EASTMAN

Eastman 168™ non-phthalate plasticizer

for vinyl plastisols and
vinyl compounds

Contents

Eastman 168™ non-phthalate plasticizer

- Is an excellent general-purpose plasticizer for flexible PVC (polyvinyl chloride). It is compatible with PVC and PVC/VA copolymer resins and offers performance equal to or better than other general-purpose plasticizers. Typical properties are listed in Table 1.
- Offers good mechanical and permanence properties and excellent low-temperature flexibility. It also provides low viscosity in plastisols with good viscosity stability.
- Was evaluated along with four *ortho*-phthalate plasticizers in flexible PVC formulations
  - DOP (Eastman Chemical Company)
  - DINP and DIDP (ExxonMobil Chemical Company)
  - 711P (BASF)

These test results are good starting points to guide the vinyl formulator when choosing a general-purpose plasticizer.

Table 1 Typical properties of Eastman 168™ non-phthalate plasticizer[a]

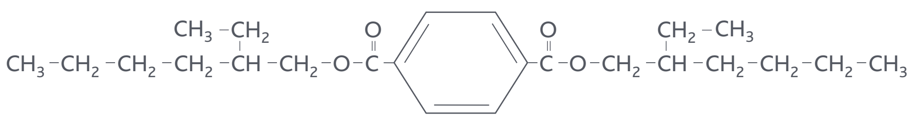
General	
Molecular weight (theoretical)	390.57
Empirical formula	$C_{24}H_{38}O_4$
Physical	
Form	Liquid
Color (Pt-Co Scale)	15
Refractive index, $n\frac{25°C}{D}$	1.4867
Acidity, as phthalic acid, wt%	0.01 max.
Specific gravity @ 20°C/20°C	0.9835
Wt/vol @ 20°C (68°F)	
lb/gal (U.S.)	8.18
kg/L	0.980
lb/gal (Imperial)	9.82
Boiling point @ 760 mm, °C (°F)	375 (707)
Freezing point, °C (°F)	−67.2 (−89)
Solubility in water @ 20°C, µg/L	0.4
Viscosity, cP	
25°C (77°F)	49
Stability	
Boiling water stability (% hydrolyzed after 96 h)	0.04
Heat stability (205°C, 2 h), % acid	0.06
Electrical	
Volume resistivity, ohm-cm (ASTM D257)	3.9×10^{12}
Dielectric constant @ 1 MHz (ASTM D150)	4.6
Dissipation factor @ 1 MHz (ASTM D150)	0.1×10^{-2}

[a]Properties are reported for information only. Eastman makes no representation that the material in any particular shipment will conform exactly to the values given.

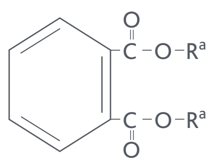
Structure

Eastman 168™ non-phthalate plasticizer is a terephthalate, while DOP, DINP, DIDP, and 711P are all *ortho*-phthalates. For comparison, these two types of plasticizers are shown in Figure 1. Structural differences between terephthalates and *ortho*-phthalate plasticizers result in some unique properties of Eastman 168.

Figure 1



1,4-benzenedicarboxylic acid, bis (2-ethylhexyl) ester
(Eastman 168™ non-phthalate plasticizer)



Ortho-phthalates

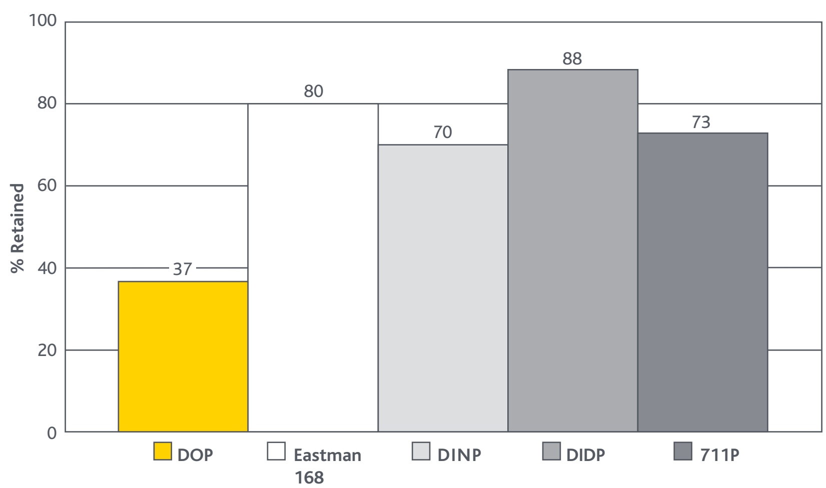
[a]*R = alcohol*

Plasticizer volatility

Plasticizer volatility was determined by heating samples in aluminum weighing pans at 177°C (350°F) for 24 hours.

Eastman 168 is more volatile than DIDP and less volatile than DOP, DINP, and 711P (see Figure 2).

Figure 2 Plasticizer volatility



Heated 24 h @ 177°C (350°F)

PVC plastisols

PVC plastisol formulations were prepared according to the formulas in Table 2. The plasticizer used in each formulation is the amount required to give equal modulus and Shore A hardness.

Table 2 Plastisol formulations (phr)

	1	2	3	4	5
PVC resin	100	100	100	100	100
DOP	60	—	—	—	—
Eastman 168	—	65	—	—	—
DINP	—	—	68	—	—
DIDP	—	—	—	66	—
711P	—	—	—	—	57
Heat stabilizer	3	3	3	3	3

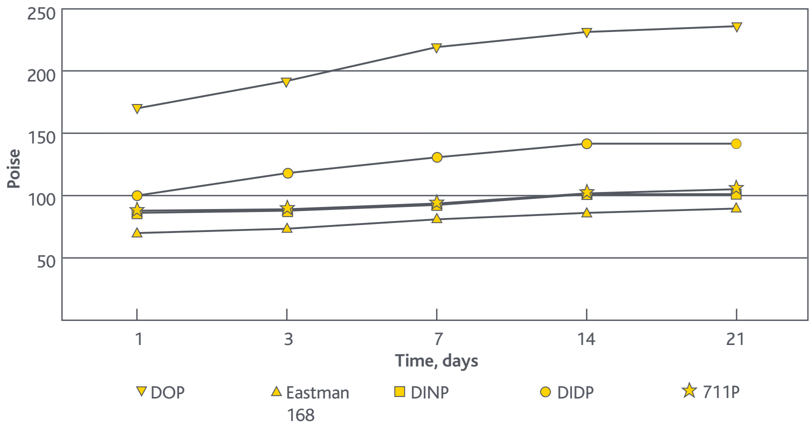
Plastisol viscosity

The plastisol formulations in Table 2 were prepared on a low-shear mixer and deaerated. The samples were aged at 23°C (73°F). Brookfield (low-shear) and Severs (high-shear) viscosities were measured.

The Brookfield viscosities were measured over a 3-week period (Figure 3). As shown, Eastman 168™ non-phthalate plasticizer imparts lower viscosity than the other general-purpose plasticizers. Excellent viscosity stability is achieved when using Eastman 168, DINP, and 711P.

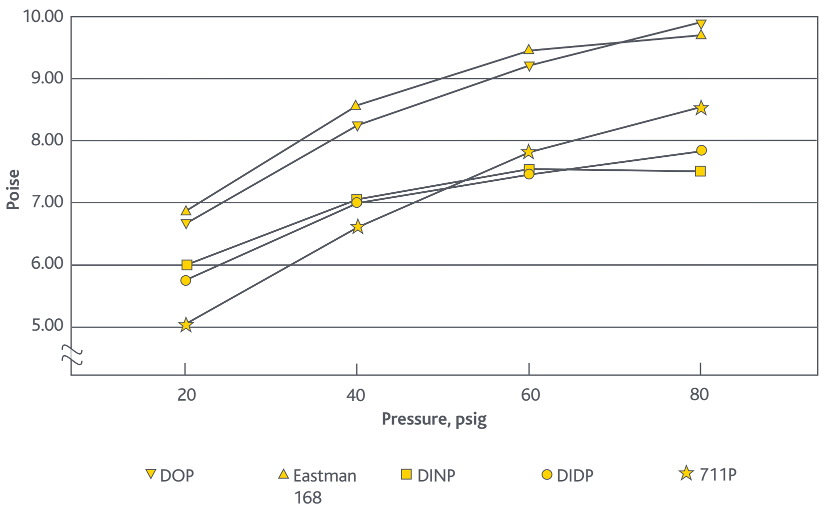
Figure 4 shows the Severs viscosities of the plastisols. At high-shear rates, the Eastman 168 plastisol exhibits viscosities very similar to DOP plasticizer. This considerably reduces the amount of work required to change from DOP to Eastman 168 in a plastisol application.

Figure 3 Brookfield viscosity



23°C (73°F), 20 RPM, #6 Spindle

Figure 4 Severs viscosity, 48 hours aging

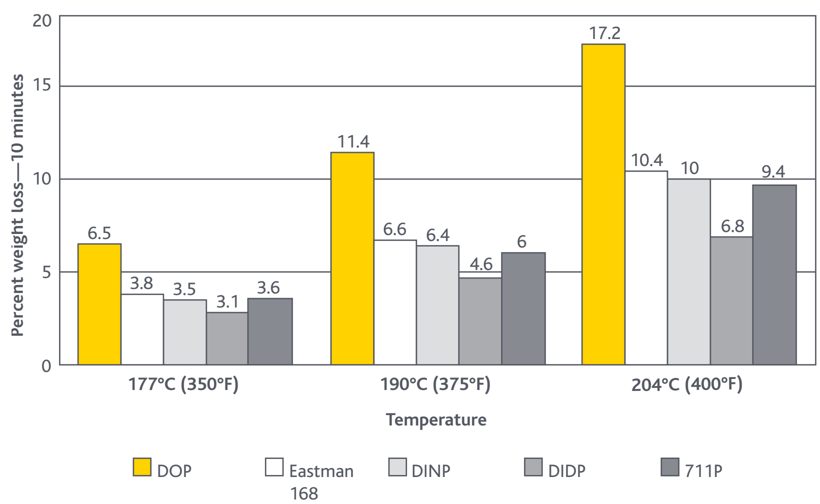


L = 5.00 cm and D = 0.1484 cm

Plasticizer volatility during fusion

Plastisol volatility during fusion was determined by measuring the percent weight loss at various fusion temperatures (Figure 5). Eastman 168™ non-phthalate plasticizer, DINP, and 711P are all less volatile than DOP, and as expected, DIDP is the least volatile.

Figure 5 Plasticizer volatility during fusion

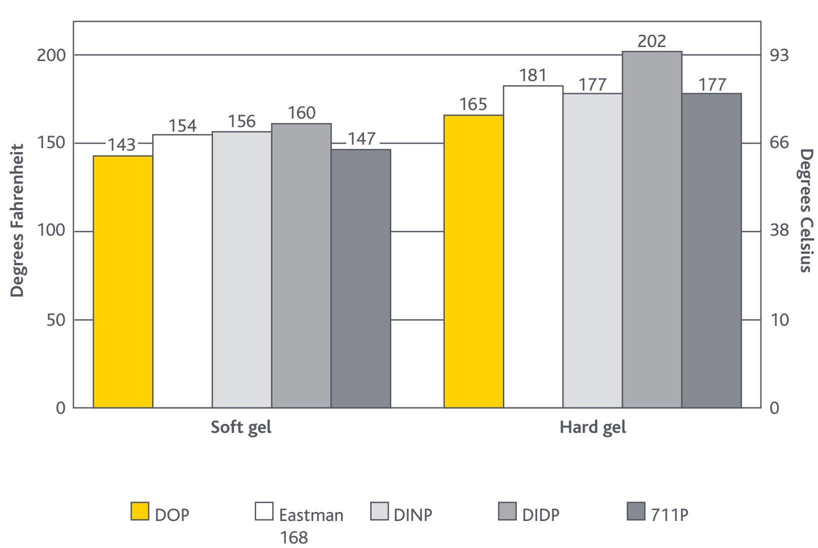


Fusion properties of plastisols

Fusion properties were determined on the temperature gradient bar (Figure 6). Plastisols were drawn down to a thickness of approximately 30 mils on the gel bar.

Soft- and hard-gel temperatures were determined and are shown in Figure 6. Fusion properties for all five plastisols are generally equal.

Figure 6 Fusion properties of plastisols



Physical properties

Plastisol formulations were fused and samples were used to determine mechanical, permanence, and low-temperature properties. As shown in Table 3, Eastman 168™ non-phthalate plasticizer imparts comparable mechanical and permanence properties. The low-temperature flexibility tests show that Eastman 168 and 711P are best.

Table 3 Physical properties of plastisols

	DOP	Eastman 168	DINP	DIDP	711P
PZ concentration to give equal modulus, phr	60	65	68	66	57
Mechanical properties					
Tensile strength,[a] MPa (psi)	16 (2,320)	15.5 (2,248)	14.5 (2,103)	14.7 (2,132)	15.8 (2,291)
Elongation,[a] %	389	400	395	405	403
Tear strength,[b] N/mm (ppi)	58 (331)	53.5 (305)	52.4 (299)	54.6 (312)	60.9 (348)
Permanence					
Soapy water,[c] % loss	0.5	1.5	0.9	1	0.6
Oil extraction,[c] % loss	9	15.6	15.5	15.7	13.2
Hexane extraction,[c] % loss	24	33	33	32	28
Activated carbon,[d] %	9	4.2	3.8	2.2	3.7
Low-temperature flexibility					
Torsion modulus,[e] °C (°F)					
35,000 psi	−30 (−22)	−31 (−23.8)	−29 (−20.2)	−30 (−22)	−31 (−23.8)
135,000 psi	−46 (−50.8)	−50 (−58)	−44 (−47.2)	−47 (−52.6)	−53 (−63.4)
Low-temperature impact,[f] °C	−39 (−38.2)	−47 (−52.6)	−42 (−43.6)	−42 (−43.6)	−46 (−50.8)

[a]ASTM D412 *[b]ASTM D624* *[c]ASTM D1239*
[d]ASTM D1203 *[e]ASTM D1043* *[f]ASTM D746*

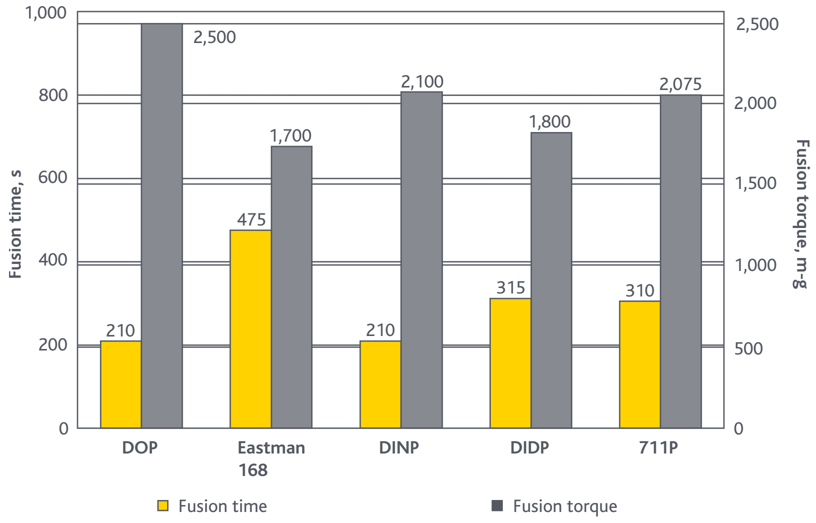
PVC compounds

Dry blends were prepared in a high-intensity mixer using the formulations given in Table 4. Brabender fusion properties were determined and are illustrated in Figure 7. Longer fusion time is required when processing a compound containing Eastman 168™ non-phthalate plasticizer. The lower torque obtained with Eastman 168 is indicative of its self-lubricating nature.

Table 4 Compound formulations (phr)

	1	2	3	4	5
PVC suspension resin	100	100	100	100	100
DOP	50	—	—	—	—
Eastman 168	—	52	—	—	—
DINP	—	—	54	—	—
DIDP	—	—	—	53	—
711P	—	—	—	—	48
Heat stabilizer	3	3	3	3	3

Figure 7 Brabender fusion properties



Physical properties

After dry-blend preparation, samples were fused on a two-roll mill and pressed into 70-mil sheets. A calender was used to prepare 10-mil samples for permanence testing. Eastman 168™ non-phthalate plasticizer imparted comparable mechanical and permanence properties to PVC along with excellent low-temperature flexibility.

Table 5 Physical properties of compounds

	DOP	Eastman 168	DINP	DIDP	711P
PZ concentration to give equal modulus, phr	50	52	54	53	48
Mechanical properties					
Tensile strength,[a] MPa (psi)	19.8 (2,876)	19.3 (2,800)	18.9 (2,741)	18.3 (2,655)	19.6 (2,847)
Elongation,[a] %	374	383	385	361	386
Tear strength,[b] N/mm (ppi)	84.1 (480)	86.2 (492)	77.6 (443)	87.2 (498)	95.8 (547)
Permanence					
Soapy water,[c] % loss	0.78	1.02	0.85	0.33	2.98
Oil extraction,[c] % loss	10.4	16.1	17.3	16.4	8.5
Hexane extraction,[c] % loss	26	26	23	27	24
Activated carbon,[d] %	5.9	2.7	3.7	1.3	3.6
Low-temperature flexibility					
Torsion modulus,[e] °C (°F)					
35,000 psi	−19 (−2.2)	−20 (−4)	−16 (3.2)	−20 (−4)	−21 (−5.8)
135,000 psi	−39 (−38.2)	−42 (−43.6)	−36 (−32.8)	−45 (−49)	−49 (−56.2)
Low-temperature impact,[f] °C	−33 (−27.4)	−37 (−34.6)	−34 (−29.2)	−30 (−22)	−41 (−41.8)

[a]ASTM D412 *[b]ASTM D624* *[c]ASTM D1239*
[d]ASTM D1203 *[e]ASTM D1043* *[f]ASTM D746*

Reduced lacquer marring

Marring of nitrocellulose lacquer by plasticized PVC is common in various applications. It can be a problem, particularly for lacquered wood furniture in contact with vinyl objects such as upholstery, tablecloths, place mats, handbags, and other items.

Such marring can be easily reduced using Eastman 168™ non-phthalate plasticizer in place of DOP or other *ortho*-phthalates in vinyl products that might come in contact with lacquered surfaces. Work in Eastman laboratories has confirmed the very low-lacquer mar properties imparted to fused vinyl with Eastman 168.

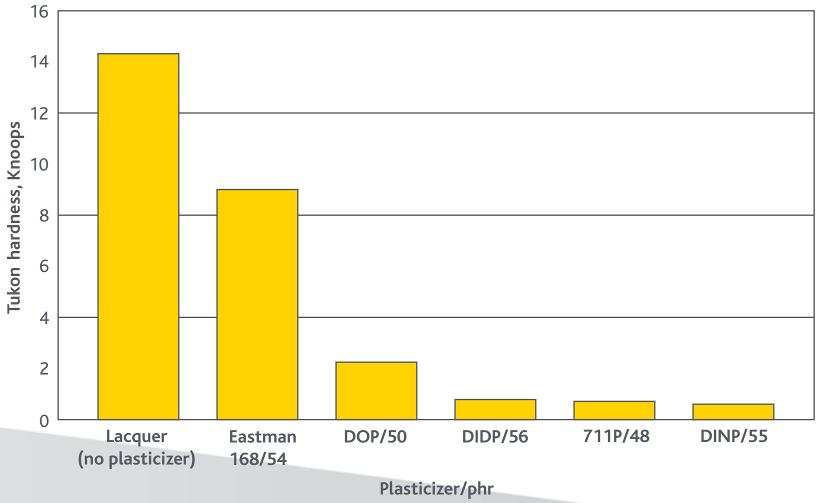
A fused vinyl formulation (Table 6) containing Eastman 168 exhibited much less lacquer marring than the same formulation containing *ortho*-phthalate plasticizers. The difference in marring is visually obvious, and the greater hardness of the lacquer contacting the vinyl, which contains Eastman 168, can be easily detected with one's fingernail. In the laboratory, the actual hardness can be measured accurately using a Tukon hardness tester. The measurement of plasticizer migration from vinyl to nitrocellulose lacquer is based on ASTM D2199.

Table 6 Formulations for lacquer mar testing (phr)

PVC resin	100
Plasticizer	As indicated in Figure 8
Heat stabilizer	3

A small sample of vinyl is placed on a nitrocellulose lacquer film under a pressure of 1/2 psi, and the assembly is heated in an oven for three days at 50°C (112°F). At the end of the test time, the lacquer is examined for marring or softening and the hardness is measured with a Tukon tester. Test results comparing the effect of Eastman 168 with those of DOP, DINP, DIDP, and 711P *ortho*-phthalate plasticizers are presented in Figure 8.

Figure 8 Nitrocellulose lacquer mar resistance



ASTM D2199; 72 h, 50°C, 1/2 psi

EASTMAN
The results of **insight**™

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