

LOW DIELECTRIC CONSTANT POLYMERS FOR NEXT GENERATION MICROELECTRONIC PACKAGING

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Next generation microelectronic packaging requirements are driving the need to produce increasingly lower dielectric constant materials while maintaining high thermal stability and ease of processing. Polymer candidates with exceptionally low dielectric constant (2.0-2.4), high thermal stability (degradation temperature higher than 400 C), high glass transition temperature (greater than 350 C), low water uptake (less than one percent), solubility in selected organic solvents, low thermal expansion coefficient and the capability for undergoing some unique post-polymerization chemistry to impart insolubility after processing have been successfully synthesized and characterized by our research group.

Highly fused ring structures, formed via intramolecular hydrogen bonding, were utilized for the enhancement of the glass transition temperature. Lowering of the dielectric constants of these polymeric structures was accomplished by the incorporation of perfluoroisopropyl groups along the polymer backbone. The design of post-polymer reactions to impart insolubility to select polymer candidates was based on the methodology of attachment of crosslinking sites to the polymer backbone. Aromatic benzoxazoles containing pendant allylether groups were synthesized from the parent structures. Upon heating, the polymer would undergo an intramolecular rearrangement reaction (Claisen rearrangement), resulting in a T_g enhancement by increasing the number of fused rings via intramolecular hydrogen bonding between the in situ-formed hydroxyl groups and the nitrogen atom of the adjacent benzoxazole group. At elevated temperature (250-300 C), crosslinking of the allyl groups would occur, thus providing a mechanism for insolubility and dimensional stability of the polymer system. Efforts are underway to control the crosslinking density of the polymer system by partial allylation of the hydroxyl groups attached to the aromatic benzoxazoles with a view to maintain the low dielectric constant value, high glass transition temperature and the insolubility as well as the mechanical toughness of the polymer system after processing.

We will address several issues relating to integration of these polymeric materials into current processes and how we have tailored our systems, to address issues such as back etching, adhesion, dimensional stability, and conformal coating of small feature sizes.

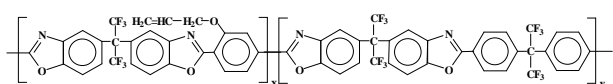


Figure 1. Structure of one family¹⁻² of copolymers being explored for low dielectric constant and integration into high speed circuitry.

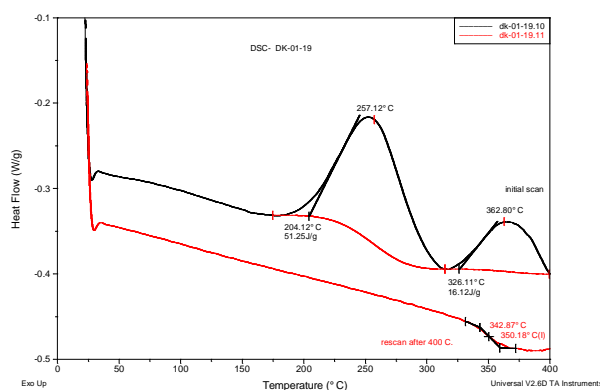


Figure 2. Differential Scanning Calorimetry of (50/50) Oxyallyl-6F-PBO / 12F-PBO polymer. Exotherm at 260C corresponds to energy released during Claisen rearrangement, while the exotherm at 360C corresponds to the energy released during cross-linking of the vinyl groups.

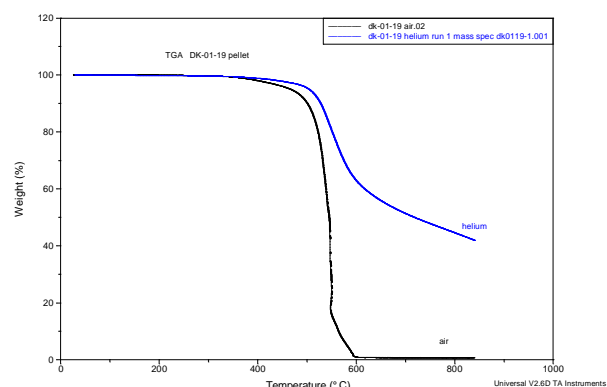


Figure 3. Thermal Gravimetric Analysis of (50/50) Oxyallyl-6F-PBO / 12F-PBO polymer. Illustrates thermal stability at temperatures up to 550C. The upper curve was run under inert gas, while lower curve was run in air.

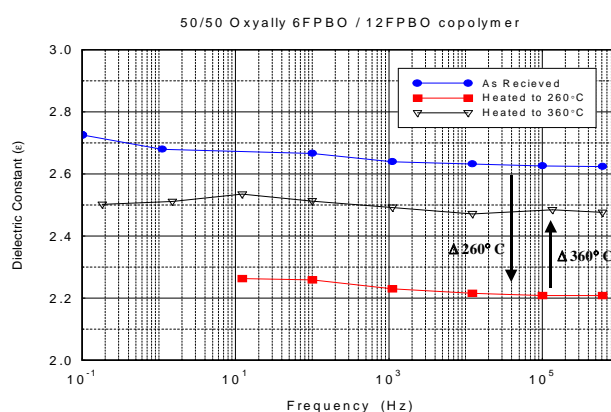


Figure 4. Dielectric Analysis of (50/50) Oxyallyl-6F-PBO / 12F-PBO polymer. Illustrates frequency dependence of the dielectric constant, as synthesized, after the Claisen Rearrangement, and after cross-linking as the finished product.

1. Thuy Dang, Leslie S. Huston, William A. Feld, and Fred E. Arnold, Polymer Preprints 41(1), 103 (2000)
2. T.D. Dang, P.T. Mather, M.D. Alexander Jr., C.J. Grayson, M.D. Houtz, R.J. Spry, F.E. Arnold, J Poly. Sci. Part A: Poly Chem, 38 1991 (2000)