



*E*astman TXIB Plasticizer in Toys

Eastman TXIB Plasticizer
has been renamed
Eastman TXIB Formulation Additive
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Introduction

Eastman TXIB plasticizer is a superior primary plasticizer for polyvinyl chloride (PVC) used in the manufacture of toys, sheet vinyl flooring, and many other high-quality vinyl products. *TXIB* plasticizer is typically used to replace some portion of the general-purpose plasticizer included in flexible PVC. The inclusion of *TXIB* plasticizer reduces the viscosity of PVC plastisols and imparts many other valuable features, such as stain resistance and a less sticky surface than those produced with the industry standard plasticizer, DOP [di (2-ethylhexyl) phthalate]. DOP is commonly known as dioctyl phthalate. *Eastman TXIB* has about the same efficiency as DOP, so it is generally used to replace some portion of the DOP on a 1:1 basis. The efficiency of a plasticizer is the amount of that plasticizer needed to produce a finished part at a given hardness or flexibility. Generally, 20 parts per hundred resin (phr) of *TXIB* plasticizer is the recommended upper limit for use in flexible PVC.

This publication deals specifically with the features of *Eastman TXIB* plasticizer when used to produce PVC toys. Rotocasting or slush molding techniques are typically used to produce these toys. As a general rule, if the toy or toy part is hollow, such as a basketball, then rotocasting or slush molding is used.

Plastisols

Using plastisols for toy production is very popular because this approach requires less-expensive production equipment. The special features of *TXIB* plasticizers are particularly useful when using plastisols because many of the advantages that will be discussed relate to the viscosity of the plastisol resin. As much of the data show, *TXIB* is a low-viscosity plasticizer that helps impart low viscosity to the plastisol. Low viscosity translates to PVC plastisols that are more easily processed.

Properties

Table 1 shows the typical physical properties of *TXIB* plasticizer. A few key features include low viscosity and low freezing point that contribute to ease of handling. Also, because of the plasticizer's relatively low specific gravity, formulators can achieve an economic advantage. Because they typically buy ingredients by weight and market end products by volume, the formulator can make more parts per pound of *TXIB* plasticizer consumed.

Table 1

Typical Properties^a

Color, APHA ppm	30 max.
Purity, % by weight	98 min.
Acidity, as isobutyric acid, % by wt	0.05 max.
Specific gravity @ 20°C/20°C	0.942–0.948
Surface tension, dynes/cm ³	27.56
Appearance	Free from insoluble matter and haze
Empirical formula	C ₁₆ H ₃₀ O ₄
Molecular weight (theoretical)	286.4
Saponification equivalent	144.8
Refractive index, n _D ^{25°C}	1.4300
Weight per unit volume, 20°C	
lb/gal (U.S.)	7.86
kg/L	0.94
lb/gal (Imperial)	9.43
Boiling point @ 760 mm, °C (°F)	280 (536)
Freezing point, °C (°F)	–70 (–94)
Flash point, <i>Cleveland</i> Open Cup, °C (°F)	143 (290)
Fire point, <i>Cleveland</i> Open Cup, °C (°F)	152 (305)
Autoignition temperature, °C (°F)	424 (795)
Solubility in water @ 20°C, g/L	0.42
Evaporation rate @ 100°C (g/1,000 cm ²)/h	0.674
Hydrolytic stability, % hydrolyzed after 96 h reflux in boiling water	0.003
<i>Brookfield</i> viscosity on No. 1 spindle @ 25°C, cP	9
Volume resistivity, ohm-cm (ASTM D 257)	1.5 × 10 ¹¹
Dielectric constant @ 1 MHz (ASTM D 150)	4.5
Dissipation factor @ 1 MHz (ASTM D 150)	0.13 × 10 ^{–2}

^aProperties are reported for information only. Eastman makes no representation that the material in any particular shipment will conform to the values given.

Advantages of *TXIB* Plasticizer in PVC Toys

A key advantage of *TXIB* plasticizer is its low viscosity (9 cP @ 25°C¹). This, along with other properties, makes it an excellent choice for use in rotocasting and slush molding of PVC toys. Table 2 contains two typical toy formulations. Formulation 1 shows a plastisol based on DOP as the sole plasticizer (90 phr); Formulation 2 substitutes *TXIB* plasticizer for 10% (9 phr) of the DOP used in the first formulation.

Table 2

Toy Formulations (Closed Mold Only)

Material	Formulation 1 phr	Formulation 2 phr
PVC dispersion resin	50	50
PVC blending resin	50	50
DOP	90	81
<i>TXIB</i> plasticizer	—	9
Epoxidized soybean oil	5	5
Stabilizer	3	3

Table 2A compares the plastisol with and without *TXIB* plasticizer for gel and hardness. Clearly there is **NO** significant change in the gel and initial properties of the two formulations.

Table 2A

Plastisol Toy Properties

Property	Formulation 1 (no <i>TXIB</i>)	Formulation 2 (with <i>TXIB</i>)
Soft gel, °C	96	99
Hard gel, °C	110	110
Shore A hardness	53	54
Property Change @ 100°C, 24 H		
Wt. loss, %	-1	-2
Tensile strength, psi	+80	+210
Elongation, %	-5	-30

¹Brookfield viscosity on No. 1 spindle

Benefits of *TXIB* Plasticizer in PVC Toys

Several of the benefits imparted by including *TXIB* plasticizer in rotocasting and slush molding of PVC toys are:

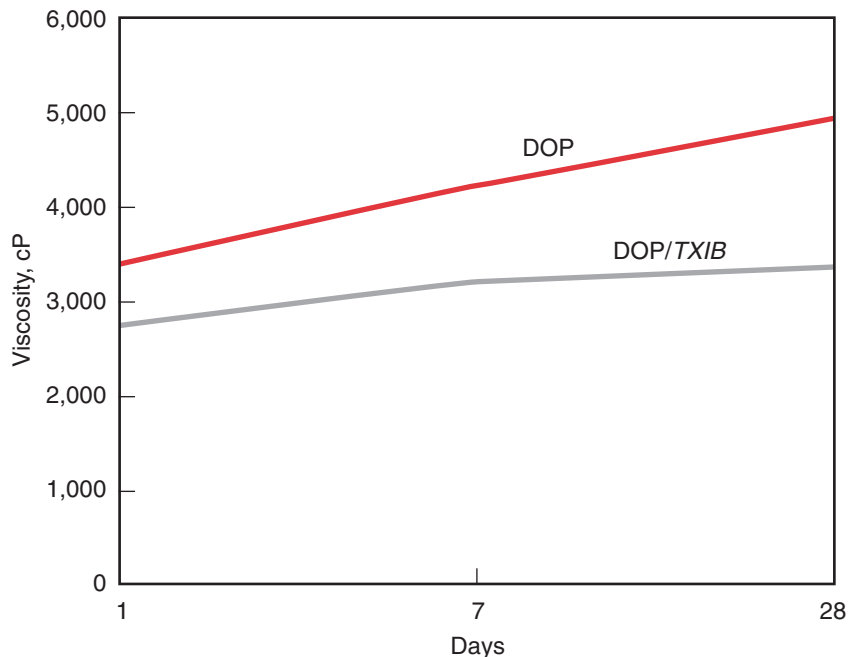
- Low viscosity
- Viscosity stability
- Faster deaeration
- Less plasticizer required
- Completely compatible
- Semi-rigid parts

Low Viscosity: Low viscosity equates to ease of processing. Because a material of low viscosity flows more freely than one of higher viscosity, handling of the plastisol consumes less time and energy. In addition, better flow can lead to thinner walls on a hollow toy. Thinner walls result in lower part weight, and lower part weight means lower production costs.

Viscosity Stability: Not only is the initial viscosity important, it is also important that the plastisol viscosity does not show a large increase over time (keeping viscosity). Figure 1 shows that the formulation containing 9 phr of *TXIB* plasticizer not only reduces the initial plastisol viscosity by about 600 cP versus the all-DOP formulation. Also, the viscosity at 28 days is 1,700 cP less, indicating the viscosity reduction **advantage becomes greater with time.**

Figure 1

Toy Plastisol Viscosity^a



^aBrookfield Viscosity @ 20 rpm

Faster Deaeration: To eliminate surface imperfections caused by air entrapment in PVC plastisol, the liquid is degassed under vacuum. A plastisol with lower viscosity will allow the air to escape faster, thus reducing production time.

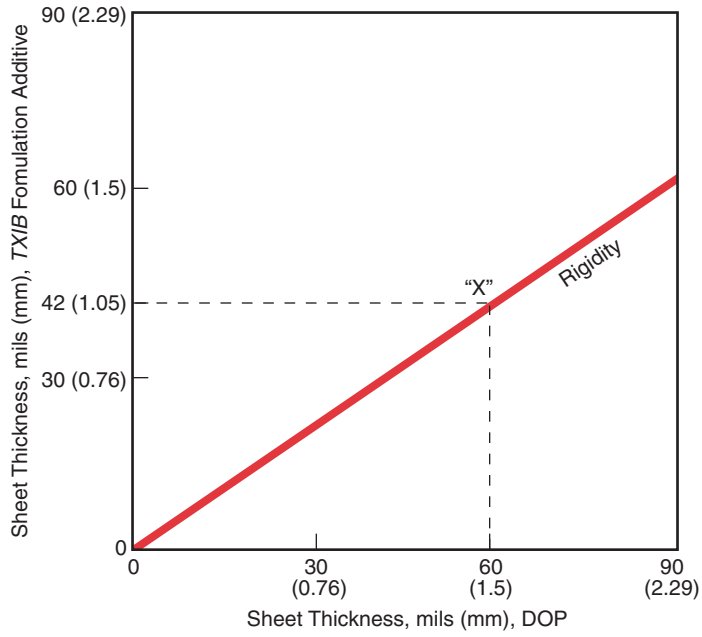
Less Plasticizer Required: A roto/slush molding operation has an optimum plastisol viscosity range needed for peak production, and it is typically relatively low. This optimum viscosity can usually be achieved by using less *TXIB* plasticizer than other primary plasticizers. If the plasticizer(s), as is usually the case, is one of the more expensive ingredients, the hardness and viscosity targets can be reached at lower cost when using *TXIB* plasticizer because of its 9-cP viscosity.

Completely Compatible: Many molding operations use secondary plasticizers to reduce viscosity. Although these materials, typically hydrocarbons, do an excellent job of viscosity reduction, they **are incompatible with PVC**. This means a large portion of the secondary plasticizer is lost during plastisol processing. *TXIB* is a primary plasticizer that is **completely compatible with PVC**. Therefore, a much greater percentage of the plasticizer is retained in the finished product.

Semirigid Parts: Figure 2 compares the results of using a *TXIB*/DOP blend versus an all-DOP blend in finished part rigidity. As an example, the *TXIB* plasticizer-containing formulation at 42 mils thickness has the same rigidity as the all-DOP part at 60 mils (see point “x”). Thus, a thinner article at equal strength saves on both material and shipping costs. This is made possible by the low viscosity of *TXIB* plasticizer. As Figure 2 shows, the viscosity of Formulation 4 with 23 phr of *TXIB* is 40 poises, while it takes 36 phr of DOP to reach the same viscosity. As discussed previously, the EFFICIENCY of *TXIB* and DOP are roughly equivalent, so the PVC produced from Formulation 3 will have a lower Shore A hardness than the PVC from Formulation 4. The increased stiffness resultant in Formulation 4 is due to the reduced amount of plasticizer, NOT due to differences in plasticizer efficiency. Also, due to the differences in the viscosity of *TXIB* plasticizer and DOP (9 and 56 cP respectively), a plastisol made at 23 phr with *TXIB* will have a viscosity that is easily processed, whereas adding 23 phr of DOP to the same PVC resin would not produce a liquid dispersion of the PVC in the plasticizer.

Figure 2

Comparison of Rigidity With Sheet Thickness
TXIB vs. DOP



Material	Formulation 3 phr	Formulation 4 phr
PVC dispersion resin	55	55
PVC blending resin	45	45
Ba, Cd, Zn stabilizer	3	3
Epoxy tallate	3	3
DOP plasticizer	36	—
<i>TXIB</i> plasticizer	—	23
Viscosity, poises, after 1 day aging	40	40

Including *TXIB* plasticizer in vinyl toy applications can achieve many benefits. Contact your Eastman Sales or Technical Representative at 800-EASTMAN (800-327-8626) to discuss your plasticizer needs.

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