MONOBENZOATE USEFUL AS A PLASTICIZER IN ADHESIVE PREPARATIONS

FIELD OF THE INVENTION

[0001] This invention is directed to a monobenzoate found to be unexpectedly useful as a plasticizer in a variety of polymer applications, including but not limited to adhesives, caulks, sealants and the like. In particular, this invention is directed to the use of a monobenzoate ester, 3-phenyl propyl benzoate, in adhesive applications or adhesive products. The inventive monobenzoate has comparable or better rheology, viscosity stability, compatibility, processability, open time, set time, peel strength and water reduction, among other advantages, over traditional plasticizers. The invention is also directed to polymeric compositions comprising the inventive monobenzoate, such as water-based adhesives, non-aqueous based adhesives, caulks and sealants.

BACKGROUND OF THE INVENTION

[0002] Adhesives are widely used in a number of applications, including without limitation envelopes; labeling; bonding, sealing and assembly of components and other materials; remoistening; stenciling; laminating; packaging; electronics manufacturing; high speed adhesive application; construction; transportation and the like. Certain polymers or polymer blends are well known, useful adhesives. By way of example only, copolymers of ethylene and vinyl acetate are useful for adhesives.

[0003] Adhesives are formulated in both water (waterborne) and solvent-based (non-aqueous) systems. Generally, solvent-based adhesives work more predictably and effectively under a wide range of conditions. Water-based systems are substantially or entirely free of most inherent toxic and hazardous properties of solvents, but do not always work in less than ideal conditions. There is a need for water-based systems that perform better or equivalent to solvent-based adhesives.

[0004] Plasticizers have been used as additives in adhesive compositions for some time to modify physical properties of the adhesive and the polymer film formed by the dried adhesive. Plasticizers facilitate the formation of an adhesive bond and prevent failure of the bond after aging. Plasticizers soften the polymer and add flexibility to the adhesive bond, without adversely affecting the degree of adhesion, lower the glass

transition temperature (Tg) of the adhesive film making the polymer more flexible and the glue more efficient, and enhance film formation by lowering the minimum film formation temperature (MFFT). Plasticizers may also act as a fluid carrier for the polymeric component.

[0005] In all applications, the plasticizer should be compatible at least partially with the base polymer. Plasticizers should possess chemical stability, non-flammability, low toxicity and low volatility. Finally, plasticizers should also be economically feasible.

[0006] Dibenzoate plasticizers, such as diethylene glycol dibenzoate (DEGDB) and dipropylene glycol dibenzoate (DPGDB), are well known as general purpose plasticizers for latex adhesive applications. Blends of dibenzoates are also known and available. A high polarity blend of DEGDB, DPGDB and triethylene glycol dibenzoates (TEGDB) is available. More recently, a new dibenzoate triblend, comprising a blend of three dibenzoate plasticizers, DEGDB, DPGDB and 1,2 propylene glycol dibenzoate (PGDB), in various ratios, was introduced as a lower VOC plasticizer/coalescent alternative for use in plastisols, adhesives, coatings, and polishes, among other polymer applications.

[0007] Other plasticizers useful for latex adhesives are the phthalates, i.e., benzyl phthalate (BBP), Di-n-butyl phthalate (DBP) and diisobutyl phthalate (DIBP). Although not necessarily high solvating polar plasticizers, other examples of non-phthalate, high solvating plasticizers useful in adhesive compositions include some glycols, citric acid esters, alkyl sulfonic acid esters, and certain phosphates.

[0008] In addition to the dibenzoates discussed above, monobenzoates known to be useful as plasticizers include: isodecyl benzoate, isononyl benzoate, and 2-ethylhexyl benzoate. 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 to Godwin et al. as a useful secondary plasticizer in combination with phthalate plasticizers for PVC plastisols. The use of 2-ethylhexyl benzoate in a blend with DEGDB and diethylene glycol monobenzoate is described in U.S. Patent No. 6,989,830 to Arendt et al. The use of isononyl 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. 7,638,569 to Grass et al.

[0009] "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 compatible with emulsions polymers, such as acrylic and/or vinyl ester polymers.

[0010] There remains a need for non-phthalate, lower VOC plasticizers for use in adhesive applications as alternatives to traditional plasticizers. Non-phthalate alternatives are particularly desirable in view of environmental, health and safety issues associated with many of the traditional plasticizers. In particular, in the food packaging industry, there is increasing concern for migratory issues associated with the use of packaging adhesives. There is, therefore, a need for a plasticizer for use in adhesive applications, which is environmentally safe, non-hazardous and non-toxic in use.

[0011] *It has been discovered that an entirely different monobenzoate, 3-phenyl* propyl benzoate (3 PPB), is a surprisingly effective lower VOC plasticizer alternative to other monobenzoates and certain phthalates for use in adhesives, caulks and sealants. Advantages of this monobenzoate 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 hazard labeling elements are required.

[0012] The monobenzoate, 3 PPB, has not been utilized in polymeric applications of the type discussed herein in the past. It has been used and continues to be used in flavoring and fragrance applications, making it an ideal candidate in applications where there are migratory concerns. It has also been used as a solubilizer for certain active or functional organic compounds in personal care products as described in U.S. Patent Publication 2005/0152858.

[0013] It is an object of the invention to provide an alternative non-phthalate plasticizer having excellent compatibility with a wide variety of polymers, with improved handling and a superior toxicological profile over traditional plasticizers, for use alone or in combination with other plasticizers in adhesive applications.

[0014] Yet another object of the invention is to provide a monobenzoate, 3 PPB, useful as a plasticizer in polymeric dispersions such as adhesives, which achieves comparable or better performance properties over traditional plasticizers, including but not limited to viscosity response, Tg suppression, set time, open time, peel strength, water reduction and chalk point (MFFT).

[0015] Still another object of the invention is to provide waterborne or non-aqueous adhesive compositions comprising the inventive monobenzoate having comparable or better properties than adhesive compositions utilizing traditional plasticizers.

[0016] A further object of the invention is to provide other inventive compositions comprising the inventive monobenzoate, including but not limited to caulks and sealants, for use in a wide variety of applications.

[0017] Other objects of the invention will be apparent from the description herein.

SUMMARY OF THE INVENTION

[0018] This invention is directed to a non-phthalate monobenzoate plasticizer useful as a plasticizer for polymeric dispersions, such as adhesives. In particular, the invention is directed to the use of 3-phenyl propyl benzoate (3 PPB), a component not previously known or used as a plasticizer for polymeric adhesive compositions.

[0019] In one embodiment, the invention is a plasticizer useful for adhesive compositions comprising 3 PPB.

[0020] In a second embodiment, the invention is a waterborne adhesive composition comprising the inventive plasticizer, including but not limited to waterborne latex glues and waterborne acrylics.

[0021] In a third embodiment, the invention is a caulk composition comprising the inventive plasticizer.

[0022] In a fourth embodiment, the invention is a sealant composition comprising the inventive plasticizer.

[0023] In a fifth embodiment, the invention is a non-aqueous based adhesive composition comprising the inventive plasticizer.

[0024] In a sixth embodiment, the invention is a blend of traditional plasticizers with the inventive plasticizer.

[0025] In still other embodiments, the invention relates to the use of the inventive plasticizer and adhesive compositions in applications.

[0026] Use of the inventive monobenzoate in the same or similar amounts as traditional plasticizers results in comparable or better performance and handling properties than that achieved with traditional plasticizers. The inventive monobenzoate is non-toxic, as is evident by its past and continued use as a flavor and fragrance additive. As such, it does not have the environmental, health and safety issues associated with traditional plasticizers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] FIG. 1 shows the volatility characteristics determined for the neat plasticizers evaluated, using the Oven Volatility test, one hour, at 110° C.

[0028] FIG. 2 shows the One Day Viscosity responses obtained in Pace® 383 polyvinyl acetate (PVAc homopolymer) at 10 wt. % of each of the plasticizers evaluated.

[0029] FIGS. 3 (a) and (b) show One Day Viscosity responses obtained in polyvinyl acetate ethylene (PVA/E) copolymers, Copolymer A (Elvace® 735) (FIG. 3 (a)) and Copolymer B (Vinnapas® 400) (FIG. 3 (b)), at 5 wt. % of each of the plasticizers evaluated.

[0030] FIG. 4 shows water reduction results (to 2000 mPa's) of the PVAc homopolymer obtained at concentrations of 5, 10, 15 and 20 wt.% of each of the plasticizers evaluated.

[0031] FIGS. 5 (a) and (b) show water reduction results (to 2000 mPa's) of the two PVA/E copolymers, A and B, respectively, obtained at concentrations of 5, 10 and 15 wt.% of each of the plasticizers evaluated.

[0032] FIG. 6 reflects Tg results obtained for plasticizer concentrations of 5, 10, 15 and 20 wt.% in PVAc homopolymer.

[0033] FIGS. 7 (a) and (b) reflect Tg results obtained for plasticizer concentrations of 5, 10, 15 and 20 wt. % in the two copolymers, A and B, respectively.

[0034] FIG. 8 shows set times obtained for the various plasticizers at 10 wt.% concentration in PVAc homopolymer.

[0035] FIGS. 9 (a) and (b) show set times obtained for the various plasticizers at 5 wt.% concentration in copolymers A and B, respectively.

[0036] FIG. 10 shows open times obtained for the various plasticizers at 10 wt.% concentration in PVAc homopolymer.

[0037] FIGS. 11 (a) and (b) show open times obtained for the various plasticizers at 5 wt.% concentration in copolymers A and B, respectively.

[0038] FIGS. 12 (a) and (b) show peel strength results obtained for the various plasticizers at 5 wt.% concentration in PVA/E copolymer, dry and after one hour water soak, respectively, using the T-Peel Cotton to Cotton Test.

[0039] FIGS. 13 and 14 show initial and one day Brookfield Viscosity results, respectively, of PVAc homopolymer at concentrations of 5, 10, 15 and 20 wt.% of each of the plasticizers evaluated.

[0040] FIGS. 15 and 16 show three and seven day Brookfield Viscosity results, respectively, of PVAc homopolymer at concentrations of 5, 10, 15 and 20 wt.% of the each of the plasticizers evaluated.

[0041] FIGS. 17 and 18 show four week and eight week Brookfield Viscosity results, respectively, of PVAc homopolymer at concentrations of 5, 10, 15 and 20 wt.% of each of the plasticizers evaluated.

[0042] FIGS. 19 (a), (b), (c) and (d) show shear results of PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0043] FIG. 20 shows Tg results of PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0044] FIG. 21 shows set time results of PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0045] FIG. 22 shows open time results of PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0046] FIG. 23 shows results of the 180° cotton to acrylic peel test for PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0047] FIG. 24 shows results of the second trial of the 180° cotton to acrylic peel test for PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of the plasticizers evaluated.

[0048] FIG. 25 shows a comparison of the results of the first trial and second trial 180° cotton to acrylic peel tests reflected in FIGS. 23 and 24.

[0049] FIG. 26 shows the average of the results obtained for the 180° cotton to acrylic peel test reflected in FIGS. 23 and 24.

[0050] FIG. 27 shows the results of the 180° cotton to flexible vinyl peel test for PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0051] FIG. 28 shows the results of the dry T-Peel, cotton to cotton test for PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0052] FIG. 29 shows the results of the water reduction (to 2000 mPa's) test for PVAc homopolymer at 5, 10, 15 and 20 wt. % concentrations of each of the plasticizers evaluated.

[0053] FIG. 30 shows the Hysteresis Loop (wet tack) results of PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0054] FIG. 31 shows the chalk point data of PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of the plasticizers evaluated.

[0055] FIGS. 32, 33 (a), 33 (b) and 34 show the initial, one, three and seven day Brookfield Viscosities, respectively, of Elvace® 735 copolymer formulations using plasticizer concentrations of 5, 10 and 15 wt.% of each of the plasticizers evaluated.

[0056] FIGS. 35, 36 and 37 show shear results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% plasticizer concentrations, respectively.

[0057] FIG. 38 shows Tg results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% concentrations of each of the plasticizers evaluated.

[0058] FIG. 39 shows set time results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% concentrations of each of the plasticizers evaluated.

[0059] FIG. 40 shows open time results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% concentrations of each of the plasticizers evaluated.

[0060] FIG. 41 shows water reduction (to 2000cP) of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% concentrations of each of the plasticizers evaluated.

[0061] FIG. 42 shows Hysteresis Loop (wet tack) results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% concentrations of each of the plasticizers evaluated.

[0062] FIG. 43 shows dry T-Peel, cotton to cotton, results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% concentrations of each of the plasticizers evaluated.

[0063] FIG. 44 shows T-Peel, cotton to cotton, results after a one hour water soak of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% of each of the plasticizers evaluated.

[0064] FIG. 45 shows T-Peel cotton to cotton strength loss after a one hour water soak of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% of each of the plasticizers evaluated.

[0065] FIG. 46 shows 180° Peel, Flexible PVC to Luan results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% of each of the plasticizers evaluated.

[0066] FIGS. 47, 48 and 49 show the initial, one and three day Brookfield Viscosities, respectively, of Elvace® 735 copolymer formulations at 5, 10, and 15 wt.% of each of the plasticizers and plasticizer blends evaluated.

[0067] FIGS. 50, 51 and 52 show the initial, one and three day Brookfield viscosities, respectively, of Pace® 383 (PVAc) homopolymer formulations at 5, 10, 15 and 20 wt.% of each of the plasticizers and plasticizer blends evaluated.

[0068] FIG. 53 shows 1 week viscosity results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% of each of the plasticizers and plasticizer blends evaluated.

[0069] FIG. 54 shows Tg results of Pace® 383 homopolymer formulations at 5, 10, 15 and 20 wt.% of each of the plasticizers and plasticizer blends evaluated.

[0070] FIG. 55 shows Tg results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% of each of the plasticizers and plasticizer blends evaluated.

[0071] FIGS. 56 and 57 show set and open times, respectively, of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% of each of the plasticizers and plasticizer blends evaluated.

[0072] FIG. 58 shows initial viscosity measurements of a basic packaging glue at 10 phr (9 wt.%) concentrations of each of the plasticizers evaluated.

[0073] FIG. 59 shows water reduction (to 1500 mPa's) of a basic packaging glue at 10 phr (9 wt.%) concentrations of each of the plasticizers evaluated.

[0074] FIGS. 60 and 61 show set times, unreduced and water reduced, for Kraft to Kraft and Kraft to Mylar samples, respectively, of packaging glue at 10 phr (9 wt.%) concentrations of each of the plasticizers evaluated.

[0075] FIG. 62 shows open time results for unreduced and water reduced samples of a basic packaging glue at 10 phr (9 wt.%) concentrations of each of the plasticizers evaluated.

DETAILED DESCRIPTION OF THE INVENTION

[0076] The present invention is directed to a unique monobenzoate plasticizer useful for a variety of applications as a primary or secondary plasticizer in adhesive applications. The unique monobenzoate comprises 3-phenyl propyl benzoate (3-PPB), a known flavor and fragrance compound, not previously known or used as a plasticizer for polymer-based adhesives, glues, sealants and caulks. The invention is also directed to adhesive, glue, sealant and caulk compositions comprising the inventive monobenzoate.

[0077] The inventive monobenzoate plasticizer can generally be utilized alone as a primary plasticizer or in blends with other plasticizers. Any of the known polymers that can be formulated into an adhesive can be used in combination with novel monobenzoate to prepare a lower VOC content, environmentally safe and non-hazardous composition in accordance with the present invention. The inventive monobenzoate may be particularly useful in food packaging applications where migration of the adhesive may be an issue.

[0078] Polymers useful to prepare the polymeric dispersions discussed herein are known in the art. The inventive composition is expected to be useful with a wide

variety of polymers, including both waterborne and non-aqueous polymer compositions. Suitable waterborne polymers, include, but are not limited to, homopolymers and/or copolymers of: acrylics, polyvinyl acetate, vinyl acetate ethylene, polyacrylates, methacrylates, styrene acrylates, polychloroprenes, polyurethanes, and nitriles. Non-aqueous based polymers useful with the inventive monobenzoate include: acrylics, polyvinyl acetates, vinyl acetate ethylene, methacrylates, styrene acrylates, polychloroprenes, thermoplastic polyurethanes, polysulfides, aminos, epoxies, and polyamides. Use of the inventive 3-PPB plasticizer is not limited to any particular polymer, and the foregoing listing is not intended to be limiting of the invention. Other polymer-based compositions useful in adhesive applications and requiring plasticizers will be known to one skilled in the art.

[0079] The novel monobenzoate of the present invention may be used as a substitute or alternative plasticizer for various traditional adhesive polymer dispersions. A typical packaging adhesive is set forth below:

Homopolymer or Copolymer	100 parts
Plasticizer	0-30 parts
Water	0-20 parts
PVOH (88%) hydrolyzed	0-100 parts
Fillers	0-100 parts
Additives (wetting agents, defoamers)	0.10 to 0.5 parts

[0080] The inventive 3-PPB plasticizer is particularly useful for waterborne latex glues, including those comprising natural rubber latex and synthetic latex like polymers, waterborne acrylics, and non-aqueous adhesive compositions. In addition, the inventive 3-PPB plasticizer may also be used in caulks and sealants, so called "filled" adhesives. Dibenzoate esters are known to function well in these "filled" adhesives. Dibenzoate esters have a lower VOC content than 3-PPB; however, for these types of applications, the levels of VOC's associated with 3-PPB may be acceptable. The performance of 3-PPB is predictable in these applications based upon its performance with the polar polymers used in the adhesive market, as demonstrated by the examples.

[0081] The total amount of 3-PPB used in any particular polymeric dispersion would range broadly depending on the particular polymer, the characteristics of the

polymer and other components, the process, the application or use and the results desired. By way of example only, in adhesives, plasticizers range in amounts from about 1 to about 50 wt.%, preferably from about 5 to about 20 wt.%, based on the weight of the wet adhesive. Preferred embodiments for an adhesive include 10 wt. % in homopolymer polyvinyl acetate and 5 wt. % in vinyl acetate ethylene copolymers. As a general rule, the harder the polymer (higher Tg), the more plasticizer required.

[0082] Useful amounts of 3 PPB are set forth in the examples. It is expected that one skilled in the art would be able to arrive at additional acceptable amounts based on the intended use and desired performance in the particular polymeric application.

[0083] The inventive 3-PPB plasticizer be, but is not required to be, blended with various other conventional plasticizers to enhance or augment properties of the adhesive compositions. Conventional plasticizers have been described herein and include, but are not limited to, phthalate esters up to C5, phosphate esters up to C4, adipates, citrates, succinates, isobutyrates, alkyl glycol esters, terephthalate esters, such as DBTP, 1,2-cyclohexane dicarboxylate esters, polyesters, alkyl glycol derivatives, sulfonamides, sulfonic acid esters, and benzoates, both mono- and di-benzoates.

[0084] Monobenzoates, such as isononyl benzoate (INB), isodecyl benzoate (IB), and 2-ethylhexyl benzoate (EHB), and 2,2,4-trimethyl-1,3-pentanediol diisobutyrate, can also be blended with the inventive monobenzoate.

[0085] The inventive monobenzoate may also combined with or include various amounts of conventional additives such as surfactants, thickeners, biocides, fillers, polyvinyl alcohol, defoamers, humectants and the like.

[0086] The inventive monobenzoate provides comparable or better compatibility, viscosity stability and response, rheology, water reduction, set time, open time, peel strength, adhesion, Tg suppression, and chalk point (MFFT), among other advantages. In many instances, the inventive monobenzoate outperforms industry standard plasticizers, regardless of VOC content, including traditional and newer dibenzoate blends. The monobenzoate is particularly useful as a plasticizer when considering the use of harder polymers as alternatives to softer polymers in a variety of low VOC formulations.

[0087] The inventive monobenzoate, 3-PPB, may be used in adhesive compositions, sealants and caulks for a large variety of applications. Example applications include packaging glues, adhesive assembly, labeling, laminates, envelopes, food packaging, wood glue, construction adhesives, transportation product assembly, electronic product assembly and pressure sensitive adhesive (PSA) applications, although this list is by no means exhaustive. Still other uses will be evident to one skilled in the adhesives art.

[0088] The invention is further described by the examples set forth herein.

[0089] Examples

[0090] The evaluation of the plasticizers consisted of a variety of experiments. First, VOC's of the neat plasticizers selected were determined. Then, effectiveness and efficiency of the plasticizers with basic polymeric compositions were determined versus established plasticizers.

[0091] The following polymers were utilized in the evaluation formulations: Pace® 383 polyvinyl acetate (PVAc), PVOH protected, homopolymer, and polyvinyl acetate/ethylene copolymers (PVA/E), 0 °C Tg, PVOH protected, from two suppliers designated "A" and "B". The "A" copolymer is Elvace® 735 from Forbo, the "B" copolymer is Wacker's Vinnapas® 400.

[0092] The following plasticizers were selected for evaluation in the examples 1-9 (in whole or part):

- K-Flex® PG (X 100) – 1, 2 propylene glycol dibenzoate (PGDB)
- X 613 – the inventive monobenzoate, 3-PPB
- K-Flex® 975 P – a next generation dibenzoate triblend comprising DEGDB, DPGDB and PGDB in specified proportions (80 wt.% of a 4:1 DEGDB:DPGDB and 20 wt.% PGDB)
- K-Flex® 850 S – a commercial diblend of diethylene glycol and dipropylene glycol dibenzoates (DEG/DPG DB)
- Benzoflex™ 2088 – a competitive dibenzoate plasticizer blend (TEG/DEG/DPG dibenzoate)
- Diisobutyl phthalate (DIBP)
- Triacetin

- Acetylated tributyl citrate (ATBC) (Citroflex® A4), a well-known plasticizer for food contact polymer applications, adhesives, inks and vinyl

[0093] Plasticizers were utilized in various levels in the examples. For PVAc, 5, 10, 15 and 20 wt.% levels were used, based on wet adhesive weight. For PVA/E, both A and B, 5, 10 and 15 wt.% levels were used, based on wet adhesive weight.

[0094] Tests Utilized – The following tests were employed:

On neat plasticizers - EPA 24, ASTM D2369 volatility, 110°C for one hour; and a TGA isothermal scan at 110°C.

On adhesives:
Viscosity Response
Tg suppression
Water Reduction
Set and Open Times
T-Peel adhesion

[0095] Test Methodology – Specific details of the test methods are described below:

[0096] Volatility: ASTM D2369 used. A TGA isothermal for one hour under air at 110° C was also employed.

[0097] Viscosity Response: Viscosity measurements were made using a Brookfield RVT at 20 RPM's for 10 revolutions at 23 ± 2° C. The Brookfield viscosity was tested using the RVDVII+ Pro Viscometer.

[0098] Tg Suppression: DSC Glass Transition Method: 10 mil (wet) films were drawn down on glass and left to dry overnight. After 24 hours, the films were removed from the plates and approximately 10 mg were placed in a closed aluminum DSC pan. The temperature was equilibrated at -75°C, then ramped at 5°C/min to 65°C. Glass transition was measured as the onset of Tg.

[0099] Water Reduction: 200 grams of plasticized polymer were weighed into 8 oz. jars. Small increments of water were added and viscosity was measured after each addition until the viscosity reached 2000 +/- 80 cP.

[0100] Set Time: Set time determinations were made using two strips of 50 lb. unbleached Kraft paper measuring 1" x 14" (top) and 1.5" x 14" (bottom). A small amount of adhesive was applied to the bottom strip, and a #20 wire wound rod metered

the adhesive onto the bottom strip while a #16 wire wound rod (rubber banded to the #20) simultaneously pressed down the top strip. A timer was then immediately started and the strips were pulled apart until significant force was required to tear apart the strips and fiber tear was noted. Time at this point was recorded as the set time. A minimum of three repetitions were performed. Evaluations were performed blind.

[0101] Open time: A 1.5" x 14" piece of 50 lb. unbleached Kraft paper was placed on a glass surface, with a 1" x 14" piece of Kraft clipped to its top, rolled back so that the bottom piece was left uncovered. The top piece was sandwiched between a #0 and #14 wire wound rod with the #0 on top. A small amount of adhesive was applied to the top of the bottom strip and a #20 wire wound rod metered out the adhesive over the entire strip. A timer was started, and at a specified time interval (with intervals of 5 seconds) the top strip was laminated to the bottom using the #0 rod. The strips were then peeled apart and assessed for adhesion and fiber tear. This process was repeated until a specific time interval was confirmed in duplicate as the last time interval to result in significant fiber tear/adhesion. Evaluations were performed blind.

[0102] T-Peel Adhesion: The methodology for various peel adhesion tests is further described in connection with Examples 7 and 8.

[0103] Example 1 – *VOC/Volatility of Neat Plasticizers*

[0104] Figure 1 illustrates the volatility characteristics determined for the neat plasticizers evaluated. Except for triacetin, which is 100% volatile and 100% water soluble, the plasticizers of the evaluation were all low in volatility and, thus, would not contribute significantly to the overall VOC of an adhesive formulation at typical levels of use. The inventive monobenzoate, 3 PPB, was slightly more volatile than dibenzoate plasticizers, but still well within an acceptable range.

[0105] Example 2 – *Viscosity Response*

[0106] The viscosity response of a Pace® 383 homopolymer (PVAc) adhesive composition with 10 wt.% plasticizer was evaluated. Viscosity response is indicative of the compatibility of the plasticizer with the polymer. Figure 2 illustrates the One Day viscosity response of the various plasticizers evaluated. All of the plasticizers showed comparable viscosity responses, reflecting compatibility with the base polymer.

[0107] Figures 3 (a) and 3 (b) show One Day viscosity responses with 5 wt.% plasticizer in PVA/E copolymers, both A and B. Again, the viscosity responses are comparable, reflecting good compatibility with the base polymer.

[0108] Example 3 – *Water Reduction*

[0109] Figures 4 and 5 (a) and 5 (b) reflect the water reduction results, i.e., the amount of water required to get to the desired viscosity of 2000 mPa's for the homopolymer (PVAc) and copolymers (PVA/E, A & B), respectively, using plasticizer concentrations of 5, 10, 15 and 20 wt.% for the homopolymer and 5, 10 and 15 wt.% for the copolymers. The amount of water required in each was comparable among the plasticizers evaluated.

[0110] Example 4 – *Glass Transition*

[0111] Glass transition temperatures (Tg) were obtained for plasticizer concentrations of 5, 10, 15 and 20 wt.% in homopolymer (PVAc) and for plasticizer concentrations of 5, 10 and 15 wt.% for the copolymers. Figure 6 reflects the Tg results for the homopolymer and demonstrates that the inventive monobenzoate, 3 PPB, was excellent in Tg suppression, thus indicating a more flexible polymer and a more efficient plasticizer.

[0112] Figures 7 (a) and 7 (b) reflect the Tg results for the copolymers A and B, respectively. While there was some variability between polymers, the inventive monobenzoate, 3-PPB, performed comparable to the dibenzoate plasticizers.

[0113] Example 5 – *Set Time*

[0114] Set Times for the various plasticizers were evaluated in the homopolymer and both copolymers. Homopolymer evaluations were conducted with 10 wt.% plasticizer levels. Copolymer evaluations (both A and B) were conducted with 5 wt.% plasticizer levels. All of the plasticizers decreased the set time of the adhesives as expected.

[0115] The inventive monobenzoate performed very well in comparison with the other plasticizers in the homopolymer, as reflected in Figure 8. Figures 9 (a) and 9 (b) show that the inventive monobenzoate performed comparable to or slightly better than the dibenzoates in the copolymers and was equivalent to ATBC. Set time results

demonstrate that the inventive monobenzoate reduces the bond formation time in the various polymeric adhesives.

[0116] Example 6 – *Open Time*

[0117] Open Times for the various plasticizers were evaluated in the homopolymer and both copolymers. Homopolymer evaluations were conducted with 10 wt.% plasticizer. Copolymer evaluations were conducted with 5 wt.% plasticizer levels. All of the plasticizers increased the open time as compared to the blank control, which is desirable in certain adhesive applications.

[0118] Figure 10 shows that the inventive monobenzoate achieved longer open times than the dibenzoate plasticizers and comparable to triacetin and ATBC in the homopolymer. Figures 11 (a) and 11 (b) show that the inventive monobenzoate achieved longer open times than the other plasticizers in Copolymer A and equivalent open times with Copolymer B, respectively.

[0119] Example 7 – *T-Peel Cotton to Cotton*

[0120] This test provides a method for determining the water resistance of an adhesive by measuring its peel strength dry and its peel strength retention after one hour of immersion in water.

[0121] Samples were prepared by first drawing down some emulsion on a 6" x 13" cotton cloth using a #10 wire wound rod, at which time a timer was started. At the end of 60 seconds, a second amount of emulsion was applied using the 4 mil side of an 8 path applicator. At the end of an additional 60 seconds, the cloth was folded over on itself and pressed twice using a rolling pin. The specimens were then allowed to dry for a minimum of 24 hours. Two 1" specimens were cut from each sample and each labeled A, B, etc. A minimum of 2 (most had 4) specimens were prepared per sample. The dry samples were pulled on the tensile tester at a rate of 12"/min. The corresponding set of wet samples was soaked in water for one hour before being pulled on the tensile tester.

[0122] The peel strength required to pull apart the bond between two cotton samples was determined on dry samples and after a one hour water soak for a PVA/E copolymer composition having 5 wt.% plasticizer. The inventive monobenzoate was compared against 1,2-propylene glycol, a dibenzoate blend, and ATBC. The results in

Figures 12 a (dry) and 12 b (after one hour water soak) show that the inventive monobenzoate performed better than the dibenzoate blend and comparable to ATBC. After the one hour water soak, the inventive monobenzoate performed slightly better than 1,2-propylene glycol dibenzoate, the dibenzoate blend and ATBC.

[0123] In the following examples 8-11, the efficacy of the inventive monobenzoate, 3-PPB (X-613), was evaluated in the identified adhesive formulations, comparing it against K-Flex® 850S (DEGDB/DPGDB) as the standard, Citroflex® A-4 (ATBC), and 1,2-propylene glycol dibenzoate (X-100, PGDB). Test methodologies are as described above. Methodologies for the additional tests conducted in these examples are set forth below.

[0124] Example 8 – *Pace® 383 (PVAc) Homopolymer Formulation*

[0125] Each plasticizer was evaluated at concentrations of 5, 10, 15 and 20 wt.%.

[0126] Brookfield Viscosity

[0127] The initial and one day Brookfield Viscosity results are shown in Figures 13 and 14. Based on viscosity response, all of the tested plasticizers appear compatible, with K-Flex® 850S giving the greatest viscosity response. 3-PPB (X613) gave a very good viscosity response, with good increases as its concentration was increased.

[0128] The three and seven day viscosities obtained are shown in Figures 15 and 16. The viscosities followed the trend set forth with the initial and one day viscosities, with no notable increase over this time period. The four week viscosities of the Pace® samples are shown in Figure 17, and the eight week viscosities are shown in Figure 18. Figure 18 reflects that all of the viscosities had increased from the previous four week reading, indicating they were all stable.

[0129] Shear

[0130] AR2000 Shear Method: A 40 mm 1° steel cone geometry with Peltier plate was used. A dime sized amount of emulsion was placed on the Peltier plate. The shear ramp was run at 25°C from 0 to 2500 s^{-1} over one minute. The results of the shear testing are shown in Figures 19 (a), (b), (c) and (d). All of the plasticizers had acceptable rheology and were fairly comparable.

[0131] Glass Transition

[0132] The Tg results are shown in Figure 20. Of the four plasticizers tested, X-100 (PGDB) was the least efficient, while 3-PPB (X-613) was the most efficient and comparable to A-4.

[0133] Set Time

[0134] The results of the set time are shown in Figure 21. The results of the 10 and 15 wt.% plasticizer concentrations were comparable, while 3-PPB (X613) showed an advantage at the 20 wt.% level of use. A-4 generally had the poorest set times.

[0135] Open Time

[0136] The results of the open time testing on the Pace® samples are shown in Figure 22. The 3-PPB (X613) adhesives had consistently better open time than the other formulations at the same concentrations, even if only marginally.

[0137] Tensile - 180° Peel, Cotton to Acrylic Coated 3B Leneta Charts

[0138] 180° Peel, Cotton to Acrylic Coated 3B Leneta Charts Method: 1" x 14" cotton strips were laminated to Leneta 3B acrylic coated charts using a #20 wire wound rod to draw down the emulsion and one pass of a rolling pin. The cotton was pulled at a 180° angle from the 3B chart at 12"/min. The data was averaged between 1" and 5" of the pull. Five specimens of each sample were run. Data was adjusted to remove slack from the results.

[0139] The results from the 180° cotton to acrylic peel are shown in Figure 23. Surprisingly, the 3-PPB (X-613) significantly enhanced the peel strength of the adhesive at all levels, with good peel strength at 5 wt.% as compared to the other plasticizers at 10 wt.% and even 15 wt.%. This suggests that 3-PPB may be useful as an additive to adhesives to enhance adhesion to certain difficult-to-adhere surfaces, such as polar surfaces. This is predictable based upon the polarity of the plasticizer and the Tg suppression.

[0140] The 180° peel of cotton to acrylic coated 3B Leneta charts was repeated to confirm the enhanced adhesion noted with the 3-PPB samples. This time, six specimens of each sample were run. The samples formulated with 3-PPB showed greatly improved adhesion to the acrylic coating than the other plasticizers that were evaluated, with peel strengths of about twice the amount of the others. In fact, the break sensitivity had to be turned down for the method, as the tensile tester several times

thought it detected a break with the 15 wt.% and 20 wt.% 3-PPB due to the large build-up of adhesion and ensuing release. Figure 24 shows the results of the 180° peels second trial, while Figure 25 compares the results of both the first trial and the second trial.

[0141] The mode of loss for all of the 180° peels was adhesive, and primarily occurred with all of the adhesive still adhered to the cotton strips. However, several of the 15 wt.% and 20 wt.% 3-PPB specimens, as well as in minor amounts with one 20 wt. % A-4 and one 20 wt. % K-Flex® 850S, had adhesive loss to the cotton, where the adhesive remained.

[0142] As described above, two trials were conducted for the cotton to acrylic 180° peel resulting in two sets of data, which showed similar trends. The data obtained for the first and second set of samples were averaged and are shown in Figure 26.

[0143] Tensile - 180° Peel, Cotton to Flexible Vinyl

[0144] The cotton to flexible vinyl 180° peels were performed on the Pace® homopolymer samples. Once again, the results in Figure 27 show very good performance with 3-PPB (X-613) adhesives at all levels of the test.

[0145] Tensile – T-Peel, Water Resistance, Cotton to Cotton

[0146] The methodology for this test is described in example 7, above.

[0147] The data from this set had good agreement from specimen to specimen (standard deviations of 0-23%). Figure 28 shows the results from the dry T-peel, cotton to cotton test for the Pace® homopolymer samples at 5, 10, 15 and 20 wt.% plasticizer concentrations. For most of the plasticizers, there was a climb in peel strength up to 10 wt.%, then a decline with increasing plasticizer concentration at 15 wt.% and 20 wt.%. The X-100 (PGDB) showed a good increase in peel strength at the higher levels. 3-PPB had good peel strength versus the other plasticizers at low levels of plasticizer concentration, although it weakened the adhesive when used at levels greater than 10%. This is predictable as it is very efficient in softening.

[0148] Water Reduction

[0149] The water reduction results (to 2000 mPa's) of the Pace® homopolymer emulsions are shown in Figure 29. The amounts of water necessary to reduce the emulsion viscosities down to 2000 cP are fairly comparable between the plasticizer

types, which was expected due to the similar viscosity responses the emulsions originally had.

[0150] Hysteresis Loop/Wet Tack

[0151] Hysteresis Loop Method: Hysteresis loop data was obtained on an AR-2000 using 20 mm steel plate geometry on a Peltier base plate at 20°C. The gap was set at 200 µm, then a small (nickel sized) amount of sample was sheared up to 1500 s^{-1} and back down within one minute. Samples were tested in triplicate using a fresh specimen for each measurement.

[0152] All of the wet tack data followed the expected trend, with an increase in wet tack as the plasticizer concentrations increased; however, some of the standard deviations were greater than 25%, and so additional data was gathered on those samples in order to obtain a better average. Figure 30 shows the additional data for Pace® homopolymer formulations.

[0153] MFFT – Chalk Point

[0154] Chalk Point Method: A sheet of aluminum foil was taped tightly over the MFFT plate and wiped down with acetone. The desired temperature range was chosen and the MFFT-90 was turned on. Cooling water was turned on, as well as an air flow of 4 L/min. The plate was left to equilibrate (about 30 minutes). A U-shaped film was drawn down using the 75 µm applicator cube. All three samples were drawn down within 10 minutes. The cover was then closed and the instrument was left to run for a minimum of an hour. The samples were then examined for chalk point and photos were taken.

[0155] The chalk points of the homopolymer adhesives were determined, and the results can be seen in Figure 31. 3-PPB did a very good job in lowering the chalk point and was substantially similar to the results achieved with the K-Flex® 850S standard. Although both X-100 and Citroflex® A-4 lowered the chalk point of the homopolymer, they were the poorer performers of the group.

[0156] Example 9 – *Elvace® 735 (Vinyl Acetate Ethylene) Copolymer Formulations*

[0157] Each plasticizer was evaluated at concentrations of 5, 10, and15 wt.%.

[0158] Brookfield Viscosity

[0159] The initial, one and three day viscosities of the Elvace® copolymer emulsions are shown in Figures 32 and 33 (a) and (b), respectively. The seven day viscosities of the Elvace® copolymer emulsions are shown in Figure 34. The viscosities of all of the samples were comparable, with 3-PPB (X-613) and A-4 showing marginally better viscosity response over the dibenzoates.

[0160] Shear

[0161] Elvace® copolymer shears were run using the cone geometry in order to obtain optimal results. The shear curves are shown in Figures 35, 36 and 37. All of the plasticizers were similar in their shear responses.

[0162] Glass Transition Temperature (Tg)

[0163] The Tg's of the Elvace® copolymer samples were measured, and the results are shown in Figure 38. The Tg suppression of 3-PPB was very efficient and mirrored that of the A-4; both had substantial improvements in Tg suppression over the dibenzoates at all levels of test.

[0164] Set Time

[0165] The set time results for the Elvace® copolymer samples are shown in Figure 39. All of the plasticizers were comparable.

[0166] Open Time

[0167] The open times of the Elvace® copolymer samples were measured, and the results are shown in Figure 40. The 3-PPB helped to extend open time slightly at lower concentrations than the other plasticizers.

[0168] Water Reduction

[0169] The viscosities of portions of the Elvace® copolymer samples were reduced to 2000 cP with water. The results of the water reduction are shown in Figure 41. At higher plasticizer levels, the Citroflex A-4 samples required the most water to reduce its viscosity, followed closely by 3-PPB (X-613). The PGDB (X-100) samples consistently required the least amount of water to be reduced. More amounts of water render the formulation less expensive whereas small amounts of water to back-add will preserve solids content. Depending on the formulator's needs, either lower or higher water to back-add may be advantageous.

[0170] Hysteresis Loop

[0171] The hysteresis loop results for the Elvace® copolymer samples are shown in Figure 42. The dibenzoates showed the best wet tack across all concentrations, while the performance of 3-PPB and A-4 were very similar to each other.

[0172] T-Peel, Water Resistance, Cotton to Cotton

[0173] Figures 43, 44 and 45 show the results of the water resistance T-Peel, cotton to cotton tests performed on the Elvace® copolymer samples. Both the dry peel strengths and the peel strength loss after water immersion were all fairly comparable between the samples, with perhaps a slight advantage in water resistance seen with the 5 wt.% and 10 wt.% 3-PPB (X-613) samples.

[0174] 180° Peel, Flexible PVC to Luan

[0175] 180° Peel, Flexible PVC to Luan Sample Preparation: 1" x 14" strips of flexible, 12 mil thick PVC were laminated to 6" x 10" pieces of Luan plywood. The adhesive was applied using a #50 wire wound rod, and four strips were laminated to each piece of wood. Gentle pressure using a rolling pin, followed by finger pressure to wet out the PVC strips, was used to press the pieces together.

[0176] 180° Peel, Flexible PVC to Luan Method: The PVC strips were pulled from the Luan at 12"/min. over 8". The average peel strength was determined by the data obtained between 2" and 7".

[0177] The peel strength of the PVC to Luan of the Elvace® copolymer samples are shown in Figure 46. Peel strengths of all samples were comparable, with no notable increase in peel strength as the plasticizer level increased.

[0178] Example 10 – *Monobenzoates and Blends*

[0179] Due to the good adhesion results for 3-PPB (X-613) obtained in the above example, new blends of 3-PPB with K-Flex® DE (DEGDB) and K-Flex® PG (PGDB, X-100) were put through a basic evaluation, along with K-Flex® IB, to provide a baseline of how typical monobenzoates behave. Samples evaluated included: 5, 10, 15 and 20 wt.% plasticizer concentrations in Pace® homopolymer, and 5, 10 and 15 wt.% plasticizer concentrations in Elvace® copolymer, using the plasticizers and blends of plasticizers listed below:

[0180] Plasticizers & Blends:

25% X-613 (3-PPB)/75% X-100 (PGDB)
50% X-613/50% X-100
25% X-613/75% K-Flex DE (DEGDB)
50% X-613/50% K-Flex DE
K-Flex® IB (isodecyl benzoate)
K-Flex® 850S (DEGDB/DPGDB diblend)

[0181] Brookfield Viscosities

[0182] Figures 47, 48 and 49 show the initial, 1 and 3 day viscosities, respectively, for Elvace® copolymer samples. The samples made with K-Flex® IB had very low initial viscosity, with a gradual build over time to values near those of the dibenzoates and blends.

[0183] The initial, one and three day viscosities of the Pace® homopolymer samples are shown in Figures 50, 51 and 52. With the exception of the IB formulations, all of the samples showed good viscosity response. At lower levels, the IB was equivalent, but at about 15 - 20 wt. % plasticizer concentration, the IB viscosity response started lagging behind the others. There also did not seem to be a dramatic increase in viscosity over time with the IB formulations in the Pace® homopolymer samples, as there was in the Elvace® copolymer samples.

[0184] Figure 53 shows the 1 week viscosities for the Elvace® copolymer samples. By this time, the IB formulations had now not only caught up, but overtaken the other samples in viscosity response. This indicates very poor stability in these formulations.

[0185] Glass Transition Temperature

[0186] The glass transition temperatures of the monobenzoate blends formulated with Pace® homopolymer are shown in Figure 54. This figure shows the limited compatibility of K-Flex IB with this homopolymer. Even at only 5 wt.%, IB has the poorest Tg suppression of all of the plasticizers that were evaluated; as the IB concentration increases, the Tg stays the same, indicating its incompatibility.

[0187] As would be expected, due to their relative efficiencies, the 3-PPB blends with K-Flex® DE showed the greatest Tg suppression, while the blends with X-100 (PGDB) showed slightly less Tg suppression.

[0188] Figure 55 shows the Tg results with the Elvace® copolymer samples. In this case, the IB actually showed a greater efficiency in reducing the Tg's of the copolymer than the K-Flex® 850S or the 3-PPB blends. This makes sense, as IB's low polarity should be more compatible with the ethylene blocks of the copolymer than the other di- and mono-benzoates. For the blends, the 50:50 X-100/X-613 showed similar Tg suppression to that of the DE blends.

[0189] Set and Open Time

[0190] Figures 56 and 57 show the set and open time of the Elvace® copolymer samples. Overall, the 75:25 X-100/X-613 samples showed the fastest set times. With the exception of the IB and the 50:50 K-Flex® DE:X-613 samples, all of the open times increased with increasing plasticizer level and all of the samples appeared to be equivalent.

[0191] Example 11 – *Basic Packaging Adhesive Evaluation*

[0192] The following example show the efficacy of the inventive monobenzoate with a basic packaging adhesive formulation described below:

Material	PHR	%
Copolymer, 0°C Tg	100	89%
Plasticizer	10	9%
PVOH, 7% Solution	2	2%
Water	Added	

[0193] Evaluations were performed comparing the inventive monobenzoate, 3-PPB, to PGDB (X 100), K-Flex® 850S (DEGDB/DPGDB diblend), Benzoflex™ 2088 (TEG/DEG/DPG dibenzoate blend), and DIBP.

[0194] Figure 58 shows the initial viscosity measurements reflecting that the inventive monobenzoate, 3-PPB, has a slightly better effect on viscosity than the dibenzoates and comparable to DIBP, a phthalate plasticizer.

[0195] Figure 59 shows the water reduction results (to 1500 mPa's) reflecting that 3-PPB has among the highest amount of water add back (among the non-phthalates) to achieve the desired viscosity reduction.

[0196] Set Times for Kraft to Kraft and Kraft to Mylar samples, respectively, unreduced and water reduced, are shown in Figures 60 and 61. The results reflect that

in some instances the inventive monobenzoate enhanced the set time and in others performed comparably to other plasticizers.

[0197] Open Time results for unreduced and water reduced samples are shown in Figure 62. These results reflect that 3-PPB performed quite well when water reduced and comparable to other plasticizers when unreduced.

[0198] The foregoing examples reflect that the inventive monobenzoate plasticizer, 3 PPB, functions well in adhesives, performing comparably or better than traditional plasticizers used in adhesives, including the dibenzoates. The inventive monobenzoate is an alternative to phthalate plasticizers and has the potential to improve upon the safety of plasticizer technology for the adhesive industry.

[0199] In accordance with the patent statutes, the best mode and preferred embodiments have been set forth; the scope of the invention is not limited thereto, but rather by the scope of the attached claims.

WHAT IS CLAIMED IS:

1. A monobenzoate plasticizer for use in polymers, comprising 3-phenyl propyl benzoate.

2. An adhesive composition comprising:

a. a polymeric dispersion; and

b. a plasticizer that is 3-phenyl propyl benzoate,

wherein the 3-phenyl propyl benzoate is used to provide viscosity response, improved open and set times, MFFT, and Tg suppression and facilitates formation of the adhesive bond, whether used alone as a primary plasticizer or as a secondary plasticizer in combination with other traditional plasticizers.

3. A waterborne latex glue comprising the monobenzoate plasticizer of claim 1.

4. A caulk composition comprising the monobenzoate plasticizer of claim 1.

5. A sealant composition comprising the monobenzoate plasticizer of claim 1.

6. A waterborne polymeric adhesive composition comprising:

a. a polymer selected from the group consisting of waterborne acrylics, polyvinyl acetate, vinyl acetate ethylene, methacrylates, styrene acrylates, polychloroprenes, polyurethanes, and nitriles; and

b. a plasticizer that is 3-phenyl propyl benzoate.

7. A non-aqueous polymeric adhesive composition comprising:

a. a polymer selected from the group consisting of acrylics, polyvinyl acetate, vinyl acetate ethylene, methacrylate, styrene acrylate, polychloroprenes, thermoplastic polyurethanes, polysulfides, aminos, epoxies and polyamides; and

b. a plasticizer that is 3-phenyl propyl benzoate.

8. A plasticizer comprising a blend of 3-phenyl propyl benzoate in combination with other plasticizers comprising: phthalate plasticizers up to C5, phosphate esters up to C4, terephthalates, polyesters, citrates, adipates, succinates, 1,2-cyclohexane dicarboxylate esters, isobutyrates, alkyl glycol esters, sulfonamides, sulfonic acid esters, benzoates, or mixtures thereof.

9. A plasticizer comprising a blend of 3-phenyl propyl benzoate in combination with other plasticizers comprising: isononyl benzoate, isodecyl benzoate, 2-ethyl hexyl benzoate, 2,2,4-trimethyl-1,3-pentanediol diisobutyrate, or mixtures thereof.

10. An adhesive composition comprising the plasticizer of claims 1, 8 or 9, useful for packaging glues, adhesive assembly, labeling, laminates, envelopes, food packaging, wood glue, construction adhesives, transportation product assembly, electronic product assembly and PSA applications.

11. A method of providing viscosity response, improved open and set times, Tg suppression and formation of the adhesive bond in adhesive formulations, comprising:

a. adding a plasticizer that is 3-phenyl propyl benzoate to a polymeric dispersion.

Docket No. EMER-P-FF-1-ADHESIVES

MONOBENZOATE USEFUL AS A PLASTICIZER IN ADHESIVE PREPARATIONS

FIELD OF THE INVENTION

[0001] This invention is directed to a monobenzoate found to be unexpectedly useful as a plasticizer in a variety of polymer applications, including but not limited to adhesives, caulks, sealants and the like. In particular, this invention is directed to the use of a monobenzoate ester, 3-phenyl propyl benzoate, in adhesive applications or adhesive products. The inventive monobenzoate has comparable or better rheology, viscosity stability, compatibility, processability, open time, set time, peel strength and water reduction, among other advantages, over traditional plasticizers. The invention is also directed to polymeric compositions comprising the inventive monobenzoate, such as water-based adhesives, non-aqueous based adhesives, caulks and sealants.

BACKGROUND OF THE INVENTION

[0002] Adhesives are widely used in a number of applications, including without limitation envelopes; labeling; bonding, sealing and assembly of components and other materials; remoistening; stenciling; laminating; packaging; electronics manufacturing; high speed adhesive application; construction; transportation and the like. Certain polymers or polymer blends are well known, useful adhesives. By way of example only, copolymers of ethylene and vinyl acetate are useful for adhesives.

[0003] Adhesives are formulated in both water (waterborne) and solvent-based (non-aqueous) systems. Generally, solvent-based adhesives work more predictably and effectively under a wide range of conditions. Water-based systems are substantially or entirely free of most inherent toxic and hazardous properties of solvents, but do not always work in less than ideal conditions. There is a need for water-based systems that perform better or equivalent to solvent-based adhesives.

[0004] Plasticizers have been used as additives in adhesive compositions for some time to modify physical properties of the adhesive and the polymer film formed by the dried adhesive. Plasticizers facilitate the formation of an adhesive bond and prevent failure of the bond after aging. Plasticizers soften the polymer and add flexibility to the adhesive bond, without adversely affecting the degree of adhesion, lower the glass

transition temperature (Tg) of the adhesive film making the polymer more flexible and the glue more efficient, and enhance film formation by lowering the minimum film formation temperature (MFFT). Plasticizers may also act as a fluid carrier for the polymeric component.

[0005] In all applications, the plasticizer should be compatible at least partially with the base polymer. Plasticizers should possess chemical stability, non-flammability, low toxicity and low volatility. Finally, plasticizers should also be economically feasible.

[0006] Dibenzoate plasticizers, such as diethylene glycol dibenzoate (DEGDB) and dipropylene glycol dibenzoate (DPGDB), are well known as general purpose plasticizers for latex adhesive applications. Blends of dibenzoates are also known and available. A high polarity blend of DEGDB, DPGDB and triethylene glycol dibenzoates (TEGDB) is available. More recently, a new dibenzoate triblend, comprising a blend of three dibenzoate plasticizers, DEGDB, DPGDB and 1,2 propylene glycol dibenzoate (PGDB), in various ratios, was introduced as a lower VOC plasticizer/coalescent alternative for use in plastisols, adhesives, coatings, and polishes, among other polymer applications.

[0007] Other plasticizers useful for latex adhesives are the phthalates, i.e., benzyl phthalate (BBP), Di-n-butyl phthalate (DBP) and diisobutyl phthalate (DIBP). Although not necessarily high solvating polar plasticizers, other examples of non-phthalate, high solvating plasticizers useful in adhesive compositions include some glycols, citric acid esters, alkyl sulfonic acid esters, and certain phosphates.

[0008] In addition to the dibenzoates discussed above, monobenzoates known to be useful as plasticizers include: isodecyl benzoate, isononyl benzoate, and 2-ethylhexyl benzoate. 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 to Godwin et al. as a useful secondary plasticizer in combination with phthalate plasticizers for PVC plastisols. The use of 2-ethylhexyl benzoate in a blend with DEGDB and diethylene glycol monobenzoate is described in U.S. Patent No. 6,989,830 to Arendt et al. The use of isononyl 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. 7,638,569 to Grass et al.

[0009] "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 compatible with emulsions polymers, such as acrylic and/or vinyl ester polymers.

[0010] There remains a need for non-phthalate, lower VOC plasticizers for use in adhesive applications as alternatives to traditional plasticizers. Non-phthalate alternatives are particularly desirable in view of environmental, health and safety issues associated with many of the traditional plasticizers. In particular, in the food packaging industry, there is increasing concern for migratory issues associated with the use of packaging adhesives. There is, therefore, a need for a plasticizer for use in adhesive applications, which is environmentally safe, non-hazardous and non-toxic in use.

[0011] It has been discovered that an entirely different monobenzoate, 3-phenyl propyl benzoate (3 PPB), is a surprisingly effective lower VOC plasticizer alternative to other monobenzoates and certain phthalates for use in adhesives, caulks and sealants. Advantages of this monobenzoate 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 hazard labeling elements are required.

[0012] The monobenzoate, 3 PPB, has not been utilized in polymeric applications of the type discussed herein in the past. It has been used and continues to be used in flavoring and fragrance applications, making it an ideal candidate in applications where there are migratory concerns. It has also been used as a solubilizer for certain active or functional organic compounds in personal care products as described in U.S. Patent Publication 2005/0152858.

[0013] It is an object of the invention to provide an alternative non-phthalate plasticizer having excellent compatibility with a wide variety of polymers, with improved handling and a superior toxicological profile over traditional plasticizers, for use alone or in combination with other plasticizers in adhesive applications.

[0014] Yet another object of the invention is to provide a monobenzoate, 3 PPB, useful as a plasticizer in polymeric dispersions such as adhesives, which achieves comparable or better performance properties over traditional plasticizers, including but

not limited to viscosity response, Tg suppression, set time, open time, peel strength, water reduction and chalk point (MFFT).

[0015] Still another object of the invention is to provide waterborne or non-aqueous adhesive compositions comprising the inventive monobenzoate having comparable or better properties than adhesive compositions utilizing traditional plasticizers.

[0016] A further object of the invention is to provide other inventive compositions comprising the inventive monobenzoate, including but not limited to caulks and sealants, for use in a wide variety of applications.

[0017] Other objects of the invention will be apparent from the description herein.

SUMMARY OF THE INVENTION

[0018] This invention is directed to a non-phthalate monobenzoate plasticizer useful as a plasticizer for polymeric dispersions, such as adhesives. In particular, the invention is directed to the use of 3-phenyl propyl benzoate (3 PPB), a component not previously known or used as a plasticizer for polymeric adhesive compositions.

[0019] In one embodiment, the invention is a plasticizer useful for adhesive compositions comprising 3 PPB.

[0020] In a second embodiment, the invention is a waterborne adhesive composition comprising the inventive plasticizer, including but not limited to waterborne latex glues and waterborne acrylics.

[0021] In a third embodiment, the invention is a caulk composition comprising the inventive plasticizer.

[0022] In a fourth embodiment, the invention is a sealant composition comprising the inventive plasticizer.

[0023] In a fifth embodiment, the invention is a non-aqueous based adhesive composition comprising the inventive plasticizer.

[0024] In a sixth embodiment, the invention is a blend of traditional plasticizers with the inventive plasticizer.

[0025] In still other embodiments, the invention relates to the use of the inventive plasticizer and adhesive compositions in applications.

[0026] Use of the inventive monobenzoate in the same or similar amounts as traditional plasticizers results in comparable or better performance and handling properties than that achieved with traditional plasticizers. The inventive monobenzoate is non-toxic, as is evident by its past and continued use as a flavor and fragrance additive. As such, it does not have the environmental, health and safety issues associated with traditional plasticizers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] FIG. 1 shows the volatility characteristics determined for the neat plasticizers evaluated, using the Oven Volatility test, one hour, at 110° C.

[0028] FIG. 2 shows the One Day Viscosity responses obtained in Pace® 383 polyvinyl acetate (PVAc homopolymer) at 10 wt. % of each of the plasticizers evaluated.

[0029] FIGS. 3 (a) and (b) show One Day Viscosity responses obtained in polyvinyl acetate ethylene (PVA/E) copolymers, Copolymer A (Elvace® 735) (FIG. 3 (a)) and Copolymer B (Vinnapas® 400) (FIG. 3 (b)), at 5 wt. % of each of the plasticizers evaluated.

[0030] FIG. 4 shows water reduction results (to 2000 mPa's) of the PVAc homopolymer obtained at concentrations of 5, 10, 15 and 20 wt.% of each of the plasticizers evaluated.

[0031] FIGS. 5 (a) and (b) show water reduction results (to 2000 mPa's) of the two PVA/E copolymers, A and B, respectively, obtained at concentrations of 5, 10 and 15 wt.% of each of the plasticizers evaluated.

[0032] FIG. 6 reflects Tg results obtained for plasticizer concentrations of 5, 10, 15 and 20 wt.% in PVAc homopolymer.

[0033] FIGS. 7 (a) and (b) reflect Tg results obtained for plasticizer concentrations of 5, 10, 15 and 20 wt. % in the two copolymers, A and B, respectively.

[0034] FIG. 8 shows set times obtained for the various plasticizers at 10 wt.% concentration in PVAc homopolymer.

[0035] FIGS. 9 (a) and (b) show set times obtained for the various plasticizers at 5 wt.% concentration in copolymers A and B, respectively.

[0036] FIG. 10 shows open times obtained for the various plasticizers at 10 wt.% concentration in PVAc homopolymer.

[0037] FIGS. 11 (a) and (b) show open times obtained for the various plasticizers at 5 wt.% concentration in copolymers A and B, respectively.

[0038] FIGS. 12 (a) and (b) show peel strength results obtained for the various plasticizers at 5 wt.% concentration in PVA/E copolymer, dry and after one hour water soak, respectively, using the T-Peel Cotton to Cotton Test.

[0039] FIGS. 13 and 14 show initial and one day Brookfield Viscosity results, respectively, of PVAc homopolymer at concentrations of 5, 10, 15 and 20 wt.% of each of the plasticizers evaluated.

[0040] FIGS. 15 and 16 show three and seven day Brookfield Viscosity results, respectively, of PVAc homopolymer at concentrations of 5, 10, 15 and 20 wt.% of the each of the plasticizers evaluated.

[0041] FIGS. 17 and 18 show four week and eight week Brookfield Viscosity results, respectively, of PVAc homopolymer at concentrations of 5, 10, 15 and 20 wt.% of each of the plasticizers evaluated.

[0042] FIGS. 19 (a), (b), (c) and (d) show shear results of PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0043] FIG. 20 shows Tg results of PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0044] FIG. 21 shows set time results of PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0045] FIG. 22 shows open time results of PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0046] FIG. 23 shows results of the 180° cotton to acrylic peel test for PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0047] FIG. 24 shows results of the second trial of the 180° cotton to acrylic peel test for PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of the plasticizers evaluated.

[0048] FIG. 25 shows a comparison of the results of the first trial and second trial 180° cotton to acrylic peel tests reflected in FIGS. 23 and 24.

[0049] FIG. 26 shows the average of the results obtained for the 180° cotton to acrylic peel test reflected in FIGS. 23 and 24.

[0050] FIG. 27 shows the results of the 180° cotton to flexible vinyl peel test for PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0051] FIG. 28 shows the results of the dry T-Peel, cotton to cotton test for PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0052] FIG. 29 shows the results of the water reduction (to 2000 mPa's) test for PVAc homopolymer at 5, 10, 15 and 20 wt. % concentrations of each of the plasticizers evaluated.

[0053] FIG. 30 shows the Hysteresis Loop (wet tack) results of PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of each of the plasticizers evaluated.

[0054] FIG. 31 shows the chalk point data of PVAc homopolymer at 5, 10, 15 and 20 wt.% concentrations of the plasticizers evaluated.

[0055] FIGS. 32, 33 (a), 33 (b) and 34 show the initial, one, three and seven day Brookfield Viscosities, respectively, of Elvace® 735 copolymer formulations using plasticizer concentrations of 5, 10 and 15 wt.% of each of the plasticizers evaluated.

[0056] FIGS. 35, 36 and 37 show shear results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% plasticizer concentrations, respectively.

[0057] FIG. 38 shows Tg results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% concentrations of each of the plasticizers evaluated.

[0058] FIG. 39 shows set time results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% concentrations of each of the plasticizers evaluated.

[0059] FIG. 40 shows open time results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% concentrations of each of the plasticizers evaluated.

[0060] FIG. 41 shows water reduction (to 2000cP) of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% concentrations of each of the plasticizers evaluated.

[0061] FIG. 42 shows Hysteresis Loop (wet tack) results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% concentrations of each of the plasticizers evaluated.

[0062] FIG. 43 shows dry T-Peel, cotton to cotton, results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% concentrations of each of the plasticizers evaluated.

[0063] FIG. 44 shows T-Peel, cotton to cotton, results after a one hour water soak of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% of each of the plasticizers evaluated.

[0064] FIG. 45 shows T-Peel cotton to cotton strength loss after a one hour water soak of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% of each of the plasticizers evaluated.

[0065] FIG. 46 shows 180° Peel, Flexible PVC to Luan results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% of each of the plasticizers evaluated.

[0066] FIGS. 47, 48 and 49 show the initial, one and three day Brookfield Viscosities, respectively, of Elvace® 735 copolymer formulations at 5, 10, 15 and 20 wt.% of each of the plasticizers and plasticizer blends evaluated.

[0067] FIGS. 50, 51 and 52 show the initial, one and three day Brookfield viscosities, respectively, of Pace® 383 (PVAc) homopolymer formulations at 5, 10, 15 and 20 wt.% of each of the plasticizers and plasticizer blends evaluated.

[0068] FIG. 53 shows 1 week viscosity results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% of each of the plasticizers and plasticizer blends evaluated.

[0069] FIG. 54 shows Tg results of Pace® 383 homopolymer formulations at 5, 10, 15 and 20 wt.% of each of the plasticizers and plasticizer blends evaluated.

[0070] FIG. 55 shows Tg results of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% of each of the plasticizers and plasticizer blends evaluated.

[0071] FIGS. 56 and 57 show set and open times, respectively, of Elvace® 735 copolymer formulations at 5, 10 and 15 wt.% of each of the plasticizers and plasticizer blends evaluated.

[0072] FIG. 58 shows initial viscosity measurements of a basic packaging glue at 10 phr (9 wt.%) concentrations of each of the plasticizers evaluated.

[0073] FIG. 59 shows water reduction (to 1500 mPa's) of a basic packaging glue at 10 phr (9 wt.%) concentrations of each of the plasticizers evaluated.

[0074] FIGS. 60 and 61 show set times, unreduced and water reduced, for Kraft to Kraft and Kraft to Mylar samples, respectively, of packaging glue at 10 phr (9 wt.%) concentrations of each of the plasticizers evaluated.

[0075] FIG. 62 shows open time results for unreduced and water reduced samples of a basic packaging glue at 10 phr (9 wt.%) concentrations of each of the plasticizers evaluated.

DETAILED DESCRIPTION OF THE INVENTION

[0076] The present invention is directed to a unique monobenzoate plasticizer useful for a variety of applications as a primary or secondary plasticizer in adhesive applications. The unique monobenzoate comprises 3-phenyl propyl benzoate (3-PPB), a known flavor and fragrance compound, not previously known or used as a plasticizer for polymer-based adhesives, glues, sealants and caulks. The invention is also directed to adhesive, glue, sealant and caulk compositions comprising the inventive monobenzoate.

[0077] The inventive monobenzoate plasticizer can generally be utilized alone as a primary plasticizer or in blends with other plasticizers. Any of the known polymers that can be formulated into an adhesive can be used in combination with novel monobenzoate to prepare a lower VOC content, environmentally safe and non-hazardous composition in accordance with the present invention. The inventive monobenzoate may be particularly useful in food packaging applications where migration of the adhesive may be an issue.

[0078] Polymers useful to prepare the polymeric dispersions discussed herein are known in the art. The inventive composition is expected to be useful with a wide variety of polymers, including both waterborne and non-aqueous polymer compositions. Suitable waterborne polymers, include, but are not limited to, homopolymers and/or copolymers of: acrylics, polyvinyl acetate, vinyl acetate ethylene, polyacrylates,

methacrylates, styrene acrylates, polychloroprenes, polyurethanes, and nitriles. Non-aqueous based polymers useful with the inventive monobenzoate include: acrylics, polyvinyl acetates, vinyl acetate ethylene, methacrylates, styrene acrylates, polychloroprenes, thermoplastic polyurethanes, polysulfides, aminos, epoxies, and polyamides. Use of the inventive 3-PPB plasticizer is not limited to any particular polymer, and the foregoing listing is not intended to be limiting of the invention. Other polymer-based compositions useful in adhesive applications and requiring plasticizers will be known to one skilled in the art.

[0079] The novel monobenzoate of the present invention may be used as a substitute or alternative plasticizer for various traditional adhesive polymer dispersions. A typical packaging adhesive is set forth below:

Homopolymer or Copolymer	100 parts
Plasticizer	0-30 parts
Water	0-20 parts
PVOH (88%) hydrolyzed	0-100 parts
Fillers	0-100 parts
Additives (wetting agents, defoamers)	0.10 to 0.5 parts

[0080] The inventive 3-PPB plasticizer is particularly useful for waterborne latex glues, including those comprising natural rubber latex and synthetic latex like polymers, waterborne acrylics, and non-aqueous adhesive compositions. In addition, the inventive 3-PPB plasticizer may also be used in caulks and sealants, so called "filled" adhesives. Dibenzoate esters are known to function well in these "filled" adhesives. Dibenzoate esters have a lower VOC content than 3-PPB; however, for these types of applications, the levels of VOC's associated with 3-PPB may be acceptable. The performance of 3-PPB is predictable in these applications based upon its performance with the polar polymers used in the adhesive market, as demonstrated by the examples.

[0081] The total amount of 3-PPB used in any particular polymeric dispersion would range broadly depending on the particular polymer, the characteristics of the polymer and other components, the process, the application or use and the results desired. By way of example only, in adhesives, plasticizers range in amounts from about 1 to about 50 wt.%, preferably from about 5 to about 20 wt.%, based on the

weight of the wet adhesive. Preferred embodiments for an adhesive include 10 wt. % in homopolymer polyvinyl acetate and 5 wt. % in vinyl acetate ethylene copolymers. As a general rule, the harder the polymer (higher Tg), the more plasticizer required.

[0082] Useful amounts of 3 PPB are set forth in the examples. It is expected that one skilled in the art would be able to arrive at additional acceptable amounts based on the intended use and desired performance in the particular polymeric application.

[0083] The inventive 3-PPB plasticizer be, but is not required to be, blended with various other conventional plasticizers to enhance or augment properties of the adhesive compositions. Conventional plasticizers have been described herein and include, but are not limited to, phthalate esters up to C5, phosphate esters up to C4, adipates, citrates, succinates, isobutyrates, alkyl glycol esters, terephthalate esters, such as DBTP, 1,2-cyclohexane dicarboxylate esters, polyesters, alkyl glycol derivatives, sulfonamides, sulfonic acid esters, and benzoates, both mono- and di-benzoates.

[0084] Monobenzoates, such as isononyl benzoate (INB), isodecyl benzoate (IB), and 2-ethylhexyl benzoate (EHB), and 2,2,4-trimethyl-1,3-pentanediol diisobutyrate, can also be blended with the inventive monobenzoate.

[0085] The inventive monobenzoate may also combined with or include various amounts of conventional additives such as surfactants, thickeners, biocides, fillers, polyvinyl alcohol, defoamers, humectants and the like.

[0086] The inventive monobenzoate provides comparable or better compatibility, viscosity stability and response, rheology, water reduction, set time, open time, peel strength, adhesion, Tg suppression, and chalk point (MFFT), among other advantages. In many instances, the inventive monobenzoate outperforms industry standard plasticizers, regardless of VOC content, including traditional and newer dibenzoate blends. The monobenzoate is particularly useful as a plasticizer when considering the use of harder polymers as alternatives to softer polymers in a variety of low VOC formulations.

[0087] The inventive monobenzoate, 3-PPB, may be used in adhesive compositions, sealants and caulks for a large variety of applications. Example applications include packaging glues, adhesive assembly, labeling, laminates,

envelopes, food packaging, wood glue, construction adhesives, transportation product assembly, electronic product assembly and pressure sensitive adhesive (PSA) applications, although this list is by no means exhaustive. Still other uses will be evident to one skilled in the adhesives art.

[0088] The invention is further described by the examples set forth herein.

[0089] Examples

[0090] The evaluation of the plasticizers consisted of a variety of experiments. First, VOC's of the neat plasticizers selected were determined. Then, effectiveness and efficiency of the plasticizers with basic polymeric compositions were determined versus established plasticizers.

[0091] The following polymers were utilized in the evaluation formulations: Pace® 383 polyvinyl acetate (PVAc), PVOH protected, homopolymer, and polyvinyl acetate/ethylene copolymers (PVA/E), 0° C Tg, PVOH protected, from two suppliers designated "A" and "B". The "A" copolymer is Elvace® 735 from Forbo, the "B" copolymer is Wacker's Vinnapas® 400.

[0092] The following plasticizers were selected for evaluation in the examples 1-9 (in whole or part):

- K-Flex® PG (X 100) – 1, 2 propylene glycol dibenzoate (PGDB)
- X 613 – the inventive monobenzoate, 3-PPB
- K-Flex® 975 P – a next generation dibenzoate triblend comprising DEGDB, DPGDB and PGDB in specified proportions (80 wt.% of a 4:1 DEGDB:DPGDB and 20 wt.% PGDB)
- K-Flex® 850 S – a commercial diblend of diethylene glycol and dipropylene glycol dibenzoates (DEG/DPG DB)
- Benzoflex™ 2088 – a competitive dibenzoate plasticizer blend (TEG/DEG/DPG dibenzoate)
- Diisobutyl phthalate (DIBP)
- Triacetin
- Acetylated tributyl citrate (ATBC) (Citroflex® A4), a well-known plasticizer for food contact polymer applications, adhesives, inks and vinyl

[0093] Plasticizers were utilized in various levels in the examples. For PVAc, 5, 10, 15 and 20 wt.% levels were used, based on wet adhesive weight. For PVA/E, both A and B, 5, 10 and 15 wt.% levels were used, based on wet adhesive weight.

[0094] Tests Utilized – The following tests were employed:

On neat plasticizers - EPA 24, ASTM D2369 volatility, 110°C for one hour; and a TGA isothermal scan at 110°C.

On adhesives:

Viscosity Response
Tg suppression
Water Reduction
Set and Open Times
T-Peel adhesion

[0095] Test Methodology – Specific details of the test methods are described below:

[0096] Volatility: ASTM D2369 used. A TGA isothermal for one hour under air at 110° C was also employed.

[0097] Viscosity Response: Viscosity measurements were made using a Brookfield RVT at 20 RPM's for 10 revolutions at 23 ± 2° C. The Brookfield viscosity was tested using the RVDVII+ Pro Viscometer.

[0098] Tg Suppression: DSC Glass Transition Method: 10 mil (wet) films were drawn down on glass and left to dry overnight. After 24 hours, the films were removed from the plates and approximately 10 mg were placed in a closed aluminum DSC pan. The temperature was equilibrated at -75°C, then ramped at 5°C/min to 65°C. Glass transition was measured as the onset of Tg.

[0099] Water Reduction: 200 grams of plasticized polymer were weighed into 8 oz. jars. Small increments of water were added and viscosity was measured after each addition until the viscosity reached 2000 +/- 80 cP.

[0100] Set Time: Set time determinations were made using two strips of 50 lb. unbleached Kraft paper measuring 1" x 14" (top) and 1.5" x 14" (bottom). A small amount of adhesive was applied to the bottom strip, and a #20 wire wound rod metered the adhesive onto the bottom strip while a #16 wire wound rod (rubber banded to the #20) simultaneously pressed down the top strip. A timer was then immediately started

and the strips were pulled apart until significant force was required to tear apart the strips and fiber tear was noted. Time at this point was recorded as the set time. A minimum of three repetitions were performed. Evaluations were performed blind.

[0101] Open time: A 1.5" x 14" piece of 50 lb. unbleached Kraft paper was placed on a glass surface, with a 1" x 14" piece of Kraft clipped to its top, rolled back so that the bottom piece was left uncovered. The top piece was sandwiched between a #0 and #14 wire wound rod with the #0 on top. A small amount of adhesive was applied to the top of the bottom strip and a #20 wire wound rod metered out the adhesive over the entire strip. A timer was started, and at a specified time interval (with intervals of 5 seconds) the top strip was laminated to the bottom using the #0 rod. The strips were then peeled apart and assessed for adhesion and fiber tear. This process was repeated until a specific time interval was confirmed in duplicate as the last time interval to result in significant fiber tear/adhesion. Evaluations were performed blind.

[0102] T-Peel Adhesion: The methodology for various peel adhesion tests is further described in connection with Examples 7 and 8.

[0103] Example 1 – *VOC/Volatility of Neat Plasticizers*

[0104] Figure 1 illustrates the volatility characteristics determined for the neat plasticizers evaluated. Except for triacetin, which is 100% volatile and 100% water soluble, the plasticizers of the evaluation were all low in volatility and, thus, would not contribute significantly to the overall VOC of an adhesive formulation at typical levels of use. The inventive monobenzoate, 3 PPB, was slightly more volatile than dibenzoate plasticizers, but still well within an acceptable range.

[0105] Example 2 – *Viscosity Response*

[0106] The viscosity response of a Pace® 383 homopolymer (PVAc) adhesive composition with 10 wt.% plasticizer was evaluated. Viscosity response is indicative of the compatibility of the plasticizer with the polymer. Figure 2 illustrates the One Day viscosity response of the various plasticizers evaluated. All of the plasticizers showed comparable viscosity responses, reflecting compatibility with the base polymer.

[0107] Figures 3 (a) and 3 (b) show One Day viscosity responses with 5 wt.% plasticizer in PVA/E copolymers, both A and B. Again, the viscosity responses are comparable, reflecting good compatibility with the base polymer.

[0108] Example 3 – *Water Reduction*

[0109] Figures 4 and 5 (a) and 5 (b) reflect the water reduction results, i.e., the amount of water required to get to the desired viscosity of 2000 mPa's for the homopolymer (PVAc) and copolymers (PVA/E, A & B), respectively, using plasticizer concentrations of 5, 10, 15 and 20 wt.% for the homopolymer and 5, 10 and 15 wt.% for the copolymers. The amount of water required in each was comparable among the plasticizers evaluated.

[0110] Example 4 – *Glass Transition*

[0111] Glass transition temperatures (Tg) were obtained for plasticizer concentrations of 5, 10, 15 and 20 wt.% in homopolymer (PVAc) and for plasticizer concentrations of 5, 10 and 15 wt.% for the copolymers. Figure 6 reflects the Tg results for the homopolymer and demonstrates that the inventive monobenzoate, 3 PPB, was excellent in Tg suppression, thus indicating a more flexible polymer and a more efficient plasticizer.

[0112] Figures 7 (a) and 7 (b) reflect the Tg results for the copolymers A and B, respectively. While there was some variability between polymers, the inventive monobenzoate, 3-PPB, performed comparable to the dibenzoate plasticizers.

[0113] Example 5 – *Set Time*

[0114] Set Times for the various plasticizers were evaluated in the homopolymer and both copolymers. Homopolymer evaluations were conducted with 10 wt.% plasticizer levels. Copolymer evaluations (both A and B) were conducted with 5 wt.% plasticizer levels. All of the plasticizers decreased the set time of the adhesives as expected.

[0115] The inventive monobenzoate performed very well in comparison with the other plasticizers in the homopolymer, as reflected in Figure 8. Figures 9 (a) and 9 (b) show that the inventive monobenzoate performed comparable to or slightly better than the dibenzoates in the copolymers and was equivalent to ATBC. Set time results demonstrate that the inventive monobenzoate reduces the bond formation time in the various polymeric adhesives.

[0116] Example 6 – *Open Time*

[0117] Open Times for the various plasticizers were evaluated in the homopolymer and both copolymers. Homopolymer evaluations were conducted with 10 wt.% plasticizer. Copolymer evaluations were conducted with 5 wt.% plasticizer levels. All of the plasticizers increased the open time as compared to the blank control, which is desirable in certain adhesive applications.

[0118] Figure 10 shows that the inventive monobenzoate achieved longer open times than the dibenzoate plasticizers and comparable to triacetin and ATBC in the homopolymer. Figures 11 (a) and 11 (b) show that the inventive monobenzoate achieved longer open times than the other plasticizers in Copolymer A and equivalent open times with Copolymer B, respectively.

[0119] Example 7 – *T-Peel Cotton to Cotton*

[0120] This test provides a method for determining the water resistance of an adhesive by measuring its peel strength dry and its peel strength retention after one hour of immersion in water.

[0121] Samples were prepared by first drawing down some emulsion on a 6" x 13" cotton cloth using a #10 wire wound rod, at which time a timer was started. At the end of 60 seconds, a second amount of emulsion was applied using the 4 mil side of an 8 path applicator. At the end of an additional 60 seconds, the cloth was folded over on itself and pressed twice using a rolling pin. The specimens were then allowed to dry for a minimum of 24 hours. Two 1" specimens were cut from each sample and each labeled A, B, etc. A minimum of 2 (most had 4) specimens were prepared per sample. The dry samples were pulled on the tensile tester at a rate of 12"/min. The corresponding set of wet samples was soaked in water for one hour before being pulled on the tensile tester.

[0122] The peel strength required to pull apart the bond between two cotton samples was determined on dry samples and after a one hour water soak for a PVA/E copolymer composition having 5 wt.% plasticizer. The inventive monobenzoate was compared against 1,2-propylene glycol, a dibenzoate blend, and ATBC. The results in Figures 12 a (dry) and 12 b (after one hour water soak) show that the inventive monobenzoate performed better than the dibenzoate blend and comparable to ATBC.

After the one hour water soak, the inventive monobenzoate performed slightly better than 1,2-propylene glycol dibenzoate, the dibenzoate blend and ATBC.

[0123] In the following examples 8-11, the efficacy of the inventive monobenzoate, 3-PPB (X-613), was evaluated in the identified adhesive formulations, comparing it against K-Flex® 850S (DEGDB/DPGDB) as the standard, Citroflex® A-4 (ATBC), and 1,2-propylene glycol dibenzoate (X-100, PGDB). Test methodologies are as described above. Methodologies for the additional tests conducted in these examples are set forth below.

[0124] Example 8 – *Pace® 383 (PVAc) Homopolymer Formulation*

[0125] Each plasticizer was evaluated at concentrations of 5, 10, 15 and 20 wt.%.

[0126] Brookfield Viscosity

[0127] The initial and one day Brookfield Viscosity results are shown in Figures 13 and 14. Based on viscosity response, all of the tested plasticizers appear compatible, with K-Flex® 850S giving the greatest viscosity response. 3-PPB (X613) gave a very good viscosity response, with good increases as its concentration was increased.

[0128] The three and seven day viscosities obtained are shown in Figures 15 and 16. The viscosities followed the trend set forth with the initial and one day viscosities, with no notable increase over this time period. The four week viscosities of the Pace® samples are shown in Figure 17, and the eight week viscosities are shown in Figure 18. Figure 18 reflects that all of the viscosities had increased from the previous four week reading, indicating they were all stable.

[0129] Shear

[0130] AR2000 Shear Method: A 40 mm 1° steel cone geometry with Peltier plate was used. A dime sized amount of emulsion was placed on the Peltier plate. The shear ramp was run at 25°C from 0 to 2500 s^{-1} over one minute. The results of the shear testing are shown in Figures 19 (a), (b), (c) and (d). All of the plasticizers had acceptable rheology and were fairly comparable.

[0131] Glass Transition

[0132] The Tg results are shown in Figure 20. Of the four plasticizers tested, X-100 (PGDB) was the least efficient, while 3-PPB (X-613) was the most efficient and comparable to A-4.

[0133] Set Time

[0134] The results of the set time are shown in Figure 21. The results of the 10 and 15 wt.% plasticizer concentrations were comparable, while 3-PPB (X613) showed an advantage at the 20 wt.% level of use. A-4 generally had the poorest set times.

[0135] Open Time

[0136] The results of the open time testing on the Pace® samples are shown in Figure 22. The 3-PPB (X613) adhesives had consistently better open time than the other formulations at the same concentrations, even if only marginally.

[0137] Tensile - 180° Peel, Cotton to Acrylic Coated 3B Leneta Charts

[0138] 180° Peel, Cotton to Acrylic Coated 3B Leneta Charts Method: 1" x 14" cotton strips were laminated to Leneta 3B acrylic coated charts using a #20 wire wound rod to draw down the emulsion and one pass of a rolling pin. The cotton was pulled at a 180° angle from the 3B chart at 12"/min. The data was averaged between 1" and 5" of the pull. Five specimens of each sample were run. Data was adjusted to remove slack from the results.

[0139] The results from the 180° cotton to acrylic peel are shown in Figure 23. Surprisingly, the 3-PPB (X-613) significantly enhanced the peel strength of the adhesive at all levels, with good peel strength at 5 wt.% as compared to the other plasticizers at 10 wt.% and even 15 wt.%. This suggests that 3-PPB may be useful as an additive to adhesives to enhance adhesion to certain difficult-to-adhere surfaces, such as polar surfaces. This is predictable based upon the polarity of the plasticizer and the Tg suppression.

[0140] The 180° peel of cotton to acrylic coated 3B Leneta charts was repeated to confirm the enhanced adhesion noted with the 3-PPB samples. This time, six specimens of each sample were run. The samples formulated with 3-PPB showed greatly improved adhesion to the acrylic coating than the other plasticizers that were evaluated, with peel strengths of about twice the amount of the others. In fact, the break sensitivity had to be turned down for the method, as the tensile tester several times

thought it detected a break with the 15 wt.% and 20 wt.% 3-PPB due to the large build-up of adhesion and ensuing release. Figure 24 shows the results of the 180° peels second trial, while Figure 25 compares the results of both the first trial and the second trial.

[0141] The mode of loss for all of the 180° peels was adhesive, and primarily occurred with all of the adhesive still adhered to the cotton strips. However, several of the 15 wt.% and 20 wt.% 3-PPB specimens, as well as in minor amounts with one 20 wt. % A-4 and one 20 wt. % K-Flex® 850S, had adhesive loss to the cotton, where the adhesive remained.

[0142] As described above, two trials were conducted for the cotton to acrylic 180° peel resulting in two sets of data, which showed similar trends. The data obtained for the first and second set of samples were averaged and are shown in Figure 26.

[0143] Tensile - 180° Peel, Cotton to Flexible Vinyl

[0144] The cotton to flexible vinyl 180° peels were performed on the Pace® homopolymer samples. Once again, the results in Figure 27 show very good performance with 3-PPB (X-613) adhesives at all levels of the test.

[0145] Tensile – T-Peel, Water Resistance, Cotton to Cotton

[0146] The methodology for this test is described in example 7, above.

[0147] The data from this set had good agreement from specimen to specimen (standard deviations of 0-23%). Figure 28 shows the results from the dry T-peel, cotton to cotton test for the Pace® homopolymer samples at 5, 10, 15 and 20 wt.% plasticizer concentrations. For most of the plasticizers, there was a climb in peel strength up to 10 wt.%, then a decline with increasing plasticizer concentration at 15 wt.% and 20 wt.%. The X-100 (PGDB) showed a good increase in peel strength at the higher levels. 3-PPB had good peel strength versus the other plasticizers at low levels of plasticizer concentration, although it weakened the adhesive when used at levels greater than 10%. This is predictable as it is very efficient in softening.

[0148] Water Reduction

[0149] The water reduction results (to 2000 mPa's) of the Pace® homopolymer emulsions are shown in Figure 29. The amounts of water necessary to reduce the emulsion viscosities down to 2000 cP are fairly comparable between the plasticizer

types, which was expected due to the similar viscosity responses the emulsions originally had.

[0150] Hysteresis Loop/Wet Tack

[0151] Hysteresis Loop Method: Hysteresis loop data was obtained on an AR-2000 using 20 mm steel plate geometry on a Peltier base plate at 20°C. The gap was set at 200 µm, then a small (nickel sized) amount of sample was sheared up to 1500 s^{-1} and back down within one minute. Samples were tested in triplicate using a fresh specimen for each measurement.

[0152] All of the wet tack data followed the expected trend, with an increase in wet tack as the plasticizer concentrations increased; however, some of the standard deviations were greater than 25%, and so additional data was gathered on those samples in order to obtain a better average. Figure 30 shows the additional data for Pace® homopolymer formulations.

[0153] MFFT – Chalk Point

[0154] Chalk Point Method: A sheet of aluminum foil was taped tightly over the MFFT plate and wiped down with acetone. The desired temperature range was chosen and the MFFT-90 was turned on. Cooling water was turned on, as well as an air flow of 4 L/min. The plate was left to equilibrate (about 30 minutes). A U-shaped film was drawn down using the 75 µm applicator cube. All three samples were drawn down within 10 minutes. The cover was then closed and the instrument was left to run for a minimum of an hour. The samples were then examined for chalk point and photos were taken.

[0155] The chalk points of the homopolymer adhesives were determined, and the results can be seen in Figure 31. 3-PPB did a very good job in lowering the chalk point and was substantially similar to the results achieved with the K-Flex® 850S standard. Although both X-100 and Citroflex® A-4 lowered the chalk point of the homopolymer, they were the poorer performers of the group.

[0156] Example 9 – *Elvace® 735 (Vinyl Acetate Ethylene) Copolymer Formulations*

[0157] Each plasticizer was evaluated at concentrations of 5, 10, and15 wt.%.

[0158] Brookfield Viscosity

[0159] The initial, one and three day viscosities of the Elvace® copolymer emulsions are shown in Figures 32 and 33 (a) and (b), respectively. The seven day viscosities of the Elvace® copolymer emulsions are shown in Figure 34. The viscosities of all of the samples were comparable, with 3-PPB (X-613) and A-4 showing marginally better viscosity response over the dibenzoates.

[0160] Shear

[0161] Elvace® copolymer shears were run using the cone geometry in order to obtain optimal results. The shear curves are shown in Figures 35, 36 and 37. All of the plasticizers were similar in their shear responses.

[0162] Glass Transition Temperature (Tg)

[0163] The Tg's of the Elvace® copolymer samples were measured, and the results are shown in Figure 38. The Tg suppression of 3-PPB was very efficient and mirrored that of the A-4; both had substantial improvements in Tg suppression over the dibenzoates at all levels of test.

[0164] Set Time

[0165] The set time results for the Elvace® copolymer samples are shown in Figure 39. All of the plasticizers were comparable.

[0166] Open Time

[0167] The open times of the Elvace® copolymer samples were measured, and the results are shown in Figure 40. The 3-PPB helped to extend open time slightly at lower concentrations than the other plasticizers.

[0168] Water Reduction

[0169] The viscosities of portions of the Elvace® copolymer samples were reduced to 2000 cP with water. The results of the water reduction are shown in Figure 41. At higher plasticizer levels, the Citroflex A-4 samples required the most water to reduce its viscosity, followed closely by 3-PPB (X-613). The PGDB (X-100) samples consistently required the least amount of water to be reduced. More amounts of water render the formulation less expensive whereas small amounts of water to back-add will preserve solids content. Depending on the formulator's needs, either lower or higher water to back-add may be advantageous.

[0170] Hysteresis Loop

[0171] The hysteresis loop results for the Elvace® copolymer samples are shown in Figure 42. The dibenzoates showed the best wet tack across all concentrations, while the performance of 3-PPB and A-4 were very similar to each other.

[0172] T-Peel, Water Resistance, Cotton to Cotton

[0173] Figures 43, 44 and 45 show the results of the water resistance T-Peel, cotton to cotton tests performed on the Elvace® copolymer samples. Both the dry peel strengths and the peel strength loss after water immersion were all fairly comparable between the samples, with perhaps a slight advantage in water resistance seen with the 5 wt.% and 10 wt.% 3-PPB (X-613) samples.

[0174] 180° Peel, Flexible PVC to Luan

[0175] 180° Peel, Flexible PVC to Luan Sample Preparation: 1" x 14" strips of flexible, 12 mil thick PVC were laminated to 6" x 10" pieces of Luan plywood. The adhesive was applied using a #50 wire wound rod, and four strips were laminated to each piece of wood. Gentle pressure using a rolling pin, followed by finger pressure to wet out the PVC strips, was used to press the pieces together.

[0176] 180° Peel, Flexible PVC to Luan Method: The PVC strips were pulled from the Luan at 12"/min. over 8". The average peel strength was determined by the data obtained between 2" and 7".

[0177] The peel strength of the PVC to Luan of the Elvace® copolymer samples are shown in Figure 46. Peel strengths of all samples were comparable, with no notable increase in peel strength as the plasticizer level increased.

[0178] Example 10 – *Monobenzoates and Blends*

[0179] Due to the good adhesion results for 3-PPB (X-613) obtained in the above example, new blends of 3-PPB with K-Flex® DE (DEGDB) and K-Flex® PG (PGDB, X-100) were put through a basic evaluation, along with K-Flex® IB, to provide a baseline of how typical monobenzoates behave. Samples evaluated included: 5, 10, 15 and 20 wt.% plasticizer concentrations in Pace® homopolymer, and 5, 10 and 15 wt.% plasticizer concentrations in Elvace® copolymer, using the plasticizers and blends of plasticizers listed below:

[0180] Plasticizers & Blends:

25% X-613 (3-PPB)/75% X-100 (PGDB)
50% X-613/50% X-100
25% X-613/75% K-Flex DE (DEGDB)
50% X-613/50% K-Flex DE
K-Flex® IB (isodecyl benzoate)
K-Flex® 850S (DEGDB/DPGDB diblend)

[0181] Brookfield Viscosities

[0182] Figures 47, 48 and 49 show the initial, 1 and 3 day viscosities, respectively, for Elvace® copolymer samples. The samples made with K-Flex® IB had very low initial viscosity, with a gradual build over time to values near those of the dibenzoates and blends.

[0183] The initial, one and three day viscosities of the Pace® homopolymer samples are shown in Figures 50, 51 and 52. With the exception of the IB formulations, all of the samples showed good viscosity response. At lower levels, the IB was equivalent, but at about 15 - 20 wt. % plasticizer concentration, the IB viscosity response started lagging behind the others. There also did not seem to be a dramatic increase in viscosity over time with the IB formulations in the Pace® homopolymer samples, as there was in the Elvace® copolymer samples.

[0184] Figure 53 shows the 1 week viscosities for the Elvace® copolymer samples. By this time, the IB formulations had now not only caught up, but overtaken the other samples in viscosity response. This indicates very poor stability in these formulations.

[0185] Glass Transition Temperature

[0186] The glass transition temperatures of the monobenzoate blends formulated with Pace® homopolymer are shown in Figure 54. This figure shows the limited compatibility of K-Flex IB with this homopolymer. Even at only 5 wt.%, IB has the poorest Tg suppression of all of the plasticizers that were evaluated; as the IB concentration increases, the Tg stays the same, indicating its incompatibility.

[0187] As would be expected, due to their relative efficiencies, the 3-PPB blends with K-Flex® DE showed the greatest Tg suppression, while the blends with X-100 (PGDB) showed slightly less Tg suppression.

[0188] Figure 55 shows the Tg results with the Elvace® copolymer samples. In this case, the IB actually showed a greater efficiency in reducing the Tg's of the copolymer than the K-Flex® 850S or the 3-PPB blends. This makes sense, as IB's low polarity should be more compatible with the ethylene blocks of the copolymer than the other di- and mono-benzoates. For the blends, the 50:50 X-100/X-613 showed similar Tg suppression to that of the DE blends.

[0189] Set and Open Time

[0190] Figures 56 and 57 show the set and open time of the Elvace® copolymer samples. Overall, the 75:25 X-100/X-613 samples showed the fastest set times. With the exception of the IB and the 50:50 K-Flex® DE:X-613 samples, all of the open times increased with increasing plasticizer level and all of the samples appeared to be equivalent.

[0191] Example 11 – *Basic Packaging Adhesive Evaluation*

[0192] The following example show the efficacy of the inventive monobenzoate with a basic packaging adhesive formulation described below:

Material	**PHR**	**%**
Copolymer, 0°C Tg	100	89%
Plasticizer	10	9%
PVOH, 7% Solution	2	2%
Water	Added	

[0193] Evaluations were performed comparing the inventive monobenzoate, 3-PPB, to PGDB (X 100), K-Flex® 850S (DEGDB/DPGDB diblend), Benzoflex™ 2088 (TEG/DEG/DPG dibenzoate blend), and DIBP.

[0194] Figure 58 shows the initial viscosity measurements reflecting that the inventive monobenzoate, 3-PPB, has a slightly better effect on viscosity than the dibenzoates and comparable to DIBP, a phthalate plasticizer.

[0195] Figure 59 shows the water reduction results (to 1500 mPa's) reflecting that 3-PPB has among the highest amount of water add back (among the non-phthalates) to achieve the desired viscosity reduction.

[0196] Set Times for Kraft to Kraft and Kraft to Mylar samples, respectively, unreduced and water reduced, are shown in Figures 60 and 61. The results reflect that in some

instances the inventive monobenzoate enhanced the set time and in others performed comparably to other plasticizers.

[0197] Open Time results for unreduced and water reduced samples are shown in Figure 62. These results reflect that 3-PPB performed quite well when water reduced and comparable to other plasticizers when unreduced.

[0198] The foregoing examples reflect that the inventive monobenzoate plasticizer, 3 PPB, functions well in adhesives, performing comparably or better than traditional plasticizers used in adhesives, including the dibenzoates. The inventive monobenzoate is an alternative to phthalate plasticizers and has the potential to improve upon the safety of plasticizer technology for the adhesive industry.

[0199] In accordance with the patent statutes, the best mode and preferred embodiments have been set forth; the scope of the invention is not limited thereto, but rather by the scope of the attached claims.

WHAT IS CLAIMED IS:

1. A plasticizer consisting of a monobenzoate that is 3-phenyl propyl benzoate, wherein the plasticizer is incorporated into a polymeric dispersion to provide viscosity response, improved open and set times, MFFT, and Tg suppression and facilitate formation of the adhesive bond, whether used alone as a primary plasticizer or as a secondary plasticizer in combination with other traditional plasticizers.

2. An adhesive composition comprising:

a. a polymeric dispersion; and

b. a plasticizer that is 3-phenyl propyl benzoate,

wherein the 3-phenyl propyl benzoate is used to provide viscosity response, improved open and set times, MFFT, and Tg suppression and facilitates formation of the adhesive bond, whether used alone as a primary plasticizer or as a secondary plasticizer in combination with other traditional plasticizers.

3. A waterborne latex glue comprising the monobenzoate plasticizer of claim 1.

4. A caulk composition comprising the monobenzoate plasticizer of claim 1.

5. A sealant composition comprising the monobenzoate plasticizer of claim 1.

6. A waterborne polymeric adhesive composition comprising:

a. a polymer selected from the group consisting of waterborne acrylics, polyvinyl acetate, vinyl acetate ethylene, methacrylates, styrene acrylates, polychloroprenes, polyurethanes, and nitriles; and

b. a plasticizer that is 3-phenyl propyl benzoate.

7. A non-aqueous polymeric adhesive composition comprising:

a. a polymer selected from the group consisting of acrylics, polyvinyl acetate, vinyl acetate ethylene, methacrylate, styrene acrylate, polychloroprenes, thermoplastic polyurethanes, polysulfides, aminos, epoxies and polyamides; and

b. a plasticizer that is 3-phenyl propyl benzoate.

8. A plasticizer comprising a blend of 3-phenyl propyl benzoate in combination with other plasticizers comprising: phthalate plasticizers up to C5, phosphate esters up to C4, terephthalates, polyesters, citrates, adipates, succinates, 1,2-cyclohexane dicarboxylate esters, isobutyrates, alkyl glycol esters, sulfonamides, sulfonic acid esters, benzoates, or mixtures thereof.

9. A plasticizer comprising a blend of 3-phenyl propyl benzoate in combination with other plasticizers comprising: isononyl benzoate, isodecyl benzoate, 2-ethyl hexyl benzoate, 2,2,4-trimethyl-1,3-pentanediol diisobutyrate, or mixtures thereof.

10. A method of providing viscosity response, improved open and set times, Tg suppression and formation of the adhesive bond in adhesive formulations, comprising:

a. adding a plasticizer that is 3-phenyl propyl benzoate to a polymeric dispersion.