

Flexidone™ Additives

Breakthrough performance and processing efficiency for your demanding industrial and specialty applications

The Flexidone family of high performance additives represents breakthrough technology in “cold flex” performance of plastics. Depending on your application, it can offer you a great deal more. Flexidone additives expand your options in PVC formulation, manufacturing and end-product design. This flexibility lets you re-imagine the potential of demanding applications and reconfigure processing for unprecedented efficiencies.

A spectrum of benefits based on alkyl chain lengths

An entirely new class of additives based on N-alkyl Pyrrolidone chemistry, Flexidone 100, 300, 400 and 500 differ in their alkyl chain lengths (C₈, C₁₂, C₁₂₋₁₆ and C₁₆₋₁₈, respectively). Short to mid-length chains are responsible for three primary benefits: solvency for PVC, plasticizing efficiency and high flexibility to -70°C (“cold flex” performance). Long length chains provide very low volatility loss at elevated temperatures.

Flexidone 100: Exhibiting superlative solvency and efficiency as a plasticizer, a little amount of Flexidone 100 goes a long way. It excels as an additive, particularly in highly filled applications where even modest addition rates deliver significant gains in quality, performance and processing efficiencies.

Flexidone 300: The workhorse of the line, Flexidone 300 balances critical performance characteristics, making it suitable for a broad range of applications. Flexidone 300 provides custom performance characteristics with 30–40% less plasticizer, all while lowering processing temperatures significantly.

Flexidone 500: Ideal for specialty applications, Flexidone 500 lends superior stability and durability to products that must hold up in hot conditions.

Applications

- Vinyl flooring
- Carpet backing
- Roofing membrane
- Coated textiles
- Cable sheathing
- Refrigerator and window gaskets
- Hoses
- Pond liners
- Tarpaulins and sheets
- Bath mats and shower curtains
- Artificial leather
- Shoe soles
- Automotive underbody coatings



Features and Benefits

- Achieves better performance with 30–40% less use (than conventional plasticizers)
- Dissolves PVC at low temperatures quickly and completely
- Reduces dry blend times significantly
- Reduces manufacturing processing temperatures significantly
- Enables addition of temperature-sensitive colors and scents
- Enables application on heat-sensitive materials
- Decreases gelling temperature in plastisol production without compromising viscosity
- Facilitates fast gelling
- Provides high flexibility at extremely low temperatures (up to -70°C)
- Exhibits very low volatility and low plasticizer loss at high temperatures
- Enhances clarity and transparency
- Enables high filler load
- Increases compatibility of secondary plasticizers, such as fatty esters, Cl-paraffines
- Contains no phthalates

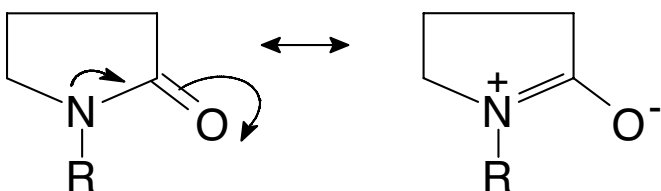
Flexidone™ Performance Additives

Enhancing performance and efficiency

High performance at lower use levels

Flexidone additives are N-alkyl pyrrolidones that consist of a flexible non-polar alkyl chain with a compact hydrophilic head. The alkyl chain varies in length, from C₈ to C₁₈ for Flexidone 100, 300, 400 and 500. This configuration, combined with the molecule's planar structure, offers excellent solubility and compatibility with PVC.

Planar configuration of pyrrolidones allows for electron delocalization



Electron delocalization of the pyrrolidone ring makes Flexidone additives highly compatible and uniformly soluble in polar and non-polar solvents.

Balancing performance benefits

With performance characteristics existing along a continuum based on alkyl chain length, Flexidone offers flexibility in fine-tuning your PVC formulation, your manufacturing process, and your end-product design for optimal efficacy and efficiency.

Flexidone performance based on alkyl chain lengths

Alkyl pyrrolidone chain length	Solvency for PVC	Plasticizing efficiency	Low weight loss at high temp.	Flexibility at low temp.
Flexidone 100 C ₈	↑	↑	↓	↑
Flexidone 300 C ₁₂				
Flexidone 400 C ₁₂ -C ₁₆				
Flexidone 500 C ₁₆ -C ₁₈				

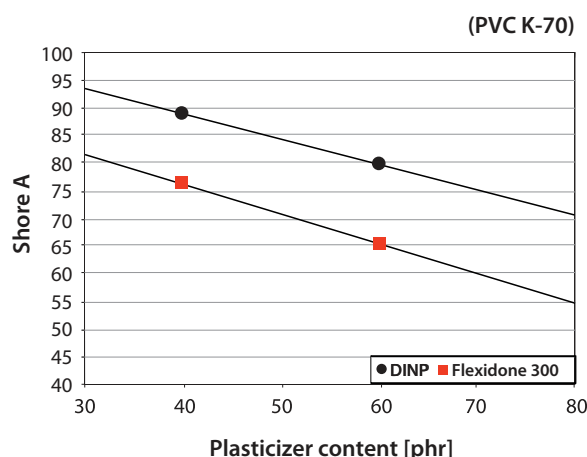
Flexidone 100 and 500 offer specialized benefits at either end of the spectrum, while Flexidone 300 balances performance and manufacturing efficiency for general purpose industrial applications.

Flexidone as a co-plasticizer or additive

Today, more than 80% of commercial plasticizers are phthalates, a general-purpose plasticizer. Other plasticizers provide specific performance characteristics to PVC, such as flame retardancy. As a co-plasticizer, Flexidone can boost the performance of phthalates, adipates, trimellitates, epoxidized oils, polymeric and other standard plasticizers, providing the end product with custom-tailored characteristics.

Flexidone can be used as much lower use levels than standard plasticizers to achieve similar, or better, performance. As shown in the chart below, Flexidone 300 consistently achieves lower Shore A values than diisononyl phthalate (DINP) at lower use levels.

Highly efficient compared with standard plasticizers



Flexidone 300 achieves a Shore A hardness value of 80 with 45% less plasticizer than DINP – only 33 phr of Flexidone 300 compared with 60 phr DINP.

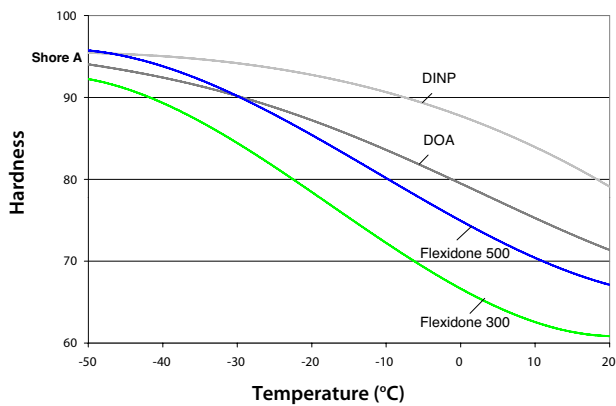
With Flexidone, you can generally achieve greater flexibility with 30-40% less plasticizer use compared with conventional plasticizers, which translates into less waste, less disposal and more post-processing savings. The combination of reduced plasticizer use, manufacturing efficiencies and higher end-product value and performance makes Flexidone highly competitive in terms of total cost-in-use.

As an additive used in amounts as small as 0.5–3.0phr, Flexidone lends its trademark performance characteristics to varying degrees. From a mere 1 phr in blends to 100 phr in flexible, filled systems, Flexidone is adaptable to the specialized needs of your application. For all products in the Flexidone line, usage amount influences the degree of end-product performance and the extent of manufacturing efficiencies.

Low temperature flexibility

Flexidone 300 and 500 produce PVC with significantly higher flexibility than DINP or the classic low temperature plasticizer dioctyl adipate (DOA) in typical cold use temperatures of -20°C to -40°C. PVC plasticized with Flexidone 500 remains fracture free down to -70°C – the first low-volatility plasticizer to achieve such a low break temperature. This remarkable characteristic opens up unprecedented product development opportunities. Furthermore, unlike DOA, which is not typically used alone, Flexidone 500 can be used as the primary plasticizer for low temperature applications.

Physically robust and flexible even at low temperatures

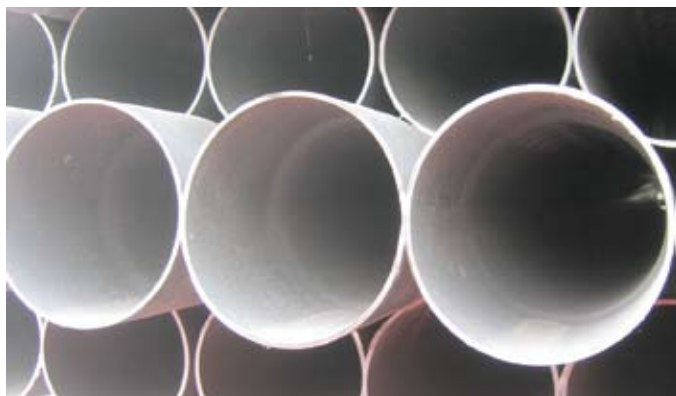


All plasticizers at 60 phr

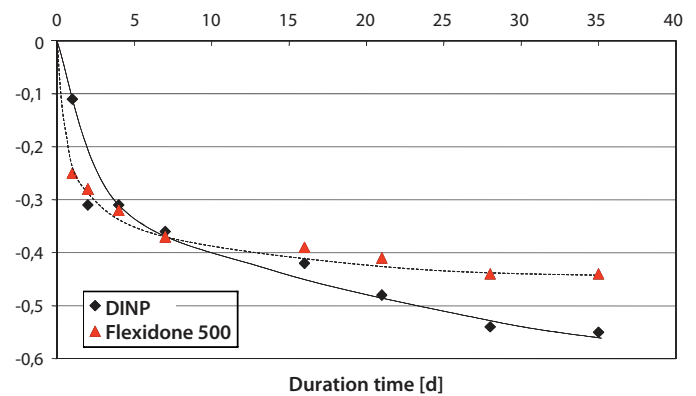
Flexidone 300 and 500 are 30–40% more efficient than standard plasticizers according to the Shore A scale for indentation hardness. The lower the Shore A value, the softer the plasticized PVC.

Long-term durability

Flexidone 500 is the ideal choice when applications require high stability/low volatility, particularly at high temperatures. With less diffusion of the plasticizer from the PVC, products containing Flexidone 500 retain their integrity and performance characteristics for longer periods of time. Flexidone 500 maintains low volatility at 80°C as well as DINP at the same Shore A value (see chart top right). Also, as already shown, Flexidone 500 is much more efficient than DINP, exhibiting high performance with less plasticizer use while improving the mechanical properties of co-plasticizers or additives.



Low volatility at high temperatures



Weight Loss at 80°C at the same Shore A

Flexidone 500 remains stable over time, even at high temperatures, making it superior to standard plasticizers for window sealing, roofing membranes and other products that need to remain stable in extreme conditions.

Better tensile strength and elasticity in highly filled systems

Flexidone plasticizers retain their excellent performance characteristics in highly filled calcite systems (up to 150 phr calcite). With conventional plasticizers, such as diisononylphthalate (DINP), tensile strength and elasticity in elongation are compromised as calcite levels increase. With Flexidone, performance remains intact.

Even a modest addition of Flexidone significantly reduces dry blend times, lowers gel temperatures and improves homogeneity. Substituting up to 10 phr of a standard plasticizer in plastisol processing with Flexidone 100, for example, significantly improves homogenization and transparency, and reduces gelling temperatures by 2°C/phr with only little effect on viscosity. End products remain flexible to -70°C, staking entirely new ground for plasticized PVC applications.

Save time and energy with Flexidone

With its high solubility and compatibility with PVC, Flexidone excels as a high performance additive or co-plasticizer in all common manufacturing processes: extrusion, injection molding, calendaring and plastisol production.

With Flexidone plasticizers you can:

- Reduce dry blend times drastically without external heating
- Lower processing temperatures significantly
- Reduce gelling temperatures and times (compared with other plasticizers)
- Produce uniform, highly flexible soft PVC formulations
- Improve cold flexibility enormously
- Reduce overall plasticizer content

These benefits translate into significant time and energy savings.

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Enhancing performance and efficiency

Flexidone product information

Flexidone 100

Chemical name C₈ Pyrrolidones
CAS number 2687-94-7

Flexidone 300

Chemical name C₁₂ Pyrrolidones
CAS number 2687-96-9

Flexidone 400

Chemical name C₁₂₋₁₆ Pyrrolidones
CAS number 68988-02-3

Flexidone 500

Chemical name C₁₆₋₁₈ Pyrrolidones
CAS number 70084-70-7

Physical properties

Appearance	Liquid
Odor	Characteristic
Specific gravity	0.91-0.92 @ 25°C
Solidification point	
Flexidone 100	-25°C
Flexidone 300	10°C
Flexidone 400	-10° to -13°C
Flexidone 500	4° to 10°C

Protecting your plastics formulations

The ISP family of Fungitrol® and PlastiGuard® biocides prevent microbial degradation in a range of resins and wood composite plastics. They outperform the competition on broad-spectrum bacterial resistance, pink staining and ease of processing, providing long-lasting protection that is also friendly on the environment.

Fungitrol and PlastiGuard biocides contain varying levels of 3-iodo-2-propynyl butylcarbamate (IPBC) or N-(Trichloromethylthio) phthalimide (Folpet), depending on the application. They are available in pellets, granules, powders and liquids for easy handling and processing by fabricators and master batch producers. All products deliver full biocidal protection at low loading levels for quick and economical incorporation into plastics.

For more details about how ISP biocides can protect your plastics and improve your manufacturing, speak with your ISP representative.

Partnership with the Cologne University of Applied Sciences

Performance tests for Flexidone were conducted by Professor Dr. Martin Bonnet in the labs at the Institute of Applied Materials (IWA), Cologne University of Applied Sciences. With industry experience and serving as Head of Faculty for the IWA, Dr. Bonnet supports ISP by providing access to state-of-the-art facilities, equipment and knowledge for ongoing product evaluation and innovation.

In partnership with Dr. Bonnet, ISP can perform customer-specific tests for development purposes, as well as joint-develop applications at the Cologne University IWA labs. For more information, contact your ISP representative.

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To find an ISP sales office in your country visit: ispcorp.com

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Flexidone is a trademark of ISP. Product Code: PCH5578-11/2009

The use of alkyl pyrrolidones as plasticizers for PVC is covered in ISP's US Patent 7,411,012. Currently, ISP is working on a new patent application that covers the use of the combination of alkyl pyrrolidones and fatty esters as plasticizers for PVC.

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