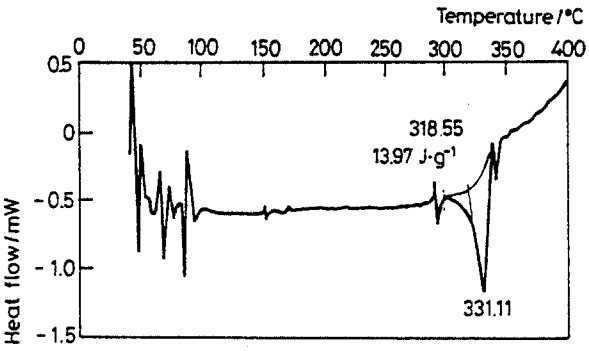


**Fig. 1** DSC curve of peek polymer

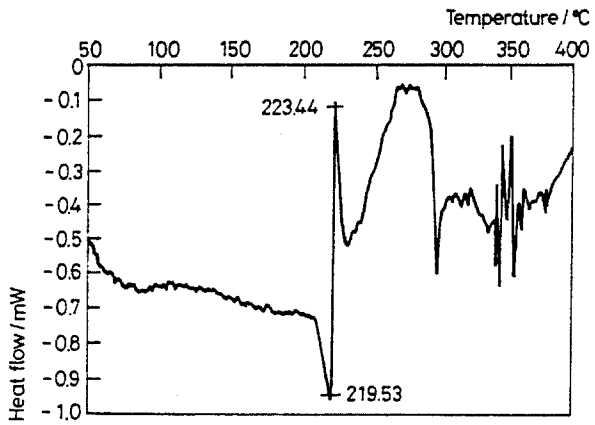


**Fig. 2** DSC curve of PEI polymer

## Results and discussions

DSC studies of PEEK and PEI and their blends, Table 1 and Figs 1 to 8, show that observed $T_g$'s match well with the reported values. Viscoelastometrically determined $T_g$ values are higher in case of neat polymers than DSC values whereas the blends show variation over the DSC value.

Table 1 Peek/polyetherimide blends relative assessment of $T_g$ using viscoelastomeric and DSC techniques

| Polymer blends | Rheovibron viscoelastometric | $DSC_{Figs\ 1-4}$ | Literature |
|---|---|---|---|
| | $T_g$/°C | | |
| PEEK | 162 | 145 | 142 |
| PEI | 231 | 219 | 215 |
| PEEK:PEI (70:30) | 134 | 166 | 161 |
| PEEK:PEI (50:50) | 177 | 174 | 176 |

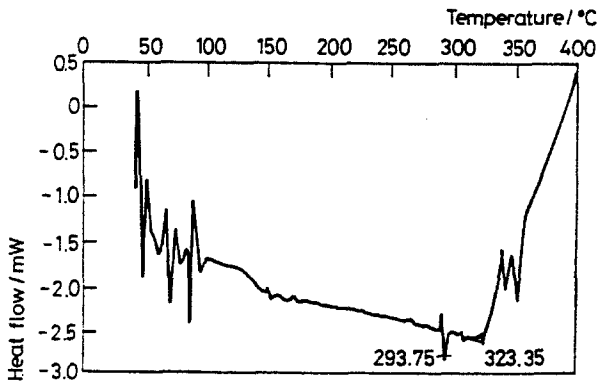


Fig. 3 DSC curve of PEEK:PEI:70:30 blend

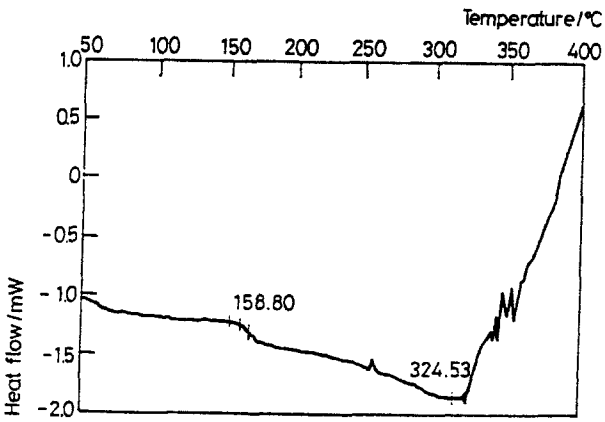


Fig. 4 DSC curve of PEEK:PEI:50:50 blend

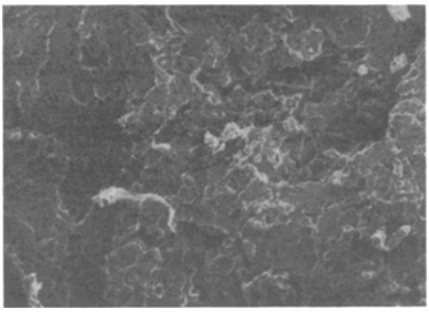

**Fig. 5** SEM photograph of PEEK specimen ×200. Resin pull is clearly seen

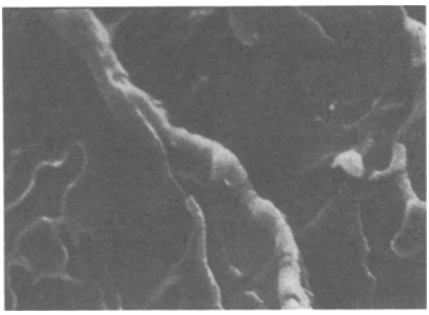

**Fig. 6** SEM photograph of PEI specimen ×400. Unstable cracks are prominently seen

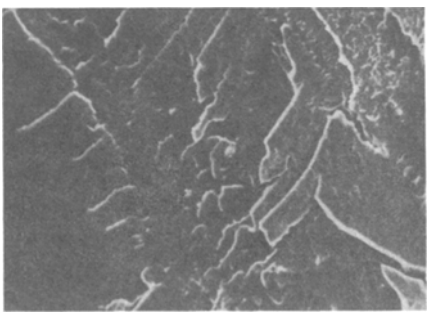

**Fig. 7** SEM photograph of PEEK:PEI blend 70:30 ×600. Unstable cracks and resin pull seen simultaneously

SEM of PEEK (Fig. 5) shows resin pull whereas PEI (Fig. 6) show unstable crack growth. The former is characteristic of ductile and latter of brittle failure. The blends show intermediate behaviour signifying both features and these features are noticeable in 70:30 (Fig. 7) or 50:50 (Fig. 8) blends.

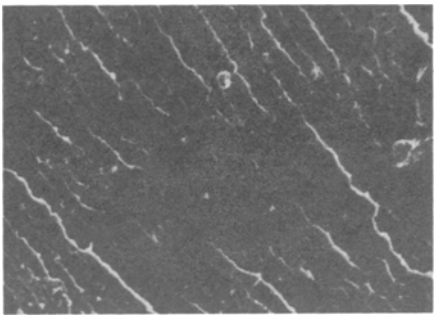

**Fig. 8** SEM photograph of PEEK:PEI blend 50:50 ×1000. Unstable cracks are more prominent

## Conclusion

The study shows that PEEK and PEI are miscible in all proportions. The blends show that the fracture property is similar in 70:30 and 50:50 blends. The DSC and Rheovibron studies show that 50:50 blends is better than 70:30 blends since it shows enhancement in $T_g$ by both techniques. We have, therefore, a thermally improved matrix system which, though slightly inferior to PEEK in fracture behaviour, has enhanced $T_g$, making it suitable for use at high temperature (177°C).

## Reference

1 J. E. Harris and I. M. Robenson, J. Appl. Polym. Sci., 35 (1988) 1877.