

Novel stabilizer system for stabilizing halogen-
containing polymers

The invention relates to stabilizer systems

5 encompassing at least one perchlorate salt and at least one or more compounds from the groups consisting of the enamines, indoles and ureas, which are suitable for stabilizing halogen-containing polymers.

10 A halogen-containing polymer, such as PVC, may be stabilized by any of a large number of additives. Compounds of lead, of barium, and of cadmium are particularly well suited to this purpose, but are nowadays controversial for environmental reasons or
15 because of their heavy metal content (cf. "Kunststoffadditive" [Plastics Additives], R. Gächter and H. Müller, Carl Hanser Verlag, 3rd Edition 1989, pp. 303-311 (see also 4th Edition 2001); and "Kunststoff Handbuch PVC" [Plastics Handbook PVC],
20 Volume 2/1, W. Becker and D. Braun, Carl Hanser Verlag, 2nd Edition, 1985, pp. 531-538; and Kirk-Othmer: "Encyclopedia of Chemical Technology", 4th Edition, 1994, Vol. 12, Heat Stabilizers, pp. 1071-1091).

25 There is therefore a continuing search for effective stabilizers and stabilizer systems which are free from lead, barium and cadmium.

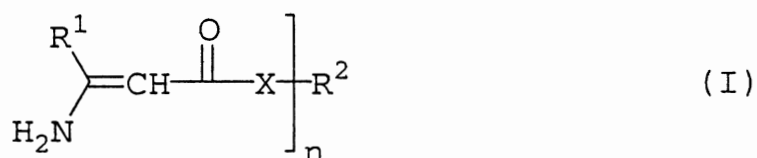
It has now been found that systems made from at least
30 one or more compounds from the groups consisting of the enamines, indoles and ureas, and from at least one perchlorate salt, are particularly highly suitable for stabilizing chlorine-containing polymers, in particular PVC.

specific" effects. This is seen by way of example in Table 1B, from which it is apparent that the use of the organic stabilizer 2-phenylindole and of the free-radical scavenger Wessalith (mixture 1/3) reduces the level of stabilization to an unexpectedly drastic extent when compared with the sole use of the organic stabilizer (mixture 1/1), but the use of the organic stabilizer and of the free-radical scavenger combined with the salt sodium perchlorate as stabilizer (mixture 1/4) results in a surprising, synergistic rise in stability.

The invention accordingly provides stabilizer systems comprising at least

- a) one perchlorate salt and
- b) at least one or more enamines and/or indole and/or ureas

where the enamines have the formula (I)



where

$n = 1$ or 2 and $\text{X} = \text{O}$ or NR^1 ,

$n = 3 - 6$ and $\text{X} = \text{O}$;

$\text{R}^1 = \text{H}$, $\text{C}_1\text{-C}_4\text{-alkyl}$, $\text{C}_2\text{-C}_6\text{-alkenyl}$, $\text{C}_6\text{-C}_{10}\text{-aryl}$, $\text{C}_7\text{-C}_{18}\text{-alkaryl}$ or $\text{C}_7\text{-C}_{18}\text{-aralkyl}$;

R^2 (for $n = 1$) = $\text{C}_1\text{-C}_{22}\text{-alkyl}$, $\text{C}_2\text{-C}_{22}\text{-alkenyl}$ or aryl , preferably phenyl , where appropriate substituted

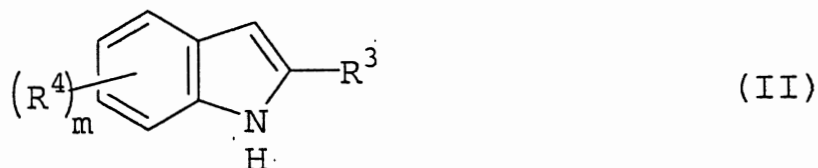
with up to 3 hydroxyl, $\text{C}_1\text{-C}_4\text{-alkoxy}$ or $\text{C}_1\text{-C}_9\text{-alkyl}$; or

R^2 (for $n = 2 - 6$) = linear or branched $\text{C}_n\text{-C}_{22}\text{-alkylene}$, where appropriate interrupted by one or

more O atoms or S atoms, where R^2 (for $n = 3$) may also be $\text{C}_2\text{-C}_3\text{-alkyl-trisubstituted isocyanurate}$;

and if $\text{X} = \text{NH}$, R^2 may also be H, and

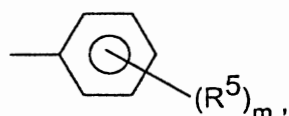
where the indoles have the general formula (II)



5 where

m = 0, 1, 2 or 3;

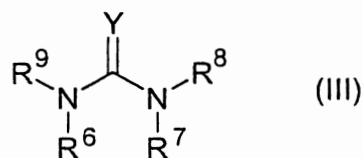
R³ = H, C₁-C₁₈-alkyl, C₂-C₁₈-alkenyl, C₆-C₁₀-aryl or



10 C₇-C₂₄-alkaryl, C₇-C₁₀-aralkyl or C₁-C₄-alkoxy;

R⁴, R⁵ = H, C₁-C₄-alkyl, or C₁-C₄-alkoxy; and

where the ureas have the general formula (III)



15

where

Y = O, S or NH;

10 R⁶, R⁷, R⁸ and R⁹, independently of one another, are
H, C₁-C₁₈-alkyl, where appropriate substituted with
hydroxyl groups and/or C₁-C₄-alkoxy groups, C₂-C₁₈-
alkenyl, C₆-C₁₀-aryl, where appropriate substituted
with up to 3 hydroxyl and/or C₁-C₄-alkyl/alkoxy
groups, C₇-C₂₀-alkaryl or C₇-C₁₀-aralkyl, and two
25 substituents from R⁶ to R⁹ may also form a ring, and
the urea used may also be a dimerized or trimerized
urea, e.g. biuret, triuret or 1,3,5-
tris(hydroxyalkyl) isocyanurate;

30 and possible reaction products of these.

Examples of the enamines of the general formula (I) (X = O or NH) are compounds where R^1 = hydrogen, methyl, ethyl, *n*-propyl, *iso*-propyl, *n*-butyl, *iso*-butyl, *sec*-butyl, *tert*-butyl, allyl, phenyl or benzyl, R^2 (for
5 $n = 1$) = 1-octyl, 2-ethylhexyl, *n*-decyl, *n*-dodecyl, *n*-tetradecyl, *n*-hexadecyl, *n*-octadecyl, oleyl, dihydroxystearyl, trihydroxystearyl or ricinoyl, R^2 (for $n = 2$) = derived from the corresponding $R^2-(OH)_2$ compound ethanediol, 1,4-butanediol, 1,3-butanediol,
10 2,3-butanediol, 1,6-hexanediol, neopentylene glycol, dialkylene glycol, trialkylene glycol, tetraalkylene glycol, pentaalkylene glycol, hexaalkylene glycol, preferably where alkylene = ethylene, propylene or butylene, thio(dialkylene glycol), dithio(trialkylene
15 glycol), trithio(tetraalkylene glycol), tetrathio(pentaalkylene glycol), pentathio(hexaalkylene glycol), preferably where alkylene = ethylene, or neopentylene glycol, R^2 (for $n = 3$) = derived from the corresponding $R^2-(OH)_3$ compound glycerol, tris(hydroxyethyl)
20 isocyanurate, tris(hydroxypropyl) isocyanurate, trimethylolethane or trimethylolpropane, R^2 (for $n = 4$) = derived from the corresponding $R^2-(OH)_4$ compound erythritol, xylitol, pentaerythritol, bis(trimethylol)ethane or bis(trimethylol)propane, R^2
25 (for $n = 6$) = derived from the corresponding $R^2-(OH)_6$ compound sorbitol, mannitol or dipentaerythritol.

Preference is given to enamines where R^1 = methyl or phenyl.

30

The enamines of the general formula (I) may be prepared by known methods, by acylating and aminating the corresponding R^2-OH or R^2-NH_2 compound (see inter alia DE-C 1,544,768).

35

Preference is given to β -aminocrotonic ester compounds and β -aminocinnamic ester compounds of the general formula (I). Particularly preferred compounds of the

general formula (I) are 1,4-butanediol bis(β -aminocrotonate), 2,3-butanediol bis(β -aminocrotonate), 1,2-dipropylene glycol bis(β -aminocrotonate) and thio (diethylene glycol) bis(β -aminocrotonate).

5

Examples of the indoles of the general formula (II) are compounds where R^3 = methyl, ethyl, propyl, phenyl, allyl or benzyl, and R^4 = methyl, ethyl, propyl or butyl. Preference is given to compounds of the general
10 formula (II) where R^3 = phenyl or phenyllauryl and R^4 = hydrogen.

Compounds of the general formula (II) may be prepared by known methods (see, inter alia, DE-C 862,512).

15 Examples of these compounds are indole, 2-phenylindole, 2-phenyllaurylindole, 2-allylindole, 2-benzylindole, 2-phenylethylindole, 2-methylindole, 2-ethylindole, 2-propylindole, 2-butylindole and 2-phenyl-5-methylindole. Preference is given to 2-phenylindole and
20 2-phenyllaurylindole, and also 2-methylindole and 2-ethylindole.

2-Phenylindole is a particularly preferred compound of the general formula (II).

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Examples of ureas of the general formula (III) are compounds where R^6 , R^7 , R^8 or R^9 = hydrogen, methyl, phenyl, benzyl, phenethyl, hydroxyethyl, hydroxypropyl or hydroxybutyl. Preference is given to compounds of
30 the general formula (III) where R^6 , R^7 , R^8 or R^9 = phenyl or benzyl.

Compounds of the general formula (III) may be prepared by known methods (see, inter alia, DE-C 746,081, Italian Patent 386,750). Examples of these compounds
35 are urea, N,N'-diphenylthiourea, N,N'-diphenylurea, N,N'-dibenzylthiourea, N,N'-dibenzylurea, N,N'-dimethylthiourea, N-benzylthiourea, N,N-dibenzylthiourea and N,N,N'-tribenzylthiourea, N,N'-

diphenylguanidine, biuret and triuret. Preference is given to examples having phenyl and, respectively, ethylene- and propyleneurea, and also N,N'-bis(hydroxyethyl)urea and tris(hydroxyethyl/propyl) isocyanurate.

Particularly preferred compounds of the general formula (III) are N,N'-diphenylthiourea and N-phenylurea.

- 10 The perchlorate salts are known to the person skilled in the art. Examples of these are those of the formula $M(ClO_4)_n$, where M is Li, Na, K, Mg, Ca, Sr, Ba, Zn, Al, La or Ce; and n is 1, 2 or 3, depending on the valency of M. Use may be made of these perchlorate salts in
15 their various commonly encountered forms, e.g. as salt or as solution in water or in an organic solvent, on their own or absorbed on a support, such as PVC, Ca silicate, zeolites or hydrotalcites. Examples of these are perchlorate salts complexed or dissolved using
20 alcohols (polyols, cyclodextrins) or using ether alcohols or ester alcohols or crown ethers. EP 0 394 547, EP 0 457 471 and WO 94/24200 describe other embodiments.
- 25 It is preferable to use sodium perchlorate or potassium perchlorate.

- The invention also provides combinations of the stabilizer systems encompassing at least one
30 perchlorate salt and at least one or more compounds from the groups consisting of the compounds of the general formula (I) or (II) or (III) with at least one or more other conventional additives or stabilizers. Preference is given to polyols and/or disaccharide
35 alcohols, glycidyl compounds, hydrotalcites, zeolites (alkali metal aluminosilicates and alkaline earth metal aluminosilicates), fillers, metal soaps, alkali metal and alkaline earth metal compounds, such as oxides and

hydroxides, lubricants, plasticizers, phosphites, pigments, epoxidized fatty esters and other epoxy compounds, antioxidants, UV absorbers and light stabilizers, optical brighteners and blowing agents.

- 5 Particular preference is given to epoxidized soya oils, alkaline earth metal or aluminium soaps and phosphites.

Particular preference is given to those components which are suitable for producing physiologically non-hazardous products.

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Examples of additional components of this type are listed and explained at a later stage below (cf. "Handbook of PVC Formulating" by E. J. Wickson, John Wiley & Sons, New York, 1993 and Synoptic Document No. 7, Scientific Committee for Food (SCF) - EU).

15

Polyols and disaccharide alcohols

Examples of possible compounds of this type are:

20 glycerol, pentaerythritol, dipentaerythritol, tripentaerythritol, trimethylolethane, bis(trimethylolpropane), polyvinyl alcohol, bis(trimethylolethane), trimethylolpropane, sugars, sugar alcohols.

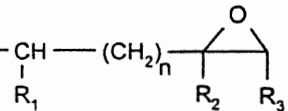
- 25 Of these, preference is given to pentaerythritol, trimethylolpropane, sorbitol and the disaccharide alcohols such as Malbit, lactitol and cellobiitol, and also Palatinit.

It is also possible to use polyol syrups, such as sorbitol syrup, mannitol syrup and maltitol syrup.

30 Examples of the amounts of the polyols used are from 0.01 to 20 parts by weight, advantageously from 0.1 to 20 parts by weight and in particular from 0.1 to 10 parts by weight, based on 100 parts by weight of PVC.

35

Glycidyl compounds

These contain the glycidyl group $\text{---CH---(CH}_2\text{)}_n\text{---}$ 

bonded directly to carbon, oxygen, nitrogen or sulphur atoms, either where both of R_1 and R_3 are hydrogen, R_2 is hydrogen or methyl and $n = 0$ or where R_1 and R_3

5 together are $\text{---CH}_2\text{---CH}_2\text{---}$ or $\text{---CH}_2\text{---CH}_2\text{---CH}_2\text{---}$, R_2 then being hydrogen and n being 0 or 1.

It is preferable to use glycidyl compounds having two functional groups. However, it is also possible in principle to use glycidyl compounds having one, three
10 or more functional groups.

Use is predominantly made of diglycidyl compounds having aromatic groups.

The amounts used of the terminal epoxy compounds are preferably at least 0.1 part, preferably from 0.1 to 50
15 parts by weight, advantageously from 1 to 30 parts by weight and in particular from 1 to 25 parts, based on 100 parts by weight of PVC.

Hydrotalcites

20 The chemical composition of these compounds is known to the skilled worker, e.g. from the patents DE 3 843 581, US 4,000,100, EP 0 062 813 and WO 93/20135.

Compounds from the hydrotalcite series may be described by the following general formula

25 $M^{2+}_{1-x}M^{3+}_x(OH)_2(A^{b-})_{x/b} \cdot d H_2O$,

where

M^{2+} = one or more of the metals selected from the group consisting of Mg, Ca, Sr, Zn and Sn

M^{3+} = Al or B,

30 A^n an anion of valency n ,

b is a number from 1-2,

$0 < x < 0.5$,

d is a number from 0-20.

Preference is given to compounds with

35 $A^n = OH^-$, ClO_4^- , HCO_3^- , CH_3COO^- , $C_6H_5COO^-$, CO_3^{2-} ,
 $(CHOHCOO)_2^{2-}$, $(CH_2COO)_2^{2-}$, $CH_3CHOHCOO^-$, HPO_3^- or HPO_4^{2-} ;

Examples of hydrotalcites are

$\text{Al}_2\text{O}_3 \cdot 6\text{MgO} \cdot \text{CO}_2 \cdot 12\text{H}_2\text{O}$ (i), $\text{Mg}_{4.5}\text{Al}_2(\text{OH})_{13} \cdot \text{CO}_3 \cdot 3 \cdot 5\text{H}_2\text{O}$ (ii),
 $4\text{MgO} \cdot \text{Al}_2\text{O}_3 \cdot \text{CO}_2 \cdot 9\text{H}_2\text{O}$ (iii), $4\text{MgO} \cdot \text{Al}_2\text{O}_3 \cdot \text{CO}_2 \cdot 6\text{H}_2\text{O}$,
 $\text{ZnO} \cdot 3\text{MgO} \cdot \text{Al}_2\text{O}_3 \cdot \text{CO}_2 \cdot 8-9\text{H}_2\text{O}$ and $\text{ZnO} \cdot 3\text{MgO} \cdot \text{Al}_2\text{O}_3 \cdot \text{CO}_2 \cdot 5-6\text{H}_2\text{O}$.

- 5 Very particular preference is given to types (i), (ii) and (iii).

Zeolites (aluminosilicates of alkali metals and/or of alkaline earth metals)

- 10 These may be described by the following general formula $\text{M}_{x/n}[(\text{AlO}_2)_x(\text{SiO}_2)_y] \cdot w\text{H}_2\text{O}$, where n is the charge on the cation M;

M is an element of the first or second main group, such as Li, Na, K, Mg, Ca, Sr or Ba;

- 15 y : x is a number from 0.8 to 15, preferably from 0.8 to 1.2; and

w is a number from 0 to 300, preferably from 0.5 to 30.

Examples of zeolites are sodium aluminosilicates of the formulae

- 20 $\text{Na}_{12}\text{Al}_{12}\text{Si}_{12}\text{O}_{48} \cdot 27 \text{H}_2\text{O}$ [zeolite A], $\text{Na}_6\text{Al}_6\text{Si}_6\text{O}_{24} \cdot 2 \text{NaX} \cdot 7.5 \text{H}_2\text{O}$, X = OH, halogen, ClO_4 [sodalite]; $\text{Na}_6\text{Al}_6\text{Si}_{30}\text{O}_{72} \cdot 24 \text{H}_2\text{O}$; $\text{Na}_8\text{Al}_8\text{Si}_{40}\text{O}_{96} \cdot 24 \text{H}_2\text{O}$; $\text{Na}_{16}\text{Al}_{16}\text{Si}_{24}\text{O}_{80} \cdot 16 \text{H}_2\text{O}$;
 $\text{Na}_{16}\text{Al}_{16}\text{Si}_{32}\text{O}_{96} \cdot 16 \text{H}_2\text{O}$; $\text{Na}_{56}\text{Al}_{56}\text{Si}_{136}\text{O}_{384} \cdot 250 \text{H}_2\text{O}$ [zeolite Y], $\text{Na}_{86}\text{Al}_{86}\text{Si}_{106}\text{O}_{384} \cdot 264 \text{H}_2\text{O}$ [zeolite X];

- 25 or the zeolites which can be prepared by partial or complete exchange of the Na atoms by Li atoms, K atoms, Mg atoms, Ca atoms, Sr atoms or Zn atoms, for example
 $(\text{Na},\text{K})_{10}\text{Al}_{10}\text{Si}_{22}\text{O}_{64} \cdot 20 \text{H}_2\text{O}$; $\text{Ca}_{4.5}\text{Na}_3[(\text{AlO}_2)_{12}(\text{SiO}_2)_{12}] \cdot 30 \text{H}_2\text{O}$;
 $\text{K}_9\text{Na}_3[(\text{AlO}_2)_{12}(\text{SiO}_2)_{12}] \cdot 27 \text{H}_2\text{O}$.

- 30 Very particular preference is given to Na zeolite A and Na zeolite P.

The hydrotalcites and/or zeolites may be used in amounts of, for example, 0.1 to 20 parts by weight, expediently 0.1 to 10 parts by weight and in particular
 35 0.1 to 5 parts by weight, based on 100 parts by weight of halogen-containing polymer.

Fillers

Fillers such as calcium carbonate, dolomite, wollastonite, magnesium oxide, magnesium hydroxide, silicates, china clay, talc, glass fibres, glass beads, wood flour, mica, metal oxides or metal hydroxides, carbon black, graphite, rock flour, heavy spar, glass fibres, talc, kaolin and chalk are used. Preference is given to chalk (HANDBOOK OF PVC FORMULATING, E. J. Wickson, John Wiley & Sons, Inc., 1993, pp. 393 - 449) and reinforcing agents (TASCHENBUCH der Kunststoffadditive [Plastics Additives Handbook], R. Gächter & H. Müller, Carl Hanser, 1990, pp. 549 - 615).

The fillers may be used in amounts of preferably at least one part by weight, for example 5 to 200 parts by weight, expediently 10 to 150 parts by weight and in particular from 15 to 100 parts by weight, based on 100 parts by weight of PVC.

Metal soaps

Metal soaps are primarily metal carboxylates, preferably of relatively long-chain carboxylic acids. Well-known examples of these are stearates, oleates, palmitates, ricinolates, hydroxystearates, dihydroxystearates and laurates, and also oleates and salts of relatively short-chain aliphatic or aromatic carboxylic acids, such as acetic acid, propionic acid, butyric acid, valeric acid, hexanoic acid, sorbic acid, oxalic acid, malonic acid, maleic acid, anthranilic acid, succinic acid, glutaric acid, adipic acid, fumaric acid, citric acid, benzoic acid, salicylic acid, phthalic acids, hemimellitic acid, trimellitic acid, pyromellitic acid.

Metals which should be mentioned are: Li, Na, K, Mg, Ca, Sr, Ba, Zn, Al, La, Ce and rare earth metals. Use is frequently made of so-called synergistic mixtures, such as barium/zinc stabilizers, magnesium/zinc stabilizers, calcium/zinc stabilizers or calcium/magnesium/zinc stabilizers. The metal soaps may

be used either alone or in mixtures. An overview of common metal soaps is found in Ullmann's Encyclopedia of Industrial Chemistry, 5th Ed., Vol. A16 (1985), pp. 361 et seq.

- 5 The metal soaps or mixtures of these may be used in amounts of, for example, 0.001 to 10 parts by weight, expediently 0.01 to 8 parts by weight, particularly preferably 0.05 to 5 parts by weight, based on 100 parts by weight of PVC.

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Alkali metal and alkaline earth metal compounds

- For the purposes of the present invention, these are mainly the carboxylates of the acids described above, but also corresponding oxides or, respectively,
- 15 hydroxides or carbonates. Mixtures of these with organic acids are also possible. Examples are LiOH, NaOH, KOH, CaO, Ca(OH)₂, MgO, Mg(OH)₂, Sr(OH)₂, Al(OH)₃, CaCO₃ and MgCO₃ (and also basic carbonates, such as magnesia alba and huntite), and also fatty-acid salts
- 20 of Na and of K. In the case of alkaline earth carboxylates and Zn carboxylates it is also possible to use adducts of these with MO or M(OH)₂ (M = Ca, Mg, Sr or Zn), so-called "overbased" compounds. In addition to the stabilizers according to the invention it is
- 25 preferable to use alkali metal carboxylates, alkaline earth metal carboxylates and/or aluminium carboxylates.

Lubricants

- Examples of possible lubricants are: fatty acids, fatty
- 30 alcohols, montan wax, fatty acid esters, PE waxes, amide waxes, chloroparaffins, glycerol esters and alkaline earth metal soaps, and fatty ketones, and also the lubricants, or combinations of the lubricants, listed in EP 0 259 783. Stearic acid, stearic esters
- 35 and calcium stearate are preferred.

Plasticizers

Examples of organic plasticizers are those from the following groups and mixtures thereof:

- A) Phthalates: such as preferably di-2-ethylhexyl, diisononyl and diisodecyl phthalate, also known by the common abbreviations DOP (dioctyl phthalate, di-2-ethylhexyl phthalate), DINP (diisononyl phthalate), DIDP (diisodecyl phthalate), di(ⁿC₉-C₁₂)phthalates, e.g. [sic] esters of aliphatic dicarboxylic acids, in particular esters of adipic, azelaic or sebacic acid: preferably di-2-ethylhexyl adipate and diisooctyl adipate.
- C) Trimellitic esters, such as tri-2-ethylhexyl trimellitate, triisodecyl trimellitate (mixture), triisotridecyl trimellitate, triisooctyl trimellitate (mixture), and also tri-C₆-C₈-alkyl, tri-C₆-C₁₀-alkyl, tri-C₇-C₉-alkyl and tri-C₉-C₁₁-alkyl trimellitate. Common abbreviations are TOTM (trioctyl trimellitate, tri-2-ethylhexyl trimellitate), TIDTM (triisodecyl trimellitate) and TITDTM (triisotridecyl trimellitate).
- D) Epoxy plasticizers: these are primarily epoxidized unsaturated fatty acids, e.g. epoxidized soybean oil (as described under the epoxidized fatty esters).
- E) Polymeric plasticizers: the commonest starting materials for preparing polyester plasticizers are: dicarboxylic acids, such as adipic, phthalic, azelaic or sebacic acid; diols, such as 1,2-propanediol, 1,3-butanediol, 1,4-butanediol, 1,6-hexanediol, neopentyl glycol and diethylene glycol.
- F) Phosphoric esters: a definition of these esters is given in the abovementioned "Taschenbuch der Kunststoffadditive" ["Plastics Additives Handbook"], Chapter 5.9.5, pp. 408-412. Examples of these phosphoric esters are tributyl phosphate, tri-2-ethylbutyl phosphate, tri-2-ethylhexyl phosphate, trichloroethyl phosphate, 2-ethylhexyl diphenyl phosphate, cresyl diphenyl phosphate, triphenyl phosphate, tricresyl phosphate and trixylenyl phosphate.

- G) Chlorinated hydrocarbons (paraffins)
- H) Hydrocarbons
- I) Monoesters, e.g. butyl oleate, phenoxyethyl oleate, tetrahydrofurfuryl oleate and alkylsulphonates.
- 5 J) Glycol esters, e.g. diglycol benzoates.
- K) Citric esters

A definition of these plasticizers and examples of the same are given in "Kunststoffadditive" ["Plastics Additives"], R. Gächter/H. Müller, Carl Hanser Verlag, 10 3rd Ed., 1989, Chapter 5.9.6, pp. 412 - 415, and in "PVC Technology", W. V. Titow, 4th Ed., Elsevier Publ., 1984, pp. 165 - 170. It is also possible to use mixtures of different plasticizers.

15 The plasticizers may be used in amounts of, for example, 5 to 20 parts by weight, expediently 10 to 20 parts by weight, based on 100 parts by weight of PVC. Rigid or semirigid PVC comprises preferably up to 10%, particularly preferably up to 5%, of plasticizer, 20 or no plasticizer.

Pigments

Suitable substances are known to the skilled worker. Examples of inorganic pigments are TiO_2 , pigments based 25 on zirconium oxide, BaSO_4 , zinc oxide (zinc white) and lithopones (zinc sulphide/barium sulphate), carbon black, carbon black-titanium dioxide mixtures, iron oxide pigments, Sb_2O_3 , $(\text{Ti}, \text{Ba}, \text{Sb})\text{O}_2$, Cr_2O_3 , spinels, such as cobalt blue and cobalt green, $\text{Cd}(\text{S}, \text{Se})$, ultramarine 30 blue. Examples of organic pigments are azo pigments, phthalocyanine pigments, quinacridone pigments, perylene pigments, diketopyrrolopyrrole pigments and anthraquinone pigments. TiO_2 in micronized form is also preferred. Mixtures of various pigments may also be 35 used. A definition and further descriptions are found in the "Handbook of PVC Formulating", E.J. Wickson, John Wiley & Sons, New York, 1993.

Phosphites (triesters of phosphorous acid)

Organic phosphites are known costabilizers for chlorine-containing polymers. Examples of these are trioctyl, tridecyl, tridodecyl, tritridecyl, tripentadecyl, trioleyl, tristearyl, triphenyl, tricresyl, tris(nonylphenyl), tris(2,4-tert-butylphenyl) and tricyclohexyl phosphite.

Other suitable phosphites are various mixed aryl dialkyl or alkyl diarylphosphites, such as phenyl dioctyl, phenyl didecyl, phenyl didodecyl, phenyl ditridecyl, phenyl ditetradecyl, phenyl dipentadecyl, octyl diphenyl, decyl diphenyl, undecyl diphenyl, dodecyl diphenyl, tridecyl diphenyl, tetradecyl diphenyl, pentadecyl diphenyl, oleyl diphenyl, stearyl diphenyl and dodecyl bis(2,4-di-tert-butylphenyl) phosphite.

Advantageous use may also be made of phosphites of various di- or polyols: e.g. tetraphenyldipropylene glycol diphosphite, polydipropylene glycol phenyl phosphite, tetramethylolcyclohexanol decyl diphosphite, tetramethylolcyclohexanol butoxyethoxyethyl diphosphite, tetramethylolcyclohexanol nonylphenyl diphosphite, bis(nonylphenyl) di(trimethylolpropane) diphosphite, bis(2-butoxyethyl) di(trimethylolpropane) diphosphite, tris(hydroxyethyl) isocyanurate hexadecyl triphosphite, didecyl pentaerythrityl diphosphite, distearyl pentaerythrityl diphosphite, bis(2,4-di-tert-butylphenyl) pentaerythrityl diphosphite, and also mixtures of these phosphites and aryl/alkyl phosphite mixtures of empirical composition $(H_{19}C_9-C_6H_4O)_{1.5}P(OC_{12,13}H_{25,27})_{1.5}$ or $[C_8H_{17}-C_6H_4-O-]_2P[i-C_8H_{17}O]$, $(H_{19}C_9-C_6H_4O)_{1.5}P(OC_{9,11}H_{19,23})_{1.5}$.

Industrial examples are Naugard P, Mark CH 300, Mark CH 301, Mark CH 302, Mark CH 304 and Mark CH 55.

Examples of total amounts of the organic phosphites used, or of mixtures thereof, are from 0.01 to 10 parts by weight, advantageously from 0.05 to 5, and in

particular from 0.1 to 3 parts by weight, based on 100 parts by weight of PVC.

Epoxidized fatty acid esters and other epoxy compounds

5 The stabilizer combination of the invention may additionally and preferably comprise at least one epoxidized fatty acid ester. Possible compounds here are especially esters of fatty acids from natural
10 sources (fatty acid glycerides), such as soya oil or rapeseed oil. However, it is also possible to use synthetic products, such as epoxidized butyl oleate. Use may also be made of epoxidized polybutadiene and polyisoprene, if desired also in a partially
15 hydroxylated form, or of glycidyl acrylate and glycidyl methacrylate as homo- or copolymer. These epoxy compounds may also have been applied to an alumino salt compound; in this connection see also DE-A-4 031 818. Examples of total amounts of the epoxy compounds used
20 are preferably at least 0.1 part by weight, for example from 0.1 to 50 parts by weight, advantageously from 1 to 30 and in particular from 1 to 25 parts by weight, based on 100 parts by weight of PVC.

Antioxidants

25 Alkylated monophenols, e.g. 2,6-di-tert-butyl-4-methylphenol, alkylthiomethylphenols, e.g. 2,4-di-octylthiomethyl-6-tert-butylphenol, alkylated hydroquinones, e.g. 2,6-di-tert-butyl-4-methoxyphenol, hydroxylated thiodiphenyl ethers, e.g. 2,2'-thiobis(6-
30 tert-butyl-4-methylphenol), alkylidenebisphenols, e.g. 2,2'-methylenebis(6-tert-butyl-4-methylphenol), benzyl compounds, e.g. 3,5,3',5'-tetratert-butyl-4,4'-dihydroxydibenzyl ether, hydroxybenzylated malonates, e.g. dioctadecyl 2,2-bis(3,5-di-tert-butyl-2-
35 hydroxybenzyl) malonate, hydroxybenzyl aromatics, e.g. 1,3,5-tris(3,5-di-tert-butyl-4-hydroxybenzyl)-2,4,6-trimethylbenzene, triazine compounds, e.g. 2,4-bis(octylmercapto)-6-(3,5-di-tert-butyl-4-

hydroxyanilino)-1,3,5-triazine, phosphonates and phosphonites, e.g. dimethyl 2,5-di-tert-butyl-4-hydroxybenzylphosphonate, acylaminophenols, e.g. 4-hydroxylauranilide, esters of beta-(3,5-ditert-butyl-4-hydroxyphenyl)propionic acid, beta-(5-tert-butyl-4-hydroxy-3-methylphenyl)propionic acid, beta-(3,5-dicyclohexyl-4-hydroxyphenyl)propionic acid, esters of 3,5-ditert-butyl-4-hydroxyphenylacetic acid with mono- or polyhydric alcohols, amides of beta-(3,5-ditert-butyl-4-hydroxyphenyl)propionic acid, such as, for example, N,N'-bis(3,5-ditert-butyl-4-hydroxyphenyl-propionyl)hexamethylenediamine, vitamin E (tocopherol) and derivatives. Mixtures of the antioxidants may also be used.

Industrial examples are Naugard 10, Naugard 76, Naugard BHT and Naugard 45.

Examples of the amounts of the antioxidants used are from 0.01 to 10 parts by weight, advantageously from 0.1 to 10 parts by weight and in particular from 0.1 to 5 parts by weight, based on 100 parts by weight of PVC.

UV absorbers and light stabilizers

Examples of these are: 2-(2'-hydroxyphenyl)benzotriazoles, such as 2-(2'-hydroxy-5'-methylphenyl)-benzotriazole, 2-hydroxybenzophenones, esters of unsubstituted or substituted benzoic acids, such as 4-tert-butylphenyl salicylate, phenyl salicylate, acrylates, nickel compounds, oxalamides, such as 4,4'-dioctyloxyoxanilide, 2,2'-dioctyloxy-5,5'-ditert-butylloxanilide, 2-(2-hydroxyphenyl)-1,3,5-triazines, such as 2,4,6-tris(2-hydroxy-4-octyloxyphenyl)-1,3,5-triazine, 2-(2-hydroxy-4-octyloxyphenyl)-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine, sterically hindered amines, such as bis(2,2,6,6-tetramethylpiperidin-4-yl)sebacate, bis(2,2,6,6-tetramethylpiperidin-4-yl)succinate. Mixtures of the UV absorbers and/or light stabilizers may also be used.

Blowing agents

Examples of blowing agents are organic azo compounds and organic hydrazo compounds, tetrazoles, oxazines, isatoic anhydride, and also soda and sodium

- 5 bicarbonate. Preference is given to azodicarbonamide and sodium bicarbonate and also mixtures of these.

Definitions for and examples of impact modifiers and processing aids, gelling agents, antistats, biocides, 10 metal deactivators, optical brighteners, flame retardants, antifogging agents and compatibilizers are given in "Kunststoffadditive" ["Plastics Additives"], R. Gächter/H. Müller, Carl Hanser Verlag, 3rd and 4th Ed., 1989 and 2001, and in "Handbook of Polyvinyl 15 Chloride Formulating", E. J. Wilson, J. Wiley & Sons, 1993, and also in "Plastics Additives", G. Pritchard, Chapman & Hall, London, 1st edition, 1998.

Impact modifiers are also described in detail in "Impact Modifiers for PVC", J. T. Lutz/D. L. 20 Dunkelberger, John Wiley & Sons, 1992.

Use may be made of one or more additives and/or mixtures thereof may be used.

- 25 The invention also provides compositions which comprise a chlorine-containing polymer and a stabilizer system of the invention.

The invention also provides compositions which comprise 30 a chlorine-containing polymer and a stabilizer system of the invention in addition to one or more other components from one of the groups exemplified by glycidyl compounds, phosphites, hydrotalcites, zeolites, and alkali metal and alkaline earth metal 35 compounds and epoxidized fatty esters.

The amounts of these compounds of the general formulae (I), (II) and (III) present for stabilization in these

chlorine-containing polymer compositions are advantageously from 0.01 to 10 parts by weight, preferably from 0.05 to 5 parts by weight, in particular from 0.1 to 2 parts by weight based on 100 parts by weight of PVC.

Examples of the amount used of the perchlorate compounds are from 0.001 to 5 parts by weight, advantageously from 0.01 to 3 parts by weight, particularly preferably from 0.01 to 2 parts by weight, based on 100 parts by weight of PVC.

The co-additives such as glycidyl compounds, phosphites, hydrotalcites, zeolites, and alkali metal and alkaline earth metal compounds and epoxidized fatty esters are used at from 0.01 to 15 parts by weight, preferably from 0.1 to 10 parts by weight, in particular from 2 to 3 parts by weight.

Examples of the chlorine-containing polymers to be stabilized are:
polymers of vinyl chloride, of vinylidene chloride, vinyl resins whose structure contains vinyl chloride units, such as copolymers of vinyl chloride and vinyl esters of aliphatic acids, in particular vinyl acetate, copolymers of vinyl chloride with esters of acrylic or methacrylic acid and with acrylonitrile, copolymers of vinyl chloride with diene compounds and with unsaturated dicarboxylic acids or anhydrides of these, such as copolymers of vinyl chloride with diethyl maleate, diethyl fumarate or maleic anhydride, postchlorinated polymers and copolymers of vinyl chloride, copolymers of vinyl chloride and vinylidene chloride with unsaturated aldehydes, ketones and others, such as acrolein, crotonaldehyde, vinyl methyl ketone, vinyl methyl ether, vinyl isobutyl ether and the like; polymers of vinylidene chloride and copolymers of the same with vinyl chloride and with

other polymerizable compounds; polymers of vinyl
chloroacetate and of dichlorodivinyl ether; chlorinated
polymers of vinyl acetate, chlorinated polymeric esters
of acrylic acid and of alpha-substituted acrylic acid;
5 polymers of chlorinated styrenes, such as
dichlorostyrene; chlorinated rubbers; chlorinated
polymers of ethylene; polymers and postchlorinated
polymers of chlorobutadiene and copolymers of these
with vinyl chloride, chlorinated natural or synthetic
10 rubbers, and also mixtures of the polymers mentioned
with themselves or with other polymerizable compounds.
For the purposes of this invention, PVC includes
copolymers with polymerizable compounds, such as
acrylonitrile, vinyl acetate or ABS, where these may be
15 suspension polymers, bulk polymers or else emulsion
polymers. Preference is given to a PVC homopolymer,
also in combination with polyacrylates.

Other possible polymers are graft polymers of PVC with
20 EVA, ABS or MBS. Other preferred substrates are
mixtures of the abovementioned homo- and copolymers, in
particular vinyl chloride homopolymers, with other
thermoplastic or/and elastomeric polymers, in
particular blends with ABS, MBS, NBR, SAN, EVA, CPE,
25 MBAS, PMA, PMMA, EPDM or with polylactones, in
particular from the group consisting of ABS, NBR, NAR,
SAN and EVA. The abbreviations used for the copolymers
are familiar to the skilled worker and have the
following meanings: ABS: acrylonitrile-butadiene-
30 styrene; SAN: styrene-acrylonitrile; NBR:
acrylonitrile-butadiene; NAR: acrylonitrile-acrylate;
EVA: ethylene-vinyl acetate. Other possible polymers
are in particular styrene-acrylonitrile copolymers
based on acrylate (ASA). A preferred component in this
35 context is a polymer composition which comprises, as
components (i) and (ii), a mixture of 25-75% by weight
of PVC and 75-25% by weight of the copolymers
mentioned. Components of particular importance are

compositions made from (i) 100 parts by weight of PVC and (ii) 0-300 parts by weight of ABS and/or SAN-modified ABS and 0-80 parts by weight of the copolymers NBR, NAR and/or EVA, but in particular EVA.

5

For the purposes of the present invention it is also possible to stabilize in particular recycled materials of chlorine-containing polymers, specifically the polymers described in more detail above, which have
10 been degraded by processing, use or storage. Recycled material from PVC is particularly preferred.

The compounds which may be used concomitantly according to the invention, and also the chlorine-containing
15 polymers, are well known to the skilled worker and are described in detail in "Kunststoffadditive" ["Plastics Additives"], R. Gächter/H. Müller, Carl Hanser Verlag, 3rd and 4th Ed., 1989 and 2001; in DE 197 41 778 and in EP-A 99 105 418.0 of 17.03.1999, which are incorporated
20 herein by way of reference.

The stabilization according to the invention is particularly advantageous for rigid PVC formulations for transparent and non-transparent applications, as
25 are common in pipes, profiles and sheets. For transparent applications, use is preferably made of compounds of the formula (I) or (II) or (III) which have a melting point below about 190°C. The stabilization is also useful for semirigid and flexible
30 formulations, and also in plastisols. The stabilization requires no heavy metal compounds (Sn stabilizers, Pb stabilizers, Cd stabilizers, Zn stabilizers) and is particularly highly suitable for producing physiologically acceptable consumer products from PVC,
35 including products for medical use.

The stabilizer systems may advantageously be incorporated by the following methods: as emulsion or

dispersion; as a dry mixture during the mixing of added components or polymer mixtures; by direct addition into the processing apparatus (e.g. calender, mixer, kneader, extruder or the like) or as a solution or melt or, respectively, as flakes or pellets in a dust-free form as one-pack.

The PVC stabilized according to the invention, which is also provided by the invention, may be prepared in a manner known per se, by using equipment known per se, such as the abovementioned processing apparatus, to mix the stabilizer system of the invention and, if desired, other additives, with the PVC. The stabilizers here may be added individually or in a mixture, or else in the form of what are known as masterbatches.

The PVC stabilized as in the present invention may be brought into the desired shape in a known manner. Examples of processes of this type are grinding, calendering, extruding, injection moulding and spinning, and also extrusion blowmoulding. The stabilized PVC may also be processed to give foams.

A PVC stabilized according to the invention is, particularly suitable for example, for hollow articles (bottles), packaging films (thermoformed films), blown films, pipes, foams, heavy profiles (window frames), translucent-wall profiles, construction profiles, sidings, fittings, office sheeting and apparatus housings (computers, household devices).

Preference is given to rigid PVC foam moldings and PVC pipes, for example for drinking water or wastewater, pressure pipes, gas pipes, cable-duct pipes and cable-protection pipes, pipes for industrial pipelines, drainpipes, outflow pipes, gutter pipes and drainage pipes. For more detail in this connection see "Kunststoffhandbuch PVC" ["Plastics Handbook PVC"], Vol. 2/2, W. Becker/H. Braun, 2nd Ed., 1985, Carl Hanser Verlag, pp. 1236 - 1277.

The examples below illustrate the invention but do not restrict the same. As in the remainder of the description, parts and percentages given are based on
5 weight.

Example 1: Dehydrochlorination test on treated PVC powder

The mixtures made from PVC + additives in accordance
5 with Tables 1A-5A and Table 7 below were pasted or
dissolved using 150 ml of methanol. The mixture was
then concentrated to dryness on a rotary evaporator at
reduced pressure (< 50 mbar) at a bath temperature of
40-45°C.

10

The PVC powder treated in accordance with this
specification was then subjected to a
dehydrochlorination test (DHC) at $T = 180^{\circ}\text{C}$, to
DIN 53381. The thermal stability test for PVC is based
15 on the elimination of gaseous hydrogen chloride on
exposure to heat. For the purposes of this standard,
the thermal stability of PVC is the time taken for
elimination of hydrogen chloride to bring about an
irreversible chemical change on exposure to heat. The
20 higher the DHC value found (200 $\mu\text{S}/\text{cm}$) in min, the more
effective the stabilizer system in inhibiting
degradation of the chlorine-containing polymer.

The results have been incorporated into Tables 1A-5A
25 and Table 7.

Example 2: Dehydrochlorination test on milled sheets

A premix made from PVC + additives in accordance with
30 the amounts given in Tables 1B-5B was rolled for 5
minutes at 180°C on mixing rolls. Test strips of film,
thickness 0.5 mm, were taken from the resultant milled
sheet and subjected to a dehydrochlorination test (DHC)
at $T = 180^{\circ}\text{C}$, to DIN 53381 (cf. in this connection
35 Example 1).

The results have been incorporated into Tables 1B-5B.

Table 1A

Dehydrochlorination test on treated PVC powder at 180°C

Mixture	1/1	1/2	1/3	1/4	1/5	1/6	1/7	1/8
Norvinyl S 6775 (S PVC K value 67)	100	100	100	100	100	100	100	100
Ca stearate	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Wessalith P ^{®1)}	1.0	1.0						
Araldit GY 250 ^{®2)}			1.0	1.0				
Alkamizer I ^{®4)}							1.0	1.0
Stabilizer a) CD 36-0020 ⁵⁾		0.1		0.1		0.1		0.1
Stabilizer b) 2-Phenylindole	0.3	0.2	0.3	0.2	0.3	0.2	0.3	0.2
DHC (200 μ S/cm) in min	82	115	123	151	96	130	104	196

1) Na zeolite A ex Degussa

2) Bisphenol A diglycidyl ether (liquid epoxy) ex Ciba

5 3) Ca hydroxide ex Schaefer Kalk

4) Hydrotalcite ex KYOWA (Japan)

5) 30% strength sodium perchlorate monohydrate solution
in butyl diglycol

Table 1B

Dehydrochlorination test on milled sheets at 180°C

Mixture	1/1	1/2	1/3	1/4	1/5	1/6
Norvinyl S 6775 (S PVC K value 67)	100	100	100	100	100	100
Ca stearate	0.6	0.6	0.6	0.6	0.6	0.6
Loxiol G 71 S ⁶⁾	0.4	0.4	0.4	0.4	0.4	0.4
Wessalith P ^{®1)}			1.0	1.0		
Araldit GY 250 ^{®2)}					1.0	1.0
Stabilizer a) CD 36-0020 ⁵⁾		0.1		0.1		0.1
Stabilizer b) 2-Phenylindole	0.3	0.2	0.3	0.2	0.3	0.2
DHC (200 μ S/cm) in min	61	93	20	155	100	179

¹⁾ Na zeolite A ex Degussa

²⁾ Bisphenol A diglycidyl ether (liquid epoxy) ex
Ciba

³⁾ Ca hydroxide ex Schaefer Kalk

⁵⁾ 30% strength sodium perchlorate monohydrate
solution in butyl diglycol

⁶⁾ Loxiol G 71 S = complex ester/lubricant ex
Henkel

It can be seen that the use of a) sodium perchlorate compound and b) 2-phenylindole leads to substantially better stabilization than the use of 2-phenylindole alone. It can also be seen that the stability can be further increased by adding one or more additives.

Table 2A

Dehydrochlorination test on treated PVC powder at 180°C

Mixture	2/1	2/2	2/3	2/4	2/5	2/6	2/7	2/8
Norvinyl S 6775 (S PVC K value 67)	100	100	100	100	100	100	100	100
Ca stearate	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Wessalith P® ¹⁾	1.0	1.0						
Araldit GY 250® ²⁾			1.0	1.0				
Precal 50 S® ³⁾					1.0	1.0		
Alkamizer I® ⁴⁾							1.0	1.0
Stabilizer a) CD 36-0020 ⁵⁾		0.1		0.1		0.1		0.1
Stabilizer b) 1,4-Butanediol bis (β-aminocrotonate)	0.3	0.2	0.3	0.2	0.3	0.2	0.3	0.2
DHC (200 μS/cm) in min	57	88	64	127	55	86	65	104

¹⁾ Na zeolite A ex Degussa

5 ²⁾ Bisphenol A diglycidyl ether (liquid epoxy) ex Ciba

³⁾ Ca hydroxide ex Schaefer Kalk

⁴⁾ Hydrotalcite ex KYOWA (Japan)

⁵⁾ 30% strength sodium perchlorate monohydrate solution
in butyl diglycol

Table 2B

Dehydrochlorination test on milled sheets at 180°C

Mixture	2/1	2/2	2/3	2/4	2/5	2/6
Norvinyl S 6775 (S PVC K value 67)	100	100	100	100	100	100
Ca stearate	0.6	0.6	0.6	0.6	0.6	0.6
Loxiol G 71 S ⁶⁾	0.4	0.4	0.4	0.4	0.4	0.4
Araldit GY 250 ^{®2)}			1.0	1.0		
Alkamizer I ^{®4)}					1.0	1.0
Stabilizer a) CD 36-0020 ⁵⁾		0.1		0.1		0.1
Stabilizer b) 1,4-Butanediol bis(β -aminocrotonate)	0.3	0.2	0.3	0.2	0.3	0.2
DHC (200 μS/cm) in min	40	66	22	137	71	127

²⁾ Bisphenol A diglycidyl ether (liquid epoxy) ex Ciba

5 ³⁾ Ca hydroxide ex Schaefer Kalk

⁴⁾ Hydrotalcite ex KYOWA (Japan)

⁵⁾ 30% strength sodium perchlorate monohydrate solution in butyl diglycol

10 ⁶⁾ Loxiol G 71 S = complex ester/lubricant ex Henkel

It can be seen that the use of a) sodium perchlorate compound and b) 1,4-butanediol bis(β -aminocrotonate) leads to substantially better stabilization than the use of 1,4-butanediol bis(β -aminocrotonate) alone. It can also be seen that the stability can be further increased by adding one or more additives.

Table 3A

Dehydrochlorination test on treated PVC powder at 180°C

Mixture	3/1	3/2
Norvinyl S 6775 (S PVC K value 67)	100	100
Ca stearate	0.6	0.6
Wessalith P® ¹⁾	1.0	1.0
Araldit GY 250® ²⁾		
Precal 50 S® ³⁾		
Alkamizer I® ⁴⁾		
Stabilizer a) CD 36-0020 ⁵⁾		0.1
Stabilizer b) Thio (diethylene glycol) bis(β- aminocrotonate)	0.3	0.2
DHC (200 μS/cm) in min	63	88

¹⁾ Na zeolite A ex Degussa

²⁾ Bisphenol A diglycidyl ether (liquid epoxy) ex Ciba

5 ³⁾ Ca hydroxide ex Schaefer Kalk

⁴⁾ Hydrotalcite ex KYOWA (Japan)

⁵⁾ 30% strength sodium perchlorate monohydrate solution
in butyl diglycol

Table 3B

Dehydrochlorination test on milled sheets at 180°C

Mixture	3/1	3/2	3/3	3/4	3/5	3/6
Norvinyl S 6775 (S PVC K value 67)	100	100	100	100	100	100
Ca stearate	0.6	0.6	0.6	0.6	0.6	0.6
Loxiol G 71 S ⁶⁾	0.4	0.4	0.4	0.4	0.4	0.4
Araldit GY 250 ^{®2)}			1.0	1.0		
Alkamizer I ^{®4)}					1.0	1.0
Stabilizer a) CD 36-0020 ⁵⁾		0.1		0.1		0.1
Stabilizer b) Thio (diethylene glycol) bis(β-aminocrotonate)	0.3	0.2	0.3	0.2	0.3	0.2
DHC (200 μS/cm) in min	49	75	14	143	78	134

²⁾ Bisphenol A diglycidyl ether (liquid epoxy) ex Ciba

5 ³⁾ Ca hydroxide ex Schaefer Kalk

⁴⁾ Hydrotalcite ex KYOWA (Japan)

⁵⁾ 30% strength sodium perchlorate monohydrate solution in butyl diglycol

10 ⁶⁾ Loxiol G 71 S = complex ester/lubricant ex Henkel

It can be seen that the use of a) sodium perchlorate compound and b) thio (diethylene glycol) bis(β-aminocrotonate) leads to substantially better
 15 stabilization than the use of thio (diethylene glycol) bis(β-aminocrotonate) alone. It can also be seen that the stability can be further increased by adding one or more additives.

Table 4A

Dehydrochlorination test on treated PVC powder at 180°C

Mixture	4/1	4/2	4/3	4/4	4/5	4/6	4/7	4/8
Norvinyl S 6775 (S PVC K value 67)	100	100	100	100	100	100	100	100
Ca stearate	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Wessalith P® ¹⁾	1.0	1.0						
Araldit GY 250® ²⁾			1.0	1.0				
Precal 50 S® ³⁾					1.0	1.0		
Alkamizer I® ⁴⁾							1.0	1.0
Stabilizer a) CD 36-0020 ⁵⁾		0.1		0.1		0.1		0.1
Stabilizer b) N,N'-Diphenylthio- urea	0.3	0.2	0.3	0.2	0.3	0.2	0.3	0.2
DHC (200 µS/cm) in min	39	90	55	112	40	73	46	87

¹⁾ Na zeolite A ex Degussa5 ²⁾ Bisphenol A diglycidyl ether (liquid epoxy) ex Ciba³⁾ Ca hydroxide ex Schaefer Kalk⁴⁾ Hydrotalcite ex KYOWA (Japan)⁵⁾ 30% strength sodium perchlorate monohydrate solution
in butyl diglycol

Table 4B

Dehydrochlorination test on milled sheets at 180°C

Mixture	4/1	4/2	4/3	4/4	4/5	4/6
Norvinyl S 6775 (S PVC K value 67)	100	100	100	100	100	100
Ca stearate	0.6	0.6	0.6	0.6	0.6	0.6
Loxiol G 71 S ⁶⁾	0.4	0.4	0.4	0.4	0.4	0.4
Wessalith P ^{®1)}			1.0	1.0		
Araldit GY 250 ^{®2)}					1.0	1.0
Stabilizer a) CD 36-0020 ⁵⁾		0.1		0.1		0.1
Stabilizer b) N,N'-Diphenylthio- urea	0.3	0.2	0.3	0.2	0.3	0.2
DHC (200 µS/cm) in min	25	54	38	100	57	122

¹⁾ Na zeolite A ex Degussa

²⁾ Bisphenol A diglycidyl ether (liquid epoxy) ex
Ciba

³⁾ Ca hydroxide ex Schaefer Kalk

⁵⁾ 30% strength sodium perchlorate monohydrate
solution in butyl diglycol

⁶⁾ Loxiol G 71 S = complex ester/lubricant ex
Henkel

It can be seen that the use of a) sodium perchlorate compound and b) N,N'-diphenylthiourea leads to substantially better stabilization than the use of N,N'-diphenylthiourea alone. Indeed, comparison with the results in Table 6 shows that the addition of N,N'-diphenylthiourea on its own leads to destabilization of the PVC. Only when a) sodium perchlorate compound and b) N,N'-diphenylthiourea are used together is there a marked improvement in the stability of the PVC. It can

also be seen that the stability can be further increased by adding one or more additives.

Table 5A

5 **Dehydrochlorination test on treated PVC powder at 180°C**

Mixture	5/1	5/2
Norvinyl S 6775 (S PVC K value 67)	100	100
Ca stearate	0.6	0.6
Wessalith P ^{®1)}	1.0	1.0
Araldit GY 250 ^{®2)}		
Precal 50 S ^{®3)}		
Alkamizer I ^{®4)}		
Stabilizer a) CD 36-0020 ⁵⁾		0.1
Stabilizer b) N-Phenylurea	0.3	0.2
DHC (200 μS/cm) in min	52	97

¹⁾ Na zeolite A ex Degussa

²⁾ Bisphenol A diglycidyl ether (liquid epoxy) ex Ciba

³⁾ Ca hydroxide ex Schaefer Kalk

⁴⁾ Hydrotalcite ex KYOWA (Japan)

10 ⁵⁾ 30% strength sodium perchlorate monohydrate solution
in butyl diglycol

Table 5B

Dehydrochlorination test on milled sheets at 180°C

Mixture	5/1	5/2	5/3	5/4	5/5	5/6
Norvinyl S 6775 (S PVC K value 67)	100	100	100	100	100	100
Ca stearate	0.6	0.6	0.6	0.6	0.6	0.6
Loxiol G 71 S ⁶⁾	0.4	0.4	0.4	0.4	0.4	0.4
Araldit GY 250 ^{®2)}			1.0	1.0		
Alkamizer I ^{®4)}					1.0	1.0
Stabilizer a) CD 36-0020 ⁵⁾		0.1		0.1		0.1
Stabilizer b) N-Phenylurea	0.3	0.2	0.3	0.2	0.3	0.2
DHC (200 μS/cm) in min	40	61	59	131	51	111

²⁾ Bisphenol A diglycidyl ether (liquid epoxy) ex Ciba

³⁾ Ca hydroxide ex Schaefer Kalk

⁴⁾ Hydrotalcite ex KYOWA (Japan)

⁵⁾ 30% strength sodium perchlorate monohydrate solution in butyl diglycol

⁶⁾ Loxiol G 71 S = complex ester/lubricant ex Henkel

It can be seen that the use of a) sodium perchlorate compound and b) N-phenylurea leads to substantially better stabilization than the use of N-phenylurea alone. It can also be seen that the stability can be further increased by adding one or more additives.

A mixture composed of

100.0 parts of Norvinyl S 6775

0.6 part of Ca stearate

- 0.4 part of Loxiol® G 71 S⁶⁾
 0.6 part of CH 300 phosphite⁷⁾ (ex Crompton)
 1.0 part of Wessalith P/GY 250/Alkamizer I
 0.1 part of CD 36-0020⁵⁾
 5 0.2 part of organic stabilizer

was processed at 180°C on mixing rolls for 5 minutes.
 The resultant milled sheets were used for determination
 of the initial colour of the milled sheet in the form
 10 of the Yellowness Index (YI) to ASTM D-1925-70. Low YI
 values mean good stabilization and, respectively,
 initial colour.

The results are given in Table 6 below.

15

Table 6

**Tests with and without CH 300 phosphite⁷⁾ on milled
 sheets using the initial colour IC (YI) thermal test**

<u>With phosphite</u>		<u>Without phosphite</u>		<u>Additive</u>	<u>Stabilizer</u>
<u>Experiment number</u>	<u>HT/IC (YI)</u>	<u>Experiment number</u>	<u>HT/IC (YI)</u>		
384	29.32	6269	40.51	-	2-Phenyl indole
389	33.29	6271	45.08	Wessalith P	
390	25.05	6273	36.24	GY 250	
385	35.84	6274	43.55	-	1,4-Butane- diol bis(β- amino- crotonate)
391	37.08	6276	42.58	GY 250	
392	40.21	6278	41.73	Alkamizer I	
386	34.54	6279	46.34	-	Thiodi- ethylene glycol bis- (β-amino- crotonate)
393	35.15	6281	44.07	GY 250	
394	38.38	6283	40.08	Alkamizer I	
387	8.38	6284	17.54	-	N,N'-di- phenylthio- urea
395	9.36	6286	17.49	Wessalith P	
396	8.77	6288	13.51	GY 250	
388	22.19	6289	37.99	-	N-phenyl- urea
397	22.36	6291	39.52	GY 250	
398	30.39	6293	39.08	Alkamizer I	

⁷⁾ CH 300 = mixed aryl/alkyl phosphite (ex Crompton)

It is apparent that addition of phosphites can give a yet further rise in initial-colour-based stabilization of the chlorine-containing polymer, using organic stabilizers in combination with a sodium perchlorate formulation.

Table 7 - Comparative Experiment

10 **Dehydrochlorination test on treated PVC powder at 180°C**

Mixture	7/1	7/2	7/3	7/4	7/5	7/6	7/7	7/8
Norvinyl S 6775 (SPVC K value 67)	100	100	100	100	100	100	100	100
Ca stearate	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Wessalith P ^{®1)}	1.0	1.0						
Araldit GY 250 ^{®2)}			1.0	1.0				
Precal 50 S ^{®3)}					1.0	1.0		
Alkamizer I ^{®4)}							1.0	1.0
Stabilizer a) CD 36-0020 ⁵⁾		0.1		0.1		0.1		0.1
DHC (200 µS/cm) in min	56	71	67	96	57	60	67	87

¹⁾ Na zeolite A ex Degussa

²⁾ Bisphenol A diglycidyl ether (liquid epoxy) ex Ciba

³⁾ Ca hydroxide ex Schaefer Kalk

⁴⁾ Hydrotalcite ex KYOWA (Japan)

15 ⁵⁾ 30% strength sodium perchlorate monohydrate solution in butyl diglycol

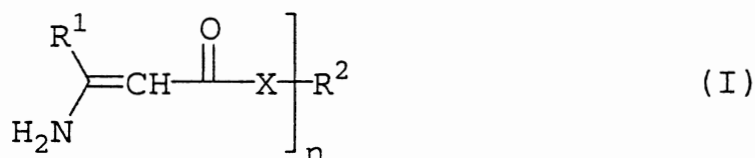
It can be seen that the use of a) sodium perchlorate compound alone leads to only very slight improvements in stability compared with the stability without addition of any stabilizer.

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Patent Claims

1. Stabilizer system for stabilizing halogen-containing polymers, comprising at least
 - a) one perchlorate salt and
 - b) at least one or more enamines

where the enamines have the formula (I)



where

$n = 1$ or 2 and $\text{X} = \text{O}$ or NR^1 ,

$n = 3 - 6$ and $\text{X} = \text{O}$;

$\text{R}^1 = \text{H}$, $\text{C}_1\text{-C}_4\text{-alkyl}$, $\text{C}_2\text{-C}_6\text{-alkenyl}$, $\text{C}_6\text{-C}_{10}\text{-aryl}$, $\text{C}_7\text{-C}_{18}\text{-alkaryl}$ or $\text{C}_7\text{-C}_{18}\text{-aralkyl}$;

R^2 (for $n = 1$) = $\text{C}_1\text{-C}_{22}\text{-alkyl}$, $\text{C}_2\text{-C}_{22}\text{-alkenyl}$ or aryl , preferably phenyl , where appropriate substituted with up to 3 hydroxyl, $\text{C}_1\text{-C}_4\text{-alkoxy}$ or $\text{C}_1\text{-C}_9\text{-alkyl}$; or

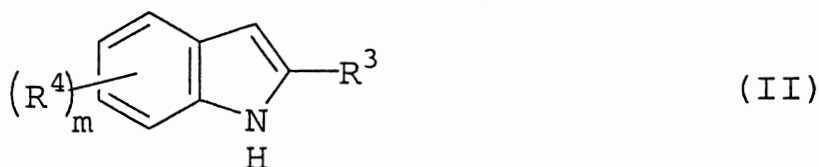
R^2 (for $n = 2 - 6$) = linear or branched $\text{C}_{1-22}\text{-alkylene}$, where appropriate interrupted by one or more O atoms or S atoms, where R^2 (for $n = 3$) may also be $\text{C}_2\text{-C}_3\text{-alkyl-trisubstituted isocyanurate}$;

and if $\text{X} = \text{NH}$, R^2 may also be H .

2. Stabilizer system according to Claim 1, where the perchlorate salt is a compound of the formula $\text{M}(\text{ClO}_4)_n$, where M is Li , Na , K , Mg , Ca , Sr , Ba , Zn , Al , La or Ce ; and n is 1 , 2 or 3 , depending on the valency of M .
3. Stabilizer system according to Claim 1 or 2, where in the compound having the general formula (I) $\text{R}^1 = \text{methyl}$ or phenyl and $\text{X} = \text{oxygen}$.

4. Stabilizer system according to any of Claims 1 to 3, where, in the perchlorate salt, $M = Na$ or K and $n = 1$.
5. Stabilizer system according to any of Claims 1 to 4, where the compounds of the general formula (I) are 1,4-butanediol bis(β -aminocrotonate) or thio(diethylene glycol) bis(β -aminocrotonate).
6. Stabilizer system according to any of Claims 1 to 5, which also, where appropriate, comprises metal soaps and/or, where appropriate, comprises at least one or more other substances from the groups consisting of the polyols and disaccharide alcohols, glycidyl compounds, hydrotalcites, alkali metal/alkaline earth metal aluminosilicates, alkali metal/alkaline earth metal hydroxides, alkaline earth metal oxides or alkaline earth metal (hydrogen)carbonates, or metal carboxylates, phosphites, plasticizers, antioxidants, fillers, pigments, light stabilizers, lubricants and epoxidized fatty esters.
7. Composition comprising a chlorine-containing polymer and a stabilizer system according to any of Claims 1 to 6.
8. Composition according to Claim 7, characterized in that, based on 100 parts by weight of chlorine-containing polymer, there are from 0.01 to 10 parts by weight of the compounds of the general formula (I) and/or (II) and/or (III) and from 0.001 to 5 parts by weight of the perchlorate salt.
9. Composition according to Claim 8, characterized in that, based on 100 parts by weight of chlorine-containing polymer, from 0.01 to 10 parts by weight of the compounds of the general formula (I) and 0.001 to 5 parts by weight of the perchlorate salt are present.
10. Process for stabilizing chlorine-containing polymers by adding a stabilizer system according to any of Claims 1 to 7 [sic] to the chlorine-containing polymer.

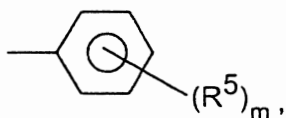
11. Consumer products comprising PVC which has been stabilized by a stabilizer system according to any of Claims 1 to 7 [sic].
12. Stabilizer system for stabilizing halogen-containing polymers, comprising at least
- a) one perchlorate salt of the formula $M(ClO_4)_n$, where M is Li, Na, K, Mg, Ca, Sr, Ba, Zn, La or Ce; and n is 1, 2 or 3, depending on the valency of M; and
 - b) at least one or more indole derivatives, where the indole derivatives have the general formula (II)



where

$m = 0, 1, 2$ or 3 ;

$R^3 = C_1-C_{18}$ -alkyl, C_2-C_{18} -alkenyl, C_6-C_{10} -aryl or



C_7-C_{24} -alkaryl, C_7-C_{10} -aralkyl or C_1-C_4 -alkoxy;

$R^4, R^5 = H, C_1-C_4$ -alkyl, or C_1-C_4 -alkoxy.

13. Stabilizer system according to Claim 12, where in the compound having the general formula (II) $R^3 = \text{phenyl}$.
14. Stabilizer system according to Claim 12 or 13, where, in the perchlorate salt, $M = \text{Na}$ or K and $n = 1$.
15. Stabilizer system according to any of Claims 12 to 14, where the compounds of the general formula (II) are 2-phenylindole or 2-phenyllaurlindole.
16. Stabilizer system according to any of Claims 12 to 15, which also, where appropriate, comprises metal soaps and/or, where appropriate, comprises at least one or more other substances from the groups consisting of the polyols

and disaccharide alcohols, glycidyl compounds, hydrotalcites, alkali metal/alkaline earth metal aluminosilicates, alkali metal/alkaline earth metal hydroxides, alkaline earth metal oxides or alkaline earth metal (hydrogen)carbonates, or metal carboxylates, phosphites, plasticizers, antioxidants, fillers, pigments, light stabilizers, lubricants and epoxidized fatty esters.

17. Stabilizer system according to any of Claims 12 to 16, where a phosphite is also present and/or possible reaction products of phosphite with components a) and/or b) are also present.
18. Composition comprising a chlorine-containing polymer and a stabilizer system according to any of Claims 12 to 17.
19. Composition according to Claim 18, characterized in that, based on 100 parts by weight of chlorine-containing polymer, there are from 0.01 to 10 parts by weight of the compounds of the general formula (II) and from 0.001 to 5 parts by weight of the perchlorate salt.
20. Process for stabilizing chlorine-containing polymers by adding a stabilizer system according to any of Claims 12 to 17 to the chlorine-containing polymer.
21. Consumer products comprising PVC which has been stabilized by a stabilizer system according to any of Claims 12 to 17.