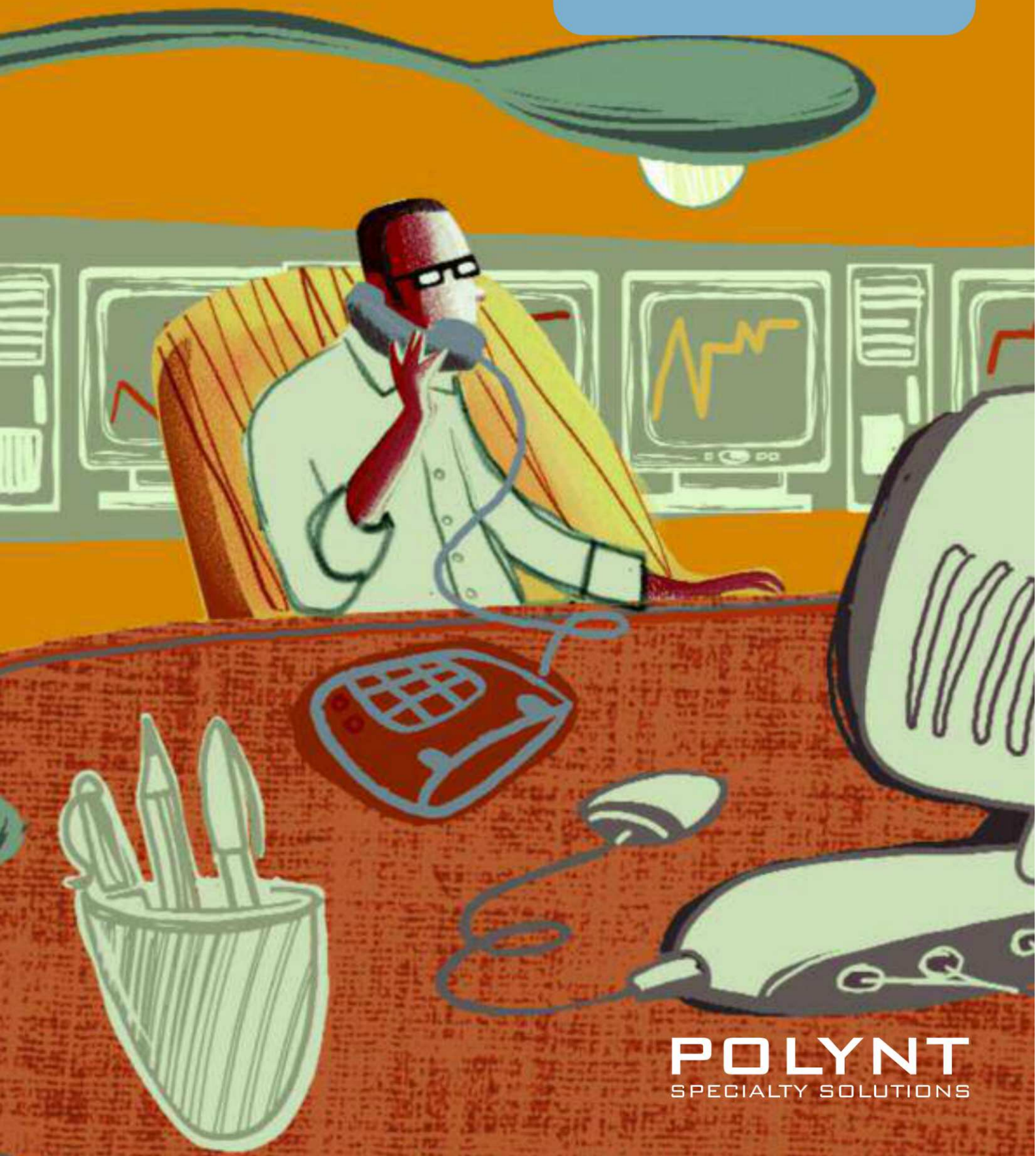


PLASTICIZERS



POLYNT
SPECIALTY SOLUTIONS

Introduction



A plasticizer or softener is a substance which is incorporated in a material (usually a plastic or elastomer) to increase its flexibility, workability, or distensibility. Since the 20's of the XX century researchers found that many esters of polycarboxylic acids, such as phthalic acid, phosphoric acid and so on, reacted physically with high polymers to form a homogeneous physical unit. Among the other polymers, polyvinylchloride (PVC) showed an unique capacity to absorb alkyl esters in its polymer structure, to form a plasticized PVC having such outstanding properties and versatility that this material was to be used

with great success for the following 80 years. Plasticized PVC is still today one of the most used thermoplastic materials all over the world. Since 1970, Polynt manufactures plasticizers in its facility located in San Giovanni Valdarno (Italy). At the beginning just standard phthalates were manufactured. In the 90's, special plasticizers such as linear phthalates, trimellitates, adipates and polymeric were introduced.





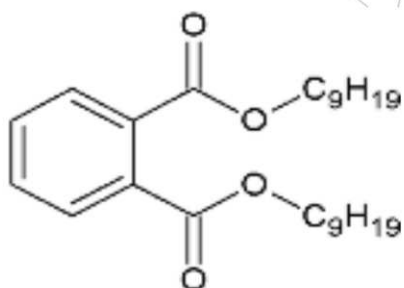
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Standard Phthalates

These plasticizers are obtained by reacting phthalic anhydride with branched alcohols.

- DIPLAST® O/MG (medical grade di-2-ethylhexyl phthalate, DOP or DEHP)
- DIPLAST® NS (di-isononyl phthalate, DINP)
- DIPLAST® RS (di-2-propylheptyl phthalate, DPHP)

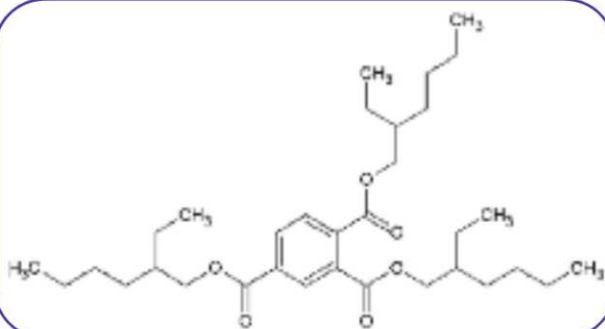


DIPLAST® NS (di-isononyl phthalate, DINP)

These plasticizers are the most commonly used plasticizers worldwide. PVC compounded with standard phthalates finds many applications, such as sheathing for electric cables, flooring, wall coverings, vinyl skins, coated fabrics, shoes, garden hoses and medical devices.

Linear Phthalates

- DIPLAST® L 9-11 (phthalate based on predominantly linear C₉-C₁₁ alcohols)
- DIPLAST® L 11 (diundecyl phthalate, DUP)



DIPLAST® TM/ST
(tri-2-ethylhexyl trimellitate, TOTM or TEHTM)

These phthalates are obtained by reacting phthalic anhydride with predominantly linear aliphatic alcohols. Due to their low volatility, compared with branched phthalates with the same molecular weight, to the good cold flexibility they impart to PVC and to the good resistance to photodegradation, these special phthalates are used in PVC roofing, anti-fogging synthetic leather for car interiors and automotive electric cables (with T2 class specifications, -40°C/+105°C, in the case of **DIPLAST® L 11**).



Plastic Boots



Plastic Cover Table



Stretch film for food

Trimellitates

These plasticizers are obtained by reacting trimellitic anhydride with aliphatic alcohols.

Polynt is the leading European company in the production and sale of trimellitates and trimellitic anhydride.

In 2008 Polynt began manufacturing Trimellitates also in China at its plant located in Changzhou (Jiangsu province), establishing a leading position also in the Asian special plasticizers market.

- DIPLAST® TM/ST (tri-2-ethylhexyl trimellitate, TOTM or TEHTM)
- DIPLAST® TM 8 (tri-n-octyl trimellitate)
- DIPLAST® TM 8-10/ST (trimellitate based on linear C8-C10 alcohols)
- DIPLAST® TM 9 (tri-n-nonyl trimellitate)

The above trimellitates, produced by Polynt, are special plasticizers that ensure a workability and an efficiency in PVC compounds comparable with those of many phthalates. In addition, trimellitates impart to plasticized PVC excellent resistance to high temperatures with retention of mechanical properties, high resistance to migration and extraction in aqueous solutions and good flexibility at low temperature (excellent in the case of **DIPLAST® TM 8-10/ST** and **DIPLAST® TM9**).

Due to such properties, these trimellitates find significant special applications, as in the production of high-temperature electric cables (in accordance with the corresponding CEI, BS, VDE, UL etc. standards) and automotive electric cables (in accordance with ISO 6722), the production of anti-fogging vinyl skins for car interiors (particularly those used for dashboards), and the production of many other compounds (foils, profiles, gaskets etc.) that have to meet stringent requirements in terms of thermal resistance, low volatility and low tendency to migration.

Polyester plasticizers and Adipates

Under the trade names Polimix and Uraplast, Polynt is an European leading supplier of polyester plasticizers. Polyester plasticizers are a must for a durable flexibility and they can be used also to improve the performance of the standard monomeric plasticizers.

We offer a comprehensive range of polyester plasticizers for PVC, elastomers, adhesives, coatings and other applications that require high performance in terms of migration, extraction, staining, UV and heat resistance.

DIPLAST® D (di-2-ethylhexyl adipate, DOA or DEHA) and **DIPLAST® D/MG** (medical grade di-2-ethylhexyl adipate, DOA or DEHA), which are particularly suitable for low-temperature PVC compounds and medical devices, are also available.



Electric cables

Polynt Plasticizers

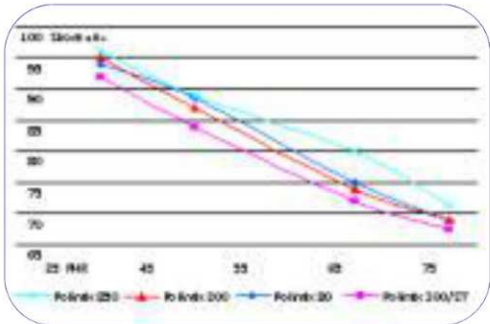
	General Name	Trade Name	Appearance	Typical viscosity (mPa.s)(*)	Typical density (g/ml)(*)
PHTHALATES	Di-2-ethylhexyl phthalate (DOP medical grade)	DIPLAST® O/MG	Clear liquid	80	0.984
	Di-isononyl phthalate (DINP)	DIPLAST® NS	Clear liquid	77	0.975
	Di-2-propylheptyl phthalate (DPHP)	DIPLAST® RS	Clear liquid	120	0.963
	Phthalate of predominantly linear C ₉ -C ₁₁ alcohols	DIPLAST® L 9-11	Clear liquid	56	0.958
	Diundecyl phthalate (DUP)	DIPLAST® L 11/ST	Clear liquid	79	0.955
ADIPATES	Di-2-ethylhexyl adipate (DOA or DEHA)	DIPLAST® D	Clear liquid	14	0.925
	Di-2-ethylhexyl adipate (DOA or DEHA medical grade)	DIPLAST® D/MG	Clear liquid	14	0.925
TRIMELLITATES	Tri-n-butyl trimellitate (TM4)	DIPLAST® TM 4	Clear liquid	73	1.062
	Tri-2-ethylhexyl trimellitate (TOTM or TEHTM)	DIPLAST® TM/ST	Clear liquid	315	0.989
	Tri-2-ethylhexyl trimellitate (TOTM or TEHTM)	DIPLAST® TM/MG	Clear liquid	315	0.989
	Tri-n-octyl trimellitate (TM8)	DIPLAST® TM 8	Clear liquid	115	0.984
	Tri-n-nonyl trimellitate (TM9)	DIPLAST® TM 9	Clear liquid	140	0.972
	Trimellitate of C ₈ -C ₁₀ linear alcohols	DIPLAST® TM 8-10/ST	Clears liquid	136	0.973
POLYMERICS	Polyester plasticizer	Polimix® 80	Clear liquid	830	1.053
	Polyester plasticizer	Polimix® 200/ST	Clear liquid	2000	1.092
	Polyester plasticizer	Polimix® 300	Clear liquid	3000	1.099
	Polyester plasticizer	Polimix® 150N	Clear liquid	1500	1.043
	Polyester plasticizer	Polimix® 740N	Clear liquid	7500	1.086
	Polyester plasticizer	Polimix® 200F	Clear liquid	2500	1.100
	Polyester plasticizer	Polimix® 400F	Clear liquid	4200	1.110
	Polyester plasticizer	Polimix® 850F	Clear liquid	8500	1.125
	Polyester plasticizer	Polimix® 800/P	Clear liquid	7800	1.168
	Polyester polyol	Polimix® H 450	Clear liquid	2700	1.241
	Polyester plasticizer	Uraplast® RA 19	Clear liquid	3100	1.080
	Polyester plasticizer	Uraplast® RA 25	Clear liquid	14000	1.110
	Polyester plasticizer	Uraplast® S 5640	Clear liquid	38000	1.120
	Polyester plasticizer	Uraplast® S 5642	Clear liquid	2900	1.080
	Polyester plasticizer	Uraplast® S 5710	Clear liquid	55	0.967
(*) Viscosity and density for Phthalates, Adipates and Trimellitates are at 20°C					
(*) Viscosity and density for Polymeric and Uraplast are at 25°C					

Main properties of Polynt plasticizers in PVC compounds

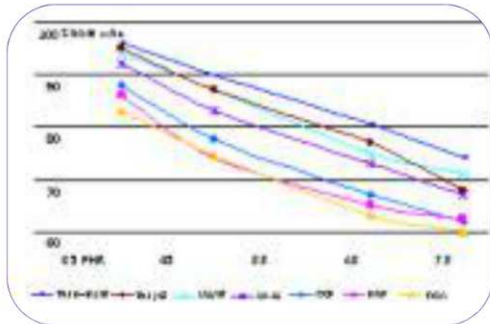
Formulation								
	Shore "A" Hardness	Cold flex Clash & Berg (°C)	Weight loss % Water (48h at 70°C)	Weight loss % Soapy water 1% (48h at 70°C)	Weight loss % Mineral oil (48h at 70°C)	Weight loss % Olive oil (48h at 70°C)	Weight loss % n-Hexane (24h at 23°C)	Volatility (Weight loss %) (7 days at 100°C)
PVC K70	100							
Plasticizer	50							
Ca/Zn	1.2							
Stearic acid	0.3							
DIPLAST® D	76.0	-52.0	-0.3	-6.4	-14.9	-15.6	-29.0	-24.6
DIPLAST® D/MG	76.0	-52.0	-0.3	-6.4	-14.9	-15.6	-29.0	-24.6
DIPLAST® O/MG	80.0	-26.0	-0.1	-3.4	-6.2	-7.0	-27.3	-13.4
DIPLAST® NS	82.0	-26.0	-0.1	-0.7	-5.5	-6.8	-27.6	-6.1
DIPLAST® RS	84.0	-20.0	-0.1	-0.1	-5.2	-6.3	-28.9	-5.5
DIPLAST® L 9-11	85.0	-34.0	-0.2	-0.3	-8.4	-9.9	-28.4	-2.5
DIPLAST® L 11/ST	88.5	-35.0	-0.2	0.0	-7.9	-10.0	-28.8	-1.9
DIPLAST® TM 4	75.0	-12.0	-0.2	-5.4	-4.4	-4.8	-5.2	-7.5
DIPLAST® TM/ST	88.0	-20.0	-0.1	-0.1	-2.8	-3.5	-27.8	-1.1
DIPLAST® TM/MG	88.0	-20.0	-0.1	-0.1	-2.8	-3.5	-27.8	-1.1
DIPLAST® TM 8	88.5	-28.5	-0.1	0.0	-5.1	-5.5	-28.6	-1.1
DIPLAST® TM 9	89.0	-30.0	-0.1	-0.3	-5.4	-13.0	-29.0	-1.1
DIPLAST® TM 8-10/ST	92.0	-32.0	-0.3	-0.5	-6.2	-14.6	-28.9	-1.0
Polimix® 80	90.5	-6.0	-0.8	-1.8	-2.3	-2.6	-4.3	-4.4
Polimix® 200/ST	87.5	-9.0	-0.6	-2.4	-2.1	-3.2	-0.6	-2.1
Polimix® 300	89.0	-5.0	-0.5	-1.8	-1.3	-2.4	-0.6	-1.9
Polimix® 150N	86.0	-11.0	-0.2	-1.0	-2.3	-2.7	-0.9	-2.3
Polimix® 740N	90.0	-6.0	-0.2	-0.9	-0.9	-1.7	-0.3	-1.4
Polimix® 200F	87.5	-7.0	-0.5	-2.4	-2.0	-3.0	-0.7	-1.9
Polimix® 400F	89.0	-4.0	-0.5	-2.1	-1.2	-2.9	-0.5	-1.3
Polimix® 850F	90.5	-2.0	-0.6	-1.6	-0.7	-1.8	-0.2	-1.2
Uraplast® RA 19	88.0	-9.0	-0.4	-2.2	-1.9	-3.2	-0.7	-1.6
Uraplast® RA 25	91.0	-5.0	-0.5	-1.7	-0.4	-1.4	-0.3	1.3
Uraplast® S 5640	92.5	-2.5	-0.6	-1.6	0.0	-0.9	-0.2	-1.0
Uraplast® S 5642	88.0	-8.5	-0.5	-1.9	-1.6	-2.8	-0.7	-1.7
Uraplast® S 5710	83.0	-33.0	-0.3	-3.0	-8.1	-9.0	-18.8	-6.1

Efficiency and cold flex in PVC compounds as a function of plasticizers content

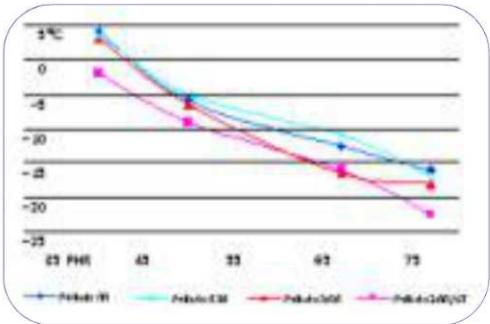
Shore "A" hardness Polimix



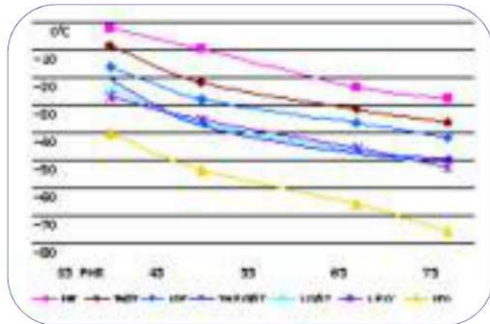
Shore "A" hardness DIPLAST



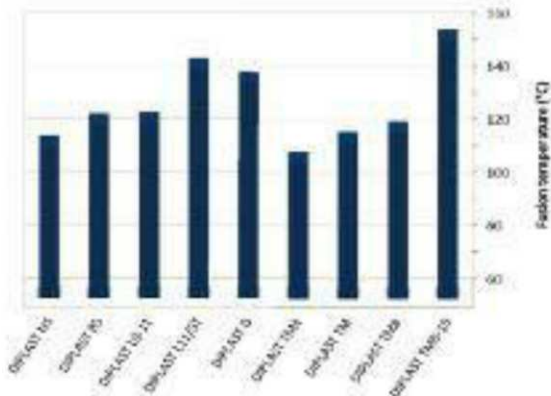
Clash & Berg (ISO/R458) Polimix



Clash & Berg (ISO/R458) DIPLAST

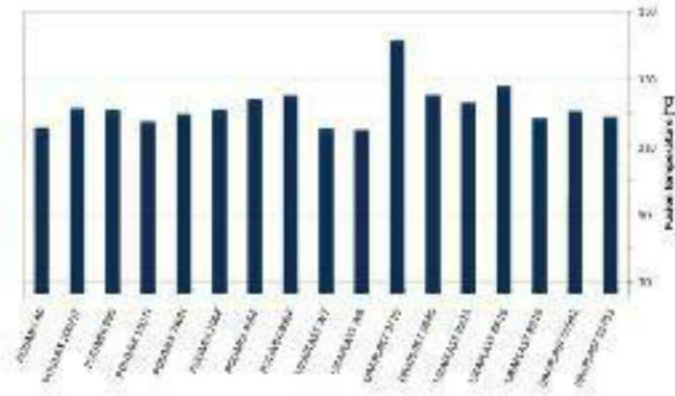


Brabender fusion temperatures of plasticized PVC (50 phr) - monomeric plasticizers



Temperature (Tf) at the fusion peak in the Brabender torque rheometer

Brabender fusion temperatures of plasticized PVC (50 phr) - polymeric plasticizers



Temperature (Tf) at the fusion peak in the Brabender torque rheometer

General properties of Polynt's Special Plasticizers

The use of special plasticizers, that is to say trimellitates, linear phthalates and polymeric, is associated with PVC applications in which the following properties are required:

- very good resistance to thermo-oxidative degradation
- low volatility
- low migration of the plasticizer in solvents or polymers that come into contact with the end product

The following tables list some physical properties that show the level of performance attainable with special plasticizers.

Trimellitates and linear phthalates are particularly recommended for heat resistant electric cables, for the following reasons:

- trimellitates offer the lowest volatility values;
- linear phthalates are less volatile than branched phthalates of the same molecular weight;
- linear phthalates and linear trimellitates have the highest thermo-oxidative stability.

These properties are illustrated in the following table:

Property	DTDP	DIPLAST® L11/ST (DUP)	DIPLAST® L9-11	DIPLAST® TM/ST (TOTM)	DIPLAST® TM8-10/ST
Mechanical properties % variation after 7days at 135°C (in air)					
Tensile Strenght	-18.5	-0.4	2.6	-6.5	-2.2
Elongation at break	-4.1	-25	-32	-3.3	-2.1
(PVC compound containing 50phr plasticizer)					

DIPLAST® TM 8-10/ST enables high temperature cables to be produced. Furthermore, trimellitates and linear phthalates are the best choice for cables for the automotive industry,

which require both high resistance and good low-temperature flexibility, as shown in the following tables (typical PVC cables formulation containing filler):

Property	DTDP	DIPLAST® L11/ST (DUP)	DIPLAST® L9-11	DIPLAST® TM/ST (TOTM)	DIPLAST® TM 8-10/ST
Original specimen 1mm					
Cold flex (Clash & Berg) °C	-20	-30	-29	-16	-28
Ageing conditions 10 days at 130°C					
Cold flex (Clash & Berg) °C	-10	-26	-23	-10	-25
% Variation	-50	-13	-21	-37	-11

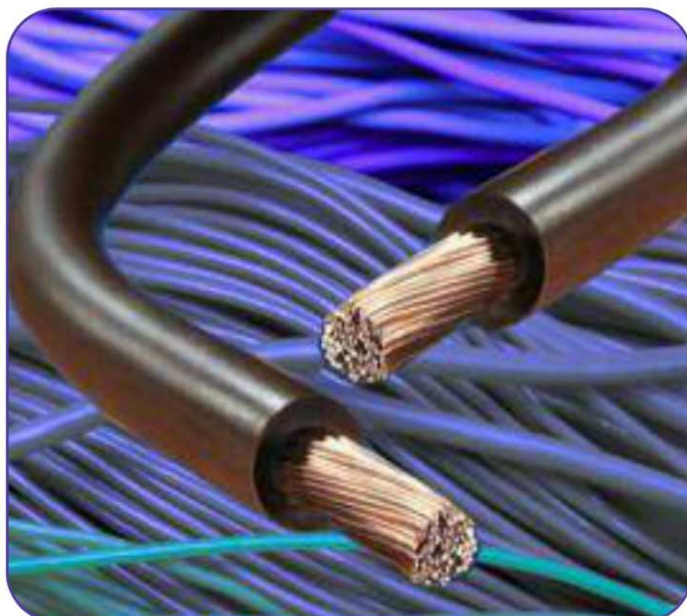
(Accelerated ageing test for PVC compound class T2 automotive cables, ISO 6722)

Property	DIPLAST® TM 8-10/ST
Original specimen 1mm	
Cold flex (Clash & Berg) °C	-25
Tensile strenght (Mpa)	20.2
Elongation at break (%)	302
Ageing conditions 10 days at 150°C	
Cold flex (Clash & Berg) °C	-24.5
% Variation of tensile strenght (±25% max)	-6.9
% Variation of elongation at break (±25% max)	-8.9
Weight loss (mg/cm ²)	-1.62

(Accelerated ageing test for PVC compound class T3 automotive cables, ISO 6722)



Car interior



Electric cables

Trimellitates have in general much lower volatility than phthalates.

The following table gives some fogging values.

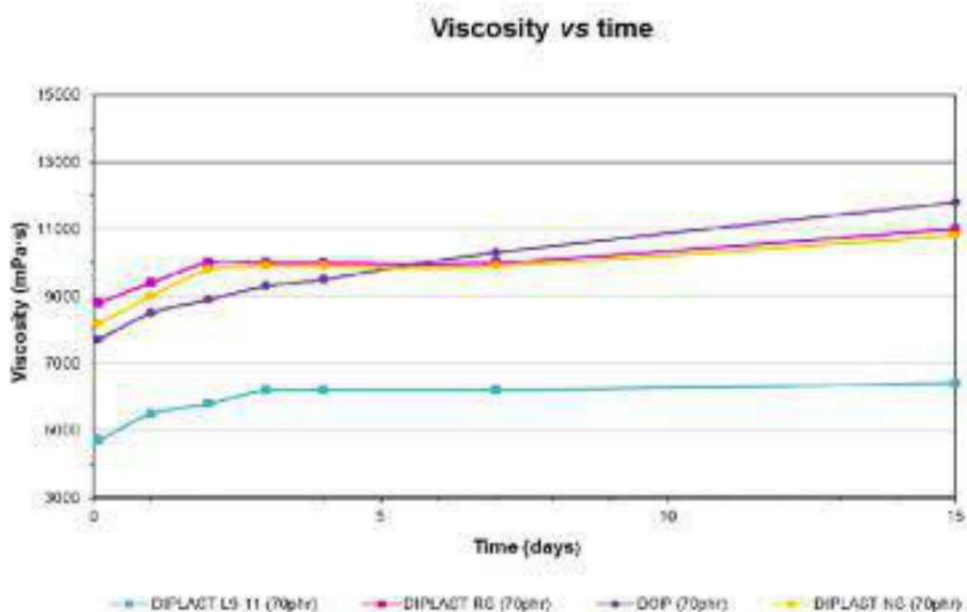
These show that trimellitates can be used in the manufacture of vinyl skins for car interiors (especially dashboards); linear phthalates such as **DIPLAST® L 11/ST** and **DIPLAST® L9-11** also give good performance

Plasticizer	Fogging
DIPLAST® TM 8-10/ST	>95%
DIPLAST® TM/ST	>95%
DIPLAST® TM 8	>95%
DIPLAST® L 11/ST	95%
DIPLAST® L 9-11	90%
DIPLAST® RS	74%

Test: DIN 75201 - Fogging 3 hours at 100°C (reflectometric) on the pure plasticizer

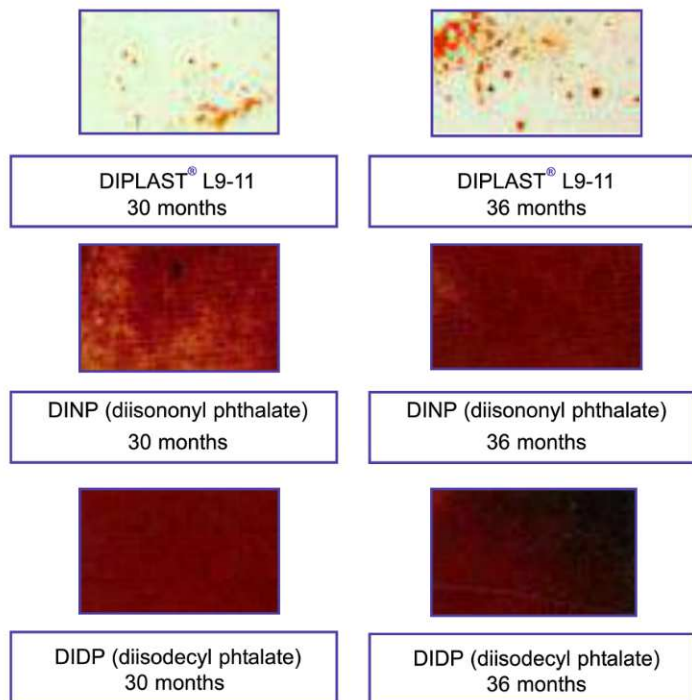
Beyond the above mentioned characteristic, linear phthalates give other advantageous properties to PVC:

1) They allow to produce PVC plastisols having lower and more stable viscosity, in comparison with branched phthalates of same molecular weight, as shown in the following figure:



Viscosity over time at 23°C measured by a Brookfield DV-E Viscometer (12 rpm, spindle LV4)

2) Due to their relatively low volatility and superior resistance to photodegradation, linear phthalates show an excellent weathering resistance, which is a key-factor for outdoor applications, as reported in the following figure. The result of a natural weathering in Arizona, on compounds containing 50 phr of plasticizers, is shown:



Temporary PVC structures and fixed permanent buildings



Garden hoses

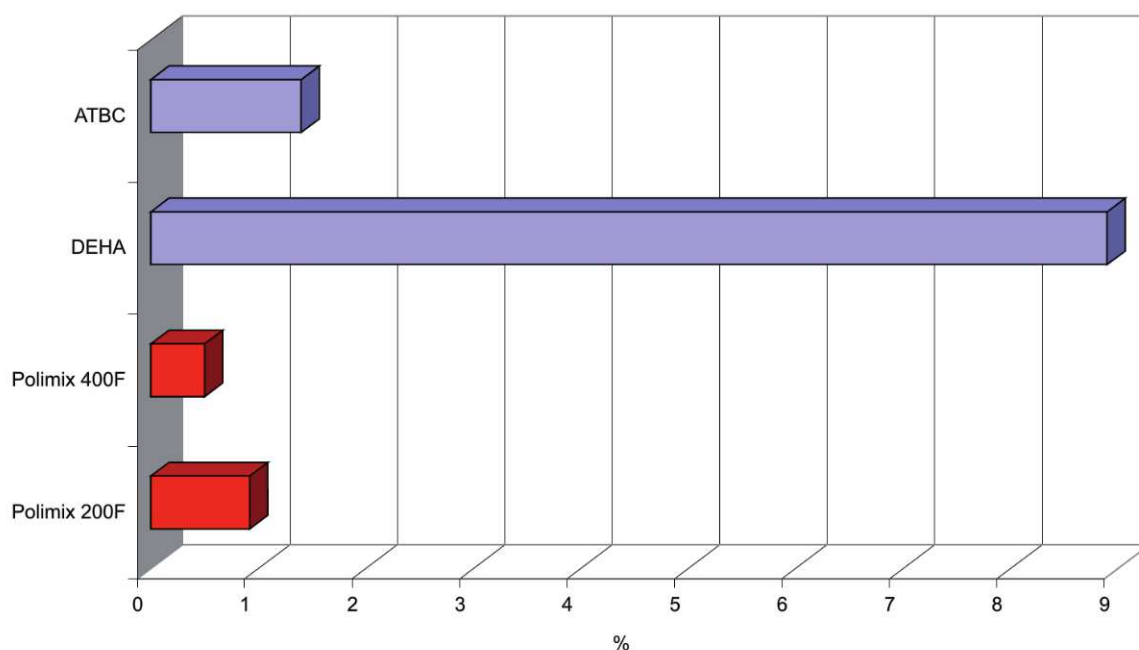
Excellent resistance to migration makes polyester plasticizers suitable for PVC products that can come into contact with various polymers, or with oils and hydrocarbons:

Plasticizer	Tensile strenght	Elongation at break
Polimix® 740N	-0.40%	-2%

Test: VDE 0472 (Resistance to ASTM n°2 mineral oil, changes in mechanical properties after 7days at 90°C, PVC compound containing 50 phr plasticizer)

Plasticizer	ABS	SAN	PS
Polimix® 80	-0.523%	-0.73%	-1.80%
Polimix® 300	-0.03%	-0.60%	+0.009%
Polimix® 150N	-0.005%	-0.02%	-0.002%
Polimix® 740N	-0.04%	-0.032%	-0.002%

Test: ISO 177 (Migration in polymers, weight loss after 15 days at 70°C, PVC compound containing 50 phr plasticizer)



ATBC=acetyl-tributyl citrate; DEHA=di-2-ethylhexyl adipate

Resistance to migration into food simulant D

Food contact articles

On the basis of their chemical composition and chemical-physical properties, some polyester plasticizers can be used in food contact materials.

For these applications Polynt suggests the following plasticizers:

- Polimix® 200F
- Polimix® 400F
- Polimix® 850F
- Uraplast® S 5640

With reference to the COMMISSION REGULATION (EU) No 10/2011 and following amendments, on plastic materials and articles intended to come into contact with food, we inform that **Polimix® 200F**, **Polimix® 400F**, **Polimix® 850F** and **Uraplast® S 5640** are polymeric substances having the chemical composition defined in Annex I (Union list of authorised monomers, other starting substances, macromolecules obtained from microbial fermentation, additives and polymer production aids), Table 1, with FCM No 73 and Ref. No 76866.

The viscosity of these plasticizers ranges from approx. 2000 mPas to approx. 40000 mPas, thus it covers a wide number of food contact applications, especially when the verification of compliance is carried out in food simulant D (olive oil) or equivalents:

- Cling films;
- Gasket seals for metal twist closures;
- Conveyor belts.

Polynt offers the widest choice for each application, ranging from low/medium viscosity products (e. g. **Polimix® 200F**, **Polimix® 400F**, **Polimix® 850F**), which are preferred when a good workability is required, to a high viscosity grade (e. g. **Uraplast® S 5640**), which exhibits an outstanding resistance to migration into food simulant D.

Regarding the FDA food contact status of Uraplast® S 5640 and for commercial information please fill in the on line form on our website at **www.polynt.com** or e-mail directly at **plasticizers.it@polynt.com**

Medical devices

Polynt SpA produces special grades of tri-2-ethylhexyl trimellitate (**TOTM** or **TEHTM**), di-2-ethylhexyl phthalate (**DOP** or **DEHP**) and di-2-ethylhexyl adipate (**DOA** or **DEHA**), according to an internal procedure for manufacturing, quality control and delivery, to ensure a very high level of product quality and absence of undesired contaminants, under Polynt's management system for Quality and Environment (ISO 9001 and ISO 14001).

These special grades called

- DIPLAST® TM/MG (TOTM or TEHTM)
- DIPLAST® D/MG (DOA or DEHA)
- DIPLAST® O/MG (DOP or DEHP)

are recommended when TOTM or DOA or DOP are required for PVC medical compounds manufacturing.



Blood Bags

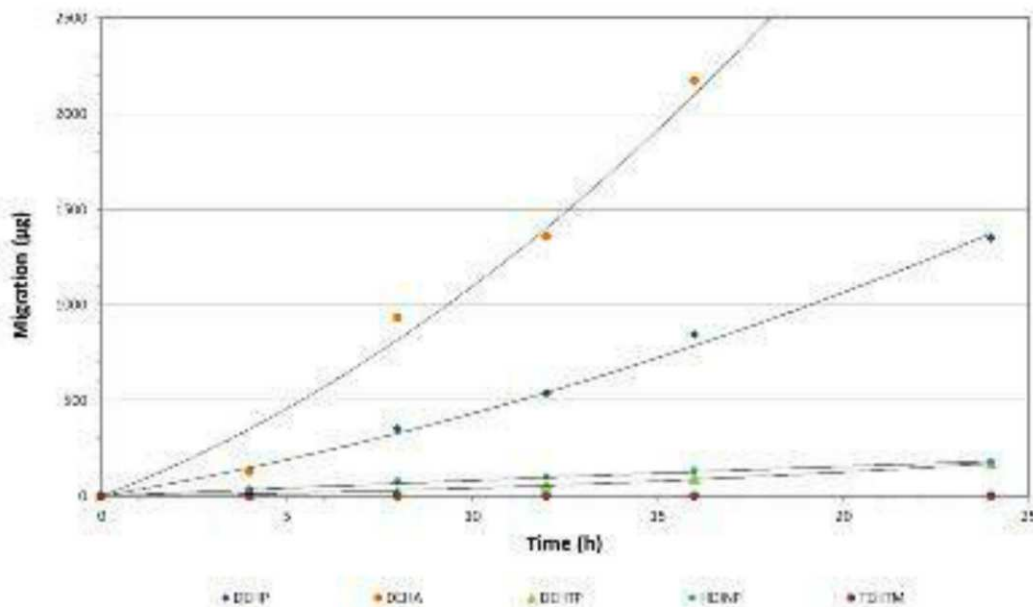
DIPLAST® TM/MG (TOTM or TEHTM) is particularly preferred in the production of medical devices, since it is characterized by a very low migration into liquids which come into contact with the articles (tubing, bags, etc...).

The very low TEHTM'S migration, as compared to other plasticizers commonly used in medical devices, is well described by the following test, which consisted in the analysis of the

plasticizer's specific migration from a soft PVC medical tubing to a feeding solution (used for enteral nutrition), having 3.9% fat concentration. In such experiment, the plasticizer's migration occurs from the internal tubing's surface to the feeding solution which flows through the tubing.

The overall data set demonstrates very clearly that **DIPLAST® TM/MG** is by far the less migrating plasticizer.

Cumulative migration of plasticizers into the 3.9% fat feeding solution



DEHP (DOP) = di-2-ethylhexyl phthalate

DEHA = di-2-ethylhexyl adipate

DEHTP = di-2-ethylhexyl terephthalate

HDINP = 1,2-Cyclohexane dicarboxylic acid, diisononyl ester

TEHTM (DIPLAST® TM/MG) = tri-2-ethylhexyl trimellitate

Plasticizer's specific migration from a soft PVC medical tubing to a feeding solutions, during a period of 24 hours at room temperature. Every sample was extracted with a suitable solvent and analyzed by a LC/MS/MS technique, with LOQ (Limit of Quantification) equal to 0.05 mg/Kg for every plasticizer.

Main applications for Polynt Plasticizers in PVC and Rubber

[illegible]

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