MONOBENZOATE USEFUL AS A PLASTICIZER IN PLASTISOL COMPOSITIONS

ALS WEICHMACHER IN PLASTISOLZUSAMMENSETZUNGEN VERWENDBARES MONOBENZOAT

MONOBENZOATE UTILE EN TANT QUE PLASTIFIANT DANS DES COMPOSITIONS DE PLASTISOL

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Als Weichmacher in Plastisolzusammensetzungen verwendbares Monobenzooat

Monobenzoate utile en tant que plastifiant dans des compositions de plastisol

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FIELD OF THE INVENTION

[0001] This invention is directed to the use of a non-phthalate monobenzoate useful as a plasticizer in a variety of polymer applications, including but not limited to plastisols, adhesives, caulks, architectural coatings, industrial coatings, OEM coatings, paints, inks, overprint varnishes ("OPV's"), other coatings, polishes and the like. In particular, this invention is directed to the use of a monobenzoate ester, 3-phenyl propyl benzoate, to improve the performance properties of polymers in plastisol applications. The inventive monobenzoate has comparable or better rheology, viscosity stability, and processability, among other advantages, over traditional high solvating or specialty plasticizers used in plastisol applications. The invention is also directed to plastisol compositions comprising the inventive monobenzoate and blends of the inventive monobenzoate with other plasticizers for use in plastisol compositions.

BACKGROUND OF THE INVENTION

[0002] Plasticizers, as polymer additives, have been known for more than a century. Most high volume plasticizers have been developed in the last seventy years, primarily for use with vinyl and other polymeric substances. Plasticizers are used more than any other type of polymer additives, particularly in polyvinyl chloride (PVC) applications. Hundreds of plasticizers have been produced, but only a few remain having acceptable performance properties when combined with vinyl or other polymeric materials.

[0003] General purpose phthalates dominate the volume of plasticizers purchased every year and are most often selected for compounding flexible vinyl.

[0004] A typical plasticizer is defined as an organic liquid that will soften a polymer and make it more workable, as long as the polymer and plasticizer are at least partially compatible. The function of a plasticizer in any polymer system requires compatibility. Plasticizers are used to adjust hardness (or softness) of a polymer, impart stain resistance, alter tensile properties (such as strength, elongation or flexibility) and to facilitate processability, as required, for a multitude of applications, including without limitation flexible vinyl applications.

[0005] Plasticizers also serve as a vehicle for the dispersion of resin (polymer) particles, such as PVC. The dispersion is initially a two-phase, heterogeneous system. Plasticizers promote the formation of homogeneous systems and polymer fusion occurs upon heating. The higher the solvating power, the lower the temperature at which a homogeneous system is fused, which, in turn, decreases the residence time and increases the speed at which polymeric compositions can be processed into an end product, resulting in a faster, more efficient and economical process.

[0006] Plasticizers are available in a wide variety of alternative chemistries and include: 1) general purpose, 2) specialty types and 3) secondary and diluent types, more fully described herein. Plasticizers are also distinguished based on their ability to solvate dispersed solid polymers and/or their gelation and fusion temperatures in plastisols. Gelation and fusion temperatures dictate the speed of production and are influenced by the solvating power of the plasticizer. By way of example only, the gelation and fusion temperatures of a plastisol containing a dibenzoate plasticizer will be lower than a plastisol containing a general purpose phthalate, thus enabling speed of processing in that particular application.

[0007] General purpose plasticizers provide an excellent compromise between performance characteristics and economy for most applications. Some examples include: bis (2-ethylhexyl phthalate) (DEHP or DOP), diisononyl phthalate (DINP), dioctyl phthalate (DnOP), diisodecyl phthalate (DIDP), dipropyloxyethyl phthalate (DPHP), di-2-ethylhexyl terephthalate (DOTP or DEHT), and diisononyl-1,2 cyclohexane dicarboxylate (DICD, BASF’s Hexamoll™, or DINC®).

[0008] Environmental scrutiny has led to the development of "next generation" general purpose non-phthalate plasticizers, such as DOTP and DIDC. Even though DOTP, chemically, is a phthalate, it is not an orthophthalate, the use of which is subject to increasing regulatory pressure. These "next generation" phthalate alternatives are viable; however, they do not always give the performance desired in vinyl compositions, particularly in plastisols (i.e., they have poorer compatibility, slow speed, high gel temperatures, low gel strength). Blends of plasticizers can be used to adjust performance, although there may be some limits to this approach.

[0009] Some applications, however, require performance that cannot be achieved by use of a general purpose plasticizer alone. Applications that require better resistance to oils and solvents are one such example. General purpose phthalates are easily extracted by nonpolar solvents such as hexanes, such that alternative plasticizers would be a much better choice. There is also a need for plasticizers that are higher solvators for PVC and other polymer applications, These high solvators should also have a favorable rheology profile.

[0010] Specialty type plasticizers were developed, in part, to fulfill the need for high solvators, the most popular being lower molecular weight phthalates. An example of such a plasticizer is butyl benzyl phthalate (BBP), which is often employed as a high solvating plasticizer. Di-n-butyl phthalate (DBP) and diisobutyl phthalate (DIBP) are also useful high solvator, specialty type plasticizers. Examples of non-phthalate, high solvating plasticizers include dibenzoate esters, some citric acid esters, alkyl sulfonic acid esters, and certain phosphates. Dibutyl terephthalate (DBTP) and N-alkyl
Benzoate plasticizers include dibenzoates and monobenzoates, such as diethylene glycol dibenzoate (DEGDB) and dipropylene glycol dibenzoate (DPGDB) esters that have been used in a wide variety of polymer applications, including in the vinyl industry. DEGDB is an excellent plasticizer, but due to its high freeze point, blends with DPGDB were also developed to capitalize on the utility and lower cost of DEGDB. Several years ago a blend of DEGDB, DPGDB and triethylene glycol dibenzoates (TEGDB) was introduced as a high solvating dibenzoate blend. More recently, a new dibenzoate triblend was introduced as low VOC plasticizer/coalescent for use in plastisols, adhesives, architectural paint and coatings, and polishes, among other applications. This triblend, comprising DEGDB, DPGDB and 1,2 propylene glycol dibenzoate (PGDB) in various ratios and sold as K-FLEX® 975P, has been found to be very versatile for a variety of applications, based on its broad range of compatibilities with polymers utilized in the coatings industry (for example, in vinyl acrylic acrylic and styrene acrylic types) and possesses good solvating properties and low volatility. Its performance properties compare favorably to traditional high solvating phthalate plasticizers as well as traditional benzoate ester plasticizers.

Monobenzoate esters known to be useful as plasticizers include: isodecyl benzoate, isonyonyl benzoate, phenyl ethyl benzoate, and 2-ethylhexyl benzoate. For example, isodecyl benzoate has been described as a useful coalescent agent for paint compositions and for use in the preparation of plastisols in U.S. Patent No. 5,236,987 to Arendt. The use of isodecyl benzoate has also been described in U.S. Patent No. 7,629,413 and U.S. Patent Publication 2010/048778 to Godwin et al. as a useful secondary plasticizer in combination with phthalate plasticizers to provide lower viscosity and lower volatility in PVC plastisols. The use of 2-ethylhexyl benzoate in a blend with DEGDB and diethylene glycol monobenzoate is described in U.S. Patent No. 6,689,830 to Arendt et al. The use of isonyonyl esters of benzoic acid as film-forming agents in compositions such as emulsion paints, mortars, plasters, adhesives, and varnishes is described in U.S. Patent No. 7,638,568 and U.S. Patent Publication 2005/049341 to Grass et al. The use of phenyl ethyl benzoate as plasticizer in compositions comprising cellulose acetate is described in U.S. Patent No. 1,899,214 to Smith.

"Half ester" monobenzoates include dipropylene glycol monobenzoate and diethylene glycol monobenzoate, which are byproducts of the production of dibenzoates, but which, most of the time, are not objects of production. Half esters are not known for being high solvators, although they may be used in conjunction therewith. Half esters are also not as useful as dibenzoate plasticizers, because they are less compatible than the corresponding dibenzoate with PVC. However, the half esters are compatible with emulsions polymers, such as acrylic and/or vinyl ester polymers.

Examples of secondary and diluent type plasticizers, used primarily to reduce plastisol viscosity, include those based on castor oil and soybean oil, isodecyl benzoate, a monobenzoate, and also a useful diluent type plasticizer.

All of the high solvator plasticizers (regardless of type) add value to vinyl compositions that traditional general purpose plasticizers cannot. Traditional general purpose plasticizers have good rheology profiles and are compatible with many polymers, but have poor solvating ability. Moreover, many of the high solvator plasticizers are phthalates, for which safer alternatives are being sought.

There remains a need for non-phthalate, low VOC plasticizers for use in polymeric applications, such as plastisols, as alternatives to traditional diluent plasticizers. These alternatives should be compatible with a wide variety of polymers and have lower VOC content and comparable or better performance properties, when used in polymer applications, such as vinyl, traditionally requiring plasticizers. Non-phthalate, low VOC alternatives are particularly desirable in view of environmental, health and safety issues associated with many of the traditional diluent type plasticizers.

It has been discovered that an entirely different monobenzoate, 3-phenyl propyl benzoate (3-PPB), is a surprisingly effective plasticizer alternative for use in polymeric applications, including but not limited to plastisols, paints and other coatings, adhesives, OPV’s and inks. Besides lower VOC’s, advantages of this monobenzoate, versus conventional higher VOC diluent plasticizers, such as 2,2,4-trimethyl-1,3-pentanediol diisobutyrate, are its excellent health, safety and environmental profile and handling properties, which are better than most dibenzoates and monobenzoates previously used. This new monobenzoate is not classified as hazardous under any "hazard" class, and no labeling elements are required.

The monobenzoate, 3-PPB, has been used in the past in flavoring and fragrance applications, but not in polymeric applications of the type discussed herein. It continues to be used in flavoring and fragrance applications. It has also been used as a solubilizer for certain active or functional organic compounds in personal care products, such as topical sunscreens, as described, in U.S. Patent Publication 200510152858.

While this invention is focused on the use of the inventive plasticizer in plastisol compositions, other applications for the inventive monobenzoate include a variety of coatings, including without limitation overprint varnishes, polishes, inks, paints, adhesives, sealants, and caulk, which are the subject of co-pending applications.

It is an object of the invention to provide a plasticizer having excellent compatibility with a wide variety of polymers and lower VOC content than traditional diluent type plasticizers used to control plastisol viscosities, for use alone or in blends with other plasticizers, in plastisols and other polymeric applications where plasticizers are traditionally limited in their usefulness due to high viscosity or poor rheology characteristics. An ideal plasticizer possesses a good balance between solvation and rheology characteristics.
required.

[0021] It is a further object of the invention to provide a non-phthalate alternative plasticizer for use as a primary or secondary plasticizer in PVC applications.

[0022] It is another object of the invention to provide a non-phthalate plasticizer that has high solvating properties and a good rheology profile, which is useful as a specialty blending plasticizer to improve the compatibility and processability of poor solvating plasticizers, while minimizing the attendant disadvantages of high viscosity and poor rheology associated with the use of traditional high solvating plasticizers.

[0023] Still a further object of the invention is to provide plasticizer blends comprising the inventive monobenzoate of the invention.

[0024] Yet another object of the invention is to provide a plastisol formulation utilizing a non-phthalate plasticizer, 3-PPB, which allows faster processing and economic efficiencies to be achieved and provides comparable or better tensile strength properties over traditional diluent type plasticizers.

[0025] Other objects of the invention will be apparent from the description herein.

SUMMARY OF THE INVENTION

[0026] This invention is directed to the use of a non-phthalate monobenzoate ester useful as a plasticizer for polymeric dispersions, such as plastisols. The inventive monobenzoate comprises 3-phenyl propyl benzoate (3-PPB), a component not previously known or used as a plasticizer for plastisol compositions.

[0027] In one embodiment, the invention is a plasticizer comprising 3-PPB useful to provide improved solvation and rheology in polymeric applications such as plastisols, melt compounding, injection molding, extrusion and calendaring, among others.

[0028] In a second embodiment, the invention is a plastisol composition comprising the inventive monobenzoate plasticizer, including but not limited to PVC and acrylics.

[0029] In a third embodiment, the invention is a blend of 3-PPB with traditional plasticizers.

[0030] In a fourth, the invention is a blend of 3-PPB with solid plasticizers.

[0031] In still other embodiments, the invention relates to the use of the inventive plasticizer in compositions used in applications such as resilient flooring, toys, gloves, wall covering, leather, textiles and the like.

[0032] Use of 3-PPB in the same or similar amounts as traditional plasticizers results in a lower VOC content compared to other diluent plasticizers, such as 2,2,4-himethyl,1,3-pentanediol diisobutyrate or isodacyl benzoate, and comparable or better performance and handling properties than that achieved with traditional plasticizers. The inventive monobenzoate has low toxicity and does not have the environmental, health and safety issues associated with many traditional plasticizers.

BRIEF DESCRIPTION OF THE DRAWINGS.

[0033] FIG. 1 shows initial viscosity data obtained for the inventive monobenzoate as compared to a dibenzoate triblend and a general purpose phthalate plasticizer, DINP.

FIG. 2 shows the gel/fusion curves for the inventive monobenzoate, a dibenzoate triblend and a general purpose phthalate plasticizer, DINP.

FIG. 3 shows thermogravimetric data for neat plasticizers, including the inventive monobenzoate, DINP, IDB and Eastman’s TXIB™.

FIG. 4 reflects volatility data from the ASTM D-1203 Extended Test at 70°C for the inventive monobenzoate, DINP, and IDB.

FIG. 5 reflects initial, one-day and 7-day viscosities obtained using Brookfield RVT Viscosity, 20 RPM, 23°C for the inventive monobenzoate, DINP and IDB.

FIG. 6 (a) shows rheology data: 1 day scan obtained for a basic plastisol composition comprising the inventive monobenzoate as compared to a dibenzoate triblend (X20, K-FLEX® 975P), BBP, DOTP, DINP and IDB.

FIG. 6 (b) shows gel fusion curves for a basic plastisol composition comprising the inventive monobenzoate as compared to a dibenzoate triblend (X20, K-FLEX® 975P), BBP, DOTP, DINP and IDB.

FIGS. 7 (a), (b) and (c) reflect tensile strength, modulus, and elongation values, respectively, for a plastisol comprising the inventive monobenzoate as compared to DINP and IDB.

FIG. 8 shows Brookfield viscosities obtained for various plastisol formulations at initial, 1 day, 3 day and 7 day as compared to a control formulation comprising 50 phr DINP.

FIG. 9 shows gel/fusion curves for various plastisol formulations as compared to a control formulation comprising 50 phr DINP.
The present invention is directed to the use of a monobenzoate plasticizer for a variety of applications as a primary or secondary plasticizer, including but not limited to plastisols. The benzoate plasticizer comprises a unique monobenzoate, 3-phenyl propyl benzoate. (3-PPB), not previously known or used as a plasticizer in polymeric applications. The preferred embodiment of the invention is the use of 3-PPB in combination with a polymeric dispersion. The present invention is not restricted to any particular polymer, although the invention may be described in terms of vinyl polymers.

The present invention is not restricted to any particular polymer, although the invention may be described in terms of vinyl polymers.

Additional details and usage examples are provided in the text, including discussions on the properties of 3-PPB and its application in various polymeric compositions. The text also includes references to experimental data, such as the heat rise experiment data comparing the inventive monobenzoate to DINP, and other plastisol formulations.

Useful amounts of 3-PPB are set forth in the examples. It is expected that one skilled in the art would be able to use these amounts in a variety of applications, including but not limited to plastisols. The benzoate plasticizer comprises a unique monobenzoate, 3-phenyl propyl benzoate, 3-PPB, as an alternative plasticizer for conventional diluent plasticizers with a higher VOC content or plasticizers that do not provide advantageous solvation and rheology. Any of the known polymers that can be formulated into a plastisol, melt compound, injection molding, extrusion, or calendaring polymer can be used in combination with novel monobenzoate to prepare a low VOC content composition in accordance with the present invention.

Use of the inventive monobenzoate is not limited to any particular polymer. Other polymer-based compositions requiring plasticizers will be known to one skilled in the art.
to arrive at additional acceptable amounts based on the intended use and desired performance in the particular polymeric application.

The inventive monobenzoate may be, but is not required to be, blended with various other conventional plasticizers to enhance or augment properties of polymeric compositions, including but not limited to improving compatibility and processability in a plastisol and enhancing solvating power. Conventional plasticizers have been described herein and include, but are not limited to, various phthalate esters, phosphate esters, adipate, azelate, oleate, succinate and sebacate compounds, citrates, trimellitates, terephthalate esters such as DOTP, 1,2-cyclohexane dicarboxylate esters, epoxy plasticizers, fatty acid esters, glycol derivatives, sulfonamides, sulfonic acid esters, benzoates, bioplastics, such as PG disoyate and PG monosoyate, chloroparaffins, polyesters, and various other hydrocarbons and hydrocarbon derivatives that are often utilized as secondary plasticizers, such as epoxidized soybean oil, and the like.

Monobenzoates, such as isononyl benzoate, isodecyl benzoate, and 2-ethylhexyl benzoate, as well as 2,2,4-trimethyl-1,3-pentanediol diisobutyrate (TXIB™, an Eastman trademark) can also be blended with the inventive monobenzoate, or the 3-PPB can replace any of these with the advantage that less is needed to achieve solvation and maintain processable viscosity and rheology.

The inventive monobenzoate may also be blended with solid plasticizers such as sucrose benzoate, dicyclohexyl phthalate, triphenyl phosphate, glycerol tribenzoate, 1,4-cyclohexane dimethanol (CHDM) dibenzoate, pentaerythritol tetrabenzoate, and alkyl glycol esters.

Other suitable plasticizers will be known to one skilled in the art.

The inventive monobenzoate may also be combined with or include various amounts of conventional additives such as oils, diluents, antioxidants, surfactants, heat stabilizers, flame retardants, blending resins, waxes, solvents and the like, depending on the particular application or polymeric dispersion. Additives amounts can generally vary widely and often range from about 0.1 to about 75 parts by weight for every 100 parts by weight of the plastisol composition.

For vinyl applications, there are two different methods of fusing: plastisols and melt compounding. A plastisol is a liquid dispersion of PVC (or other polymer) in plasticizer, which may be heated as a spread coating, fused in slush molding, dip molding or rotationally molded. The plastisols of the invention may be compounded by simple mixing or blending, followed by de-aerating in most instances. Melt compounding is a process that uses heat and pressure while mixing to fuse vinyl (or other polymer). Its overall purpose is to combine the polymer and plasticizer into a homogeneous material which can be formed through a calendrer, extruder or injection mold.

Exemplary formulations for simple basic starting plastisols and melt compounds are set forth in the examples; however, the invention is not limited to these formulations.

The inventive monobenzoate provides a lower VOC content alternative over secondary and diluent type plasticizers and, depending on the application, provides comparable or better compatibility, viscosity stability, and rheology, among other advantages. In many instances, the inventive monobenzoate outperforms industry standard plasticizers, including traditional and newer dibenzoate blends. Many traditional plasticizers have either high solvating properties or low viscosity, but not both. Surprisingly, the inventive monobenzoate strikes a good balance between high solvating power, better rheology and lower viscosity even when used alone.

There are a large variety of uses for the plastisols and melt compounds of the invention, including but not limited to resilient flooring, wear layers, wall coverings, toys, gloves, and leather and textile applications. Other uses will be known to one skilled in the art.

The invention is further described by the examples set forth herein.

Examples

Experimental Methodology

Plastisol and Vinyl Preparation:

The plastisols were prepared in a Hobart Model N-50 mixer. A ten minute mix at speed one (1) was used. A high speed disperser was also used to prepare other plastisols evaluated employing a ten minute mix at 1000 RPM’s, All of the plastisols were degassed at 1 mmHg until as completely air free as possible.

The vinyl for the basic screen was fused in a closed mold at a thickness of 1.2 mm at 177°C for 15 minutes in a Blue M oven. Vinyl for the stain testing was fused in a Mathis oven at a thickness of 0.5 mm at 204° C for 2.5 minutes. The air flow was set at 1500 RPM’s.

Tests/Evaluations

The goal was to determine the basic performance parameters of the inventive plasticizer versus known or standard and currently available plasticizers. Tests demonstrating efficiency (Shore A and tensile properties), perma-
nence (extraction and volatility) and processability (viscosity, viscosity stability, rheology, and gel/fusion) were utilized. Unless otherwise indicated in specific examples, the general tests and/or methodologies described below were used. The tests and methods are known to one skilled in the art.

Viscosity and Rheology: Low shear - Viscosity measurements were made using a Brookfield RVT at 20 RPM's for 10 revolutions at 23 ± 2°C. ASTM D1823. High shear - TA AR2000ex used. Parallel plates were set at appropriate gap (350 microns). Shear to 1000 sec-1. Viscosity Response: Both the initial and 24 hour viscosities were measured.

Gel/Fusion: TA AR2000ex in oscillatory mode. Parallel plates were set at appropriate gap (600 microns). The test temperature was started at 40° C and heated at a rate of 5° C/minute to 220° C.

Efficiency - Shore A - ASTM D2240; Tensile - ASTM D638, type IV die, 50.8 cm/minute pull rate.

Permanence - Volatility -EPA 24, ASTM D2369 volatility, 110°C for one hour; and a TGA isothermal scan at 110°C for four hours. A TGA isothermal for one hour under air at 110°C was also employed. ASTM D1203 was also utilized as an extended test for volatile loss.

Example 1 - Basic Plastisol Evaluations - Processability

The following examples show the efficacy of the inventive monobenzoate with a basic starting plastisol formulation described below:

<table>
<thead>
<tr>
<th>Material</th>
<th>PHR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispersion Resin, K76, Geon 121 A</td>
<td>100</td>
</tr>
<tr>
<td>Plasticizer</td>
<td>70</td>
</tr>
<tr>
<td>Ca/Zn stabilizer, Mark 1221</td>
<td>3</td>
</tr>
</tbody>
</table>

The inventive monobenzoate was compared to X-20 (K-FLEX® 975P, a new dibenzoate triblend comprising 20 wt. % 1, 2-propylene glycol dibenzoate and 80 wt. % of an 80/20 DEG/DPG dibenzoate blend) and DINP. Figure 1 shows initial viscosity data obtained for the inventive monobenzoate, which compares favorably to a general purpose phthalate and reflects better rheology than the new dibenzoate triblend.

Table 1, below, reflects gel fusion values obtained for 3-PPB, X-20, and DINP (a general purpose phthalate plasticizer).

<table>
<thead>
<tr>
<th>Plasticizer</th>
<th>Initial Inflection</th>
<th>G' Maximum</th>
<th>G' x G&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temp (°C)</td>
<td>Temp (°C)</td>
<td>Modulus (Pa)</td>
</tr>
<tr>
<td>3-PPB</td>
<td>57</td>
<td>81</td>
<td>1.6 x 10^6</td>
</tr>
<tr>
<td>X-20</td>
<td>58</td>
<td>87</td>
<td>1.2 x 10^6</td>
</tr>
<tr>
<td>DINP</td>
<td>79</td>
<td>125</td>
<td>3.5 x 10^5</td>
</tr>
</tbody>
</table>

Figure 2 shows the gel/fusion curves for 3-PPB, X20, and DINP.

The results above reflect that 3-PPB is a viable alternative for use in plastisol compositions and is an acceptable partial substitute for general purpose phthalates traditionally used in this type of application. Unexpectedly, 3-PPB has low viscosity, better rheology, and higher solvating properties when used in plastisol applications over more traditional plasticizers. The 3-PPB also achieved a lower fusion temperature as shown in Table 1 and Figure 2, which facilitates faster processing times and/or lower energy costs in plastisol applications. These results are consistent with heat rise experiments conducted with melt compounds comparing 3-PPB and DINP as reflected in Figure 12.

Example 2 - Basic Plastisol Evaluations - Processability. Permanence

The basic plastisol formulation of Example 1 was utilized in this example. The inventive monobenzoate (X-613) was compared to DINP, IDB (isodecyl benzoate), and 2,2,4-trimethyl.1,3-pentanediol diisobutyrate (TXIB, an Eastman trademark).

The thermogravimetric data of the neat plasticizers is shown in Figure 3. The results demonstrate that 3-PPB is significantly less volatile than TXIB™ and IDB, has more permanence and provides a lower VOC alternative over these two plasticizers. An extended test showing volatile loss over 3 days at 70°C comparing DINP, IDB and 3-PPB is
shown in Figure 4. The results show that 3-PPB is somewhat better than IDB in terms of volatility (permanence) over
the three day period.

[0071] Initial, one-day and 7-day viscosities obtained for 3-PPB, DINP and IDB are shown in Figure 5. This data
demonstrates a higher viscosity for 3-PPB than that obtained for IDB, but much lower than the phthalate DINP. The data
demonstrates that 3-PPB has good solvation properties and lower viscosity as compared to the traditional phthalate and
is a viable alternative for plastisol applications. IDB has a lower viscosity, but is a poorer solvator than 3-PPB.

Example 3 - Basic Plastisol Evaluation - Rheology and Gel/Fusion

[0072] The basic plastisol formulation of Example 1 was utilized in this example.

[0073] In this example, 3-PPB (X-613) was compared to DINP, Eastman’s TXIB™, DOTP, X20, IDB and BBP (butyl
benzyl phthalate). Rheology data (1 day scan) and gel/fusion curves were obtained for the group as reflected in Figures
6 (a) and 6 (b), respectively.

[0074] The results reflect that as shear rate was increased, higher and higher viscosity was expected. Viscosity for
DINP, IDB and 3-PPB remained level, while DOTP and BBP increased slightly and leveled off. The dibenzoate triblend
(X20) increased rapidly, followed by a decline. The results show that 3-PPB is comparable to IDB and DINP and has
superior rheology over X20, BBP, and DOTP.

[0075] Gel fusion data illustrates the relative solvation characteristics of various plasticizers. Figure 6 (b) shows the
results of the gel/fusion evaluation, which reflected better results for 3-PPB as compared to X20 and unexpectedly better
than the BBP control that is considered an industry standard. DOTP, DINP, and IDB demonstrated much poorer solvation
properties than 3-PPB. 3-PPB is at least twice as efficient as IDB as a solvator, yet viscosity and rheology are not sacrificed.

[0076] Overall, the results demonstrated that 3-PPB imparts a combination of excellent rheology and much better
solvation properties than many currently available plasticizers.

Example 4 - Basic Plastisol Evaluation - Efficiency

[0077] Tensile Strength (psi), Modulus (100%) and Elongation (%) values were obtained for DINP, IDB and 3-PPB
(X-613). The results obtained are shown in Figures 7 (a), (b) and (c), respectively, and reflect that 3-PPB is slightly more
efficient than IDB overall.

Example 5 - Plastisol Wear Layer Evaluations

[0078] The basic formulations evaluated are set forth below in Table 2, including blends of DINP and IDB, DINP and
3-PPB, DINP, IDB and 3-PPB (X-613).

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Control</th>
<th>10 PHR IDB</th>
<th>10 PHR X613</th>
<th>5 PHR IDB</th>
<th>5 PHR X613</th>
<th>IDB/X613</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC (Geon 179)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>DINP</td>
<td>50</td>
<td>40</td>
<td>40</td>
<td>45</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>Isodecyl Benzoate</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>X613</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>ESO</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Mineral Spirits</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Ca/Zn Stabilizer (Mark 1221)</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Table 2

[0079] Figure 8 shows Brookfield viscosities obtained for the various formulations: initial 1 day, 3 day and 7 day as
compared to the control formulation comprising 50 phr DINP. The results show that 3-PPB had higher viscosity initially
than IDB, but lower than DINP.

[0080] Over time, the viscosity of 3-PPB remained fairly stable, while the formulation having 5 phr IDB increased
viscosity as compared to 5 phr 3-PPB.

[0081] Gel/Fusion data obtained for the various formulations is shown below in Table 3 and gel/fusion curves are
shown in Figure 9. The results demonstrate that at equal levels, 3-PPB is better than DINP control in terms of relative
solvation characteristics and is comparable to or slightly better than IDB in terms of its relative solvation characteristics. 3-PPB data reflects good balance between gel and fusion such that rheological behavior may be predicted and tailored.

Table 3

<table>
<thead>
<tr>
<th>Plastisol</th>
<th>G' at 500 Pa (°C)</th>
<th>G'Max Temp (°C)</th>
<th>Modulus (Pa)</th>
<th>G'XG'' (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DINP (50 PHR)</td>
<td>91</td>
<td>141</td>
<td>4.8 x 10^5</td>
<td>191</td>
</tr>
<tr>
<td>10 PHR IDB</td>
<td>87</td>
<td>139</td>
<td>2.8 x 10^5</td>
<td>190</td>
</tr>
<tr>
<td>5 PHR IDB</td>
<td>89</td>
<td>140</td>
<td>4.0 x 10^5</td>
<td>191</td>
</tr>
<tr>
<td>10 PHR X613</td>
<td>80</td>
<td>134</td>
<td>3.2 x 10^5</td>
<td>188</td>
</tr>
<tr>
<td>5 PHR X613</td>
<td>86</td>
<td>137</td>
<td>3.8 x 10^5</td>
<td>190</td>
</tr>
<tr>
<td>5 PHR IDB/5 PHR X613</td>
<td>84</td>
<td>136</td>
<td>4.1 x 10^5</td>
<td>190</td>
</tr>
</tbody>
</table>

Example 6 - Melt Compounding Evaluations

Torque rheometry is a method for measuring real processing conditions of a compound. Heat rise experiments illustrate the differences between when fusion occurs with different plasticizers. The measured torque and temperature curves, along with the physical changes of the compound taking place can be studied. Another point of interest is the relative fusion temperature, which occurs when the stock temperature initially rapidly increases. This temperature indicates the point at which the surface solvation begins to take place, resulting in a considerable increase in torqued leading to the generation of fusion in the melt compound. The relative fusion temperature is helpful in determining the solvating characteristics of the plasticizers used in plasticized PVC. From there, an analysis of how different plasticizers affect the processing ability of a PVC melt compound or plastisol can be conducted, demonstrating how the processing factors of one plasticizer may be more favorable than the other.

Brabender Heat Rise. The general heat rise formula shown in Table 4 below was weighed out and mixed using a metal spatula, forming a white cake-like powder. A C.W. Brabender Intellitorque® mixer was used for the study. The Brabender was equilibrated at a starting temperature of 40°C and after being charged with 50 cc of sample, the temperature was ramped at a rate of 3°C/minute up to 200°C. Number 6 roller heads mixed the compound at a speed of 63 rpm with 1 second damping. After loading the chute was closed using a press and a 5 kg weight. Each sample was run until degradation began to occur. The plasticizers evaluated included PGDB (1,2-propylene glycol dibenzoate), K-FLEX® 975P (X20, a dibenzoate triblend), PG, K-FLEX® 850P (a dibenzoate diblend), X-613 (3-PPB), BBP, DINP, DIDC and DOTP.

The results of the heat rise experiments are shown in Tables 5 and 6.

Table 4. General Brabender heat rise formula

<table>
<thead>
<tr>
<th>Material</th>
<th>PHR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC</td>
<td>100</td>
</tr>
<tr>
<td>Plasticizer</td>
<td>50</td>
</tr>
<tr>
<td>Stearic Acid</td>
<td>0.5</td>
</tr>
<tr>
<td>Ca/Zn Stabilizer</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 5. Brabender heat rise data

<table>
<thead>
<tr>
<th>Plasticizer</th>
<th>First Torque Peak</th>
<th>Fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time (min)</td>
<td>Torque (Nm)</td>
</tr>
<tr>
<td>X-613</td>
<td>5.6</td>
<td>50</td>
</tr>
<tr>
<td>PGDB</td>
<td>8.4</td>
<td>45</td>
</tr>
<tr>
<td>850P</td>
<td>7.9</td>
<td>50</td>
</tr>
<tr>
<td>X-20</td>
<td>7.9</td>
<td>48</td>
</tr>
<tr>
<td>BBP</td>
<td>8.5</td>
<td>41</td>
</tr>
<tr>
<td>DINP</td>
<td>14</td>
<td>36</td>
</tr>
<tr>
<td>DOTP</td>
<td>16</td>
<td>34</td>
</tr>
<tr>
<td>DIDC</td>
<td>17</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 6. Brabender heat rise data - Degradation

<table>
<thead>
<tr>
<th>Material</th>
<th>Time (min)</th>
<th>Torque (Nm)</th>
<th>Temp (°C)</th>
<th>Initial Temp (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-613</td>
<td>48</td>
<td>2</td>
<td>178</td>
<td>64</td>
</tr>
<tr>
<td>PGDB</td>
<td>51</td>
<td>2</td>
<td>183</td>
<td>66</td>
</tr>
<tr>
<td>850P</td>
<td>48</td>
<td>3</td>
<td>176</td>
<td>67</td>
</tr>
<tr>
<td>X-20</td>
<td>48</td>
<td>3</td>
<td>176</td>
<td>67</td>
</tr>
<tr>
<td>BBP</td>
<td>46</td>
<td>3</td>
<td>175</td>
<td>69</td>
</tr>
<tr>
<td>DINP</td>
<td>48</td>
<td>3</td>
<td>178</td>
<td>83</td>
</tr>
<tr>
<td>DOTP</td>
<td>48</td>
<td>3</td>
<td>179</td>
<td>85</td>
</tr>
<tr>
<td>DIDC</td>
<td>50</td>
<td>3</td>
<td>182</td>
<td>89</td>
</tr>
</tbody>
</table>

[0087] Table 5, above, illustrates the torque, time and temperature for each sample and indicated when the melt flow of the compound was reached. Overall, the benzoates showed faster fusion times than the general purpose plasticizers. Shorter fusion times indicate superior solvating properties of the plasticizer.

[0088] Heat rise results of Table 6 indicate the time, torque, and temperature where degradation began to occur for each sample. The time, torque and temperature at which relative fusion occurs are also represented. DINP, DOTP and DIDC had the highest temperatures for relative fusion, indicating lower solvating ability.

[0089] Figure 11 shows Brabender heat rise data for 3-PPB, and Figure 12 shows Brabender data for 3-PPB compared to DINP. Figure 12 represents a good demonstration of the high solvating properties of 3-PPB versus general purpose plasticizers. Both compounds were run using the same starting temperatures and the same temperature ramp rate. The difference in their torque values was due to the differences in fusion characteristics that each sample produced. Figure 12 shows unequivocally that 3-PPB fused quicker than the DINP melt compound. The 3-PPB compound began fusing within the first 5 minutes of starting the run. The DINP compound required a higher temperature and more energy in order to start fusing.

[0090] Brabender Isothermal Evaluations - The same plasticizers tested in the heat rise experiments were tested for the isothermal tests. The formula utilized was modified slightly to include epoxidized soybean oil (ESO) as well as higher levels of stearic acid and plasticizer. The formula is set forth below in Table 7.

[0091] Using the formula in Table 7, the raw materials were weighed out and mixed with a metal spatula. In this test, the Brabender Intellitorque® was programmed to remain at a constant temperature of 150° C. The sample volume of
50 cc charge was loaded in the same manner as in the heat rise tests. The experiments were terminated at the onset of rapid torque increase.

Table 7. General Brabender isothermal formula

<table>
<thead>
<tr>
<th>Material</th>
<th>PHR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC</td>
<td>100</td>
</tr>
<tr>
<td>Plasticizer</td>
<td>70</td>
</tr>
<tr>
<td>Stearic Acid</td>
<td>0.5</td>
</tr>
<tr>
<td>ESO</td>
<td>2</td>
</tr>
<tr>
<td>Ca/Zn Stabilizer</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>174</td>
</tr>
</tbody>
</table>

The isothermal test is important because different plasticizers can be analyzed for effect of solvator class too. This experiment simulates actual processing conditions better and can be used to rank the ability of the plasticizers to facilitate the processing of vinyl. The data below in Table 8 show very little distinction between the various high solvating and general purpose plasticizers that were tested, as the melt compounds fused very rapidly, because they were subjected to such a high temperature for the entire test. None of the samples underwent degradation during their test times.

Table 8. Isothermal Brabender data

<table>
<thead>
<tr>
<th>Plasticizer</th>
<th>MaxTorque (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-613</td>
<td>9</td>
</tr>
<tr>
<td>PGDB</td>
<td>11</td>
</tr>
<tr>
<td>850P</td>
<td>11</td>
</tr>
<tr>
<td>X-20</td>
<td>12</td>
</tr>
<tr>
<td>BBP</td>
<td>10</td>
</tr>
<tr>
<td>DINP</td>
<td>8</td>
</tr>
<tr>
<td>DOTP</td>
<td>7</td>
</tr>
<tr>
<td>DIDC</td>
<td>6</td>
</tr>
</tbody>
</table>

Claims

1. Use of 3-phenyl propyl benzoate as a plasticizer in polymeric dispersions.

2. A plastisol composition comprising a polymer dispersed in the plasticizer as used in claim 1, wherein the plasticizer is either used alone or in combination with other plasticizers, and wherein the plasticizer provides improved solvation and rheology characteristics over that achieved with known high solvating plasticizers.

3. A PVC-based melt compound comprising the plasticizer as used in claim 1.

4. A PVC plastisol comprising the plasticizer as used in claim 1.

5. An acrylic-based plastisol comprising the plasticizer as used in claim 1.

6. The plasticizer as used in claim 1 blended with a phthalate ester, a phosphate ester, an adipate, an azelate, an oleate, a succinate, a sebacate, a citrate, a trimellitate, a terephthalate ester, 1,2-cyclohexane dicarboxylate esters, epoxy plasticizers, fatty acid esters, glycol derivatives, sulfonamides, sulfonic acid esters, benzoates, bioplasticizers,
7. The plasticizer as used in claim 1 blended with any of isononyl benzoate, isodecyl benzoate, 2-ethylhexyl benzoate, 2,2,4-trimethyl-1,3-pentanediol diisobutyrate, epoxidized soybean oil, PG disoyate, PG monosoyate, or mixtures thereof.

8. The plasticizer as used in claim 1 blended with a solid plasticizer that is sucrose benzoate, dicyclohexyl phthalate, triphenyl phosphate, glycerol tribenzoate, 1,4-cyclohexane dimethanol (GHDM) dibenzoate, pentaerythritol tetrabenzoate, an alkyl glycol ester, or mixtures thereof.

9. The use according to claim 1, wherein the plasticizer as used in claim 1, or the plasticizer blends of claims 6, 7 or 8, is present in a polymeric composition.

10. A method of improving the solvating and rheology properties of a plasticizer used in plastisol applications, comprising the step of blending the plasticizer with the plasticizer as used in claim 1.

Patentansprüche


2. Plastisolzusammensetzung, umfassend ein Polymer, das in dem Weichmacher dispergiert ist, wie in Anspruch 1 verwendet, wobei der Weichmacher entweder allein oder in Kombination mit anderen Weichmachern verwendet wird, und wobei der Weichmacher verbesserte Solvatations- und Rheologieeigenschaften gegenüber denen, die mit bekannten hochsolvatisierenden Weichmachern erreicht werden, bietet.

3. Schmelzverbindung auf PVC-Basis, umfassend den Weichmacher, wie er in Anspruch 1 verwendet wird.

4. PVC-Plastisol, umfassend den Weichmacher, wie er in Anspruch 1 verwendet wird.

5. Plastisol auf Acrylbasis, umfassend den Weichmacher, wie er in Anspruch 1 verwendet wird.

6. Weichmacher, wie er in Anspruch 1 verwendet wird, gemischt mit einem Phthalatester, einem Phosphatester, einem Adipat, einem Azelat, einem Oleat, einem Succinat, einem Sebacat, einem Trimesitrat, einem Terphthalat, 1,2-Cyclohexandicarboxylat, Epoxidweichmachern, Fettsäureestern, Glykolderivaten, Sulfoamiden, Sulfoxäureestern, Benzaten, Bioweichmachern, Chlorparaffinen, Polyestern oder Mischungen davon.

7. Weichmacher, wie er in Anspruch 1 verwendet wird, gemischt mit einem Isononylbenzoat, Isodecylbenzoat, 2-Ethylhexylbenzoat, 2,2,4-trimethyl-1,3-pentanediol diisobutyrate, epoxidiertem Sojaöl, PG Disoyat, PG Monosoyat oder Mischungen davon.

8. Weichmacher, wie er in Anspruch 1 verwendet wird, gemischt mit einem festen Weichmacher, der Sucrosebenzoat, Dicyclohexylphthalat, Triphenylphosphat, Glyceroltribenzoat, 1,4-Cyclohexandimethanol (GHDM)-dibenzoat, Pentaerythritoltribenzoat, ein Alkylglycolester oder Mischungen davon ist.

9. Verwendung nach Anspruch 1, wobei der Weichmacher, wie er in Anspruch 1 verwendet wird, oder die Weichmachermischungen aus den Ansprüchen 6, 7 oder 8, in einer Polymerzusammensetzung vorliegt.


Revendications

1. Utilisation de benzoate de 3-phénylpropyle en tant que plastifiant dans des dispersions polymériques.

2. Composition de plastisol comprenant
un polymère dispersé dans le plastifiant tel qu’utilisé dans la revendication 1, dans lequel le plastifiant est soit utilisé seul soit en combinaison avec d’autres plastifiants, et dans lequel le plastifiant fournit des caractéristiques de solvatation et de rhéologie améliorées par rapport à celles obtenues avec des plastifiants de haute solvatation connus.

3. Composé obtenu par fusion à base de PVC comprenant le plastifiant tel qu’utilisé dans la revendication 1.

4. Plastisol de PVC comprenant le plastifiant tel qu’utilisé dans la revendication 1.

5. Plastisol à base d’acrylique comprenant le plastifiant tel qu’utilisé dans la revendication 1.

6. Plastifiant tel qu’utilisé dans la revendication 1 mélangé avec un ester de phtalate, un ester de phosphate, un adipate, un azélate, un oléate, un succinate, un sébacate, un citrate, un trimellitate, un ester de téraphtalate, des esters de 1,2-cyclohexane de dicarboxylate, des plastifiant époxy, des esters d’acide gras, des dérivés du glycol, des sulfonamides, des esters d’acide sulfonique, des benzoates, des bioplastifiants, des chloroparaffines, des polyesters, ou des mélanges de ceux-ci.

7. Plastifiant tel qu’utilisé dans la revendication 1 mélangé avec l’un du benzoate d’isononyle, du benzoate d’isodécyle, du benzoate de 2-éthylhexyle, du diisobutyrate de 2,2,4-triméthyle-1,3-pentanediol, de l’huile de soja époxydée, du disoyate de PG, du monosoyate de PG, ou des mélanges de ceux-ci.

8. Plastifiant tel qu’utilisé dans la revendication 1 mélangé avec un plastifiant solide qui est le benzoate de sucre, le phtalate de dicyclohexyle, le phosphate de triphényle, le tribenzoate de glycérol, le dibenzoate de 1,4-cyclohexane diméthanol (GHDM), le tétrabenzoate de pentaérythritol, un ester de glycol alkylique, ou des mélanges de ceux-ci.

9. Utilisation selon la revendication 1, dans laquelle le plastifiant tel qu’utilisé dans la revendication 1, ou les mélanges de plastifiants selon les revendications 6, 7 ou 8, est présent dans une composition polymérique.

10. Procédé d’amélioration des propriétés de solvatation et de rhéologie d’un plastifiant utilisé dans des applications de plastisol, comprenant l’étape de mélange du plastifiant avec le plastifiant tel qu’utilisé dans la revendication 1.
FIG. 1  Rheology Data, Initial
FIG. 2 – Gel/Fusion Curves
FIG. 3 – Thermogravimetric Data, Neat Plasticizer 110°C Four Hours
**FIG. 4** – Volatility, ASTM D-1203 Extended Test at 70°C

**FIG. 5** – Brookfield RVT Viscosity, 20 RPM, 23°C
**FIG. 7 a**

**Tensile Strength**

- DINP
- X613
- IDB

**FIG. 7 b**

**100% Modulus**

- DINP
- X613
- IDB

**Fusion Temperature (°C)**
Elongation, %

Strain at Break (%)

Fusion Temperature (°C)

FIG. 7 c

Viscosity (CP)

Initial  1 Day  3 Day  7 Day

50 PHR DINP Control  10 PHR IDB  5 PHR IDB
10 PHR X613  5 PHR X613  IDB/X613

FIG. 8 - Brookfield Viscosity
FIG. 9 - Gel/Fusion Curves

FIG. 10 - Initial Shear
FIG. 11 - Brabender heat rise experiment with X-613.

FIG. 12 - Heat rise experiment comparing X-613 to DINP.
REFERENCES CITED IN THE DESCRIPTION

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