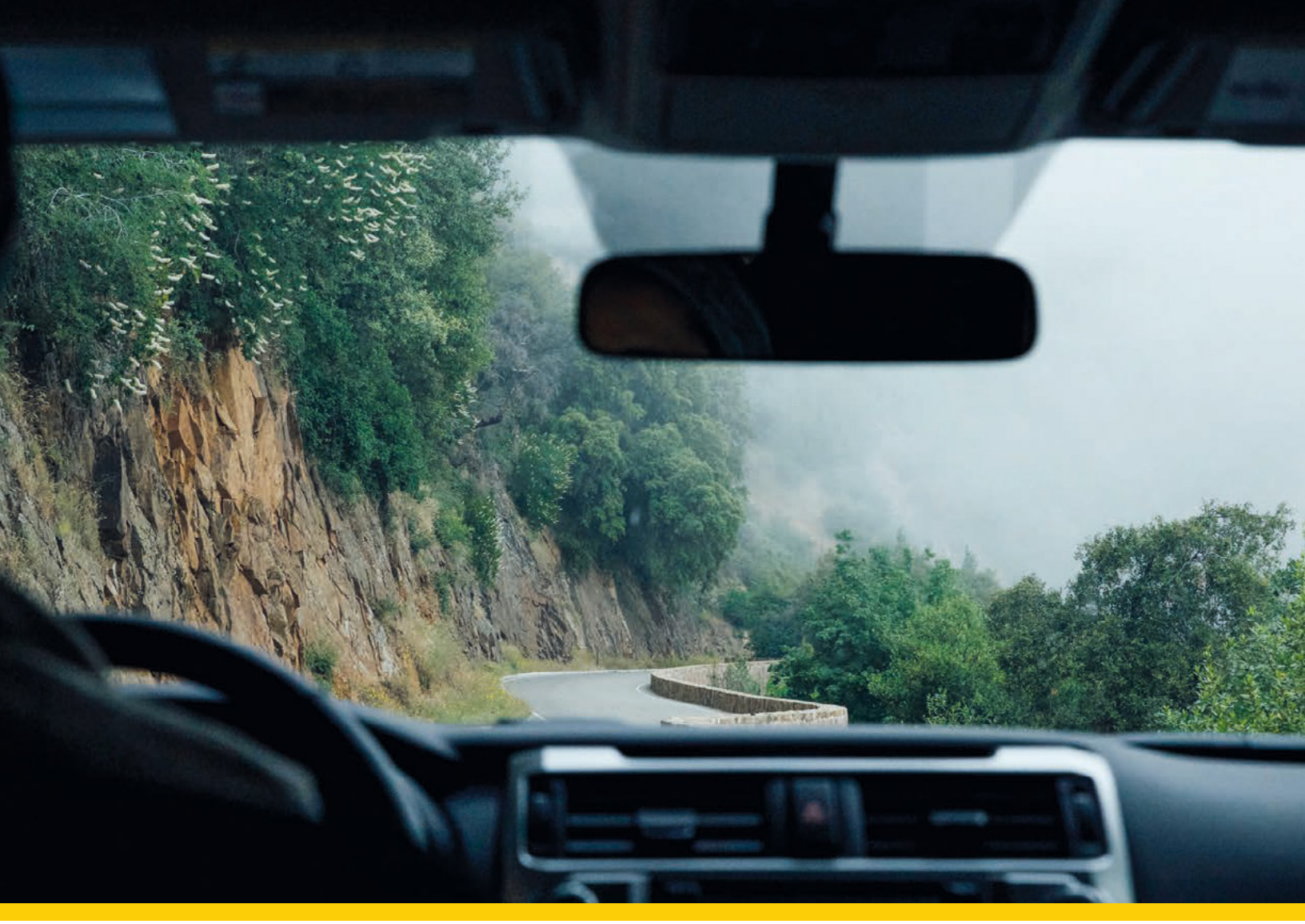


THE PLASTICIZER ALCOHOL OF CHOICE

Shell
LINEVOL™ Plasticizer Alcohols

The Shell Chemicals LINEVOL series is made up of high-purity synthetic alcohols that have both odd and even-numbered hydrocarbon chains, ranging from C9 to C11. LINEVOL alcohols are used in the manufacture of many premium plasticizers, primarily in PVC-resin based applications. Typical end-market uses can range from automotive interior trim, to high-and-low temperature wire and cable jacketing, to roofing and pond membranes and more.

PLASTICIZER ALCOHOLS

Shell Chemicals is a leading global supplier of essentially linear alcohols for use in the manufacture of plasticizers. Plasticizers are additives that improve the softness and flexibility of the polymers into which they are incorporated. Phthalate esters make up the largest global plasticizer market by volume. Phthalate esters are mainly used in the production of flexible polyvinyl chloride (PVC).

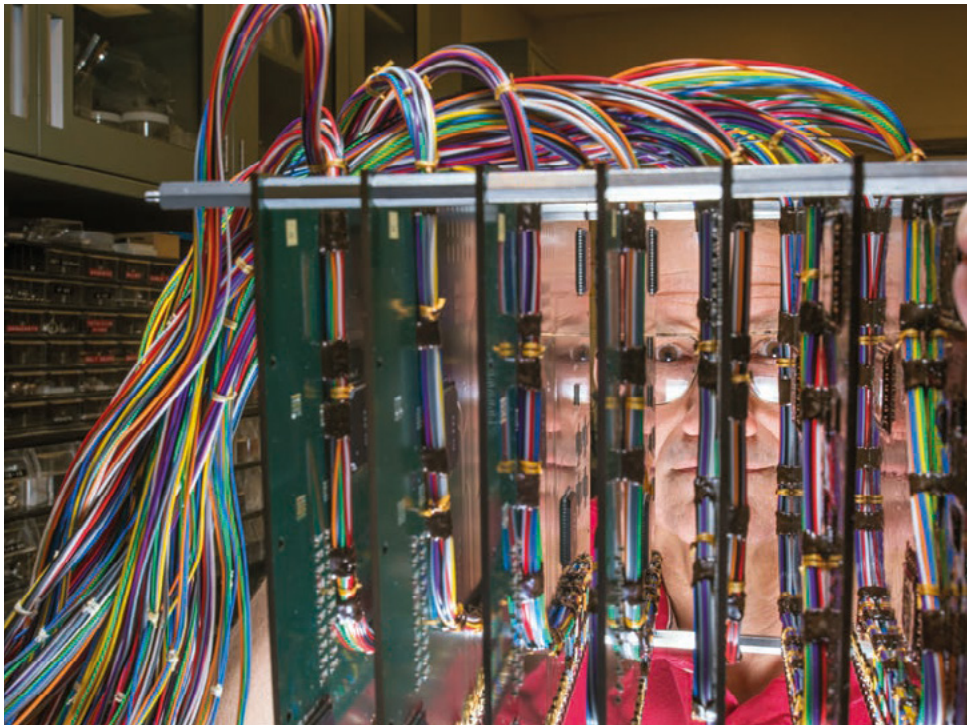
The properties of the alcohol play an important role in determining the properties of the plasticizer and, therefore, the performance of the (flexible PVC) endproduct.Shell's LINEVOL alcohols can be used in the manufacture of both phthalate and non-phthalate plasticizers (terephthalates, adipates, trimellitates, and sebacates).

Thanks to their unique, essentially linear structure, LINEVOL alcohols enhance many desirable technical properties such as:

- increased UV permanence
- low volatility
- low temperature performance

Shell's LINEVOL alcohol series is incredibly versatile, promoting technical performance across an array of desired properties. Where most other plasticizers perform well on only one end of the spectrum or the other, the LINEVOL-based plasticizers perform well on both. For example, LINEVOLs provide balanced performance across both Heat Aging and Low Temperature requirements. This unique versatility enables our customers to create finished plasticizers that can reach new, premium, more technically demanding markets.

For wire and cable applications, plasticizers are essential to make PVC bendable and soft

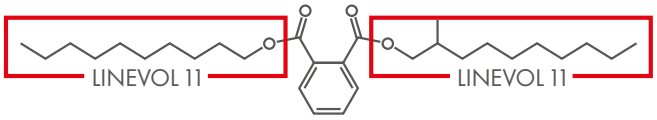


SHELL LINEVOL PRODUCT RANGE

Shell LINEVOL alcohols are essentially linear synthetic alcohols that are manufactured from higher olefins using proprietary Shell Hydroformylation (SHF) technology, known as the Modified OXO process. The product range, which consists of LINEVOL 911 and LINEVOL 11, is manufactured at the Shell Chemical Geismar plant in Louisiana, USA.

LINEVOL 911 has a carbon range of C9 to C11 while LINEVOL 11 mainly consists of C11. Shell has the capability to develop other plasticizer alcohols, such as a C13. Please contact us with any plasticizer alcohol development requests.

Figure 1: example of a phthalate ester based on LINEVOL 11



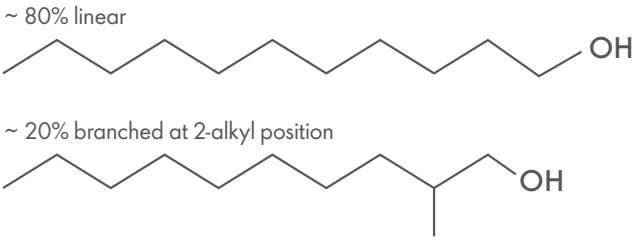
Shell's one-of-a-kind manufacturing process and global product quality specification assure consistent batch-tobatch composition.

Having an essentially linear structure, the Shell LINEVOL alcohols differ markedly from commodity branched alcohols used for many phthalate ester plasticizers.

- They are readily biodegradable and are not expected to bioaccumulate.
- They adsorb to soil and have low mobility.

In plasticizers, the linearity (see Figure 2) provides a strong interaction between the plasticizer and PVC matrix that enhances high and low-temperature performance as wellas weather resistance of compounds and plastisols.

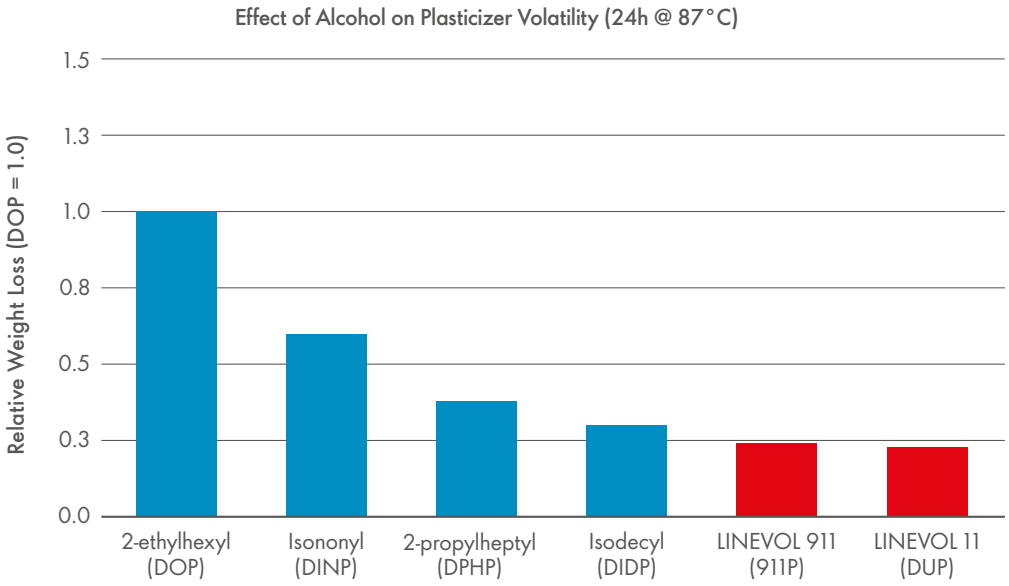
Figure 2: unique molecular structure of LINEVOL alcohols



Unique Structure: High Performance and Readily Biodegradable

Industry data shows that, when using essentially linear alcohols like Shell LINEVOL 911 or 11, the volatile loss of the plasticizer is dramatically decreased (see Figure 3). This translates, for example, to reduced fogging of windshields in cars whose interiors are extensively based on PVC.

Figure 3: Lower weight loss can be achieved when using LINEVOL alcohols compared to branched alcohols

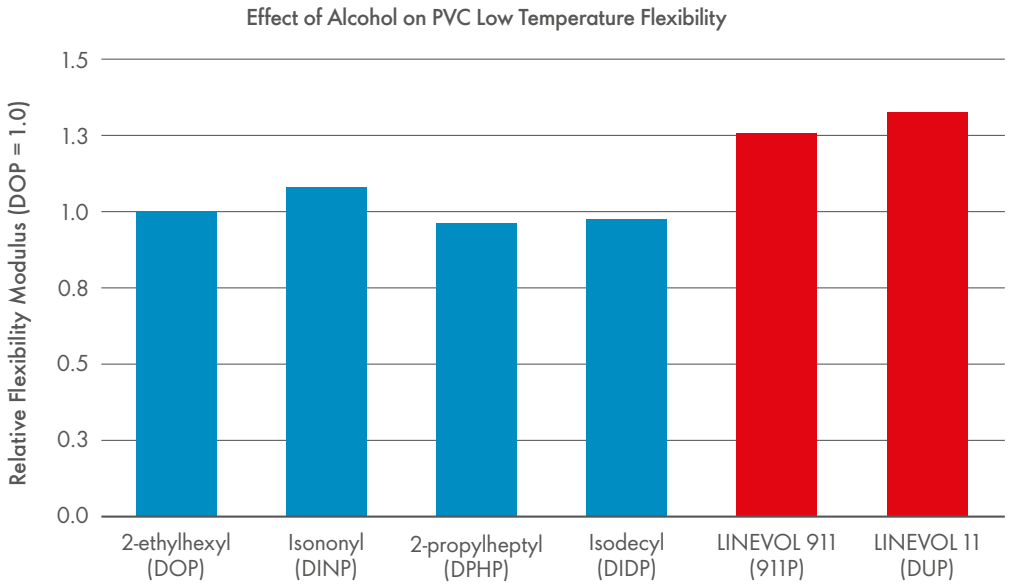


Low volatility of LINEVOL alcohols provides low degree of window fogging

LINEVOL alcohols keep PVC flexible and preserve key properties in varying weather conditions

Linearity also has a positive effect on the low temperature flexibility of PVC. When using LINEVOL alcohols, the flexibility can increase up to 25% compared to branched alcohols with similar molecular weight, see Figure 4.

Figure 4: LINEVOL alcohols deliver significantly better low temperature flexibility than plasticised PVC



DESIGNED TO MEET APPLICATION REQUIREMENTS

As shown in the figures, alcohols with higher linearity, used in the manufacture of phthalate ester plasticizers, offer important performance advantages over branched alcohols. These desirable properties make LINEVOL-based plasticizers the superior choice for many technically demanding uses, see Table 1.

Table 1: Overview of applications, their key requirements and how LINEVOL alcohols match

Application	Requirement	Why choose LINEVOL alcohols for the plasticizer?
Wire and cable products	Excellent heat aging and low volatility	Linear alcohols penetrate more deeply into the PVC matrix through van de Waal interactions. This anchors them more strongly than branched alcohols of similar molecular weight and means they have lower volatility.
Vinyl film and sheet	Low temperature flexibility	Linear alcohol structures contribute to improved low temperature properties of phthalate plasticizers and provide higher resistance to embrittlement of PVC.
Vinyl-coated fabrics	Good weathering resistance and UV stability	Linear plasticizers are more resistant to degradation in outdoor applications than branched plasticizers as they are less susceptible to free-radical attack, from atmospheric pollutants or UV radiation in sunlight.
Automotive plastic interiors	Anti-fogging of windscreens; reduced cracking	As stated in the first box above, linear alcohols interact more strongly than branched alcohols with the PVC matrix giving dual advantages of lower volatility and greater permanency of the plasticizer molecule. This results in reduced windscreen fogging and reduced plastic interior cracking with time.

GLOBAL PRODUCT ACCESSIBILITY

Shell LINEVOL alcohols are listed on global inventories (see Table 2), manufactured to various ISO quality management standards (e.g., ISO 9001) and certified by Responsible Care® (RC 14001).

Table 2: Summary of registration status

Product	CAS registry nr.	Inventory listings
LINEVOL 911	66455-17-2	AICS, DSL, IECSC, EINECS, REACH*, ENCS/ISHL, KECI, NZIoC, TSCI, TSCA
LINEVOL 11	112-42-5	AICS, DSL, IECSC, EINECS, REACH*, ENCS/ISHL, KECI, NZIoC, PICCS, TSCI, TSCA

*EU REACH registration applies only when product is procured from Shell Chemicals Europe (SCE).

CONTACT US

Our website **www.shell.com/chemicals/LINEVOL** provides access to technical data.

The Shell Chemicals Business Development and Technical teams are just a phone call away. Contact your sales representative to request samples, further information or a virtual meeting.

The expression "Shell Chemicals" refers to the companies of the Shell Group engaged in chemical businesses. Each of the companies which make up the Shell Group of companies is an independent entity and has its own separate identity.

THE SHELL CHEMICALS ADVANTAGE:

Global Supply Chain and Quality Assurance

LINEVOL alcohols are produced in the Gulf Coast, USA and distributedvia Shell Chemicals' extensive global supply network.

LINEVOL alcohols are manufactured to global specifications. This allows customers to create global formulations and achieve economies of scale.

Product and Technical Support

Shell Chemicals has a network of product and technical professionals, supported by world-class technology facilities in Amsterdam and Houston. We offer technical support, on the phone or in person.

Focus on Sustainability

Shell Chemicals' sustainability agenda is focused on two broad goals, to reduce the CO2 intensity of chemical products and to enable the circular economy. Shell is proud to be a founding member of the global Alliance to End Plastic Waste and has started using feedstock made from plastic waste in its chemical plants.