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(54) **UNSATURATED POLYESTER RESIN**

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(57) **ABSTRACT**

The present invention relates to a resin composition comprising an unsaturated polyester resin comprising 1,3-propane diol building blocks and C5-C10 unsaturated dicarboxylic acid building blocks and further comprising a reactive diluent. Preferably, at least part of the 1,3-propane diol is derived from a non-fossil source. Preferably, itaconic acid or anhydride is used as the C5 unsaturated dicarboxylic acid.

UNSATURATED POLYESTER RESIN

[0001] The present invention relates to resin compositions, suitable to be used in the manufacturing of structural parts, comprising an unsaturated polyester resin and reactive diluent.

[0002] Unsaturated polyester resins are well known to be suitable for many construction purposes, however in view of handling properties of the resin composition, it is desired that the viscosity of the resin composition is not too high. For example, relining encompasses impregnating of fiber with resin composition. Therefore, viscosity of the resin composition may not be too high in view of handling and time for impregnation. This fact that viscosity is very important also holds for many other applications such as chemical anchoring, injection, vacuum injection but also simple laminating processes like open mould applications run much smoother with lower viscosity resins. Consequently there is a large need for methods to reduce the viscosity of the resin composition without affecting the properties of the cured resin, especially the thermal stability as indicated by the HDT in a negative way. One way to lower the viscosity is to add more reactive diluent, however, due to the lower content of resin in the resin composition, this results generally in a deterioration of the properties of the cured resin composition and this may result in a decline of the thermal stability (as for example indicated by HDT) and can therefore not generally be applied. An example of an application requiring a high HDT is in the automotive industry. Especially parts which are applied under the hood are exposed to high temperatures. Also, in the more common tanks applications high temperature resistance is important as in the full sun the temperature of parts of the tank can easily rise to a high level.

[0003] Furthermore in view of the ecological footprint, there is a high desire to make unsaturated polyesters, which can be used for manufacturing of structural parts, which comprise bio-based building blocks.

[0004] The use of petroleum based monomers in the manufacture of consumer products is expected to decline in the coming years because of the continuous rise in the price of oil and the high rate of depletion of known oil reserves. This, in connection with strict government regulations all around the world on environmental protection against pollution, has inspired the investigation of renewable resources as a possible alternative to petroleum based monomers. With the diminishing of the limited petroleum resources, use of renewable resources as chemicals for industrial applications is of great interest. A very suitable example of a biobased building block for unsaturated polyesters is 1,3-propanediol as it can be obtained for instance from corn.

[0005] However, it has been found that using 1,3-propane diol in combination with maleic anhydride results in an increased viscosity of the diluted resin, which may result in that the diluted resin can no longer be applied for construction purposes.

[0006] The object of the present invention is to obtain a resin composition with a reduced viscosity, while the thermal stability of the cured objects is retained at a similar level.

[0007] The inventors have surprisingly found that this objective can be achieved with unsaturated polyester resin comprising 1,3-propane diol building blocks and C5-C10 unsaturated dicarboxylic acid building blocks.

[0008] It has surprisingly been found that with this combination of building blocks in the unsaturated polyester resin, the viscosity of the diluted resin can be reduced to a level even below the viscosity of a similar diluted resin that contains other diol building blocks than 1,3-propane diol building blocks. Furthermore, the fact that with this combination of building blocks in the unsaturated polyester resin, the thermal stability, as indicated by HDT, is maintained is very surprising considering GB 806730. Example 9 of this patent application describes an unsaturated polyesters which comprises itaconic acid. However the cured part obtained from the resin disclosed in this application only had a low thermal stability as indicated by the low HDT of only 70° C. As shown in the experimental part, also a resin prepared from itaconic acid and 1,2-propyleneglycol also resulted in a cured object with a lower thermal stability compared with a resin prepared from maleic acid and 1,2-propyleneglycol.

[0009] An additional advantage is that the elongation at break of a cured part obtained from a resin composition according to the invention can be improved.

[0010] In a preferred embodiment of the invention itaconic acid or anhydride is used for the C5 unsaturated dicarboxylic acid building blocks. This is especially preferred as itaconic acid or anhydride can be derived from non fossil source such as for example corn.

[0011] In a preferred embodiment of the invention, at least part of the 1,3-propane diol and/or at least part of the itaconic acid or itaconic anhydride that is preferably used to obtain the unsaturated polyester present in the resin composition according to the invention is derived from a non-fossil source. In a more preferred embodiment of the invention, at least part of the 1,3-propane diol and at least part of the itaconic acid or itaconic anhydride that is used to obtain the unsaturated polyester present in the resin composition according to the invention is derived from a non-fossil source.

[0012] The unsaturated polyester present in the resin composition according to the invention comprises 1,3-propane diol building blocks and C5-C10 unsaturated dicarboxylic acid building blocks.

[0013] The unsaturated polyester present in the resin composition according to the invention can be manufactured by polycondensation of at least 1,3-propane diol as polyol and at least C5-C10 unsaturated dicarboxylic acid or anhydride as unsaturated dicarboxylic acid. The polycondensation may also be effected in the presence of other dicarboxylic acids containing reactive unsaturations, such as for example maleic acid or anhydride and fumaric acid and/or in the presence of saturated aliphatic dicarboxylic acids or anhydrides, like for example oxalic acid, succinic acid, adipic acid, sebacic acid and/or in the presence of aromatic saturated dicarboxylic acids or anhydrides like for example phthalic acid or anhydride and isophthalic acid. In the polymerisation a further di- or polyfunctional alcohol may be used. Preferred further diols are for example 1,2-propylene glycol, ethylene glycol, diethylene glycol, triethylene glycol, dipropylene glycol, tripropylene glycol, neopentyl glycol, hydrogenated bisphenol-A. or ethoxylated/propoxylated bisphenol A. According to a preferred embodiment the molecular weight of the further diol in the unsaturated polyester resin is in the range from 60 to 250 Dalton.

[0014] In one preferred embodiment according to the invention, the unsaturated polyester is manufactured by polycondensation of 1,3-propane diol and C5-C10 unsaturated dicarboxylic acid and/or anhydride, and optionally other

building blocks selected from other diols and/or polyols, other unsaturated dicarboxylic acids and/or anhydrides, saturated aliphatic dicarboxylic acids and/or anhydrides, and/or aromatic saturated dicarboxylic acids and/or anhydrides. Preferably, itaconic acid or anhydride is used for the C5 unsaturated dicarboxylic acid building blocks.

[0015] In another preferred embodiment according to the invention, the unsaturated polyester is manufactured by polycondensation of 1,3-propane diol and C5-C10 unsaturated dicarboxylic acid and/or anhydride, and optionally other building blocks selected from other diols and/or other acids or anhydrides. Preferably, itaconic acid or anhydride is used for the C5 unsaturated dicarboxylic acid building blocks.

[0016] In another preferred embodiment according to the invention, the unsaturated polyester is manufactured by polycondensation of 1,3-propane diol, 1,2-propylene glycol and C5-C10 unsaturated dicarboxylic acid and/or anhydride, and optionally other building blocks selected from other diols and/or other acids or anhydrides. Preferably, itaconic acid or anhydride is used for the C5 unsaturated dicarboxylic acid building blocks.

[0017] In the unsaturated polyester resin present in the resin composition according to the invention, the molar amount of 1,3-propane diol is preferably at least 10%, more preferably at least 25% and even more preferably at least 45% (relative to the total amount of diols).

[0018] In the unsaturated polyester resin present in the resin composition according to the invention, preferably at least 25 wt. % of the dicarboxylic acid building blocks are itaconic acid building blocks. More preferably, at least 55 wt. % of the dicarboxylic acid building blocks are itaconic acid building blocks in the unsaturated polyester present in the resin composition according to the invention.

[0019] Preferably at least 25 wt. %, more preferably at least 55 wt. %, of the unsaturated dicarboxylic acid building blocks are itaconic acid building blocks.

[0020] The acid value of the unsaturated polyester resin present in the resin composition according to the invention is preferably in the range from 25 to 125 mg KOH/g resin, more preferably in the range from 30 to 100 mg KOH/g resin, more preferably in the range from 35 to 75 mg KOH/g resin. As used herein, the acid value of the resin is determined titrimetrically according to ISO 2114-2000.

[0021] The molar ratio of hydroxyl end groups and carboxylic acid end groups in the unsaturated polyester resin present in the resin composition according to the invention is preferably in the range from 0.33 to 3. In one preferred embodiment, the molar ratio of hydroxyl end groups and carboxylic acid end groups in the unsaturated polyester resin present in the resin composition according to the invention is in the range from 0.33 to 0.9. In another preferred embodiment, the molar ratio of hydroxyl end groups and carboxylic acid end groups in the unsaturated polyester resin present in the resin composition according to the invention is in the range from 1.1 to 3.

[0022] The hydroxyl value of the unsaturated polyester resin present in the resin composition according to the invention is preferably higher than 25 mg KOH/g resin and more preferably higher than 40 mg KOH/g resin. As used herein, the hydroxyl value of the polyester is determined according to ISO 4629-1996.

[0023] Preferably, the molecular weight of the unsaturated polyester is at least 300 Dalton, preferably at least 500 Dalton and more preferably at least 750 Dalton. Preferably, the molecular weight M_n of the unsaturated polyester is at most 10.000 Dalton, more preferably at most 5000 Dalton. The molecular weight (Mn) is determined in tetrahydrofurane using GPC according to ISO 13885-1 employing polystyrene standards and appropriate columns designed for the determination of the molecular weights

[0024] In a preferred embodiment of the invention, the molecular weight M_n is in the range from 750 to 5000 Dalton.

[0025] The glass transition temperature T_g of the unsaturated polyester is preferably at least −70° C. and at most 100° C. In case the unsaturated polyester is applied for construction purposes, the glass transition temperature T_g of the unsaturated polyester resin present in the resin composition according to the invention is preferably at least −70° C., more preferably at least −50° C. and even more preferably at least −30° C. The T_g of the unsaturated polyester resin present in the resin composition according to the invention is preferably at most 70° C., more preferably at most 50° C. and even more preferably at most 30° C. As used herein, the T_g is determined by means of DSC (heating rate 5° C./min).

[0026] The unsaturated polyester resin present in the resin composition according to the invention can be advantageously prepared in the presence of at least one radical inhibitor selected from copper carboxylate, benzoquinone, alkyl substituted benzoquinone, hydroquinone and/or a methylated hydroquinone. In a preferred embodiment, the unsaturated polyester present in the resin composition according to the invention is prepared by

[0027] (i) charging the reactor with C5-C10 unsaturated dicarboxylic acid and/or anhydride and optionally other diacids, 1,3-propane diol and optionally other diols, and at least one radical inhibitor selected from copper carboxylate, benzoquinone, alkyl substituted benzoquinone, hydroquinone and/or a methyl substituted hydroquinone,

[0028] (ii) heating the reactor till a temperature of from 180 to 200° C. until the acid value of the formed unsaturated polyester is below 60,

[0029] (iii) cooling the formed resin, preferably to a temperature of from 20 to 120° C., and

[0030] (iv) optionally diluting the resin with reactive diluent.

[0031] Preferably, the unsaturated polyester resin present in the resin composition according to the invention is prepared in the presence of hydroquinone, 2-methylhydroquinone, benzoquinone or 2-methylbenzoquinone, as inhibitor, more preferably in the presence of 2-methylhydroquinone as inhibitor and even more preferably, in the presence of hydroquinone and 2-methylhydroquinone as inhibitor.

[0032] In one embodiment, the unsaturated polyester resin can be applied as a powder coating resin. The preparation of powder coating compositions is described by Misev in "Powder Coatings, Chemistry and Technology" (pp. 224-300; 1991, John Wiley) hereby incorporated by reference. Therefore the present invention also relates to a powder coating composition comprising reactive diluent and an unsaturated polyester comprising 1,3-propane diol building blocks and C5-C10 unsaturated dicarboxylic acid building blocks. In case the unsaturated polyester according to the invention is applied in a powder coating composition, the glass transition temperature T_g of the unsaturated polyester resin is preferably at least 20° C., more preferably at least 25° C. and even more

preferably at least 30° C. and at most 100° C., more preferably at most 80° C. and even more preferably at most 60° C.

[0033] A common way to prepare a powder coating composition is to mix the separately weight-out components in a premixer, heat the obtained premix, for example in a kneader, preferably in an extruder to obtain an extrudate, cool down the obtained extrudate until it solidifies and crush it into granules or flakes that are further grinded to reduce the particle size followed by appropriate classification to obtain a powder coating composition of the right particle size. Therefore, the invention also relates to a process for the preparation of a powder coating composition according to the invention comprising the steps of:

[0034] a. mixing the components of the powder coating composition to obtain a premix

[0035] b. heating the obtained premix, preferably in an extruder, to obtain an extrudate

[0036] c. cooling down the obtained extrudate to obtain a solidified extrudate and

[0037] d. breaking the obtained solidified extrudate into smaller particles to obtain the powder coating composition

and preferably comprising the further step of classifying the thus prepared powder particles via a sieve and collect sieve fraction with particle size below 90 μm.

[0038] The powder coating composition of the present invention may optionally contain the usual additives, such as for example fillers/pigments, degassing agents, flow agents, or (light) stabilizers. Examples of flow agents include Byk 361 N. Examples of suitable fillers/pigments include metal oxides, silicates, carbonates or sulphates. Examples of suitable stabilizers include UV stabilizers, such as for example phosphonites, thioethers or HALS (hindered amine light stabilizers). Examples of degassing agents include benzoin and cyclohexane dimethanol bisbenzoate. Other additives, such as additives for improving tribo-chargeability may also be added.

[0039] In another aspect, the invention relates to a process for coating a substrate comprising the following steps:

[0040] 1) applying a powder coating composition comprising the unsaturated polyester to a substrate such that the substrate is partially or fully coated with a coating.

[0041] 2) heating the obtained partially or fully coated substrate for such time and to such temperature such that the coating is at least partially cured.

[0042] The powder coating composition of the present invention may be applied using the techniques known to the person skilled in the art, for example using electrostatic spray or electrostatic fluidized bed.

[0043] The unsaturated polyester resin composition according to the invention comprises one or more reactive diluents.

[0044] The amount of such reactive diluent in the resin composition according to the invention is usually in the range from 5 to 75 wt. %, preferably in the range from 20 to 60 wt. %, most preferably in the range from 30 to 50 wt. % (relative to the total amount of unsaturated polyester and reactive diluent present in the resin composition). The diluent will be applied, for instance, for lowering of the viscosity of the resin composition in order to make handling thereof more easy. For clarity purpose, a reactive diluent is a diluent that is able to copolymerize with the unsaturated polyester resin. Ethylenically unsaturated compounds can be advantageously used as reactive diluent. Preferably, styrene, dimethyl itaconate and/or a methacrylate containing compound is used as reactive diluent. In one embodiment of the invention, styrene, α-methylstyrene, 4-methylstyrene, (meth)acrylate containing compounds, N-vinylpyrrolidone and/or N-vinylcaprolactam is used as reactive diluent. In this embodiment, styrene and/or (meth)acrylate containing compound is preferably used as reactive diluent and more preferably (meth)acrylate containing compound is used as reactive diluent. In another embodiment, itaconic acid or an ester of itaconic acid is used as reactive diluent. In a more preferred embodiment, the reactive diluent comprises an ester of itaconic acid and at least another ethylenically unsaturated compound, such as for example styrene, α-methylstyrene, 4-methylstyrene (meth)acrylates, N-vinylpyrrolidone and/or N-vinylcaprolactam. In this embodiment, the resin composition preferably comprises an ester of itaconic acid as reactive diluent and styrene as reactive diluent or a methacrylate containing compound as reactive diluent. A preferred ester of itaconic acid is dimethyl itaconate.

[0045] The resin composition preferably further comprises a co-initiator for the radical curing of the resin composition, in an amount of from 0.00001 to 10 wt % (relative to the total amount of unsaturated polyester and reactive diluent present in the resin composition). A preferred co-initiator is an amine or a transition metal compound.

[0046] The amine co-initiator that may be present in the composition is preferably an aromatic amine and even more preferably a tertiary aromatic amine. Suitable accelerators include N,N-dimethylaniline, N,N-diethylaniline; toluidines and xylidines such as N,N-diisopropanol-para-toluidine; N,N-dimethyl-p-toluidine; N,N-bis(2-hydroxyethyl)xylidine and -toluidine. The amount of amine in the resin composition (relative to the total amount of unsaturated polyester and reactive diluent present in the resin composition) is generally at least 0.00001 wt. % and preferably at least 0.01 wt. % and more preferably at least 0.1 wt. %. Generally, the amount of amine in the resin composition is at most 10 wt. %, preferably at most 5 wt. %.

[0047] Examples of suitable transition metal compounds as co-initiator are compounds of a transition metal with an atomic number of in the range from 22 to 29 or with an atomic number in the range from 38 to 49 or with an atomic number in the range from 57 to 79, such as vanadium, iron, manganese, copper, nickel, molybdenum, tungsten, cobalt, chromium compounds. Preferred transition metals are V, Cu, Co, Mn and Fe.

[0048] After having diluted the unsaturated polyester according to the invention with reactive diluent, additional radical inhibitors may be added. These radical inhibitors are preferably chosen from the group of phenolic compounds, hydroquinones, catechols, stable radicals and/or phenothiazines. The amount of radical inhibitor that can be added may vary within rather wide ranges, and may be chosen as a first indication of the gel time as is desired to be achieved.

[0049] Suitable examples of radical inhibitors that can be used in the resin compositions according to the invention are, for instance, 2-methoxyphenol, 4-methoxyphenol, 2,6-di-t-butyl-4-methylphenol, 2,6-di-t-butylphenol, 2,4,6-trimethylphenol, 2,4,6-tris-dimethylaminomethyl phenol, 4,4'-thio-bis (3-methyl-6-t-butylphenol), 4,4'-isopropylidene diphenol, 2,4-di-t-butylphenol, 6,6'-di-t-butyl-2,2'-methylene di-p-cresol, hydroquinone, 2-methylhydroquinone, 2-t-butylhydroquinone, 2,5-di-t-butylhydroquinone, 2,6-di-t-butylhydroquinone, 2,6-dimethylhydroquinone, 2,3,5-

trimethylhydroquinone, catechol, 4-t-butylcatechol, 4,6-di-t-butylcatechol, benzoquinone, 2,3,5,6-tetrachloro-1,4-benzoquinone, methylbenzoquinone, 2,6-dimethylbenzoquinone, napthoquinone, 1-oxyl-2,2,6,6-tetramethylpiperidine, 1-oxyl-2,2,6,6-tetramethylpiperidine-4-ol (a compound also referred to as TEMPOL), 1-oxyl-2,2,6,6-tetramethylpiperidine-4-one (a compound also referred to as TEMPON), 1-oxyl-2,2,6,6-tetramethyl-4-carboxyl-piperidine (a compound also referred to as 4-carboxy-TEMPO), 1-oxyl-2,2,5,5-tetramethylpyrrolidine, 1-oxyl-2,2,5,5-tetramethyl-3-carboxylpyrrolidine (also called 3-carboxy-PROXYL), galvinoxyl, aluminium-N-nitrosophenyl hydroxylamine, diethylhydroxylamine, phenothiazine and/or derivatives or combinations of any of these compounds.

[0050] Advantageously, the amount of radical inhibitor in the resin composition according to the invention (relative to the total amount of unsaturated polyester and reactive diluent present in the resin composition) is in the range of from 0.0001 to 10% by weight. More preferably, the amount of inhibitor in the resin composition is in the range of from 0.001 to 1% by weight. The skilled man quite easily can assess, in dependence of the type of inhibitor selected, which amount thereof leads to good results according to the invention.

[0051] The present invention further relates to a process for radically curing the resin composition according to the invention, wherein the curing is effected by adding an initiator to the resin composition as described above. Preferably, the curing is effected at a temperature in the range of from −20 to +200° C., preferably in the range of from −20 to +100° C., and most preferably in the range of from −10 to +60° C. (so-called cold curing). The initiator is a photoinitiator, a thermal initiator and/or redox initiator.

[0052] As meant herein, a photo initiator is capable of initiating curing upon irradiation Photo initiation is understood to be curing using irradiation with light of a suitable wavelength (photo irradiation). This is also referred to as light cure.

[0053] A photo-initiating system may consist of a photo initiator as such, or may be a combination of a photo initiator and a sensitizer, or may be a mixture of photo initiators, optionally in combination with one or more sensitizers.

[0054] The photo initiating system that can be used in the context of the present invention can be chosen from the large group of photo-initiating systems known to the skilled person. A vast number of suitable photo initiating systems, can be found in, for instance, Volume 3 of "Chemistry and Technology of UV and EB Formulations", 2nd Edition, by K. Dietliker and J. V. Crivello (SITA Technology, London; 1998).

[0055] The thermal initiator can be selected from azo compounds like for example azo isobutyronitril (AIBN), C—C labile compounds like for example benzopinacole, peroxides, and mixtures thereof. The thermal initiator is preferably an organic peroxide, or a combination of two or more organic peroxides.

[0056] The redox initiator is preferably an organic peroxide in combination with at least one of the above mentioned co-initiators. Examples of suitable peroxides are, for instance, hydroperoxides, peroxy carbonates (of the formula —OC(O)OO—), peroxyesters (of the formula —C(O)OO—), diacylperoxides (of the formula —C(O)OOC(O)—), dialkylperoxides (of the formula —OO—), etc.

[0057] The present invention further also relates to cured objects or structural parts prepared from unsaturated polyester resin compositions as described above, by curing with an initiator as described above. As used herein, structural resin compositions are capable of providing structural parts. Generally such resin compositions are non-aqueous systems. They contain at most 5% by weight of water, mainly resulting from the reactions during resin preparation. As meant herein, structural parts are considered to have a thickness of at least 0.5 mm and appropriate mechanical properties. End segments where the resin compositions according to the present invention can be applied are for example automotive parts, boats, chemical anchoring, roofing, construction, containers, relining, pipes, tanks, flooring, windmill blades.

[0058] The present invention in particular relates to cured objects or structural parts obtained by curing of a resin composition according to the invention with an initiator, preferably comprising a peroxide. According to one embodiment, the curing is preferably effected by moulding, more preferably the curing is effected by compression moulding to obtain in particular a SMC or BMC part. The moulding is preferably effected at a temperature of at least 130° C., more preferably at least 140° C.; and at a temperature of at most 170° C., more preferably of at most 160° C.

[0059] The invention is now demonstrated by means of a series of examples and comparative examples. All examples are supportive of the scope of claims. The invention, however, is not restricted to the specific embodiments as shown in the examples.

Standard Resin Synthesis

[0060] The diols, dicarboxylic acids and/or anhydrides, optional inhibitor and catalyst were charged in a reactor equipped with a packed column, a temperature measurement device and inert gas inlet. The mixture was heated slowly by usual methods to 200° C. The mixture in the reactor was kept at 200° C. until the distillation of water stopped. The packed column was removed and the mixture was kept under reduced pressure until the acid value reached a value below 50 mg KOH/g resin. Then the vacuum was relieved with inert gas, and the mixture was cooled down to 130° C. or lower. The solid UP resins were obtained in this way. Next the solid resin was dissolved in a reactive diluent at temperatures below 80° C.

Monitoring of Curing

[0061] Curing was monitored by means of standard gel time equipment. This is intended to mean that both the gel time (T_{gel} or $T_{25->35° C.}$) and peak time (T_{peak} or $T_{25->peak}$) were determined by exotherm measurements according to the method of DIN 16945 when curing the resin with the peroxide as indicated.

Mechanical Property Determination

[0062] For the determination of mechanical properties 4 mm castings were prepared. After 16 hrs the castings were released from the mould and postcured using 24 hr at 60° C. followed by 24 hr at 80° C.

[0063] Mechanical properties of the cured objects were determined according to ISO 527-2. The Heat Distortion Temperature (HDT) was measured according to ISO 75-A.

[0064] The viscosity of the dissolved resin was determined at 23° C. using a Physica instrument.

[0065] Barcoll hardness was determined according to DIN EN59.

Materials

[0066] Biobased itaconic acid, obtained from corn, was commercially obtained from Quingdao Langyatai.

[0067] Biobased 1,3-propane diol, obtained via a fermentation process from corn, was commercially obtained from DuPont Tate & Lyle.

[0068] Biobased isosorbide, obtained from corn, was commercially obtained from Roquette.

[0069] 1,2-Propylene glycol was commercially obtained from BASF.

[0070] Maleic anhydride was commercially obtained from DSM Fine Chemicals.

[0071] 2-methylhydroquinone was commercially obtained from Aldrich.

EXAMPLE 1 AND COMPARATIVE EXPERIMENTS A-C

[0072] Resins were prepared via the standard synthesis procedure with the listed ingredients in table 1. The resins were cured using 0.5% of a cobalt solution (NL-49P) followed by 2% Trigonox 44B as peroxide. The curing was monitored with the gel time equipment.

TABLE 1

	Example 1	Comp A	Comp B	Comp C
Itaconic acid (g)	732	732		
Maleic anhydride (g)			640	640
1,2-Propylene glycol (g)		471		471
1,3-propane diol (g)	471		471	
2-methyl hydroquinone	500 ppm	500	500	500
Acid Value of the resin (mg KOH/g resin)	44	43	31.2	43
Reactive diluent	Styrene	Styrene	Styrene	Styrene
Solids (%)	65	65	65	65
Viscosity @23° C. (mPa · s)	669	840	Solid	1200
Gel time (min)	320	135	Nd	36
Peak time (min)	334	151	Nd	42
Peak temperature (° C.)	143	135	Nd	185
Tensile strength (MPa)	63	77		64
Tensile modulus (GPa)	2.9	3.6		3.6
Elongation @ break (%)	3.1	2.9		2.1
Flexural strength (MPa)	90	105		108
Flexural modulus (GPa)	2.8	3.5		3.7
HDT (° C.)	105	97		109
Barcol hardness	43	43		44

Nd = not determined as a solidified mixture was obtained from the resin. The corresponding casting clearly showed heterogeneity and was a material unsuitable for construction purposed.

[0073] Table 1 clearly shows that a resin with a similar HDT and a lower viscosity can be obtained using a mixture of both itaconate and 1,3-propanediol. This is very surprising considering the fact that using 1,3 propanediol in combination with maleic anhydride resulted in a in solidified mixture which was not applicable whereas using itaconic acid in combination with 1,2-propylene glycol resulted in a lowering of the HDT. Furthermore, a higher elongation is obtained in Example 1. So, only the combination according to the invention yields the very suitable combination of elongation at break, low viscosity and thermal stability.

EXAMPLE 2 AND 3

[0074] Resins were prepared via the standard synthesis procedure with the listed ingredients in table 2. The resins were cured using 0.5% of a cobalt solution (NL-49P) followed by 2% Trigonox 44B as peroxide. The curing was monitored with the gel time equipment.

TABLE 2

	Example 2	Example 3
Itaconic acid (g)	732	732
1,2-Propylene glycol (g)	47	235.5
1,3-propane diol (g)	424	235.5
2-methyl hydroquinone	500 ppm	500 ppm
Acid Value of the resin (mg KOH/g resin)	48	31
Reactive diluent	Styrene	Styrene
Solids (%)	65	65
Viscosity @23° C. (mPa · s)	687	784
Gel time (min)	137	164
Peak time (min)	157	177
Peak temperature (° C.)	131	145
Tensile strength (MPa)	61	64
Tensile modulus (GPa)	3.1	3.3
Elongation @ break (%)	2.5	2.5
Flexural strength (MPa)	117	114
Flexural modulus (GPa)	3.1	3.5
HDT (° C.)	108	104
Barcol hardness	49	42

[0075] These experiments clearly demonstrate that mixtures of starting materials like mixtures of diols can be used according to the invention.

EXAMPLES 4 AND 5

[0076] A resin prepared according to the synthesis procedure of example 1 was diluted with a mixture of styrene and dimethyl itaconate (25/10 ratio) and with butanedioldimethacrylate respectively to a solid content of 65%. The cure results using 0.5% of a cobalt solution (NL-49P) followed by 2% Trigonox 44B as peroxide were as follows:

[0077] Sty/DMI mixture:gel time=75 min, peak time 94 min and peak temperature 113° C.

[0078] BDDMA: gel time=132 min, peak time 159 min and peak temperature 60° C.

[0079] These examples demonstrate that various reactive diluents can be used. Furthermore the dilution with methacrylates also shows that styrene free resin compositions can be obtained according to the invention.

EXAMPLE 6

[0080] A resin was prepared using the standard synthesis procedure using 429.3 g itaconic acid, 117.4 g 1,2-propylene glycol, 117.4 g 1,3-propanediol and 79.6 g isosorbide. After dilution in styrene to a solid content of 65% the resin was cured using 0.5% of a cobalt solution (NL-49P) followed by 2% Trigonox 44B as peroxide. The viscosity @23° C. of the diluted resin was 1700 mPa·s. The curing was monitored with the gel time equipment. resulting in a gel time of 32 min, a peak time of 40 min and a peak exotherm of 153° C. The HDT of the cured object was 105° C.

[0081] This example clearly shows that also other diols can be employed in combination with 1,3-propane diol and itaconic acid.

EXAMPLE 7

[0082] A resin was prepared using the standard synthesis procedure using 429.3 g itaconic acid, 234.8 g 1,3-propanediol and 79.6 g isosorbide. After dilution in styrene to a solid content of 65% the resin was cured using 0.5% of a

cobalt solution (NL-49P) followed by 2% Trigonox 44B as peroxide. The viscosity @23° C. of the diluted resin was 1250 mPa·s. The curing was monitored with the gel time equipment. The resulting cure characteristics are: a gel time of 292 min, a peak time of 305 min and a peak exotherm of 135° C. The HDT of the cured object was 109° C.

[0083] Example 6 and 7 clearly show that also other diols can be employed in combination with 1,3-propane diol and itaconic acid. Furthermore these examples show that isosorbide, being another non-fossil based diol, can be applied in combination with itaconic acid and 1,3-propane diol.

1. Resin composition comprising unsaturated polyester resin and a reactive diluent, wherein the unsaturated polyester comprises 1,3-propane diol building blocks and C5-C10 unsaturated dicarboxylic acid building blocks.

2. Resin composition according to claim **1**, wherein itaconic acid or anhydride is used for the C5 unsaturated dicarboxylic acid building blocks.

3. Resin composition according to claim **1**, wherein at least part of the itaconic acid or anhydride is derived from a non-fossil source and/or at least part of the 1,3-propane diol is derived from a non-fossil source.

4. Resin composition according to claim **1**, wherein the molar amount of 1,3-propane diol is at least 10% relative to the total amount of diols.

5. Resin composition according to claim **1**, wherein at least 25 wt. % of the unsaturated dicarboxylic acid building blocks of the unsaturated polyester are itaconic acid building blocks.

6. Resin composition according to claim **1**, wherein the unsaturated polyester is manufactured by polycondensation of 1,3-propane diol and C5-C10 unsaturated dicarboxylic acid and/or anhydride, and optionally other building blocks selected from other diols and/or polyols, other unsaturated dicarboxylic acids and/or anhydrides, saturated aliphatic dicarboxylic acids and/or anhydrides, and/or aromatic saturated dicarboxylic acids and/or anhydrides.

7. Resin composition according to claim **1**, wherein the unsaturated polyester is manufactured by polycondensation of 1,3-propane diol and C5-C10 unsaturated dicarboxylic acid and/or anhydride, and optionally other building blocks selected from other diols and/or other acids or anhydrides.

8. Resin composition according to claim **1**, wherein the unsaturated polyester is manufactured by polycondensation of 1,3-propane diol, 1,2-propylene glycol and C5-C10 unsaturated dicarboxylic acid and/or anhydride, and optionally other building blocks selected from other diols and/or other acids or anhydrides.

9. Resin composition according to claim **1**, wherein the composition comprises styrene, dimethyl itaconate and/or a methacrylate containing compound as reactive diluent.

10. Cured object or structural part obtained by curing a resin composition according to claim **1** with an initiator.

11. Cured object or structural part according to claim **10**, wherein the initiator comprises a peroxide.

12. A cured object or structural part according to claim **10**, wherein the curing is effected by compression moulding.

13. Use of the cured object or structural part according to claim **10** in automotive parts, boats, chemical anchoring, roofing, construction, containers, relining, pipes, tanks, flooring or windmill blades.

14. Powder coating composition comprising a resin composition according to claim **1**.

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