

## NEW FURAN-BASED THERMOSETTING POLYMER SYSTEMS

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Furan building blocks for chemicals and polymers are derived from the processing of cellulose and hemicellulose. A new family of furan-based thermosetting materials will be discussed. Furfuryl amine (FA) was coupled using aldehydes and di-aldehydes to form di-furan di-amine (DFDA) and tetra-furan tetra-amine (TFTA) molecules containing two or four furan rings respectively (Figure 1). These amines form the basis for epoxy, benzoxazine, and polyimide thermosetting systems with unique properties (Figure 2). Furan-based epoxy amine systems were found to possess higher density and Young's modulus (>5 GPa), as well as higher yield strength (>150 MPa in compression) and high char-yield compared to traditional epoxies. Benzoxazine monomers were synthesized by reacting DFDA's with a number of phenolic compounds and formaldehyde resulting in solid powders that melt at temperatures ranging between 70°C and 150°C to form low-viscosity liquids. Onset cure temperature varied in the range of 120°C-240°C depending on composition. The resulting polybenzoxazine systems possess T<sub>g</sub>'s ranging from 220°C to 280°C and char-yield as high as 70% measured at 800°C by TGA in an inert environment. DFDA was also used to prepare nadic end-capped polyimides analogous to PMR-15. These materials were found to process high T<sub>g</sub> (>330°C) and excellent processing characteristics because of low melt viscosity and facile imidization. This family of thermosetting systems could provide additional capability for composite, coating, and adhesive applications that require good ambient performance characteristics as well as good thermal management in extreme environments.

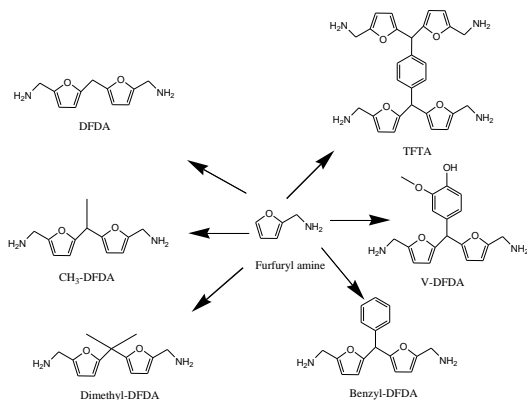


Figure 1 – Di- and tetra-aminines obtained from the coupling of furfuryl amine with appropriate aldehydes.

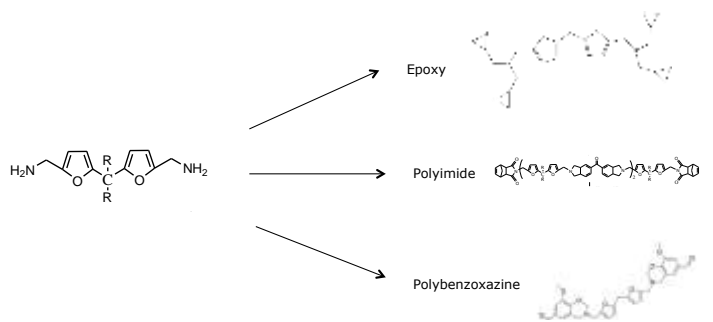


Figure 2 – Use of DFDA type amines as a basis for epoxy, benzoxazine, and polyimide thermosetting systems.

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