R. Miller*

Susterra propanediol

A renewable and sustainable building block that delivers performance for the urethane industry

A recent trend in urethanes has been the use of bio-based raw materials derived from renewable resources as viable alternatives for non-renewable materials. While many leading OEM's in the automotive, furniture, and footwear industries are looking to increase the renewable content in their products, delivering high performance material is just as critical.

Introduction

An increasing number of polyurethane manufacturers are looking to provide their customers with differentiated products that combine performance with environmental consciousness. A study of consumer purchasing habits has shown that demand for sustainable offerings remains strong despite the recent downturn in the economy. According to a recent Cone Consumer Survey (February 2009), 44 % of consumers say their "green" buying habits remain unchanged despite the current economy and one-third of consumers say they are more likely to buy green today than they were previously. As a result, the DuPont portfolio of renewably-sourced products is seeing an increase in demand among well-known market brands.

In May 2004, DuPont and Tate & Lyle, a leader in renewable ingredients, formed an equally owned joint venture – DuPont Tate & Lyle Bio Products, LLC – and invested USD 100 million in one of the largest biomaterials processing facilities in the world at Loudon, TN, USA. Originally built to meet the global demand for the DuPont Sorona polymer, a renewably-sourced polytrimethylene terepthalate (PTT), the proprietary production process ferments corn sugar, a rapidly renewable feedstock, to manufacture a 100 % bio-based 1,3-propanediol. This material has been available since 2006 under the registered trade name Susterra. The commercial success of this product has led to the recent announcement that capacity is to be expanded by 35 % for start up in the second quarter 2011.

A life cycle assessment (LCA) based on design data of the cradle-to-gate production of this new material versus the production of chemically derived propanediol shows significant environmental benefits. The unique manufacturing process consumes up to 42 % less energy and reduces greenhouse gas emissions by more than 56 %, saving the energy equivalent of over 15 million gallons of gasoline per year. The LCA has been externally reviewed and Susterra is also certified as readily biodegradable based on an OECD Guideline Test for biodegradation.

Opportunities as an urethane raw material

There are great opportunities for Susterra as a raw material for the production of polyester polyols and as a chain extender. For example, polyurethanes formulated with Susterra-based polyesters can expect improved low temperature flexibility, soft feel and improved abrasion resistance. In addition, this high purity, speciality diol offers improved handling and can be used in formulations to create clear polyurethanes. The use of Susterra propanediol in these polyester polyols at levels of up to 40 wt.-%, in combination with a Susterra chain extender at levels of 3 – 10 wt.-%, makes it possible to yield a final product containing up to 33 wt.-% bio-based content.

One example of polyester polyols made from this bio-based PDO are those derived from adipic acid. Differential Scanning Calorimeter studies by DuPont Tate & Lyle **(fig. 1)** have shown that Susterra adipates have melt transitions at 30 and 40 °C (M_n = 2,000 g/mol, second heating run, 10 °C/min). By comparison, these transitions occur at lower temperatures than those of ethylene glycol (EG) adipate (48 °C) or 1,4-butanediol (BDO) adipate (53 °C). Interestingly, mixed glycol adipates based on Susterra exhibit even lower melt transitions and the mixed Susterra/EG adipate is a liquid at room temperature, making it very easy to handle.

When evaluating the crystallisation half times, a quenched sample of Susterra adipate crystallises slowly at room temperature (20 °C). Its crystallisation half time is 390 s. Additional development work has found that the crystallisation half time of Susterra adipate at 5 °C (60 s), exhibits comparable results to BDO adipate at 20 °C (45 s) and EG adipate at 15 °C (30 s).

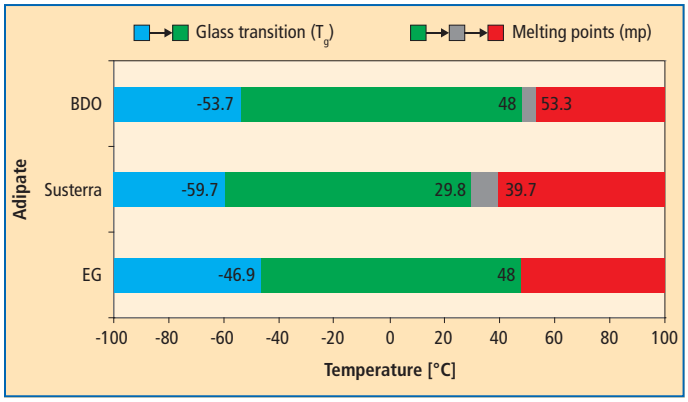

Fig. 1: *Thermal transition of glycol adipates*

* *Robert Miller*
robert.miller@usa.dupont.com
Technical Service Specialist
DuPont Tate & Lyle Bio Products, LLC

Overall, these thermal properties make the novel Susterra-based adipates highly suitable for use in products for the CASE (coatings, adhesives, sealants and elastomers) sector of the urethane industry that require low temperature flexibility, and room temperature softness and transparency.

Suitability for use in elastomers

When used in thermoplastic urethane formulations, Susterra easily reacts with MDI to yield linear urethane domains with low melt energies. To illustrate the effect of lower crystallinity in a polyurethane, a cast elastomer was produced substituting BDO with Susterra as the chain extender and the polyester polyol. The resulting elastomers showed comparable Shore A hardness to conventional products, improved pot life and abrasion resistance, while satisfying the required mechanical properties. Based on thermal transitions of Susterra adipates at lower temperatures and lower energies, formulators can increase the hard blocks at desired polyurethane hardness and develop softer polyurethane grades with increased abrasion resistance. The cast elastomer industry is probably one of the most versatile application segments of the CASE industry, well-known for stringent high performance requirements. Application examples include industrial wheels and casters, transportation, sports and recreation, and footwear.

In summary, Susterra is a great fit for the polyurethanes industry. It offers a functional, consistent, and high purity building block that is especially suitable for use in coatings, adhesives, sealants, and (microcellular) elastomers (CASE), thermoplastic polyurethanes, and aqueous polyurethane dispersions. Uses in downstream markets include footwear, where Susterra has been incorporated into various layers of the shoe sole as well as artificial leather. Properties such as a soft feel and low temperature performance are key in the latter.

An in depth view on the properties and applications of Susterra in the CASE and footwear markets is expected on 11–13 October 2010 during the Polyurethanes 2010 Technical Conference and UTECH North America exhibition in Houston, TX, USA. ■