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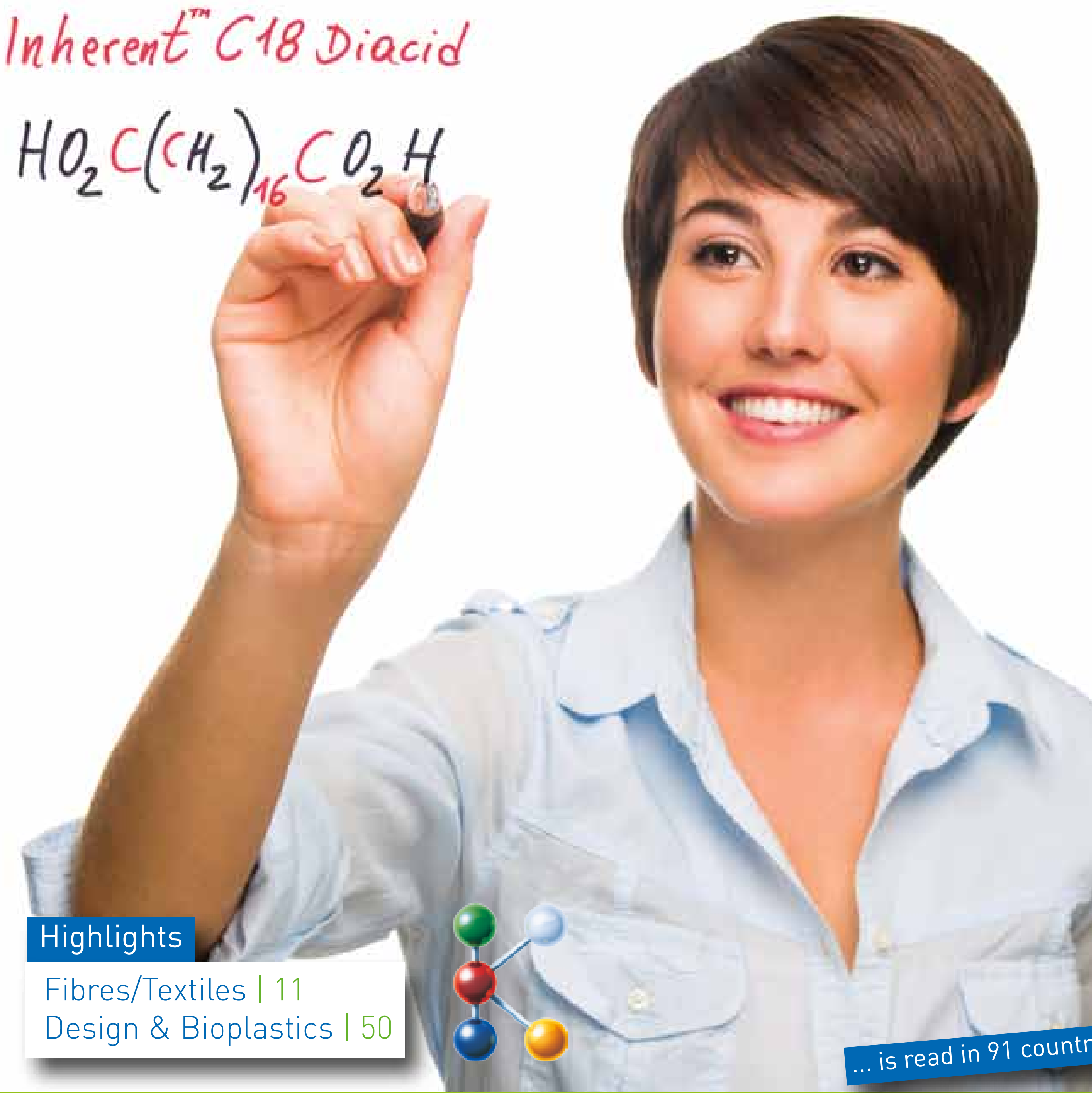
Cover Story

Elevance® makes ODDA a commercial reality | 08



Highlights

Fibres/Textiles | 11
Design & Bioplastics | 50

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Consumer electronic applications made with different Polyamides and Polyesters (photo: Shutterstock) Note: all photographs show potential applications made with polyamides, polyesters or polyurethanes using Inherent C18 Diacid.

Inherent™ C18 Diacid

Proprietary technology and novel specialty chemicals enable game-changing solutions for plastics industry

By
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Diacids are a commercially important class of chemicals with tens of thousands of tonnes of diacids produced annually and applications in a variety of end uses. Elevance Renewable Sciences®, Inc., a high-growth specialty chemicals company, has commercialized a bio-based diacid that will significantly broaden and revolutionize product portfolios across a variety of industries from automotive and electronics to medical and sporting goods.

Elevance® is making Inherent™ C18 Diacid, also known as octadecanedioic diacid or ODDA, using a unique and efficient production process and materials produced from its world-scale biorefinery in Gresik, Indonesia — the first based on Elevance's proprietary metathesis technology. The process allows for the purity required for demanding applications like polymers and is a solution that is cost competitive with other specialty diacids in the marketplace. A mid-chain diacid, Inherent C18 Diacid enables performance attributes not possible by more common, shorter chain diacids.

"Inherent C18 Diacid is the most recent addition to our growing line of bio-based commercial products that can provide our customers with high-performance solutions for their markets," said Elevance CEO K'Lynne Johnson. "We now are advancing innovation in the plastics industry by bringing to market new linear molecules that allow our customers to improve existing polymers and create completely new polymers."

Uses for Diacids

Diacids are particularly useful building blocks in condensation polymerization applications. The variable aliphatic chain length between the two carboxylic acid groups results in the ability to achieve an assortment of physical properties. As such, the properties of the products made can be tailored by choosing the appropriate chain length.

Polyamide and polyurethane polymers from diacids are typically produced by condensation polymerization. Polyamides range from very high melting point materials, such as PA 6,6, to mid-chain length materials, such as PA 6,12, to the aliphatic long-chain diacid polyamides that make up high-performance, hot-melt adhesives. Figure 1 shows some important commercial polyamides and their range of melting temperatures.

Polyamide applications under the hood of a modern car (photo: Shutterstock)

Inherent C18 Diacid enables polyamides with improved moisture resistance, better optical transparency, and greater material toughness for new automotive and electronic applications. Using Inherent C18 Diacid with polyester polyols helps polyurethane manufacturers create polymers with exceptional solvent resistance, hydrolytic stability, optical clarity and toughness that will benefit a variety of markets.

Polyamide hot-melt adhesives made from shorter chain lengths exhibit the best adhesion to surfaces due to the higher polarity of the molecule but, for the same reason, these adhesives are more susceptible to moisture pickup and can delaminate in high humidity environments. The less polar, longer chain lengths (C36) have lower moisture uptake, but also can have fewer amide linkages in the chain, and therefore lower overall adhesion. This is depicted as the performance range in Figure 2.

With the use of Inherent C18 Diacid in hot-melt adhesives, this performance gap would be overcome. Specifically, using a C18 mid-range diacid to make the hot-melt polyamide should impart a combination of both higher polarity and higher adhesion due to increased amide linkages and lower moisture uptake.

Properties of Materials from C18 Diacid

Noteworthy products that can be made using Inherent C18 Diacid include polyesterification products and polyamides. Aliphatic polyamides based on the diacid (from PA 2,18 to PA12,18) have been synthesized via melt condensation [3]. Note the trend (Figure 4) in the polyamide series as the spacing between amide groups increases with the longer diacids. The resulting polyamides are still highly crystalline, however the melting point decreases as the length of the amide repeat unit increases. With higher aliphatic content, the polyamides become more resistant to moisture and organic solvents. Interestingly, even the long-chain and highly aliphatic PA 4,18 and PA 6,18 polyamides exhibit very high melting points, greater than both PA10 and PA11, enabling a very high-use temperature for these C18-based polyamides.

Copolyamides of 6,18 with other monomers have been reported in the literature. PA 6,18 was co-polymerized with PA 6 for use in molded and extruded thermoplastics. The resulting polyamide was reported to be more resistant to salt stress corrosion cracking and to have a lower melting point than PA 6,6 and PA 6,10 [4].

Hot-melt adhesives containing PA 6,18 have been reported in the manufacture of filters. Incorporation of the long-chain diacid is reported to decrease water absorption (the Achilles' heel of polyamides) and to provide significant increases in chemical and solvent resistance of the polyamide, including resistance to gasohol [5, 6].

The cycloaliphatic polyamide of bis(2-methyl-4-aminocyclohexyl)methane and C18 diacid was synthesized and shown to be a moldable amorphous polymer with lower density, increased flexibility, better chemical resistance and reduced clouding as compared to the corresponding polymer derived from dodecanedioic (C12) acid. In addition, the optical transparency

Different protective applications made from different polymers made with carboxylic acids (photo: Shutterstock)

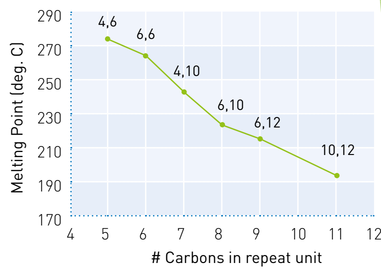


Fig. 1: Commercial Polyamides from diacids

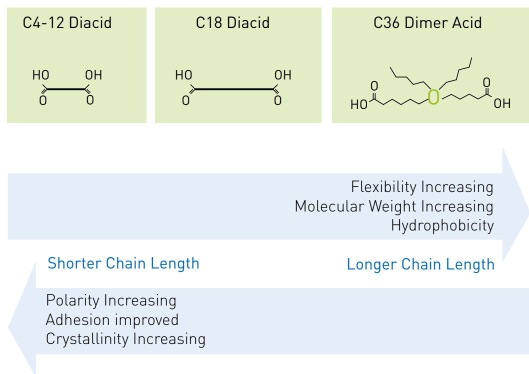


Fig. 2: Structure-Property Relationships of Polyamide Adhesives

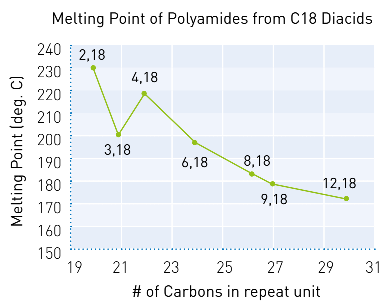
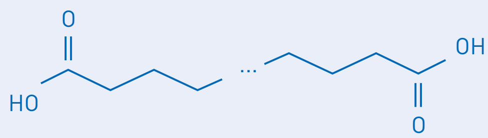


Fig. 4: Melting points of x,18 polyamides from C18 diacid [4]

Polyurethane and Polyetheramid applications used in sports (photo: Shutterstock)

Info:

Aliphatic diacids comprise two carboxylic acid functional groups linked by an aliphatic hydrocarbon spacer. The general formula for this class of compound is $HO_2C(CH_2)_nCO_2H$. Typically, n is between 0 and 22.



was improved over dodecanedioic acid — equivalent to PMMA and superior to polycarbonate and polystyrene [7].

Block copolymers of polyamides and polyethers, also known as polyetheresteramides, have been formed into shaped articles such as fibers, fabrics, films, sheets, rods, pipes, injection molded components or shoe soles. The polyetheresteramides that utilized C18 diacid afford a product with improved optical properties as compared to its shorter chain homologues [8].

Polyurethanes are typically synthesized via condensation polymerization of a di-isocyanate (typically MDI), a chain extender (typically butane diol) and a longer chain polyol (typically polyester or polyether). Long-chain diacids (such as C18) can also be used to make polyester polyols that make up the soft segment in polyurethanes. The use of the longer hydrophobic chain in the polyols is expected to result in a new class of polyurethanes with a very flexible, less polar soft segment with better elasticity at low temperatures, better hydrolytic stability (due to the lower ester content) and lower moisture pick-up in high-humidity environments such as automotive.

Condensation polymers based on C18 diacid are also expected to have much lower moisture pickup than shorter chain diacids. When C18 diacid is incorporated into polar polymers — such as polyamides, polyesters and polyurethanes — the resulting polymers are expected to have high-temperature performance in high-humidity environments and exhibit better hydrolytic stability. This set of features is critical in under-the-hood automotive applications such as air intake manifolds, tanks for power steering fluids, coolant pumps, electronic housings, connectors and fuel lines. Other applications requiring high-humidity performance include sporting goods (e.g., roller wheels, ski boots, bicycle tires, horseshoes and athletic shoes), power tool housings, mobile phone housings, gears, sprockets, automotive panels, bumpers and airbags.

Inherent C18 Diacid Sustainability

Elevance's products combine high performance with renewable content. The Elevance technology can use a diversity of renewable feedstocks, including palm, mustard, soybean and, when they become commercially available, jatropha or algal oils. Each of these feedstocks can be sourced locally, enabling Elevance and its customers to reduce the carbon footprint across the entire supply chain.

High-performance polymers, used in durable goods, have had limited options for using renewable feedstocks, with castor oil being the most significant. With Inherent C18 Diacid and other products now possible using the Elevance technology, alternate renewable feedstock possibilities creating new material sourcing options and innovative performance-based solutions are available for high-performance polymer and durable goods manufacturers to expand their portfolios, supply chains and achieve sustainability goals.

Summary

The advantages of long-chain diacids, such as Inherent C18 Diacid, are numerous and varied. Incorporation of this monomer into polymers, pre-polymers and low molecular compounds is expected to impart low surface tension, better dispersion and miscibility, high crystallinity, low moisture pick-up, high optical transparency, low dielectric constant, and increased hydrolytic stability over shorter chain, more common diacids.

Also contributing to this article: Brian Albert, Paul Bertin, Steve Cohen and Jordan Quinn

www.elevance.com

This article is based on a more comprehensive white paper. That is why the numbering of figures and references is not continuous. A full version of the white paper can be found at www.bioplasticsmagazine.de/201305.

PDF

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