Introduction

The last twenty-five years of this century have seen a flurry of activity in the synthesis and development of high performance and high temperature polymers. This has been in large part due to need for advanced materials required for a diverse range of applications including aerospace, automotive and microelectronic industries. These applications often demand a unique combination of properties including high glass transition temperatures, toughness, good adhesion, oxidative and thermal stability, and low dielectric constant. In this regard, a large number of polymers have been developed which can be broadly categorized as either thermosets or thermoplastics. Examples of thermosetting materials include epoxies, polyimides and bismaleimides while the example of thermoplastic materials largely consist of poly(sulfones), poly(ether ether ketones) and poly(ether imide).

From an application point of view, thermoplastic materials often possess some distinct advantages such as increased ductility and toughness of the material, ease of processing, and in many cases, potential to recycle the material. Furthermore, presence of crystallinity in thermoplastic polymers provides advantages such as improved solvent resistance, increased dimensional stability at higher temperatures and improved radiation resistance. These features make the development of high-performance and high temperature semicrystalline thermoplastics particularly attractive. From this standpoint, polyimides as a class of materials are very promising due to an array of desirable characteristics that these materials possess including excellent mechanical properties, wear resistance, radiation resistance, inertness to solvents, hydrolytic stability, low dielectric constants and good adhesion strengths.

Indeed significant advances have been made in the diverse field of polyimides in the past five decades and today these versatile materials find use in a broad range of applications. These functions include use as structural adhesive to bond wing panels and fuselage of both civilian and military aircraft, as interlayer dielectrics in microelectronic applications and as coatings in optoelectronic applications. However, one important research area still lagging behind has been the development of melt processable semicrystalline polyimides. In fact, to this day, the vast majority of polyimides are exclusively processed using the solvent-based methods. In this regard, it is obvious that development of novel melt processable semicrystalline polyimides will be advantageous both from a processing standpoint and also due to many advantages that the presence of crystallinity would provide. This research addresses specifically this issue.

The primary subjects of this research work are two novel semicrystalline polyimides, both of these being based on commercially available monomers. This research thesis presents the encouraging results concerning these two polyimides. In this research effort, several different areas have become important especially in the way they are critically interconnected. This document therefore first reviews the literature in this area with respect to the goals of the conducted research work. The first four chapters thus provide the literature review focussing on the areas of 'Polyimide Chemistry', 'Polymer Crystallization', 'Semicrystalline Polyimides' and 'Polyimides as Adhesives' respectively. The next four chapters present the conducted research using the two polyimides.

Chapter 5 discusses the research concerning the melt processable semicrystalline polyimide structural adhesive based on 1,3-bis(4-aminophenoxy) benzene and 3,3',4,4'-biphenyltetracarboxylic dianhydride. Chapter 6 provides the results on the same polyimide concerning its thermal stability, crystallization kinetics and morphology. Chapter 7 discusses the research concerning the crystallization and multiple melting behavior of a new semicrystalline polyimide based on 1,3-bis (4-aminophenoxy) benzene (TPER) and 3,3', 4,4'-benzophenonetetracarboxylic dianhydride (BTDA). Chapter 8 presents the results on the wedge and double cantilever beam tests on a high temperature melt processable polyimide adhesive, TPER-BPDA-PA.

Additionally the later four chapters are presented in the form of journal publications with each chapter including its own abstract, introduction, experimental section, results and discussion and list of references. Also, all the relevant figures are presented together at the end of the respective chapter. All polyimides were synthesized in Dr. McGrath's laboratory in chemistry, with the synthesis for TPER-BPDA being primarily carried out by Dr. Amba Ayambem and, by this author, for TPER-BTDA.