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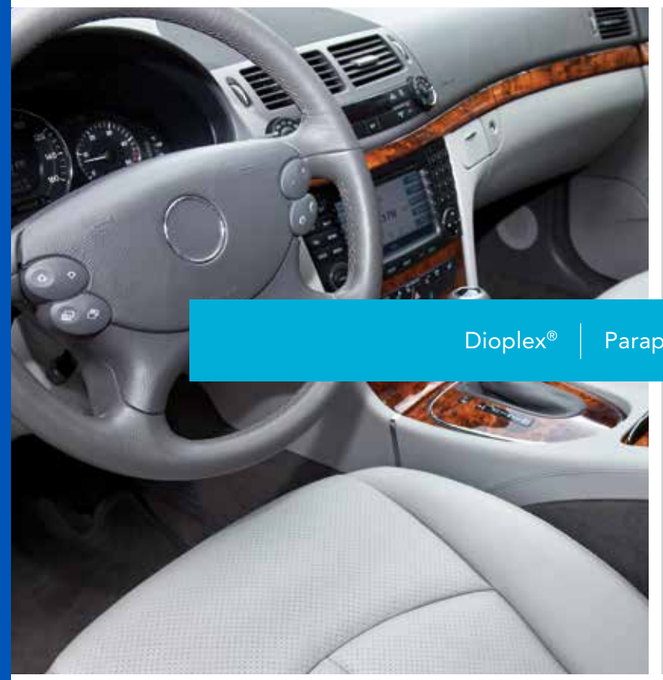
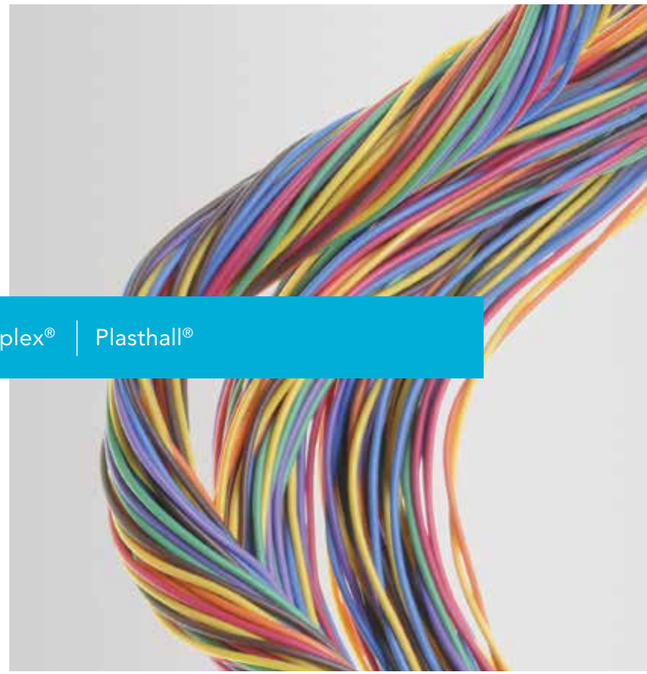
LET'S WORK WONDERS™

HALLSTAR

PLASTICIZERS FOR PVC





Dioplex® | Paraplex® | Plasthall®

Hallstar works collaboratively with companies around the world to deliver chemistry solutions that enhance next generation products.

As manufacturers find themselves under pressure to innovate, their ability to compete globally depends increasingly on how well they can leverage the knowledge of technology suppliers.

Hallstar's expertise in polymer modification and optimization, coupled with our application knowledge across a wide range of industrial products, is unique in the specialty chemical industry. Our ability to continually invent and formulate with esters to craft important functionality—including meeting the challenge of replacing phthalates—is based on years of specialized esterification experience only we can claim.

This experience has led to the development of our proprietary molecular design, the Paraplex Approach. Selecting ester plasticizers can be difficult, but with the Paraplex Approach, our customers can quickly identify unique plasticizer solutions based on tightly defined performance requirements.

Taking a collaborative approach to new products and solutions is what Hallstar is all about. Together we can explore new approaches and possibilities and anticipate what it takes to succeed tomorrow, next year and for years to come. Explore what our innovative plasticizers can do, then give us a call.

LET'S WORK WONDERS™

HOW TO SELECT A PLASTICIZER

Difference between monomerics and polymerics:

Monomerics

typically provide excellent low temperature performance, but may not always be the most permanent choice for more demanding applications that require low volatility and migration. For instance, if low temperature performance is critical, one could choose between DOS and DOZ. If, however, volatility resistance is a secondary consideration, review of the volatility data (weight change percentage) will lead to another selection: DIDA. Rarely will one find an application that requires only a single performance property; usually, two or more performance parameters must be met. This sometimes results in a compromise when selecting a plasticizer system.

Polymerics

are used to provide flexibility, softness and lower modulus values, and can maintain these characteristics after exposure of the Polyvinyl Chloride (PVC) compound to severe conditions or harsh environments. Polymerics are more permanent (stable) under extended, high heat conditions and are less likely to volatilize out of the compound than are monomeric plasticizers. Polymeric plasticizers are resistant to extraction by solvents, oils and fluids, and they resist migration to other polymer compounds in contact with the PVC material. In short, polymeric plasticizers provide greater permanence than monomerics. Polymeric and monomeric ester plasticizers can often be blended together. This imparts the best attributes of both classes, resulting in optimal performance in the end-use application.

The best way to select a plasticizer is to first determine what the critical performance parameters are for the end-product application. Normally, one can determine the two or three most necessary properties in their order of importance. Some of these properties would include efficiency, low temperature, volatility and extraction. Hallstar produces the industry's widest selection of high performance monomeric and polymeric ester plasticizers.

The following are different industry applications and end uses for our plasticizers:

BY INDUSTRY

Adhesives
Aerospace
Appliances
Automotive
Caulks
Coatings
Construction
Hydrocarbon and chemical
Medical
Packaging
Transmission and storage
Transportation

BY END USE

Automotive trim (interior and exterior)
Belting
Decals
Decorative film and tape
Food wrap
Gloves and boots
Hose and tubing
Instrument panels
Pond and lake liners
Rainwear
Refrigerator gaskets
Rollers
Roofing membranes
Tank linings
Upholstery
Wall coverings
Wire and cable

Monomeric Plasticizer Performance Summary

	PLASTICIZER									
	Plasthall®									
	DIDA	DOA	DOS	DOZ	8-10TM	TOTM	DIDP	DINP	DOTP	DOP
Original Physical Properties										
Hardness, pts.	67	64	68	66	75	70	70	72	70	67
100% Modulus, psi	6.6	5.2	6.0	5.9	8.1	7.6	7.4	6.6	7.4	6.2
Elongation @ Break, %	380	410	380	385	385	375	405	375	375	390
Tensile Strength, MPa	13.5	12.6	12.9	12.9	15.2	14.8	15.9	14.3	15.0	14.0
Tensile Strength, psi	1950	1825	1875	1875	2200	2150	2300	2075		2025
Specific Gravity	1.161	1.167	1.158	1.160	1.195	1.198	1.191	1.195	1.200	1.200
Low Temperature										
Brittle Point, °C	-53	-53	-56	-56	-33	-23	-32	-29	-34	-30
T-45,000 psi, °C	-46	-69	-69	-70	-64	-39	-40	-39	-42	-44
T-135,000 psi, °C	-61	-85	-87	-86	-86	-49	-52	-50	-54	
Air Oven Aging, 3 Days @ 120°C										
Tensile Change, %	-1	*	9	7	-6	-2	-3	3	1	17
Elongation Change, %	-25	*	5	-27	-3	0	-11	-20	-20	-45
Weight Change, %	12.0	-34.0	-7.0	-14.0	1.0	0.9	-3.3	-6.3	-8.3	-20.0
Immersion/Extraction, Percent Weight Change After:										
n-Hexane, 24hrs @ 23°C, DO	-34	-32	-34	-33	-33	-32	-35	-36	-38	-34
1% Soapy Water, 7d @ 90°C, DO	-10	-25	-7	-36	-1	-1	-6	-11	-12	-15
Cottonseed Oil, 24h @ 60°C	-28	-29	-28	-27	-23	-16	-21	-21	-23	-19
Distilled Water, 24h @ 60°C, DO	-1.9	-1.7	-1.8	-1.9	-0.8	-0.5	-1.1	-1.0	-0.7	-0.6
High Humidity, 9d @ 90°C, DO	-4.1	-2.3	-1.4	-11.0	-1.1	-0.7	-1.0	-1.1	-0.8	-1.0

***Samples too brittle to test**

Recipe: Resin - 100 PPHR, Plasticizer - as indicated, Stabilizer - 2.5 PPHR, Paraplex® G-62 - 5.0 PPHR
Plasticizer shown is at 67 PPHR (40 percent) of total compound

Polymeric Plasticizer Performance Summary

	PLASTICIZER																												
	Paraplex®											Plasthall®										Dioplex®							
	A-8000	A-8200	A-8600	G-25	G-30	G-40	G-41	G-50	G-54	G-57	G-59	P-550	P-643	P-650	P-670	P-953	P-970	P-971	P-7046	P-7092	UVC	100	195	430	904	925	PLA	VLV	DOP
Original Physical Properties																													
Hardness, pts.	65	70	70	75	79	87	82	79	77	78	74	75	74	73	70	71	71	77	79	84	72	70	70	74	70	65	72	63	72
100% Modulus, psi	850	1225	1375	1200	1350	1550	1500	1100	1250	1300	1200	1300	1050	1150	850	1330	1480	1550	1450	1550	1265	1125	1200	1375	1195	1075	1325	720	850
Elongation @ Break, %	415	390	385	420	430	420	380	470	430	470	430	370	430	450	450	345	370	315	430	420	365	420	390	420	395	475	395	495	440
Tensile Strength, MPa	2300	2625	2600	2200	2550	2450	2550	2550	2450	2550	2450	2450	2350	2450	2300	2600	2775	2665	2650	2550	2665	2415	2500	2625	2525	2310	2575	2075	2100
Tensile Strength, psi	15.8	18.1	18.2	15.2	17.6	16.9	17.6	17.6	16.9	17.6	16.9	16.9	16.2	16.9	16.2	18	19.1	18.4	18.3	17.6	18.4	16.7	17.3	18.1	17.4	15.9	17.7	14.3	14.5
Specific Gravity	1.241	1.275	1.266	1.253	1.267	1.297	1.289	1.273	1.271	1.278	1.29	1.253	1.264	1.252	1.259	1.266	1.269	1.261	1.277	1.28	1.281	1.278	1.267	1.274	1.267	1.242	1.263	1.207	1.209
Low Temperature																													
Brittle Point, °C	-24	-12	-6	-18	-7	-12	-13	-8	-15	-19	-14	-11	-15	-15	-24	-12	-12	7	-5	-3	-10	-17	-14	-14	-17	-18	-14	-44	-34
T-45,000 psi, °C	-27	-17	-13	-12	-14	-10	-10	-16	-16	-17	-11	-14	-18	-14	-25	-23	-24	-3	-6	-3	NT	-27	-28	-27	-28	-26	-27	-49	-37
T-135,000 psi, °C	-33	-26	-22	-20	-24	-18	-19	-25	-25	-26	-19	-21	-27	-20	-34	-31	-33	-10	-13	-10	NT	-27	-28	-38	-37	-35	-38	-59	-46
Air Oven Aging, 3 days @ 136°C																													
Tensile Change, %	0	-4	8	-11	0	-6	-1	-10	-4	-2	-4	0	-13	0	-7	-5	-11	1	24	-6	5	-1	-1	0	0	7	-3	24	rigid
Elongation Change, %	-11	-7	-8	-10	-12	-6	-2	-2	-12	-9	-7	3	-9	-4	-4	9	-5	-5	-9	-19	0	-1	1	7	4	-8	0	-16	rigid
Weight Change, %	-2.6	-0.8	-0.6	-1.0	-8.4	-2.0	-0.4	-1.9	-1.4	-1.5	-1.1	-2.2	-2.1	-2.4	-2.3	-1.0	-1.1	-7.1	-2.0	-1.6	-3.6	0.0	-1.4	-0.8	-1.1	-1.7	-0.9	-13.0	-28.0
Immersion/Extraction, Percent Weight Change After:																													
n-Hexane, 24h @ 23°C, DO	-6.6	-0.5	-0.3	-0.4	-4.8	-0.6	0.1	-2.9	-2.8	-1.5	-0.6	-1.9	-3.9	-2.6	-5.4	-1.2	-1.8	-3.4	-0.7	-0.4	-2.4	-0.2	-3.0	-0.4	-2.1	-5.4	-2.3	-24.0	-31.0
1% Soapy Water, 7d @ 90°C, DO	-3.3	-3.1	-1.8	-5.3	-16.0	-17.0	-11.0	-20.0	-15.0	-16.0	-11.0	-11.0	-21.0	-9.0	-6.5	-5.1	-6.3	-5.2	-12.0	-8.4	-12.2	-3.3	-11.0	-14.0	-0.8	-5.9	-9.8	-8.4	-19.0
Cottonseed Oil, 24h @ 60°C	-7.8	-2.5	-1.6	-0.1	-5.1	-1.9	-0.4	-5.1	-3.6	-4.6	-1.6	-3.8	-5.0	-3.6	-6.8	-2.6	-3.6	-2.8	-2.8	-1.9	-5.8	-2.6	-4.9	-2.6	-4.0	-4.9	-4.0	-17.0	-16.0
Distilled Water, 24h @ 60°C, DO	-0.8	-0.9	-0.4	-0.3	-0.8	-2.4	-0.7	-2.5	-1.1	-1.3	-0.8	-1.0	-2.2	-0.5	-0.9	-0.5	-0.7	-0.5	-1.0	-0.9	-2.2	-0.4	-1.2	-6.6	1.9	-0.9	-1.2	-1.4	-0.8
High Humidity, 9d @ 90°C, DO	-0.3	-0.2	-0.2	-0.1	-0.3	-8.4	-5.0	-7.7	-3.0	-4.6	-2.7	-0.5	-4.5	-0.4	-0.3	-0.4	-0.7	-0.2	-0.3	-0.2	-0.9	-0.2	-2.2	-9.9	-0.3	-0.5	-2.1	-1.0	-0.4
Roll Spew	NT	NT	NT	E	E	E	E	P	P	E	E	E	P	E	E	E	E	NT	E	E	E	E	NT	NT	NT	NT	NT	NT	E
ABS Migration	F	G	E	G	P	P	G	P	F	F	F	G	F	G	P	E	G	F	E	E	F	E	F	G	F	E	G	G	P
Polystyrene Migration	F	E	E	E	P	G	G	E	F	G	F	E	F	G	P	E	E	F	E	G	E	E	E	G	E	E	E	P	P
Nitrocellulose Migration	NT	NT	NT	E	P	G	P	P	F	F	G	G	F	G	F	NT	NT	NT	G	G	NT	NT	NT	NT	NT	NT	NT	NT	P

First Choice **Second Choice** **NT = Not Tested, E = Excellent, G = Good; F = Fair, P = Poor; DO = Dry Out**

Formulation: Resin - 100 PPHR; Plasticizer - as indicated; Stabilizer - 2.5 PPHR; Paraplex® G-62 - 5.0 PPHR
Plasticizer shown is at 67 PPHR (40 percent) of total compound

The test results have been color coded to highlight the plasticizers most effective in achieving specific property advantages, with dark blue being best and yellow being second best.

PLASTHALL® PR-SERIES INFORMATION

Hallstar's innovative Plasthall® PR-Series of plasticizers is on the leading edge of phthalate replacement technology. The PR-Series is a full line of commercially available phthalate replacements for use in all types of polymer applications. These products meet or exceed the performance and economic demands of the marketplace without the environmental problems. Some of these phthalate replacements are even based on 100 percent renewable raw material streams. Our philosophy is not just to offer a phthalate alternative, but to provide our customers with products that will improve physical properties.

As environmental and toxicity concerns rise, the desire to remove phthalates from vinyl compounds around the globe is rapidly increasing. DOP (DEHP – Di-2-ethylhexyl phthalate) first fell out of favor when it was required to be classified as a potential carcinogen. The natural progression for most compounders was to Di-isononyl phthalate (DINP) and Di-isodecyl phthalate (DIDP), and most recently, Di-2-propyl heptyl phthalate (DPHP). However, as health and environmental concerns continue to grow, the use of phthalate esters as a whole is declining, especially after the European Union announced a ban on DEHP, BBP and DBP by 2015.

EXPLANATION OF TEST DATA

On the adjacent page is a comparative performance study in PVC. In this study, Hallstar evaluated our phthalate alternatives Plasthall® PR-A200, PR-A217, PR-LCOA and PR-A610 versus industry standard phthalates DOTP, DIDP, DINP and DOP. The test recipe consists of 100 PPHR of calendaring grade PVC resin, 7.0 PPHR of a heavy metals-free stabilizer system, and 67 PPHR of plasticizer. Compounds were tested using our full battery of PVC tests.

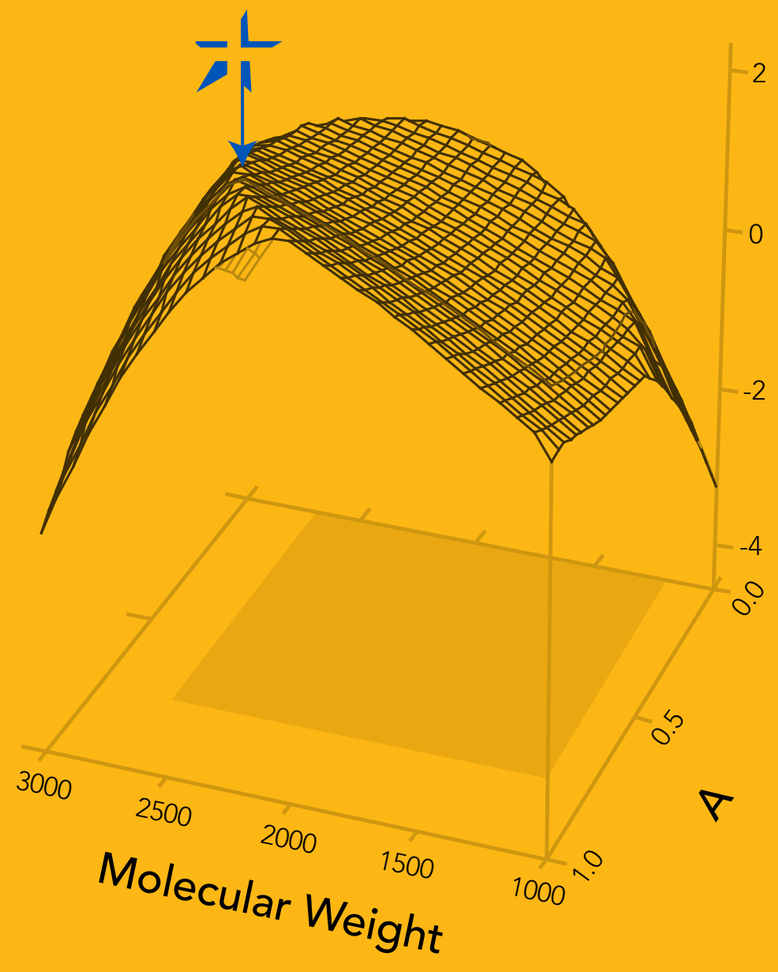
The test results have been color coded to highlight the plasticizers most effective in achieving specific property advantages, with dark blue being best and yellow being second best, so the user can quickly determine the plasticizers that provide the best combination of physical properties for an application.

	PLASTICIZER							
	Plasthall® PR-Series				Industry Standard Phthalates			
	PR-A217	PR-A200	PR-LCOA	PR-A610	DOTP	DIDP	DINP	DOP
Plasticizer Viscosity @ 25°C, cPs	250	60	950	52	63	87	77	57
Original Physical Properties								
100% Modulus, MPa	6.3	5	6.1	6.5	7.4	7.4	6.2	6.1
200% Modulus, MPa	9.8	7.7	9.7	10.1	10.9	10.7	9.8	9.2
300% Modulus, MPa	12.6	10.1	12.6	13	13.5	13.3	11.8	11.9
Tensile Strength, MPa	14.7	14.3	15.9	15.8	15	15.9	14.8	14.8
Elongation at Break, %	376	495	410	400	375	405	425	408
Hardness, Shore A, pts.	67	63	65	69	70	70	65	66
Specific Gravity	1.236	1.207	1.295	1.223	1.2	1.191	1.2	1.203
Tg,°C	-22.7	-32	-22.6	-41.1	NA	NA	-32.6	-27.8
Low Temperature Impact: Brittleness								
Brittle Point, °C	-27	-44	-25	-31	-34	-32	-25	-30
Volatility Resistance, 3 days @ 136°C								
Tensile Strength, MPa	15.1	17.8	16.1	16.4	15.2	16.0	16.2	17.0
Tensile Change, %	3.0	24.0	1.0	4.0	1.0	1.0	9.0	15.0
Elongation at Break, %	350.0	418.0	430.0	380.0	300.0	360.0	285.0	125.0
Elongation Change, %	-7.0	-16.0	5.0	-5.0	-20.0	-11.0	-42.0	-69.0
Retention of Elongation, %	93.0	84.0	105.0	95.0	80.0	89.0	58.0	31.0
Hardness, Shore A, pts.	67.0	63.0	63.0	62.0	74.0	71.0	72.0	92.0
Hardness Change, pts.	0.0	10.0	-2.0	-7.0	4.0	1.0	7.0	26.0
Weight Change, %	-4.9	-13.0	-2.1	-4.2	-9.3	-8.5	-11.0	-30.0
Immersion/Extraction, Percent Weight Change After:								
Hexane, % 24h @ 23°C, DO	-10.0	-22.0	-6.0	-27.0	-38.0	-35.0	-28.0	-30.0
Cottonseed Oil, 24h @ 70°C	-10.0	-17.0	-8.0	-20.0	-23.0	-21.0	-18.0	-14.0
Distilled Water, 24h @ 90°C, DO	-0.8	-1.4	-0.4	-1.4	-0.8	-1.1	-0.3	-0.8
1% Soapy Water, 7d @ 90°C, DO	-6.8	-8.4	-3.7	-12.0	-6.0	-5.9	-3.4	-6.8
Humid Environment, 9d @ 90°C, DO	-0.5	-1.0	-0.2	-0.7	-0.8	-1.0	-0.2	-0.4

First Choice **Second Choice**

Formulation: PVC Resin K-65 - 100 PHR, Plasticizer Variable - 67.0 PHR, Stabilizer System, heavy metal free - 7.0 PHR

THE PARAPLEX APPROACH



Three-dimensional Response Surface Diagrams and other models are generated as part of the Paraplex Approach. The image to the left illustrates the optimized chemical composition of a custom-designed plasticizer with the best combination of properties for the application in question. The Hallstar star next to the arrow indicates the optimal solution point.

With decades of experience formulating specialty plasticizers, Hallstar is recognized as a premier supplier to the polymer industry. Our Paraplex® brand is the benchmark for high performance plasticizers and continues to be strengthened through our innovative approach to customized plasticizer formulation, which combines cutting edge technology with our broad expertise.

The Paraplex Approach is a molecular design system developed by Hallstar to characterize and synthesize plasticizer solutions for well-defined customer performance requirements. Through the use of existing performance data, application knowledge, and the latest in computer technology, raw materials can be rapidly adjusted in precise combinations to create a plasticizer that solves critical performance issues.

Our targeted approach helps reduce product qualification time, improve speed to market for new product development and meet the continuously changing needs of your customers.