

Commercialization of LARC™-SI Polyimide Technology
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Abstract

LARC™-SI, Langley Research Center-Soluble Imide, was developed in 1992. This new polyimide won a 1995 R&D 100 Award, with the first patent issuing in 1997 and subsequent issued patents in 1998 and 2000. Currently, this polymer has been successfully licensed by NASA, and has generated revenues in excess of 1.4 million dollars. This might seem insignificant in comparison to industrially developed technology, where the customer is understood, technologies that use a novel assembly of commercial off the shelf (COTS) components, or software patents and “method based” innovations that do not require any material beyond labor, as examples. However, consider that LARC™-SI competes in areas currently dominated by traditional materials at a cost disadvantage (\$350/lb) and that the physical-mechanical properties of LARC™-SI are similar to other high performance polymers. Indeed the success of this particular polymer was due to many factors and many lessons learned to the point that the invention was the most important, but least significant part in the commercialization of this material. This brief paper outlines the significant factors that occurred to make this technology available for the public access and application development that led to the licensing success of this material.

Discussion

Commercial LARC™-SI is a polyimide composed of two molar equivalents of dianhydrides 4,4'-Oxydiphthalic Anhydride (ODPA) and 3,3',4,4'-Biphenyltetracarboxylic dianhydride (BPDA) and 3,4'-Oxydianiline (3,4'-ODA) as the diamine. The unique feature of this aromatic polyimide is that it remains soluble after solution imidization in high boiling polar aprotic solvents, even at solids contents of 50% by weight.¹ However, once isolated and heated above its T_g of 240°C, it becomes insoluble and exhibits high temperature thermoplastic melt flow behavior. With these unique structure property characteristics, it was thought this would be an advantage to have an aromatic polyimide that is both solution and melt processable in the imide form. This could potentially lead to lower cost production as it was not as equipment or labor intensive as other high performance polyimide materials that either precipitate or are intractable. It is this unique combination of properties that allowed patents with broad claim coverage to set the stage for potential commercialization. After the US Patent applications were filed, an SBIR contract was awarded to Imitec, Inc. to develop and supply this and other polyimide thermosets for NASA's High Speed Research Program.² Technical articles were published to spread the scientific knowledge of LARC™-SI, and to serve as a marketing venue. Some examples of demonstration parts made with LARC™-SI ranged from aircraft wire and multilayer printed circuit boards to gears, composite panels, supported adhesive tape, composite coatings, cookware and polyimide foam.³ Even with its unique processing characteristics, the thermal and mechanical properties were not drastically different from other solution or melt processable

polyimides. LARCTM-SI risked becoming another interesting but costly high performance material. In order to increase visibility and demonstrate the utility of this polyimide, it was entered for an R&D 100 Award. The entry for the R&D 100 Award included Journal articles, marketing material and video to fully represent the advantages of this material. It was during this time that a licensee was sought and a specific application was developed, the THUNDER piezoelectric actuator, a 1996 R&D 100 Award winner. This actuator used LARCTM-SI as the adhesive to thermally bond metal shims to the piezoelectric ceramic. This gave the THUNDER actuator a mechanical pre-stress resulting in enhanced solid state motion. Since this actuator had separate fields of use, and all the test data was developed using LARCTM-SI as one of the components, the commercial THUNDER actuator used LARCTM-SI as the adhesive and was thus partially responsible for keeping LARCTM-SI in the public spotlight. Both LARCTM-SI and THUNDER were licensed to several companies including Dominion Resources Inc, formerly Virginia Power Inc., an industrial service conglomerate that contained a large electric and natural gas utility as investment cornerstones. A major hurdle was now overcome because a known company was actively investing to market a material developed by NASA. The effect was the reduction in the amount of time until licensing would take place. The most immediate path to their success was to find another large company that had continuous sales of high value added products that could support the initial price and benefit from the use of an expensive new material to gain market share. Several types of industries have this product capability with sporting equipment, military hardware suppliers and medical products are examples. It was the medical products industry that licensed LARCTM-SI for use as a new wire varnish for pace maker leads, an application that was never envisioned!

Conclusion

In conclusion, there were several factors required for establishing LARCTM-SI as a potential commercial product. They were the use of commercially available monomers and the submission of several patents with very broad coverage prior to public disclosure. This was followed by the creation of a unique application, THUNDER, and the marketing arm of a large service company. Another important criteria for success, in this case, is NASA being the developer of the material. Lastly, it must be realized that this effort took place during a time when the cost of borrowing money was lower. It is debatable if LARCTM-SI would have been as successful in the current economic environment.

References

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