POLYSULFONE - EARLY MARKET DEVELOPMENT ACTIVITIES

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INTRODUCTION AND BACKGROUND

UDEL® Polysulfone, formerly known as BAKELITE® Polysulfone, was introduced via a flurry of promotional activities. The initial introduction was performed via two press conferences, capping several years of research and product development activities. Both conferences were held at Union Carbide's Bound Brook facility. The first conference held on March 25, 1965 consisted of an informal presentation of polysulfone with respect to its physical properties, chemical structure and processing methods. In attendance were a select group of editors representing the following professional publications: Managing Editor of Modern Plastics, Editor of Plastic Technology, and Associate Editor of Materials in Design Engineering.

The main purpose of the second conference held on April 7, 1965 was to announce the development of a new heat resistant structural plastic: UDEL® Polysulfone; and to also announce the construction of a plant to produce this product. In attendance were representatives of the following publications: Chemicals Engineering, Plastics Technology, Modern Plastics, Materials in Design Engineering, Steel, New York Times, Chemical Engineering Progress, Chemical Processing, EEE-The Magazine of Circuit Design Engineering, Iron Age, Design News, Electronic Design, Plastics Design and Processing, and Industrial and Engineering Chemistry.

Accompanying these guests and representing Union Carbide were:

- Dr. A. G. Farnham, Co-inventor
- Dr. R. N. Johnson, Co-inventor
- Dr. R. W. Quarles, R&D Director
- Mr. W. T. Higgins, R&D Director
- Mr. R. K. Walton, Product Development Manager
- Mr. R. K. Dearing, Product Development Engineer

The conference included presentations covering polysulfone's chemical structure, physical properties and manufacturing processes; followed by a tour of the fabrication and laboratory facilities with accompanying demonstrations.

The production facility began producing commercial product in January 1966, and since then UDEL® Polysulfone has gained significant market acceptance.

In 1967 3M introduced another member of the polysulfone family -- Astrel 360.

In 1972 another member of this important family of products was introduced by Imperial Chemical Industries. In October 1976, Union Carbide announced RADEL® R, a polyphenylsulfone, thereby adding a fourth member to the polyarylsulfone family. The last member of this group was introduced by Union Carbide in 1983, RADEL® A Polyarylethersulfone.

Any discussion of markets and applications needs to be preceded with an understanding of the polymer's properties and potential utility. Prior to the introduction of this polymer, extensive laboratory evaluations were
conducted in order to determine this utility. The following two sections on structure and properties are a result of these studies.

**STRUCTURE**

UDEL® Polysulfone is prepared by a nucleophilic substitution reaction between the disodium salt of bisphenol A and 4,4'-dichlorodiphenyl sulfone yielding the following structure:

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\text{UDEL® Polysulfone Structure}
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The unique feature of the chemical structure is the diarylsulfone grouping (reference figure below)

\[
\text{Diarylsulfone Group}
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This is a highly resonating structure in which the sulfone group tends to draw electrons from the phenyl rings. This resonance is enhanced by having oxygen atoms para to the sulfone group. Oxidation, by definition, is the loss of electrons.

Having the electrons tied up in resonance imparts excellent oxidation resistance to the polymer. Also, the sulfur atom is in its highest state of oxidation and therefore is not susceptible to further oxidation.

The high degree of resonance has two additional effects: (1) it increases the strength of the bonds involved and, (2) it fixes this grouping spatially into a planar configuration. This provides excellent thermal stability to the polymer and provides rigidity to the polymer chain which is retained at high temperatures.

The excellent thermal stability of polysulfone is verified by thermal gravimetric analysis which shows that UDEL® Polysulfone is stable to air up to 450°C (840°F). The excellent thermal stability coupled with excellent oxidation resistance of polysulfones provides excellent melt stability for molding and extrusion.

The ether linkage imparts some flexibility to the polymer chain which gives inherent toughness to the material. Common with all tough, rigid thermoplastic polymers, polysulfone has a second low-temperature glass transition at -100°C. This minor glass transition is assigned to the ether linkages.

In these polysulfones the linkages connecting the benzene rings are hydrolytically stable. Therefore, the polymers are resistant to hydrolysis and to aqueous acid and alkaline environments. This is a distinct advantage over the ester linkages present in polycarbonates and thermoplastic polyesters.