

Description:

The present invention is concerned with novel cyclohexanecarbonitriles, their manufacture, liquid crystalline mixtures which contain these compounds as well as their use for electro-optical purposes.

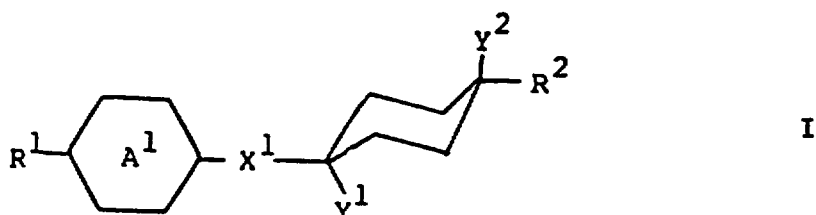
Liquid crystals have recently gained considerable importance as dielectrics in indicating devices, since the optical properties of such substances can be influenced by an applied voltage. Electro-optical devices based on liquid crystals are well known to the person skilled in the art and can be based on various effects such as, for example, the dynamic scattering, the deformation of aligned phases (DAP cell) the Schadt-Helfrich effect (rotation cell), the guest/host effect (guest/host cell) or a cholesteric-nematic phase transition (phase change cell).

The liquid crystals which are used must have a good stability towards heat, moisture, air, electromagnetic radiation, electrical fields and the like. Further, they should be colourless, should have short response times and low viscosity, should give a good contrast and should have a nematic or cholesteric mesophase in the entire temperature range in which the liquid crystal cell is to be operated. Since liquid crystals are usually used as mixtures, it is, moreover, important that the components have a good miscibility with one another and at the same time form a nematic or cholesteric mesophase. Other properties such as, for example, the electrical conductivity, the threshold potential, the multiplexibility and the dielectric anisotropy must fulfil different conditions depending on the type of cell which is used.

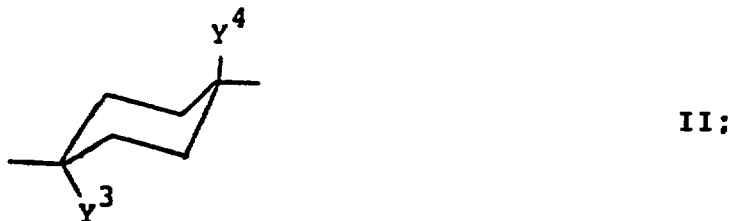
Liquid crystals with negative anisotropy of the dielectric constants ($\Delta\epsilon = \epsilon_{||} - \epsilon_{\perp}$ less than 0, $\epsilon_{||}$ signifying the dielectric constant along the longitudinal axis of the molecule and $\epsilon_{\perp}$ signifying the dielectric constant perpendicular thereto) can be used, for example, in liquid crystal cells of the light-scattering type, in DAP cells or in guest/host cells. Further, a two-frequency matrix addressing has been proposed (e.g. German Offenlegungsschriften 2856134 and 2907940) in order to improve the multiplex ratio in the multiplex control of liquid crystal devices, especially of rotation cells and guest/host cells. In order to improve the dielectric anisotropy above the "cross-over frequency" (dielectric relaxation frequency at which $\epsilon_{||} = \epsilon_{\perp}$), components with negative dielectric anisotropy can be added to the corresponding dielectrics (e.g. German Offenlegungsschriften 3221462).

Compounds with a large negative anisotropy of the dielectric constants are already known, examples of such compounds being pyridazines, pyridazine oxides and compounds containing a 2,3-dicyano-1,4-phenylene group. However, these compounds have various disadvantages such as e.g. poor solubility in mixtures, high viscosities, high melting points, strong smectic tendencies, chemical instability, high electrical conductivity or large clearing point depressions in mixtures and are therefore usable only to a very limited extent.

It has now been found that the compounds of the general formula



wherein X^1 represents a single covalent bond, $-CH_2CH_2-$, $-COO-$, $-OOC-$ or 1,4-phenylene; one of the symbols Y^1 and Y^2 denotes hydrogen and the other denotes cyano; R^2 signifies trans-1-alkenyl, cis-2-alkenyl, trans-3-alkenyl, 4-alkenyl or alkyl; R^1 stands for the group $R^{11}-A^4-A^5-$ and A^5 independently of each other represent a single covalent bond, 1,4-phenylene or trans-1,4-cyclohexylene; R^{11} signifies trans-1-alkenyl, cis-2-alkenyl, trans-3-alkenyl, 4-alkenyl, trans-2-alkenyloxy, 3-alkenyloxy or, when R^2 stands for an alkenyl group, also alkyl or alkoxy; ring A^1 represents 1,4-phenylene or a group of the general formula



and Y^3 and Y^4 denote hydrogen or, insofar as X^1 represents $-CH_2CH_2-$, $-COO-$ or $-OOC-$, one of the symbols Y^3 and Y^4 also denotes cyano, have a relatively large negative anisotropy of the dielectric constants, good miscibility with other liquid crystal components and low viscosity. They are colourless and have a good chemical stability. The compounds of formula I in which R^1 and/or R^2 contain a trans-1-

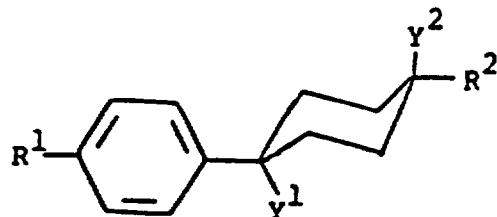
-alkenyl, trans-3-alkenyl or trans-2-alkenyloxy group have an especially favourable mesophase range, while the compounds of formula I in which R¹ and/or R² contain a cis-2-alkenyl, 4-alkenyl or 3-alkenyloxy group have primarily a favourable ratio of the elastic constants k₃₃ (bend) and k₁₁ (splay) and give comparatively low threshold potentials. The compounds in accordance with the invention are accordingly especially suitable as components of liquid crystal mixtures with negative dielectric anisotropy and as components of liquid crystal mixtures which are used in the two-frequency matrix addressing. The compounds of formula I in which A⁴ and A⁵ signify single covalent bonds, i.e. R¹ stands for R¹¹, are suitable primarily as basic components having low viscosity, while the remaining compounds of formula I are useful mainly as additives for increasing the clearing point. The compounds in accordance with the invention can, however, also be used in mixtures with positive dielectric anisotropy, for example in order to adapt the threshold potential to the electro-optical cell which is used.

Alkenyl, alkenyloxy, alkyl and alkoxy groups in general formula I generally have up to 12, preferably up to 7, carbon atoms.

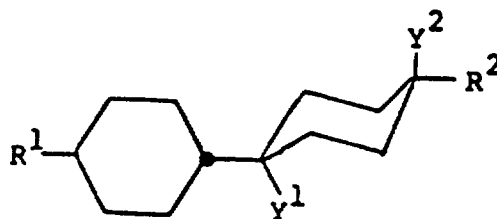
In the scope of the present invention the term "alkyl" preferably signifies straight-chain alkyl such as methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl and dodecyl. The term "trans-1-alkenyl" embraces 1E-alkenyl residues such as vinyl, 1E-propenyl, 1E-butenyl, 1E-pentenyl, 1E-hexenyl, 1E-heptenyl, 1E-octenyl, 1E-nonenyl, 1E-decenyl, 1E-undecenyl and 1E-dodecenyl. The term "cis-2-alkenyl" embraces 2Z-alkenyl residues such as 2-propenyl, 2Z-butenyl, 2Z-pentenyl, 2Z-hexenyl, 2Z-heptenyl, 2Z-octenyl, 2Z-nonenyl, 2Z-decenyl, 2Z-undecenyl and 2Z-dodecenyl. The term "trans-3-alkenyl" embraces 3E-alkenyl residues such as 3-butenyl, 3E-pentenyl, 3E-hexenyl, 3E-heptenyl, 3E-octenyl, 3E-nonenyl, 3E-decenyl, 3E-undecenyl and 3E-dodecenyl. The term "4-alkenyl" embraces residues such as 4-pentenyl and the E- and/or Z-form of 4-hexenyl, 4-heptenyl, 4-octenyl, 4-nonenyl, 4-decenyl, 3-undecenyl and 4-dodecenyl. The term "alkoxy" embraces preferably straight-chain alkoxy such as methoxy, ethoxy, propyloxy, butyloxy, pentyloxy, hexyloxy, heptyloxy, octyloxy, nonyloxy, decyloxy, undecyloxy and dodecyloxy. The term "trans-2-alkenyloxy" embraces 2E-alkenyloxy residues such as 2-propenyloxy, 2E-butenyloxy, 2E-pentyloxy, 2E-hexenyloxy, 2E-heptenyloxy, 2E-octenyloxy, 2E-nonyloxy, 2E-decenyloxy, 2E-undecenyloxy and 2E-dodecenyloxy. The term "3-alkenyloxy" embraces residues such as 3-butenyloxy and the E- and/or Z-form of 3-pentyloxy, 3-hexenyloxy, 3-heptenyloxy, 3-octenyloxy, 3-nonyloxy, 3-decenyloxy, 3-undecenyloxy and 3-dodecenyloxy.

In the scope of the present invention the term "halogen" signifies chlorine, bromine or iodine and the term "alkali metal" signifies lithium, sodium or potassium. The term "aryl" signifies phenyl, tolyl and the like.

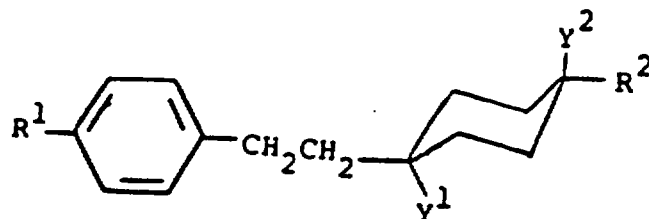
Formula I above embraces the following formulae:



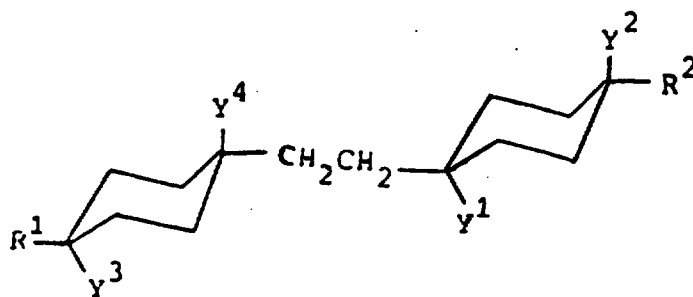
Ia



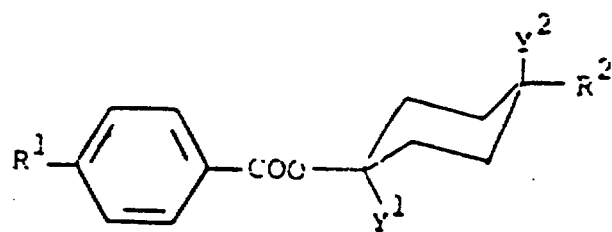
Ib



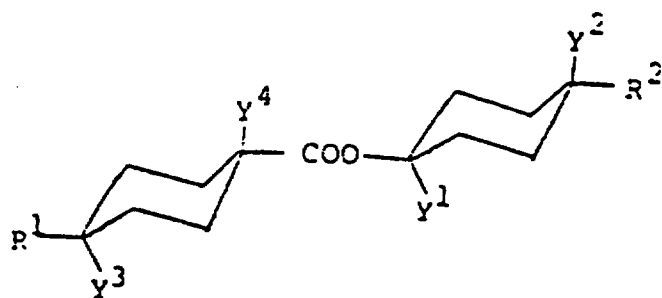
Ic



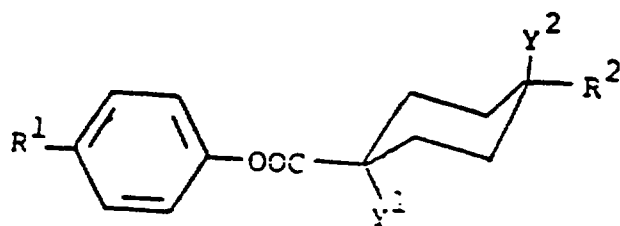
Id



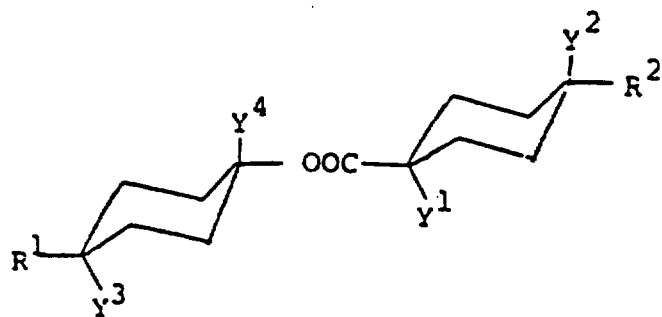
Ie



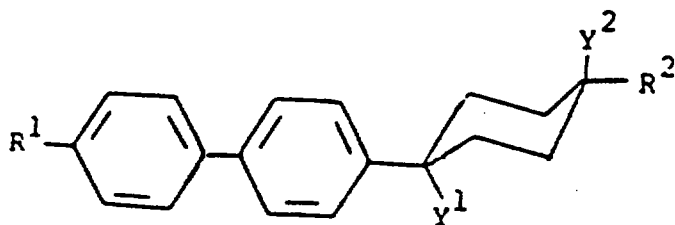
If



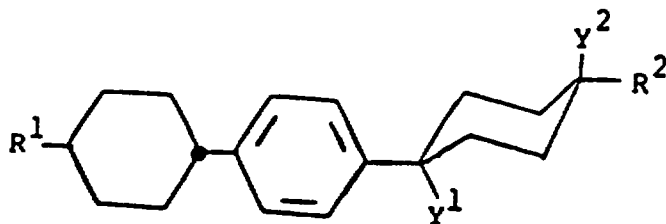
Ig



Ih



II



Ij

wherein one of the symbols Y^1 and Y^2 signifies hydrogen and the other signifies cyano; Y^3 and Y^4 denote hydrogen or one of the symbols Y^3 and Y^4 also denotes cyano; and R^1 and R^2 have the above significances.

Preferred compounds of formula I and of formulae Ia-Ij are those in which A^5 represents a single covalent bond. Those compounds in which A^4 and A^5 represent single covalent bonds, i.e. R^1 stands for R^{11} , are especially preferred.

R^{11} and R^2 preferably stand for straight-chain residues with a maximum of 12 carbon atoms, especially for straight-chain trans-1-alkenyl with 2 to 12 carbon atoms, straight-chain cis-2-alkenyl with 3 to 12 carbon atoms, straight-chain trans-3-alkenyl with 4 to 12 carbon atoms, straight-chain 4-alkenyl with 5 to 12 carbon atoms or one of the residues R^{11} and R^2 also stands for straight-chain alkyl with 1 to 12 carbon atoms. Residues R^{11} and R^2 with a maximum of 7 carbon atoms are especially preferred.

Preferably, R^{11} and R^2 independently of each other signify trans-1-alkenyl, trans-3-alkenyl or 4-alkenyl or one of the residues R^{11} and R^2 , preferably R^{11} , also signifies alkyl. The compounds of formula I or of formulae Ia-Ij in which one of the residues R^{11} and R^2 signifies trans-3-alkenyl and the other signifies trans-1-

-alkenyl, trans-3-alkenyl, 4-alkenyl or alkyl are especially preferred.

In the compounds of formula I in which ring A¹ represents 1,4-phenylene, i.e. in the compounds of formulae Ia, Ic, Ie, Ig and Ii, R¹ preferably signifies trans-3-alkenyl, 4-alkenyl or alkyl.

4-Alkenyl residues which may be present in R¹ and/or R² and a 3-alkenyloxy residue which may be present in R¹ preferably have the Z-form.

3-Butenyl, 4-pentenyl, 3E-pentenyl and 1E-pentenyl are especially preferred alkenyl residues.

Preferred compounds of formula Id are those in which Y³ and Y⁴ signify hydrogen, as well as those in which Y⁴ and at the same time Y² signify cyano. Of the remaining compounds of formula I there are generally preferred those in which Y² signifies cyano and substituents Y³ and Y⁴ which may be present signify hydrogen.

Furthermore, there are generally preferred those compounds of formula I in which ring A¹ represents trans-1,4-cyclohexylene, i.e. the compounds of formulae Ib and Ij and the compounds of formulae Id, If and Ih in which Y³ and Y⁴ denote hydrogen.

The compounds of formula I can be manufactured in accordance with the invention by

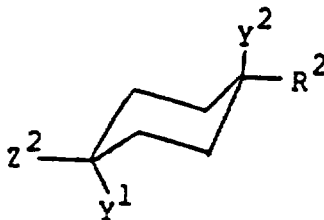
a) for the manufacture of the compounds of formula I in which X¹ represents -COO- or -OOC-, esterifying a com-

pound of the general formula



III

with a compound of the general formula

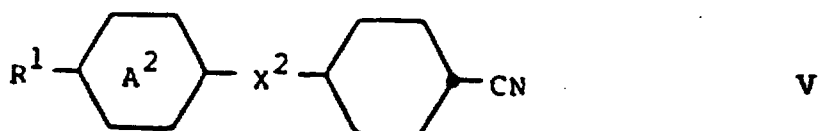


IV

wherein one of the groups Z^1 and Z^2 signifies $-\text{COOH}$ or $-\text{COCl}$ and the other signifies $-\text{OH}$; ring A^1 represents 1,4-phenylene or a group of formula II above; Y^3 and Y^4 in formula II denote hydrogen or one of these symbols also denotes cyano; and R^1 , R^2 , Y^1 and Y^2 have the above significances,

or

b) for the manufacture of the compounds of formula I in which X^1 represents a single covalent bond, $-\text{CH}_2\text{CH}_2-$ or 1,4-phenylene, Y^2 denotes cyano and R^2 signifies cis-2-alkenyl, trans-3-alkenyl, 4-alkenyl or alkyl, reacting a compound of the general formula



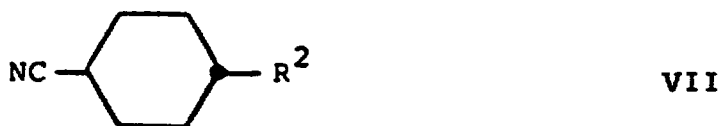
firstly with base and then with a compound of the general formula



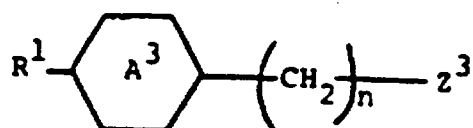
wherein X^2 represents a single covalent bond, $-\text{CH}_2\text{CH}_2-$ or 1,4-phenylene; ring A^2 denotes 1,4-phenylene or a group of formula II; Y^3 and Y^4 in formula II signify hydrogen or, insofar as X^2 represents $-\text{CH}_2\text{CH}_2-$, one of the symbols Y^3 and Y^4 also denotes cyano; Z^3 denotes halogen; R^5 signifies cis-2-alkenyl, trans-3-alkenyl, 4-alkenyl or alkyl; and R^1 has the above significance,

or

c) for the manufacture of the compounds of formula I in which X^1 represents a single covalent bond or $-\text{CH}_2\text{CH}_2-$, ring A^1 signifies trans-1,4-cyclohexylene and Y^1 denotes cyano, reacting a compound of the general formula



firstly with base and then with a compound of the general formula

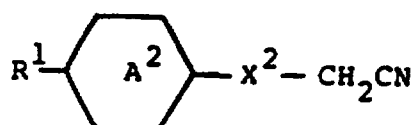


VIII

wherein n stands for the number 0 and ring A³ stands for cis-1,4-cyclohexylene or n stands for the number 2 and ring A³ stands for trans-1,4-cyclohexylene; Z³ denotes halogen; and R¹ and R² have the above significances,

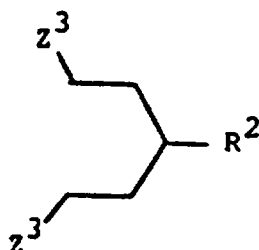
or

d) for the manufacture of the compounds of formula I in which X¹ represents a single covalent bond, -CH₂CH₂- or 1,4-phenylene and Y¹ denotes cyano, reacting a compound of the general formula



IX

firstly with base and then with a compound of the general formula



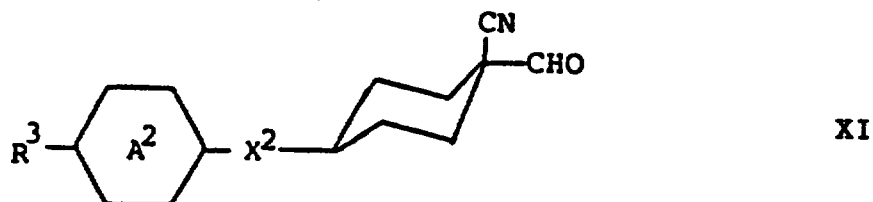
X

wherein X² represents a single covalent bond, -CH₂CH₂- or 1,4-phenylene; ring A² denotes 1,4-phenylene or a group of formula II; Y³ and Y⁴ in formula II signify hydrogen or, insofar as X² represents -CH₂CH₂-, one of the symbols Y³ and Y⁴ also denotes cyano; Z³ denotes halogen; and R¹ and R² have the above significances,

or

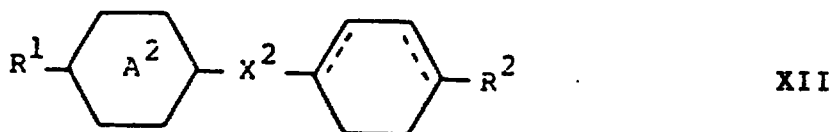
e) for the manufacture of the compounds of formula I in which X¹ represents a single covalent bond,

-CH₂CH₂- or 1,4-phenylene, Y² denotes cyano and R² signifies trans-1-alkenyl, reacting a compound of the general formula



wherein X² represents a single covalent bond, -CH₂CH₂- or 1,4-phenylene; ring A² denotes 1,4-phenylene or a group of formula II; Y³ and Y⁴ in formula II signify hydrogen or, insofar as X² represents -CH₂CH₂-, one of the symbols Y³ and Y⁴ also denotes cyano; and R³ has the significances given for R¹ in formula I, in the presence of a base with an alkyl-triarylphosphonium halide, or

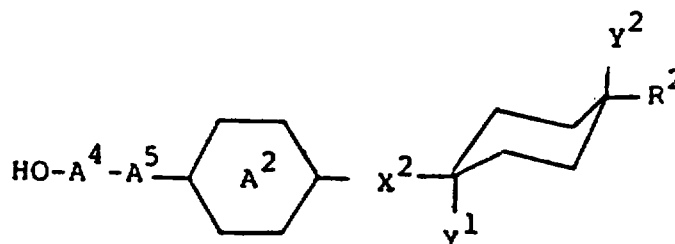
f) for the manufacture of the compounds of formula I in which X¹ represents a single covalent bond, -CH₂CH₂- or 1,4-phenylene, adding HCN to a compound of the general formula



wherein X² represents a single covalent bond, -CH₂CH₂- or 1,4-phenylene; ring A² denotes 1,4-phenylene or a group of formula II; Y³ and Y⁴ in formula II signify hydrogen or, insofar as X² represents -CH₂CH₂-, one of the symbols Y³ and Y⁴ also denotes cyano, one of the dotted lines denotes an additional bond; and R¹ and R² have the above significances,

or

g) for the manufacture of the compounds of formula I in which X¹ represents a single covalent bond, -CH₂CH₂- or 1,4-phenylene and R¹ signifies trans-2-alkenyloxy, 3-alkenyloxy or alkoxy, etherifying a compound of the general formula



LXXXI

wherein X^2 represents a single covalent bond, $-CH_2CH_2-$ or 1,4-phenylene; ring A^2 denotes 1,4-phenylene or a group of formula II; Y^3 and Y^4 in formula II signify hydrogen or, insofar as X^2 represents $-CH_2CH_2-$, one of the symbols Y^3 and Y^4 also denotes cyano; and A^4 , A^5 , R^2 , Y^1 and Y^2 have the significances given in formula I, with a trans-2-alkenyl halide, a 3-alkenyl halide or an alkyl halide.

The esterification of a compound of formula III with a compound of formula IV (process variant a) can be carried out in a manner known per se. The esterification of the acid chlorides (which are obtainable from the carboxylic acids e.g. by heating with thionyl chloride) can be carried out, for example, in diethyl ether, tetrahydrofuran, dimethylformamide, benzene, toluene, carbon tetrachloride, pyridine and the like. The esterification of the carboxylic acids is preferably carried out in the presence of 4-(dimethylamino)pyridine and dicyclohexylcarbodiimide or in the presence of oxalyl chloride and dimethylformamide. Temperature and pressure of these esterification reactions are not critical. In general, atmospheric pressure and a temperature between about -30°C and the boiling temperature of the reaction mixture are used.

The reaction of a nitrile of formula V, VII or IX with base and subsequently with a halide of formula VI, VIII or X (process variants b-d) can also be carried out in a manner known per se. The preferred halogen Z^3 is bromine. Suitable bases are, for example, sodium hydride, sodium amide, lithium diisopropylamide, potassium t-butyrate and the like. Preferred bases are the alkali metal dialkylamides in which the term "alkyl" preferably signifies straight-chain or branched residues with 1 to 5 carbon atoms. Lithium diisopropylamide is the especially preferred base. The reaction is conveniently carried out in an inert organic solvent, for example an ether, an aromatic hydrocarbon, an amide or a sulfoxide, such as tetrahydrofuran, dioxan, diethyl ether, toluene, dimethylformamide or dimethyl sulfoxide. Temperature and pressure are not critical; in general, however, process variants b and c are carried out at atmospheric pressure and a

temperature of about -80°C to room temperature and process variant d is carried out at atmospheric pressure and a temperature of about $0-150^{\circ}\text{C}$.

The reaction of a compound of formula XI with an alkyl-triarylphosphonium halide, preferably an alkyl-triphenylphosphonium chloride or alkyl-triphenylphosphonium bromide, (process variant e), can also be carried out in a manner known per se. Suitable bases are the bases named above under process variants b-d. Preferred bases are, however, the alkali metal carbonates and especially the alkali metal alcoholates with 1 to 5 carbon atoms. Potassium carbonate, sodium methylate and potassium t-butylate are examples of preferred bases. The reaction is conveniently carried out in an inert organic solvent, for example an ether such as diethyl ether, tetrahydrofuran or dioxan. Temperature and pressure are not critical; in general, however, the reaction is carried out at atmospheric pressure and a temperature from room temperature to the reflux temperature.

The addition of HCN to a compound of formula XII (process variant f) can also be carried out in a manner known per se. The reaction is conveniently carried out in an inert organic solvent, for example a nitrile, amide or chlorinated hydrocarbon such as acetonitrile, dimethylformamide, methylene chloride or chloroform. Temperature and pressure are not critical; in general, however, a temperature of about -10°C to 150°C and a pressure of about 1-100 bar are used. If desired, the reaction can also be carried out in the presence of a catalyst such as palladium-bis-[2,3-O-isopropylidene-2,3-dihydroxy-1,4-bis-(diphenylphosphino)butane] and the like.

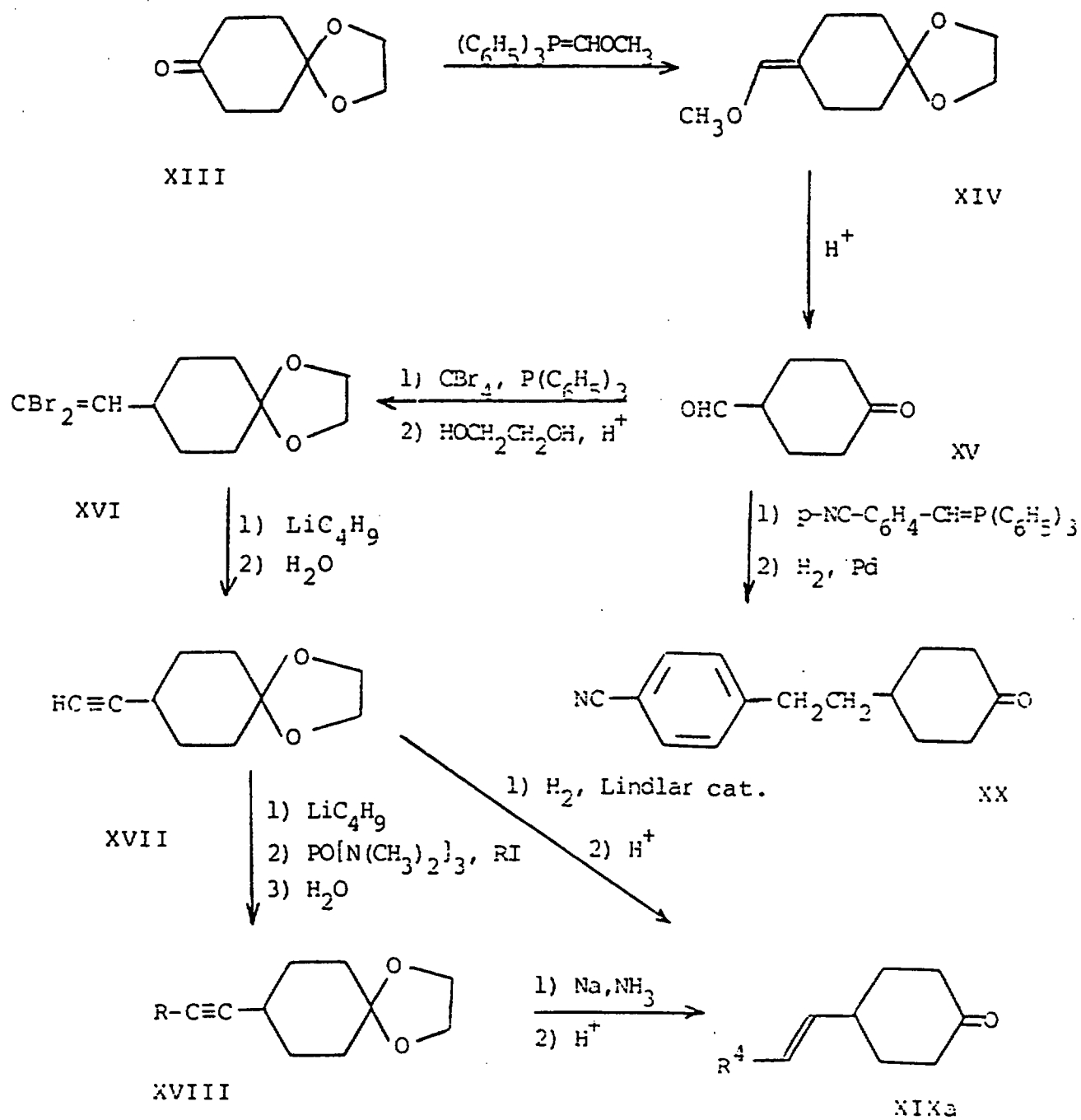
The etherification of a compound of formula LXXXI (process variant g) can also be carried out in a manner known per se. The reaction is conveniently carried out in an inert organic solvent in the presence of a base such as sodium hydride, sodium, sodium carbonate, potassium carbonate and the like. Preferred halides are the bromides and especially the iodides. The reaction is preferably carried out at atmospheric pressure and a temperature from room temperature to the reflux temperature.

The compounds of formulae III-V, VII-X and LXXXI in which R^1 or R^2 has an alkyl or alkoxy group and the compounds of formula VI are known compounds or analogues of known compounds.

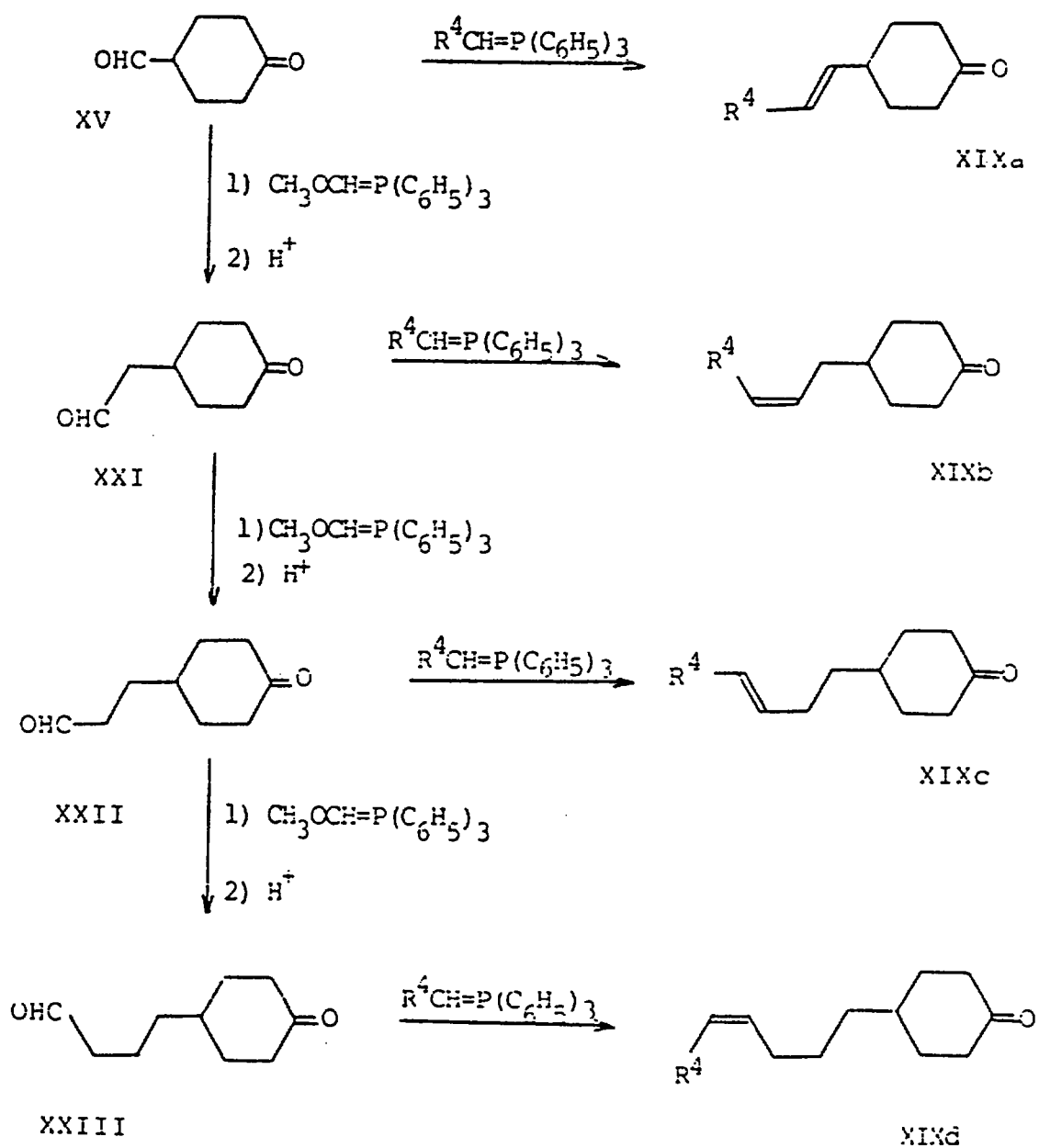
The remaining starting materials, i.e. the compounds of formulae III-V, VII-X and LXXXI in which R^1 or R^2 has an alkenyl or alkenyloxy group and the compounds of formulae XI and XII are novel. The preparation of these

starting materials is illustrated on the basis of the following Reaction Schemes 1-12 in which R signifies alkyl, R⁴ signifies hydrogen or alkyl and THP signifies the tetrahydropyranyl group, R⁵ denotes cis-2-alkenyl, trans-3-alkenyl, 4-alkenyl or alkyl and R¹, R², R³, X² and ring A² have the above significances.

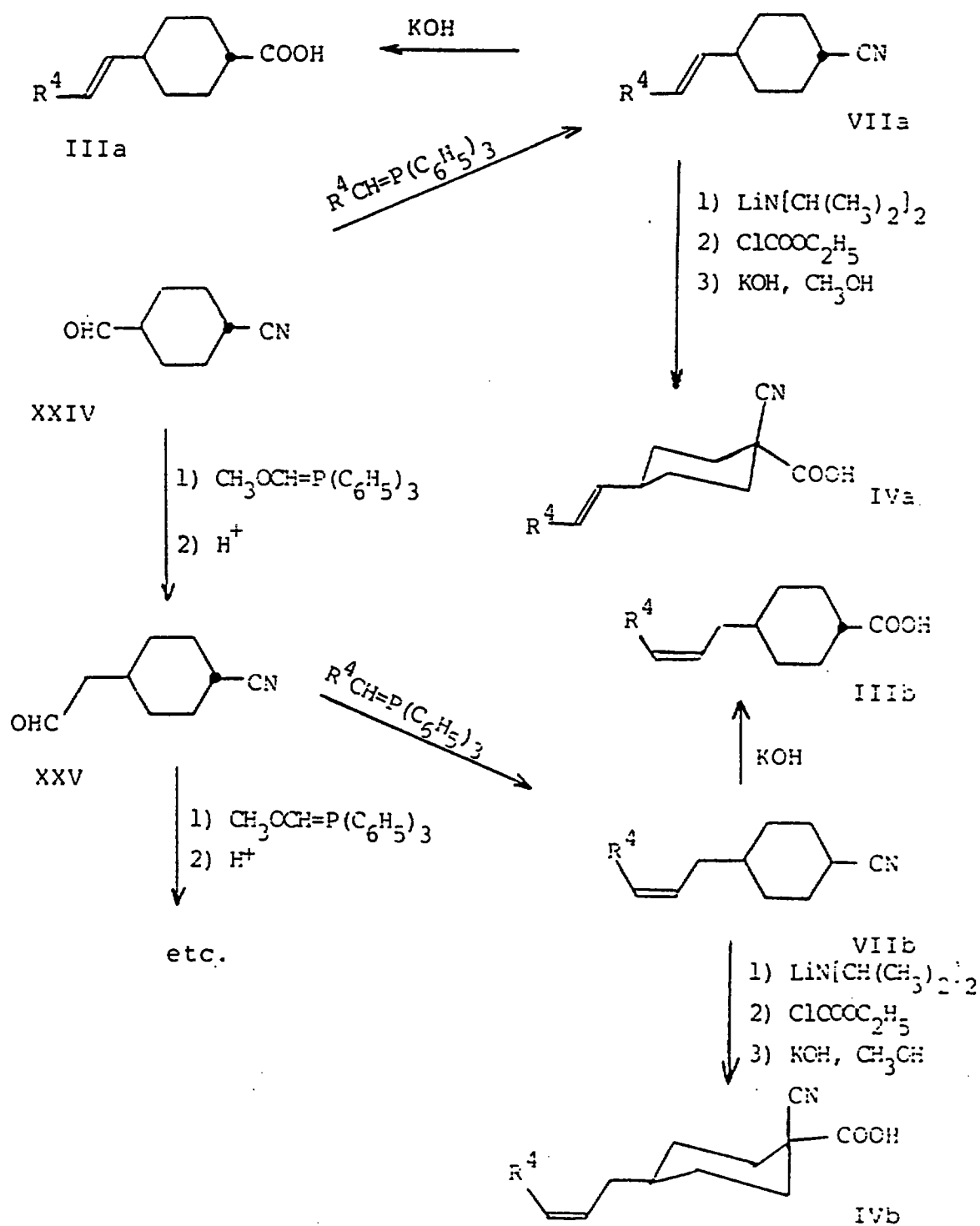
Scheme 1



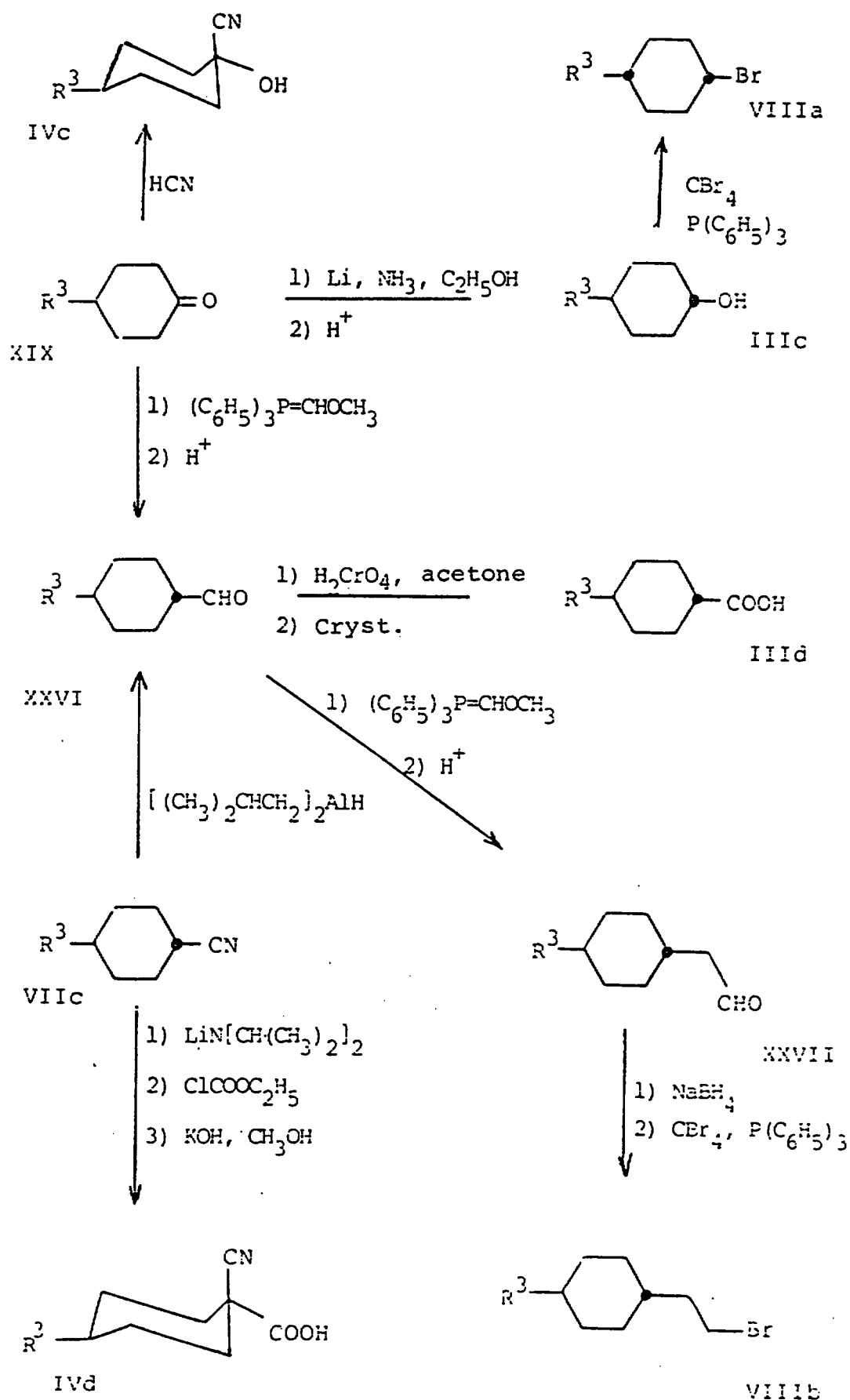
Scheme 2



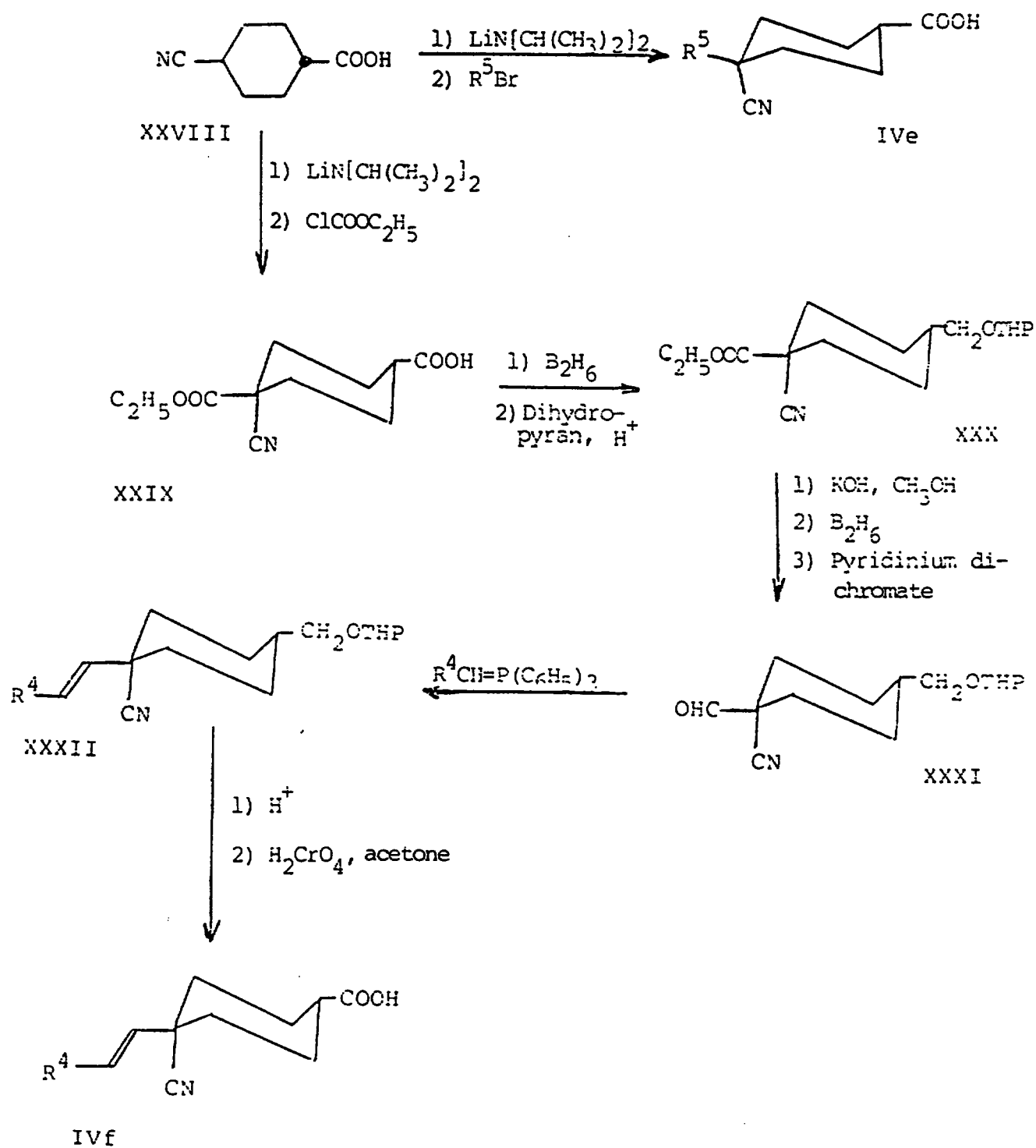
Scheme 3



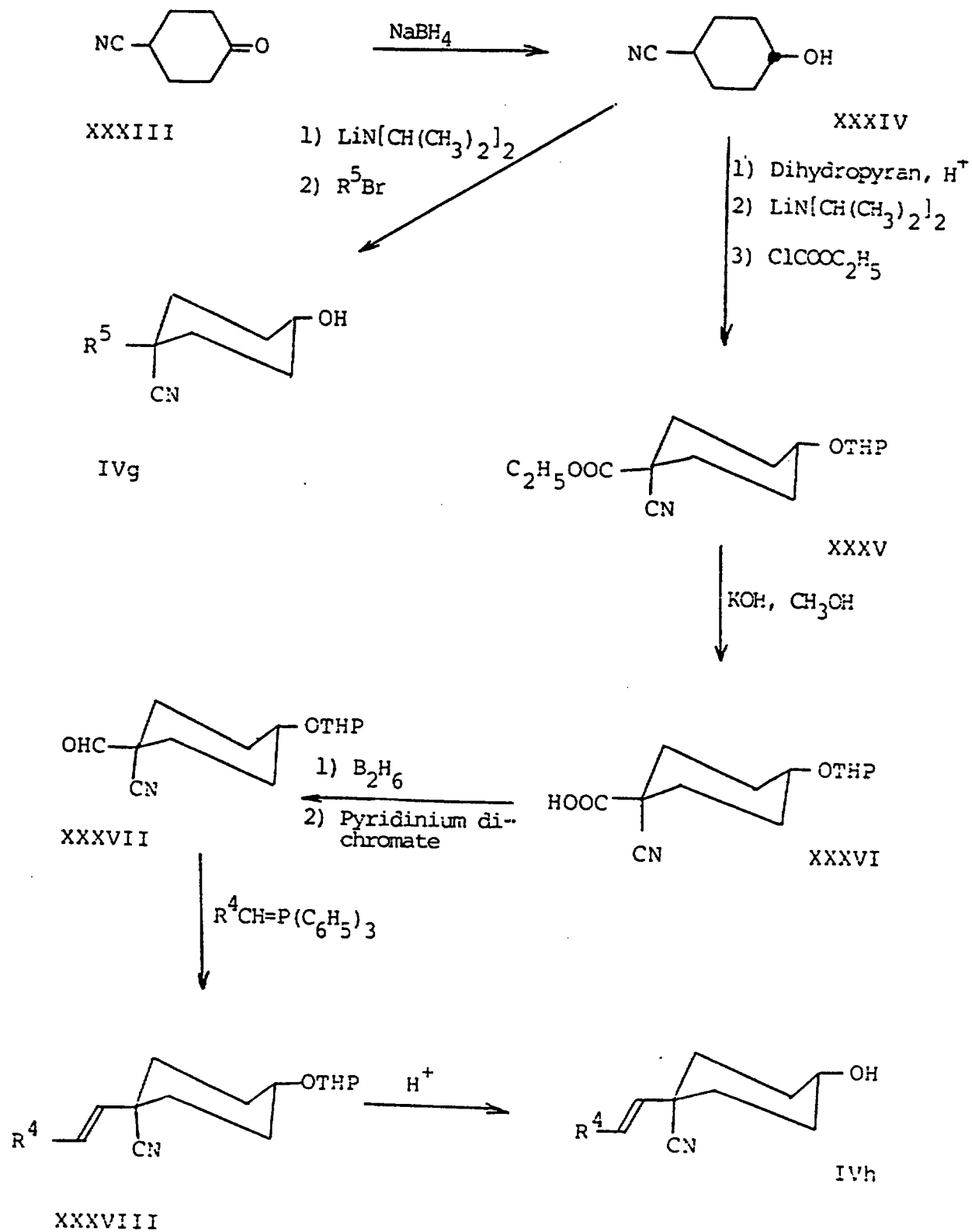
Scheme 4



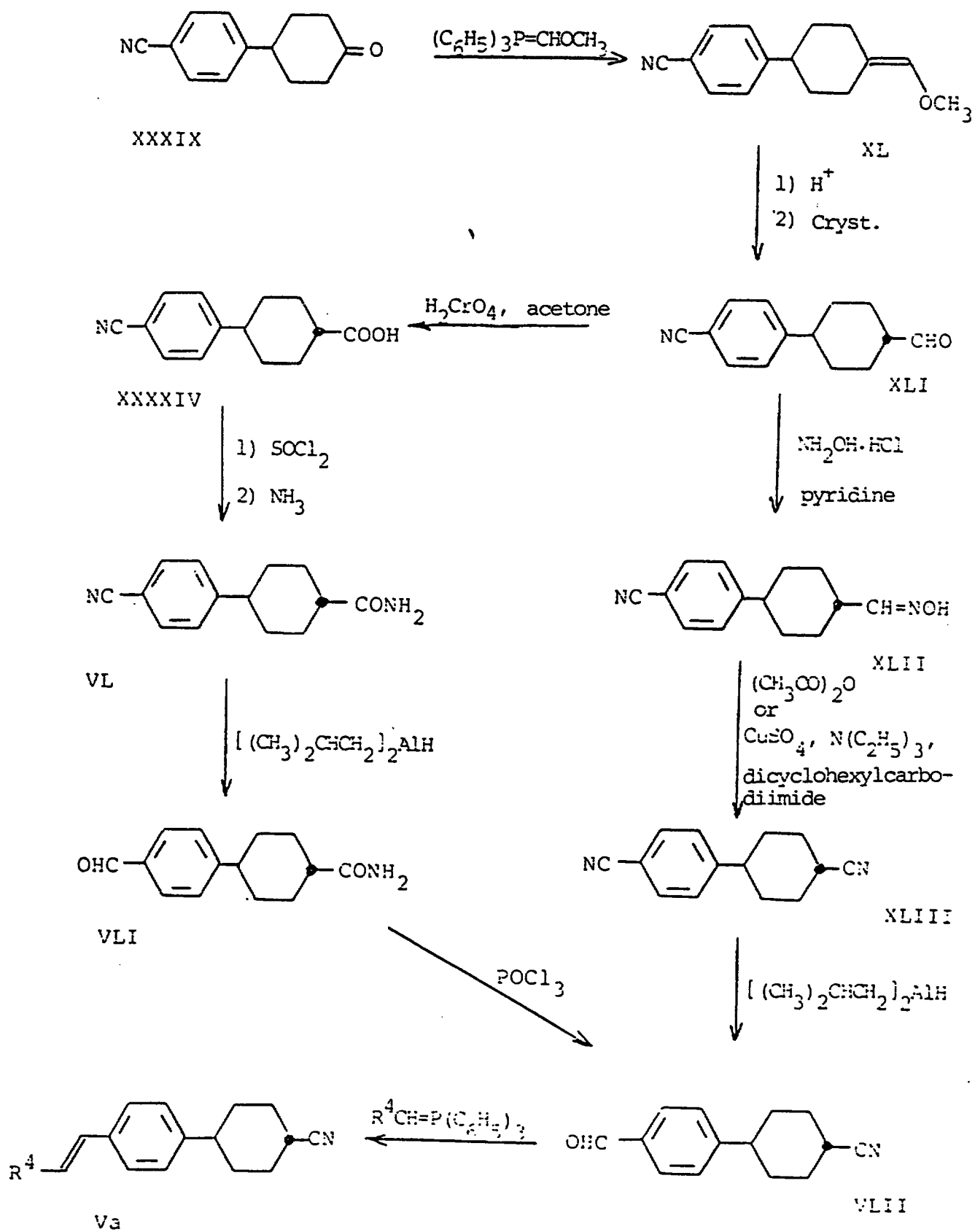
Scheme 5



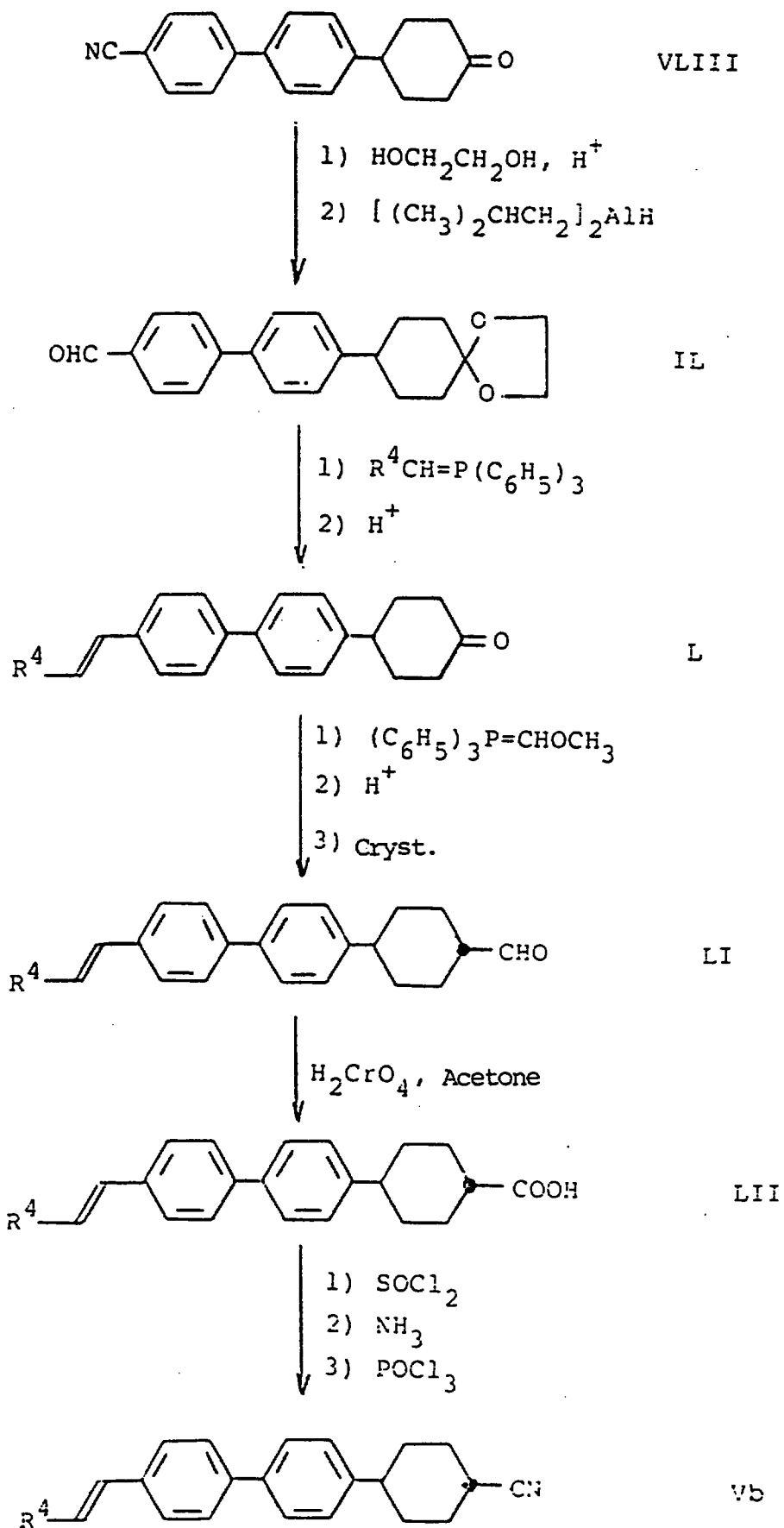
Scheme 6



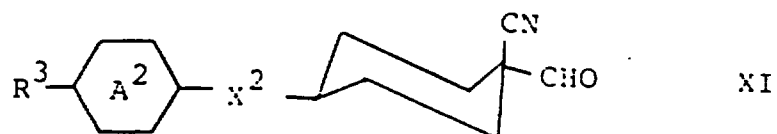
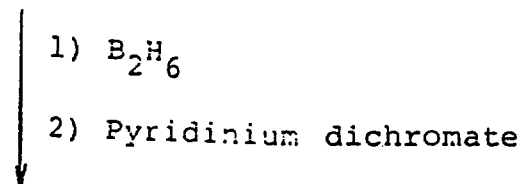
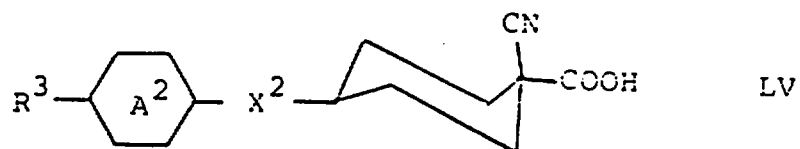
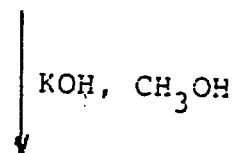
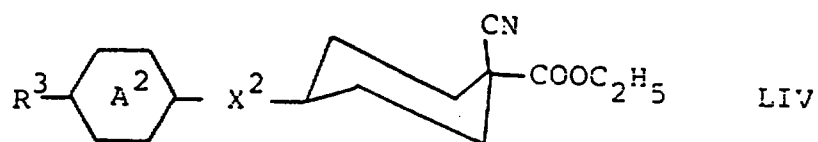
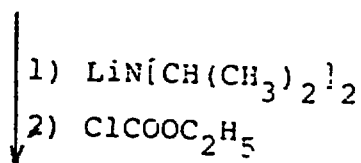
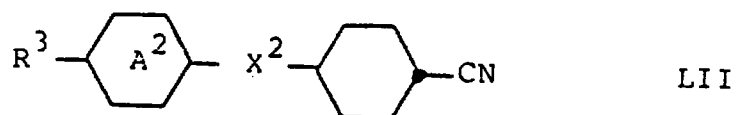
Scheme 7



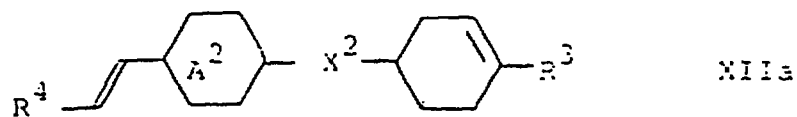
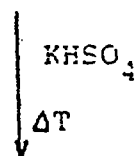
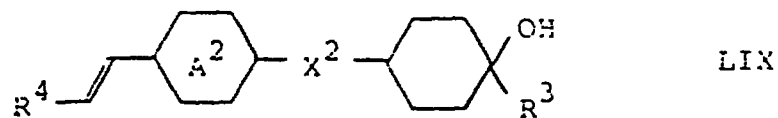
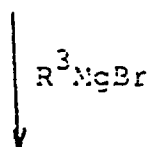
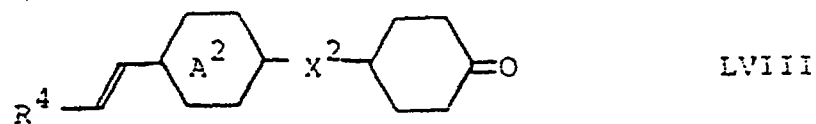
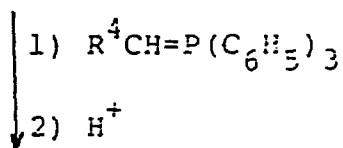
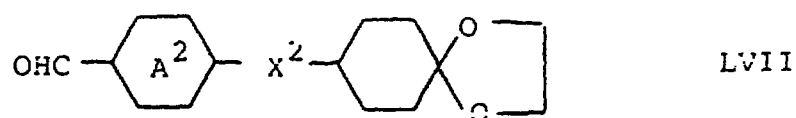
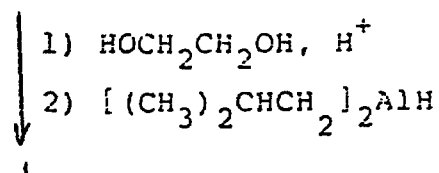
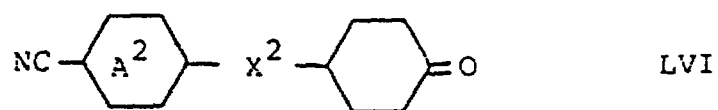
Scheme 8



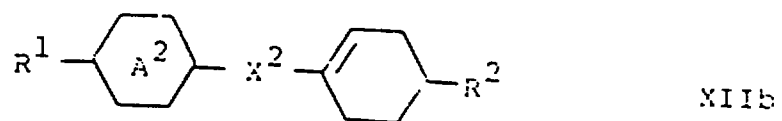
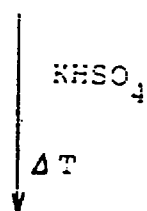
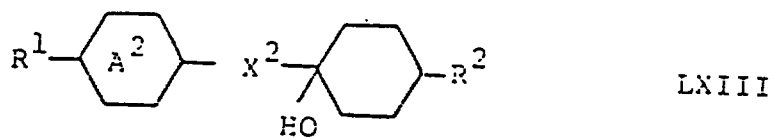
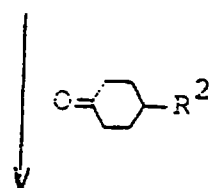
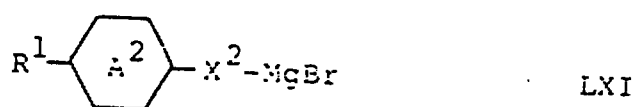
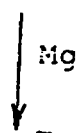
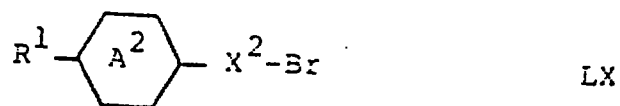
Scheme 9



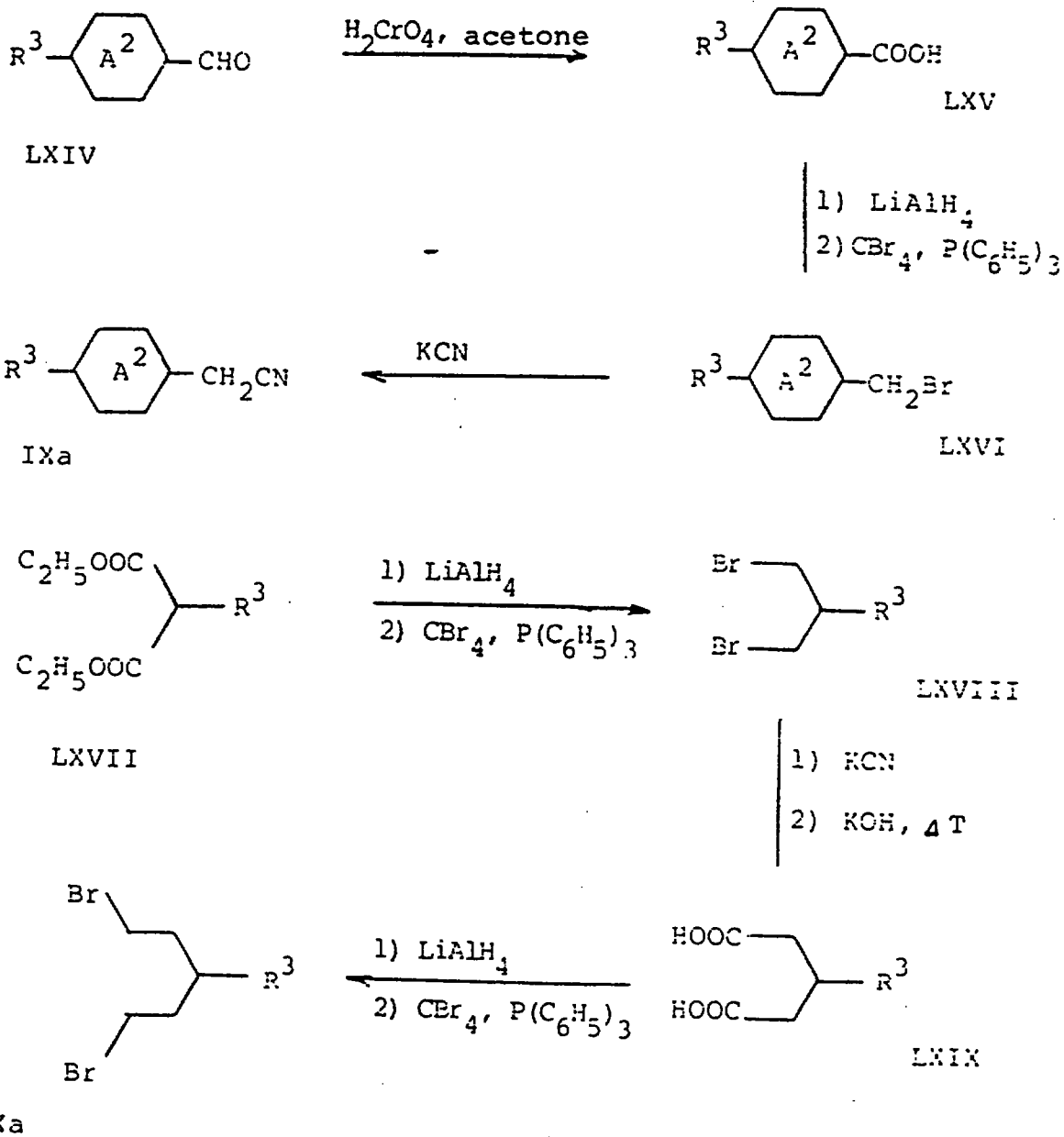
Scheme 10



Scheme 11



Scheme 12



In the above reactions there are obtained in certain cases mixtures of cis/trans-isomeric cyclohexane derivatives which, however, can be separated in a manner known per se, e.g. by chromatography and/or crystallization. Further, in certain cases there are obtained mixtures of cis/trans-isomeric alkenyl compounds, especially when the alkenyl group is introduced by a Wittig reaction. These can also be separated according to methods known per se, e.g. by chromatography. In this case, silica gel impregnated with silver nitrate has been found to be especially advantageous. If desired, the undesired alkenyl isomer can be converted into the desired isomer, for example by reaction with p-toluenesulphonic acid or via the epoxide, e.g. by reaction with m-chloroperbenzoic acid in the presence of potassium carbonate, halogenation of the epoxide with triphenylphosphine-bromine in benzene and reduction of the halide with zinc in glacial acetic acid.

Additional alkenyl derivatives to those shown in Schemes 3, 7, 8 and 10 and additional compounds of formula IX can be obtained after chain-lengthening an aldehyde according to the method indicated in Scheme 2.

The phenols in which R^1 signifies an alkenyl group, which fall under formula III, can be obtained from the corresponding phenols which have a formyl group in place of the residue R^1 , e.g. by introducing a 2-methoxyethoxymethyl protecting group, introducing the alkenyl group by a Wittig reaction, optionally after previous chain-lengthening (in a manner analogous to Scheme 2), and finally cleaving off the protecting group by means of zinc bromide.

The compounds of formula LXVII (Scheme 12) in which R^3 signifies alkyl or trans-1-alkenyl are known compounds or analogues of known compounds. The remaining compounds of formula LXVII can be obtained from diethyl malonate, e.g. by reaction with lithium diisopropylamide and an alkenyl bromide.

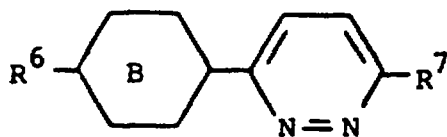
The compounds in accordance with the invention can be used in the form of mixtures with one another or with other liquid crystals such as e.g. with substances from the classes of Schiff's bases, azobenzenes, azoxybenzenes, phenyl benzoates, cyclohexanecarboxylic acid phenyl esters, cyclohexanecarboxylic acid cyclohexyl esters, biphenyls, terphenyls, phenylcyclohexanes, cyclohexylbiphenyls, phenylpyrimidines, diphenylpyrimidines, cyclohexyl-phenylpyrimidines, phenyldioxanes, phenylpyridazines, 2,3-dicyano-1,4-phenylene derivatives and the like. Such compounds are known to the person skilled in the art and many of them are, moreover, commercially obtainable.

The mixtures in accordance with the invention preferably contain about 1-90 wt.% and particularly about 10-50 wt.% of compounds of formula I.

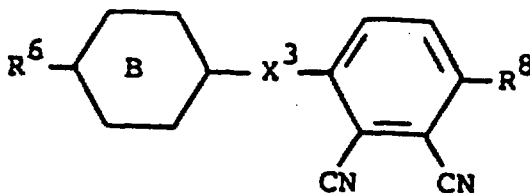
Preferably, the compounds in accordance with the invention are used for mixtures with negative dielectric anisotropy or for mixtures which are suitable for two-frequency control. The manufacture of such mixtures is known per se.

The mixtures in accordance with the invention for the two-frequency matrix addressing preferably contain a component A with a dielectric anisotropy below -2 and a component B which has a dielectric anisotropy above +10, a clearing point of at least 100°C and a cross-over frequency in the total mixture of at most 15 kHz at 20°C. The amount of component A preferably amounts to about 5-85 wt.% and the amount of component B preferably amounts to about 3-30 wt.%. The mixtures in accordance with the invention for the two-frequency matrix addressing can contain additional compounds, preferably a component C which has a viscosity (bulk viscosity) of at most 40 cP, a clearing point of at least 40°C and a dielectric anisotropy between -2 and +1. The amount of component C conveniently amounts to about 0-70 wt.% and preferably about 10-50 wt.%. Components A, B and C each consist of one or more compounds and component A contains at least one compound of formula I above.

Component A can contain further compounds besides one or more compounds of formula I, for example compounds of the general formulae



LXX

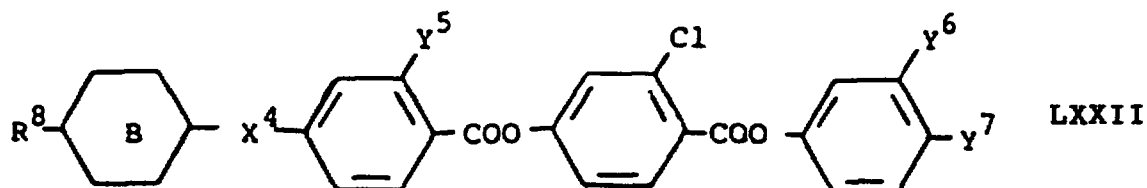


LXXI

wherein ring B represents 1,4-phenylene or trans-1,4-cyclohexylene; X^3 denotes a single covalent bond, $-CH_2CH_2-$ or $-COO-$; R^6 and R^7

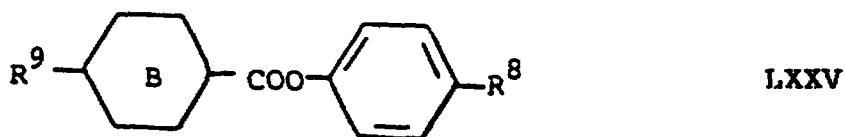
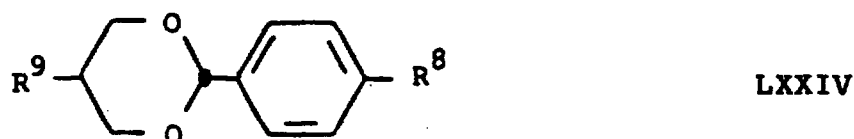
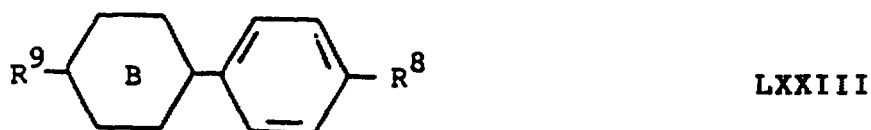
signify straight-chain C₁-C₇-alkyl; and R⁸ represents straight-chain C₁-C₇-alkyl or straight-chain C₁-C₆-alkoxy.

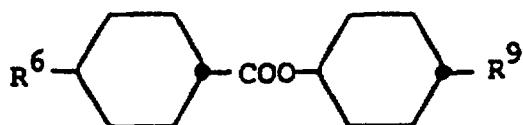
Component B preferably contains at least one compound of the general formula



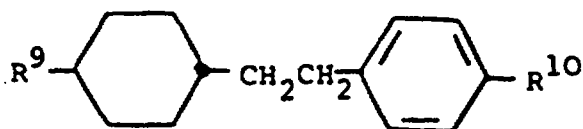
wherein ring B represents 1,4-phenylene or trans-1,4-cyclohexylene; X⁴ denotes a single covalent bond, -CH₂CH₂-, -COO- or 1,4-phenylene; R⁸ signifies straight-chain C₁-C₇-alkyl or on a benzene ring also straight-chain C₁-C₆-alkoxy; Y⁵ stands for hydrogen or chlorine; and Y⁶ and Y⁷ signify cyano, nitro, fluorine, chlorine or bromine or Y⁶ signifies hydrogen and Y⁷ signifies 2,2-dicyanovinyl or 2,2-dicyano-1-methylvinyl.

Compounds and mixtures which are suitable as component C are to a large extent known. Preferably, component C contains one or more compounds of the following general formulae

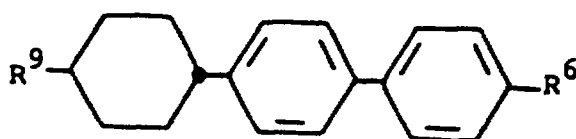




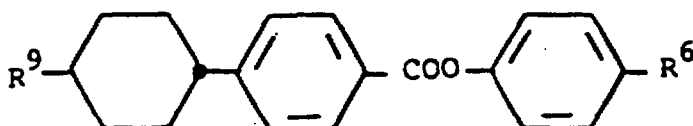
LXXVI



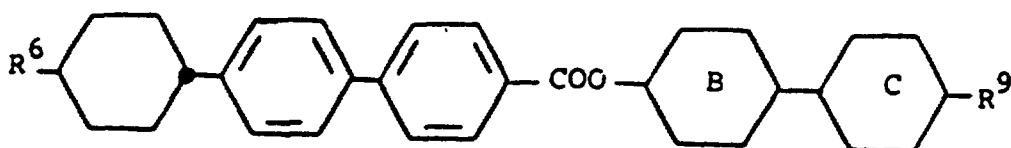
LXXVII



LXXVIII



LXXIX



LXXX

wherein rings B and C represent 1,4-phenylene or trans-1,4-cyclohexylene; R^6 signifies straight-chain C_1 - C_7 -alkyl; R^8 stands for straight-chain C_1 - C_7 -alkyl or straight-chain C_1 - C_6 -alkoxy; R^9 denotes straight-chain C_1 - C_7 -alkyl, straight-chain C_4 - C_7 -trans-3-alkenyl or on a cyclohexane or dioxane ring also straight-chain C_2 - C_7 -trans-1-alkenyl; R^{10} represents alkyl, alkoxy, p-alkyl-phenyl, p-alkoxyphenyl, trans-4-alkylcyclohexyl, 4'-alkyl-4-biphenyl, p-(trans-4-alkylcyclohexyl)-phenyl, 2-(trans-4-alkylcyclohexyl)ethyl, p-[2-(trans-4-alkylcyclohexyl)-ethyl]phenyl or 2-[p-(trans-4-alkylcyclohexyl)phenyl]ethyl, and the alkyl and alkoxy residues in R^{10} are straight-chain residues with 1 to 7 carbon atoms.

The mixtures in accordance with the invention with negative dielectric anisotropy preferably contain, in addition to one or more compounds of formula I, one or more compounds of formulae LXX, LXXI and LXXIII-LXXX above.

The mixtures in accordance with the invention can also contain optically active compounds (for example optically active biphenyls) and/or dichroic colouring substances (for example azo, azoxy or anthraquinone colouring substances). The amount of such compounds is determined by the solubility and the desired pitch, colour, extinction and the like. Preferably, the amount of optically active compounds amounts to a maximum of about 4 wt.% and the amount of dichroic colouring substances amounts to a maximum of about 10 wt.% in the total mixture.

The manufacture of the mixtures in accordance with the invention can be carried out in a manner known per se, e.g. by heating a mixture of the components to a temperature barely above the clearing point and subsequently cooling down. The manufacture of an electro-optical device can also be carried out in a manner known per se, e.g. by evacuating a suitable cell and introducing the mixture into the evacuated cell.

The compounds of formulae LXXIII-LXXX in which R⁹ signifies alkenyl are novel. They can be obtained in an analogous manner to the methods described in connection with the manufacture of the compounds of formula I. The remaining compounds of formulae LXXIII-LXXX and the compounds of formula LXX-LXXII are known compounds or analogues of known compounds.

The following mixtures 1-6 are examples of preferred mixtures in accordance with the invention. V₀ denotes the homeotropic threshold potential, Δε denotes the dielectric anisotropy and Δn denotes the optical anisotropy measured at 22°C.

Mixture 1

8.54 wt. %	of	trans-4-butylcyclohexanecarboxylic acid p-ethoxyphenyl ester,
7.54	"	trans-4-pentylcyclohexanecarboxylic acid p-methoxyphenyl ester,
9.92	"	4-ethoxy-1-[2-(trans-4-pentylcyclohexyl)ethyl] benzene,
11.00	"	1-[2-(trans-4-butylcyclohexyl)ethyl]-4-(trans-4-pentylcyclohexyl)benzene,
7.00	"	4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-(trans-4-pentylcyclohexyl)-1,1'-ethylenedibenzene,
20.00	"	r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-butylcyclohexyl)cyclohexane,

10.00 wt.% of r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-pentylcyclohexyl)cyclohexane,
 26.00 " r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-heptylcyclohexyl)cyclohexane;
 m.p. < -20°C, cl.p. 73°C, nematic; $\Delta\epsilon = -4$, $V_0 = 1.75V$; $\Delta n = 0.06$.

Mixture 2

7.8 wt.% of trans-4-butylcyclohexanecarboxylic acid p-ethoxyphenyl ester,
 3.7 " trans-4-butylcyclohexanecarboxylic acid p-pentyloxyphenyl ester,
 7.7 " trans-4-pentylcyclohexanecarboxylic acid p-methoxyphenyl ester,
 13.0 " 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-(trans-4-pentylcyclohexyl)benzene,
 9.0 " 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-(trans-4-pentylcyclohexyl)-1,1'-ethylenedibenzene,
 17.7 " r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-butylcyclohexyl)cyclohexane,
 6.1 " r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-pentylcyclohexyl)cyclohexane,
 35.0 " r-1-cyano-1-(3-butenyl)-cis-4-[2-(trans-4-propylcyclohexyl)ethyl]cyclohexane;
 m.p. < -20°C, cl.p. 71°C, nematic; $\Delta\epsilon = -3.8$, $V_0 = 1.85V$; $\Delta n = 0.05$.

Mixture 3

11.0 wt.% of trans-4-butylcyclohexanecarboxylic acid p-ethoxyphenyl ester,
 10.0 " trans-4-butylcyclohexanecarboxylic acid p-pentyloxyphenyl ester
 10.0 " trans-4-pentylcyclohexanecarboxylic acid p-methoxyphenyl ester,
 9.5 " trans-4-pentylcyclohexanecarboxylic acid p-propyloxyphenyl ester,
 10.0 " 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-(trans-4-pentylcyclohexyl)benzene,
 4.0 " 4-[2-(trans-4-butylcyclohexyl)ethoxy]-4'-(trans-4-pentylcyclohexyl)biphenyl,
 5.0 " 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-(trans-4-pentylcyclohexyl)-1,1'-ethylenedibenzene,
 6.5 " 4-butyl-1-[2-(trans-4-butylcyclohexyl)ethyl]-2,3-dicyanobenzene,
 7.5 " 4-butyl-1-[2-(trans-4-pentylcyclohexyl)ethyl]-2,3-dicyanobenzene,
 26.5 " r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-butylcyclohexyl)cyclohexane;
 cl.p. 67°C, nematic.

Mixture 4

7.79 wt.% of trans-4-butylcyclohexanecarboxylic acid
p-ethoxyphenyl ester,
3.64 " trans-4-butylcyclohexanecarboxylic acid
p-pentyloxyphenyl ester,
7.77 " trans-4-pentylcyclohexanecarboxylic acid
p-methoxyphenyl ester,
13.00 " 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-(trans-
-4-pentylcyclohexyl)benzene,
9.00 " 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-
-(trans-4-pentylcyclohexyl)-1,1'-ethylenedi-
benzene,
14.00 " r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-butyl-
cyclohexyl)cyclohexane,
4.80 " r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-pentyl-
cyclohexyl)cyclohexane,
40.00 " r-1-cyano-1-(3-butenyl)-cis-4-[2-(trans-4-pro-
pylcyclohexyl)ethyl]cyclohexane;
m.p. < -20°C, cl.p. 70°C, nematic: $\Delta\epsilon = -3.82$, $V_0 =$
1.85V; $\Delta n = 0.055$.

Mixture 5

2.80 wt.% of trans-4-butylcyclohexanecarboxylic acid
p-ethoxyphenyl ester,
2.59 " trans-4-pentylcyclohexanecarboxylic acid
p-methoxyphenyl ester,
9.00 " 4-ethoxy-1-[2-(trans-4-pentylcyclohexyl)-
ethyl]benzene,
14.20 " 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-(trans-
-4-pentylcyclohexyl)benzene,
9.77 " 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-
-(trans-4-pentylcyclohexyl)-1,1'-ethylenedi-
benzene,
14.00 " r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-butyl-
cyclohexyl)cyclohexane,
5.54 " r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-pentyl-
cyclohexyl)cyclohexane,
42.10 " r-1-cyano-1-[2-(trans-4-propylcyclohexyl)-
ethyl]-cis-4-(3-butenyl)cyclohexane;
m.p. < -20°C, cl.p. 64°C, nematic; $\Delta\epsilon = -4.04$, $V_0 =$
1.8V; $\Delta n = 0.05$.

Mixture 6

6.90 wt.% of trans-4-butylcyclohexanecarboxylic acid
p-ethoxyphenyl ester,
6.42 " trans-5-pentylcyclohexanecarboxylic acid
p-methoxyphenyl ester,
19.23 " 4-ethoxy-1-[2-(trans-4-pentylcyclohexyl)-
ethyl]benzene,
11.55 " 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-(trans-
-4-pentylcyclohexyl)benzene,

6.79 wt.% of 4-butyl-1-[2-(trans-4-butylcyclohexyl)ethyl]-
-2,3-dicyanobenzene,
8.55 " 4-butyl-1-[2-(trans-4-pentylcyclohexyl)ethyl]-
-2,3-dicyanobenzene,
25.14 " r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-butyl-
cyclohexyl)cyclohexane,
15.42 " r-1-cyano-1-(3-butenyl)-cis-4-(4'-pentyl-4-
-biphenyl)cyclohexane;
cl.p. 52°C, nematic.

The manufacture of the compounds of formula I is illustrated further by the following Examples. C signifies a crystalline phase, S signifies a smectic phase, N signifies a nematic phase and I signifies the isotropic phase.

Example 1

A solution of 1.157 g of diisopropylamine in 95 ml of absolute tetrahydrofuran was treated dropwise within 2 minutes with 7.0 ml of a 1.6M solution of butyl lithium in hexane while stirring and gassing with nitrogen at -74°C to -69°C. The mixture was stirred for 15 minutes at this temperature, then treated dropwise within 3 minutes at -50°C with a solution of 2.5 g of 4'-pentyl-4-bicyclohexylcarbonitrile in 8.5 ml of absolute tetrahydrofuran and the mixture was stirred for a further 30 minutes at -50°C. Thereafter, the mixture was treated dropwise within 7 minutes with a solution of 1.291 g of 4-bromo-1-butene in 8.5 ml of absolute tetrahydrofuran and the resulting mixture was stirred for a further 1.5 hours at -50°C and subsequently for 1.5 hours at room temperature. The reaction mixture was then poured into 190 ml of saturated ammonium chloride solution and extracted with diethyl ether. The organic phases were washed with water, dried over sodium sulphate and freed from solvent in vacuo. The residual, yellow, liquid crystalline oil (2.982 g) was chromatographed on 90 g of silica gel in hexane. Hexane/toluene (vol. 9:1, 8:2 and 7:3) eluted r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-pentylcyclohexyl)cyclohexane as a colourless, liquid crystalline oil which crystallized upon cooling. Recrystallization from methanol gave colourless crystals with m.p. (C-N) 26.0°C and cl.p. (N-I) 61°C.

The following compounds were manufactured in an analogous manner:

r-1-Cyano-1-(3-butenyl)-cis-4-(trans-4-ethylcyclohexyl)cyclohexane; m.p. (C-I) 23.0° and 25.6°C (2 modifications), cl.p. (N-I) 13.8°C,

r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-propylcyclohexyl)cyclohexane; m.p. (C-N) 31.4°C, cl.p. (N-I) 48°C,

r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-butylcyclohexyl)cyclohexane; m.p. (C-N) 29.5°C, cl.p. (N-I) 51.2°C,

r-1-cyano-1-(3-butenyl)-cis-4-(trans-4-heptylcyclohexyl)cyclohexane; m.p. (C-S) 21.5°C, transition (S-N) 27°C, cl.p. (N-I) 63.5°C,

r-1-cyano-1-(3E-pentenyl)-cis-4-(trans-4-pentylcyclohexyl)cyclohexane; m.p. (C-N) 43.0°C, cl.p. (N-I) 68.6°C,

r-1-cyano-1-(4-pentenyl)-cis-4-(trans-4-pentylcyclohexyl)cyclohexane; m.p. (C-S) 4.6°C, cl.p. (S-I) 21.9°C,

r-1-cyano-1-(3-butenyl)-cis-4-[2-(trans-4-butylcyclohexyl)ethyl]cyclohexane; m.p. (C-N) 30.5°C, cl.p. (N-I) 44.5°C,

r-1-cyano-1-(3-butenyl)-cis-4-[2-(trans-4-propylcyclohexyl)ethyl]cyclohexane; m.p. (C-N) 10.1°C and 12.3°C (2 modifications), cl.p. (N-I) 40.1°C,

r-1-cyano-1-(3-butenyl)-cis-4-[2-(trans-4-pentylcyclohexyl)ethyl]cyclohexane; m.p. (C-N) 27.1°C, cl.p. (N-I) 54.1°C,

r-1-cyano-1-(3-butenyl)-cis-4-(4-pentylphenyl)cyclohexane; m.p. below 20°C, b.p. (0.1 mbar) 155-160°C,

r-1-cyano-1-(3-butenyl)-cis-4-(4'-pentyl-4-biphenyl)-cyclohexane; m.p. (C-N) 55.6°C, cl.p. (N-I) 134.7°C.

Example 2

A solution of 5.933 g of diisopropylamine in 480 ml of absolute tetrahydrofuran was treated dropwise within 11 minutes with 35.5 ml of a 1.6M solution of butyl lithium in hexane while stirring and gassing with nitrogen at -72°C to -70°C. The mixture was stirred for 15 minutes at this temperature, then treated dropwise within 8 minutes at -50°C with a solution of 8.0 g of 4-(3-butenyl)-cyclohexanecarbonitrile in 45 ml of absolute tetrahydrofuran (rinsing with 6 ml of absolute tetrahydrofuran) and the resulting mixture was stirred for a further 15 minutes at -50°C. Thereafter, the mixture was treated dropwise within 10 minutes with a solution of 11.42 g of trans-4-propyl-1-(2-bromoethyl)cyclohexane in 45 ml of absolute tetrahydrofuran and the resulting mixture was stirred for a further 1.5 hours at -50°C and subsequently for 1.5 hours at room temperature. The reaction mixture was then poured into 1 l of saturated ammonium chloride solution and extracted with diethyl ether. The organic phases were washed with water, dried over magnesium sulphate and freed from solvent in vacuo. The residual, yellow oil (16.1 g) was chromatographed on 300 g of silica gel in hexane. Hexane/toluene (vol. 19:1, 9:1, 8:2 and 7:3) eluted r-1-cyano-1-[2-(trans-4-propylcyclohexyl)ethyl]-cis-4-(3-butenyl)cyclohexane as a yellowish oil which was liquid crystalline upon cooling and which later crystallized. Recrystallization from 2-propanol gave pure product with m.p. (C-N) 5.3°C and cl.p. (N-I) 29.3°C.

The 4-(3-butenyl)cyclohexanecarbonitrile used as the starting material was prepared as follows:

a) A suspension of 133.7 g of methoxymethyl-triphenylphosphonium chloride in 1200 ml of absolute diethyl ether was treated with 46.6 g of solid potassium t-butyrate while stirring and gassing with nitrogen at room temperature and the mixture was stirred for a further 1 hour at room temperature. The mixture was then cooled to -60°C and treated dropwise within 20 minutes with a solution of 35.7 g of 4-cyanocyclohexanecarboxaldehyde in 200 ml of absolute tetrahydrofuran. The reaction mixture was left to warm to room temperature within 2.5 hours and then freed from solvent on a rotary evaporator at 50°C . The residual, red-brown, viscous oil was taken up in methylene chloride and the solution was washed twice with water. The aqueous phases were back-extracted twice with methylene chloride. The organic phases were dried over sodium sulphate and evaporated in vacuo. The residue was partially freed from triphenylphosphine oxide by recrystallization from toluene/hexane. The filtrate was chromatographed on 600 g of silica gel in hexane/toluene (vol. 1:1). Toluene/hexane (vol. 1:1), toluene and toluene/acetone (vol. 97.5:2.5) eluted 39.330 g of 4-(2-methoxyvinyl)cyclohexanecarbonitrile as a yellowish liquid.

b) A mixture of 39.330 g of 4-(2-methoxyvinyl)cyclohexanecarbonitrile, 387 ml of tetrahydrofuran and 97 ml of 2N hydrochloric acid was heated to reflux while stirring and gassing with nitrogen for 1 hour. After cooling the reaction mixture was poured into 900 ml of water and extracted three times with methylene chloride. The organic phases were washed twice with water, dried over sodium sulphate and freed from solvent in vacuo. There were obtained 34.9 g of 4-cyanocyclohexyl-acetaldehyde as a yellowish liquid which was reacted further without additional purification.

c) A suspension of 118.5 g of methoxymethyl-triphenylphosphonium chloride in 1000 ml of absolute diethyl ether was treated with 41.3 g of solid potassium t-butyrate while stirring and gassing with nitrogen at room temperature and the mixture was stirred for a further 1 hour at room temperature. The mixture was then cooled to -30°C and treated dropwise within 18 minutes with a solution of 34.9 g of 4-cyanocyclohexyl-acetaldehyde in 200 ml of absolute diethyl ether. The reaction mixture was left to warm to room temperature within 2 hours and then freed from solvent on a rotary evaporator at 50°C . The residual, brown oil was taken up in methylene chloride and the solution was washed twice with water. The aqueous phases were back-extracted twice with methylene chloride. The organic phases were dried over sodium sulphate and evaporated in vacuo. The residue was partially freed from triphenylphosphine oxide by recrystallization from toluene/hexane. The filtrate was chromatographed on 400 g of

silica gel in hexane/toluene (vol. 1:1). Toluene/hexane (vol. 1:1), toluene and toluene/acetone (vol. 97.5:2.5) eluted 36.297 g of 4-(3-methoxy-2-propenyl)cyclohexanecarbonitrile as a yellowish liquid.

d) A mixture of 36.297 g of 4-(3-methoxy-2-propenyl)-cyclohexanecarbonitrile, 330 ml of tetrahydrofuran and 83 ml of 2N hydrochloric acid was heated to reflux while stirring and gassing with nitrogen for 30 minutes. After cooling the reaction mixture was poured into 765 ml of water and extracted three times with methylene chloride. The organic phases were washed twice with water, dried over sodium sulphate and freed from solvent in vacuo. There were obtained 32.7 g of 3-(4-cyanocyclohexyl)propionaldehyde as a light brownish oil which was reacted further without additional purification.

e) A suspension of 27.9 g of methyl-triphenylphosphonium bromide in 350 ml of absolute t-butyl methyl ether was treated with 8.8 g of solid potassium t-butyrate while stirring and gassing with nitrogen at room temperature and the mixture was stirred for a further 1 hour at room temperature. The mixture was subsequently treated dropwise with a solution of 8.6 g of 3-(4-cyanocyclohexyl)propionaldehyde in 90 ml of absolute t-butyl methyl ether within 16 minutes and the yellow suspension was stirred further for 2 hours at room temperature. The reaction mixture was then freed from solvent on a rotary evaporator at 50°C. The residue was taken up in 200 ml of methanol/water (vol. 6:4) and the solution was extracted once with 200 ml of hexane and twice with 100 ml of hexane each time. The extracts were washed once with 130 ml of methanol/water (vol. 6:4) and twice with water, dried over sodium sulphate and freed from solvent in vacuo. The 4-(3-butenyl)-cyclohexanecarbonitrile obtained was used without further purification.

The trans-4-propyl-1-(2-bromoethyl)cyclohexane also used as a starting material was prepared in an analogous manner to the pentyl derivative described hereinafter:

f) A solution of 76.1 g of (trans-4-pentylcyclohexyl)-acetyl chloride in 500 ml of absolute diethyl ether was added dropwise while stirring to a suspension of 12.5 g of lithium aluminium hydride in 750 ml of absolute diethyl ether in such a manner that the reaction mixture did not boil too strongly. The mixture was stirred for a further 2 hours and then treated dropwise firstly with 30 ml of acetone and thereafter with 75 ml of water. The reaction mixture was subsequently acidified with 3N hydrochloric acid, the organic phase was separated and the aqueous phase was back-extracted with 200 ml of diethyl ether. The combined organic phase was washed neutral with water,

dried over sodium sulphate and concentrated, whereby 62.6 g of 2-(trans-4-pentylcyclohexyl)ethanol were obtained as a yellowish liquid.

g) 50.1 g of N-bromosuccinimide were added portionwise within 30 minutes to a solution of 49.6 g of 2-(trans-4-pentylcyclohexyl)ethanol and 71.9 g of triphenylphosphine in 160 ml of dichloromethane while stirring and cooling with an ice-bath in such a manner that the temperature did not rise above 30°C. The mixture was subsequently stirred for a further 3 hours, the suspension was then suction filtered and the filtrate was concentrated on a rotary evaporator. The still warm residue (2 phases) was treated slowly with 200 ml of hexane while shaking. The finely granular, orange precipitate was filtered off under suction and rinsed several times with hexane. The filtrate was concentrated and the crude trans-4-pentyl-1-(2-bromoethyl)cyclohexane obtained was distilled in vacuo. Yield: 53.3 g of main distillate; b.p. 93-99°C/about 0.1 Torr; purity 98.2%.

The following compounds were manufactured in an analogous manner:

r-1-Cyano-1-[2-(trans-4-propylcyclohexyl)ethyl]-cis-4-(1E-pentenyl)cyclohexane; m.p. (C-I) 28.5°C. cl.p. (N-I) 22°C.

r-1-cyano-1-[2-(trans-4-propylcyclohexyl)ethyl]-cis-4-(3E-pentenyl)cyclohexane; m.p. (C-N) 26.5°C. cl.p. (N-I) 41.8°C.

r-1-cyano-1-[2-(trans-4-propylcyclohexyl)ethyl]-cis-4-(4-pentenyl)cyclohexane; m.p. (C-I) 25.3°C.

Example 3

a) 10.4 g of triphenyl-methoxymethyl-phosphonium chloride were suspended in 60 ml of t-butyl methyl ether while gassing with argon in a sulphonation flask having a thermometer, mechanical stirrer, dropping funnel and solid substance addition tube and the suspension was treated with 3.6 g of solid potassium t-butyrate at -10°C within 10 minutes. After completion of the addition the mixture was stirred for a further 30 minutes at -10°C to 0°C and then the deep orange, heterogeneous reaction mixture was treated dropwise at 0°C with a solution of 4.2 g of 4-(p-cyanophenyl)cyclohexanone in 50 ml of absolute tetrahydrofuran. The reaction mixture was subsequently stirred for a further 2 hours at room temperature, then poured into 500 ml of hexane and filtered. Low-pressure chromatography (0.5 bar) of the concentrated residue (7.1 g) on silica gel with ethyl acetate/petroleum ether (vol. 5:95) gave 4.5 g (94%) of p-[4-(methoxymethylene)cyclohexyl]benzonitrile as a colourless oil; purity 95%, Rf-value (ethyl acetate/petroleum ether vol. 1:9) 0.30.

b) A mixture of 4.2 g of p-[4-methoxymethylene)cyclohexyl]benzonitrile and 100 ml of tetrahydrofuran/2N hydrochloric acid (vol. 4:1) was heated to reflux for 30 minutes in a round flask. The reaction mixture was subsequently poured into 100 ml of water and extracted three times with 100 ml of diethyl ether each time. The organic phases were washed once with 100 ml of water, dried over magnesium sulphate and concentrated. There were obtained 3.9 g (100%) of 4-(p-cyanophenyl)cyclohexanecarboxaldehyde as a colourless oil which was used in the next step without further purification; trans/cis ratio about 3:1, Rf-value (ethyl acetate/petroleum ether vol. 3:7) 0.41. By crystallization from hexane there could be obtained pure trans-4-(p-cyanophenyl)cyclohexanecarboxaldehyde; m.p. 57.1°C.

Example 4

a) 149 g of methoxymethyl-triphenylphosphonium chloride and 860 ml of t-butyl methyl ether were placed at room temperature in a sulphonation flask while stirring and gassing with nitrogen, the suspension was cooled to -10°C and treated with 51.6 g of potassium t-butyrate within 10 minutes. The suspension was stirred for a further 30 minutes at -10°C to 0°C and then treated dropwise within 45 minutes at 0°C with a solution of 47.3 g of 4,4-ethylenedioxycyclohexanone in 720 ml of tetrahydrofuran. The orange suspension was stirred for a further 2 hours at room temperature, then poured into 5 l of hexane, stirred for 10 minutes and suction filtered. The filtrate was concentrated in vacuo and the yellow-brownish oil obtained (104.1 g) was treated with 500 ml of hexane and suction filtered. The filtrate was concentrated in vacuo, whereby 61.7 g of yellow-brownish oil were obtained. Chromatographic separation of this crude product on silica gel with methylene chloride/acetone (vol. 98:2 and 95:5) finally gave 53.5 g of 1,1-ethylenedioxy-4-(methoxymethylene)cyclohexane as a colourless oil.

b) A mixture of 28.2 g of 1,1-ethylenedioxy-4-(methoxymethylene)cyclohexane, 770 ml of glacial acetic acid and 385 ml of water was heated to reflux for 1 hour in a round flask while gassing with nitrogen. Thereafter, the yellowish clear solution was cooled to room temperature, diluted with 800 ml of water and extracted three times with 700 ml of methylene chloride each time. The organic phases were washed twice with 500 ml of 10% (wt./vol.) sodium carbonate solution each time, dried over sodium sulphate, filtered and concentrated. Chromatographic separation of the brownish liquid obtained (18.5 g) on silica gel with methylene chloride as the eluent finally gave 16.7 g of 4-formylcyclohexanone as a brownish liquid.

c) 63.3 g of p-cyanobenzyl-triphenylphosphonium chloride, 17.2 g of potassium t-butyrate and 195 ml of ethylene glycol dimethyl ether were placed in a sulphonation flask while stirring and gassing with nitrogen, whereby the internal temperature rose to 44°C. The brown suspension was cooled to 0°C and treated within 2 minutes with a solution of 16.7 g of 4-formylcyclohexanone in 100 ml of ethylene glycol dimethyl ether. Thereafter, the cooling bath was removed and the reaction mixture was stirred for a further 3.5 hours at room temperature. The suspension was subsequently poured into 500 ml of water and extracted three times with 600 ml of methylene chloride each time. The organic phases were washed twice with 500 ml of 10% (wt./vol.) sodium chloride solution each time, dried over sodium sulphate, filtered and concentrated, whereby 76.9 g of a brownish paste remained behind. Chromatographic separation of this crude product on silica gel with methylene chloride as the eluent gave 33.0 g of 4-[2-(p-cyanophenyl)vinyl]cyclohexanone as a yellow-brownish oil.

d) A mixture of 33.0 g of 4-[2-(p-cyanophenyl)vinyl]cyclohexanone, 520 ml of toluene, 260 ml of ethanol and 3.2 g of palladium/carbon (5%) was placed at room temperature in a round flask equipped with a magnetic stirrer and the mixture was hydrogenated until the hydrogen uptake had come to a standstill. The black suspension was subsequently suction filtered (rinsing with toluene) and the filtrate was concentrated in vacuo. The slightly turbid, yellowish oil obtained (34.1 g) was separated by chromatography on silica gel. Methylene chloride/hexane (vol. 1:1), methylene chloride/hexane (vol. 8:2) and methylene chloride eluted 25.6 g of yellowish oil which was crystallized from t-butyl methyl ether. There were thus obtained 22.6 g of 4-[2-(p-cyanophenyl)ethyl]cyclohexanone as colourless crystals with m.p. 62.5-64.3°C.

Example 5

a) 261.2 g of methoxymethyl-triphenylphosphonium chloride were suspended in 550 ml of t-butyl methyl ether and the suspension was treated at -10°C with 90.53 g of potassium t-butyrate. The cooling bath was removed and the mixture was stirred for a further 1 hour at room temperature. The suspension was subsequently treated slowly at -10°C with a solution of 70 g of 4,4-ethylenedioxycyclohexanone in 350 ml of tetrahydrofuran, the mixture was stirred for a further 1 hour at room temperature, then treated with water and extracted three times with diethyl ether. The organic phases were washed twice with water and the aqueous phases were back-extracted with diethyl ether. The combined organic phases were dried over magnesium sulphate and concentrated. The crystalline residue obtained was dissolved in ethyl acetate, diluted with petroleum ether,

filtered and freed from solvent. Distillation of the yellow oil obtained (100 g) gave in the main run (71°C/0.20-0.17 Torr) 75.28 g (91.17%) of 1,1-ethylenedioxy-4-(methoxymethylene)cyclohexane as a clear, colourless liquid.

b) A mixture of 10.55 g of 1,1-ethylenedioxy-4-(methoxymethylene)cyclohexane, 130 ml of water and 200 ml of glacial acetic acid was heated to reflux for 1 hour. The solvent was subsequently distilled off on a rotary evaporator and the distillate was extracted twice with methylene chloride. The distillation residue (a yellow oil) was diluted with 200 ml of water, neutralized with sodium carbonate solution and extracted three times with methylene chloride. The organic phases were washed with saturated sodium carbonate solution and the aqueous phases were back-extracted with methylene chloride. The organic phases were dried over magnesium sulphate and evaporated. Distillation of the residual, yellow oil gave, at 70°C/0.15 Torr, 6.7 g (93%) of 4-formylcyclohexanone.

c) A solution of 36.72 g of triphenylphosphine in 200 ml of methylene chloride was treated slowly at -20°C with 23.22 g of carbon tetrabromide and the mixture was stirred for a further 10 minutes. The mixture was subsequently added dropwise by means of a cannula to a solution, cooled to -60°C, of 6.30 g of 4-formylcyclohexanone in 100 ml of methylene chloride. The reaction mixture was stirred for a further 15 minutes at -60°C and then partitioned in water/methylene chloride. The aqueous phases were extracted twice with methylene chloride. The organic phases were washed twice with water, dried over magnesium sulphate and evaporated. Low-pressure chromatography of the pale yellow oil obtained (16 g) on silica gel with ethyl acetate/petroleum ether (vol. 10:90) gave 12.08 g (85.8%) of 4-(2,2-dibromovinyl)cyclohexanone as a pale yellow liquid.

d) A mixture of 2 g of 4-(2,2-dibromovinyl)cyclohexanone, 3.43 g of ethylene glycol, 0.202 g of p-toluenesulphonic acid and 240 ml of benzene was boiled at reflux for 5 hours with the separation of water. The reaction mixture was subsequently treated with potassium carbonate, stirred briefly and left to stand overnight. Thereafter, the mixture was filtered and the filtrate was freed from solvent on a rotary evaporator. The residue was taken up in 200 ml of methylene chloride and the solution was washed twice with dilute sodium hydroxide solution and once with water. The aqueous phases were back-extracted with methylene chloride. The organic phases were dried over magnesium sulphate, filtered and evaporated. There were thus obtained 14 g of 1,1-ethylenedioxy-4-(2,2-dibromovinyl)-cyclohexane as a light yellow, crystallizing liquid.

e) A solution of 14 g of 1,1-ethylenedioxy-4-(2,2-dibromovinyl)cyclohexane in 70 ml of tetrahydrofuran was cooled to -20°C and treated slowly at this temperature with 76.62 ml of a 1.4M solution of butyl lithium in hexane (exothermic reaction). The cooling bath was removed and the mixture was left to warm to 20°C within about 20 minutes. The reaction mixture was subsequently treated with 150 ml of water and extracted three times with diethyl ether. The organic phases were washed twice with water and the wash-water was back-extracted with diethyl ether. The organic phases were dried over magnesium sulphate, filtered and evaporated. Low-pressure chromatography of the residual, yellow liquid (8 g) on silica gel with ethyl acetate/petroleum ether (vol. 7:93) gave 6.5 g (91%) of 4-ethynyl-1,1-ethylenedioxycyclohexane as a clear liquid.

f) A solution of 6.5 g of 4-ethynyl-1,1-ethylenedioxy-cyclohexane in 40 ml of tetrahydrofuran was treated at -20°C with 39.1 ml of a 1.4M solution of butyl lithium in hexane. The mixture was subsequently treated at 0°C with 60 ml of hexamethylphosphoric acid triamide (brief temperature increase to 26°C) and then dropwise with 6.5 ml of propyl iodide. The cooling bath was removed and the mixture was left to warm to room temperature. A white precipitate formed. After 30 minutes the reaction mixture was treated with 150 ml of water and extracted three times with hexane. The organic phases were washed three times with water and the wash-water was back-extracted with hexane. The organic phases were dried over magnesium sulphate, filtered and freed from solvent on a rotary evaporator. Low-pressure chromatography of the yellow liquid obtained (9 g) on silica gel with ethyl acetate/petroleum ether (vol. 10:90) and treatment with active carbon gave 6.23 g (76.5%) of 1,1-ethylenedioxy-4-(1-pentynyl)cyclohexane as a slightly pale yellow liquid.

g) A solution of 4.5 g of 1,1-ethylenedioxy-4-(1-pentynyl)cyclohexane in 54 ml of tetrahydrofuran was treated dropwise with about 50 ml of pre-condensed ammonia in a sulphonation flask having a magnetic stirrer. The mixture was subsequently treated portionwise at -78°C within 7 hours with 1.3 g of sodium. 1.5 hours after the last addition the ammonia was evaporated off and the reaction mixture was neutralized with 25% hydrochloric acid and left to stand overnight. Thereafter, the reaction mixture was partitioned three times in water/diethyl ether. The aqueous phases were back-extracted with diethyl ether. The organic phases were dried over magnesium sulphate and freed from solvent on a rotary evaporator. The pale yellow liquid obtained (3.8 g) was treated with 200 ml of acetone and 0.1 ml of concentrated sulphuric acid. The mixture was heated to reflux for 10 minutes.

then treated with water and freed from acetone on a rotary evaporator. The residue was partitioned three times in methylene chloride/water. The aqueous phases were back-extracted with methylene chloride. The organic phases were dried over magnesium sulphate and evaporated. Chromatographic separation of the residual, yellow liquid (3.5 g) on silica gel with ethyl acetate/petroleum ether (vol. 7:93) gave 3.0 g (83.5%) of 4-(trans-1-pentenyl)-cyclohexanone as a pale yellow liquid.

h) 1.63 g of 4-(trans-1-pentenyl)cyclohexanone were dissolved in 8 ml of diethyl ether and 14 ml of ethanol. The solution was subsequently-treated dropwise with about 70 ml of ammonia and the mixture was treated portionwise with lithium wire until the colour of the reaction mixture remained constant for 1.5 hours (about 1.3 g of lithium). Thereafter, the ammonia was evaporated off and the mixture was made acid with ammonium chloride and hydrochloric acid and left to stand for 3 days. The reaction mixture was then partitioned in diethyl ether/water and the aqueous phases were back-extracted with diethyl ether. The organic phases were dried over magnesium sulphate, filtered and freed from solvent on a rotary evaporator. Low-pressure chromatography of the residual, yellow oil on silica gel with ethyl acetate/petroleum ether (vol. 10:90) gave 1.47 g (89.1%) of trans-4-(trans-1-pentenyl)cyclohexanol as a light yellow, viscous oil.

Example 6

a) 7 g of methoxymethyl-triphenylphosphonium chloride were suspended in 35 ml of t-butyl methyl ether and the suspension was treated at -20°C with 2.43 g of potassium t-butyrate. The mixture was stirred for a further 1 hour at room temperature, then treated dropwise at -20°C with a solution of 2 g of 4-(trans-1-pentenyl)cyclohexanone in 18 ml of tetrahydrofuran and the mixture was stirred for a further 1 hour at room temperature. The reaction mixture was subsequently treated with water and extracted three times with 50 ml of diethyl ether each time. The extracts were washed with water and the wash-water was back-extracted with diethyl ether. The organic phases were dried over magnesium sulphate and freed from solvent. The residue was dissolved in ethyl acetate and the solution was diluted with petroleum ether, freed from precipitated triphenylphosphine oxide by filtration and the filtrate was concentrated. This procedure for the separation of triphenylphosphine oxide was repeated twice and the crude product of 1-(methoxymethylene)-4-(trans-1-pentenyl)cyclohexane obtained was processed without additional purification.

b) 2.75 g of 1-(methoxymethylene)-4-(trans-1-pentenyl)-cyclohexane (crude product from paragraph a) were heated to boiling for 30 minutes with 100 ml of tetrahydrofuran/2N hydrochloric acid (vol. 4:1) and then stirred overnight at room temperature. The mixture was subsequently treated with 100 ml of water and extracted three times with 100 ml of diethyl ether each time. The extracts were washed with dilute sodium hydrogen carbonate solution and water and the aqueous phases were back-extracted with diethyl ether. The organic phases were dried over magnesium sulphate and evaporated. Low-pressure chromatography of the residual yellowish liquid (2.5 g) on silica gel with petroleum ether and ethyl acetate/petroleum ether (vol. 3:97) gave 1.65 g (76%) of 4-(trans-1-pentenyl)-cyclohexanecarboxaldehyde.

c) A solution of 1.6 g of 4-(trans-1-pentenyl)cyclohexanecarboxaldehyde in 120 ml of acetone was cooled to -10°C , treated dropwise with 8N chromic acid (about 10 ml) until the colour of the reaction mixture remained brown-orange and the mixture was stirred for a further 1 hour. Excess chromic acid was reduced by adding isopropanol. The green solution was subsequently partitioned three times in water/methylene chloride. The organic extracts were washed twice with water and the wash-water was back-extracted with methylene chloride. The organic phases were dried over magnesium sulphate and evaporated. The pale brown crystalline residue (2.01 g) was dissolved partially in 20 ml of petroleum ether. Undissolved residue was filtered off and the filtrate was evaporated. Recrystallization of the residue obtained from 60 ml of petroleum ether at -78°C gave 866 mg (49.5%) of 4-(trans-1-pentenyl)cyclohexanecarboxylic acid as white crystals.

d) A mixture of 1.29 g of 4-(trans-1-pentenyl)cyclohexanecarboxylic acid and 20 ml of a 11% (wt./vol.) solution of potassium hydroxide in diethylene glycol was boiled at reflux for 20 hours while gassing with argon. The reaction mixture was subsequently made slightly acid with 25% hydrochloric acid and partitioned three times in water/methylene chloride. The organic extracts were washed twice with water and the wash-water was back-extracted with methylene chloride. The organic phases were dried over magnesium sulphate and freed from solvent on a rotary evaporator. Recrystallization of the dark brown, crystallizing oil obtained (1.17 g) from 50 ml of petroleum ether at -78°C gave 0.44 g of trans-4-(trans-1-pentenyl)cyclohexanecarboxylic acid as pale brown crystals. The mother liquor containing 0.695 g of crude cis/trans-4-(trans-1-pentenyl)cyclohexanecarboxylic acid was not worked-up.

Example 7

A solution of 16.1 g of diethyl 2-(trans-1-pentenyl)-malonate (Tetrahedron Lett. 1979, 861) in 75 ml of tetrahydrofuran was added dropwise within 1 hour at 5°C to a suspension of 5.3 g of lithium aluminium hydride in 200 ml of dry tetrahydrofuran while stirring in an inert gas atmosphere. The mixture was stirred for a further 3.5 hours at room temperature and then treated dropwise successively with 15 ml of acetone and 20 ml of saturated sodium hydrogen carbonate solution. The reaction mixture was filtered, the filtrate was concentrated and the residue (8.2 g) was distilled in a bulb-tube at 150°C/about 1 Torr. There were thus obtained 6.5 g of 2-(trans-2-pentenyl)-1,3-propanediol as a colourless oil.

Example 8

A solution of 1.692 g of diisopropylamine in 138 ml of absolute tetrahydrofuran was treated dropwise within 3 minutes with 10.2 ml of a 1.6M solution of butyl lithium in hexane while stirring and gassing with nitrogen at -73°C to -70°C. The mixture was stirred for 15 minutes at this temperature and then treated dropwise at -50°C within 3 minutes with a solution of 4.40 g of 4-[2r-(trans-4-pentyl-cis-1-cyanocyclohexyl)ethyl]-1-cyclohexanecarbonitrile (cis/trans mixture) in 12.5 ml of absolute tetrahydrofuran (rinsing with 7 ml of absolute tetrahydrofuran). The yellow solution was stirred for 15 minutes at -50°C, treated dropwise within 7 minutes with a solution of 1.889 g of 4-bromo-1-butene in 12.5 ml of absolute tetrahydrofuran and stirred for a further 1.5 hours at -50°C and then for 1.5 hours at room temperature. The reaction mixture was poured into 280 ml of saturated ammonium chloride solution and extracted with diethyl ether. The organic phases were washed with water, dried over sodium sulphate and freed from solvent in vacuo. The yellow, solid residue (5.41 g) was chromatographed on silica gel in toluene. Toluene and toluene/1% acetone eluted 3.16 g of colourless, crystalline 1'(3-butenyl)-4α-pentyl-1,4'α-ethylenedi-1α-cyclohexanecarbonitrile. Recrystallization from diethyl ether/hexane gave pure product with m.p. 110.2°C.

The 4-[2r-(trans-4-pentyl-cis-1 -cyanocyclohexyl)-ethyl]-1-cyclohexanecarbonitrile used as the starting material was prepared as follows:

a) A solution of 38.7 g of 4-cyanocyclohexyl-acetaldehyde in 400 ml of methanol was treated portionwise within 20 minutes with 9.67 g of solid sodium borohydride at 0°C while stirring and gassing with nitrogen. After the exothermic reaction had faded the yellowish reaction mixture

was stirred at 0°C for 30 minutes, poured on to 1 l of ice-water and extracted with methylene chloride. The organic phases were washed with water and dried over sodium sulphate. After removing the solvent in vacuo there were obtained 38.4 g of 2-(4-cyanocyclohexyl)ethanol.

b) A solution of 38.4 g of 2-(4-cyanocyclohexyl)ethanol and 69.1 g of triphenylphosphine in 850 ml of absolute methylene chloride was treated portionwise within 1 hour with 87.3 g of solid tetrabromomethane while stirring and gassing with argon at -10°C. The yellowish, clear solution was stirred for a further 30 minutes at -10°C and for 30 minutes at 15°C and then freed from solvent in vacuo. The residual brownish oil was dissolved in methylene chloride and filtered through a column of silica gel in methylene chloride. There were thus obtained 62.6 g of crude 4-(2-bromoethyl)cyclohexanecarbonitrile (cis/trans mixture). Distillation gave a colourless liquid with b.p. (0.6 mbar) 111-112°C.

c) A solution of 6.176 g of diisopropylamine in 500 ml of absolute tetrahydrofuran was treated dropwise within 4 minutes with 37 ml of a 1.7M solution of butyl lithium in hexane while stirring and gassing with nitrogen at -72°C to -70°C and the mixture was stirred for a further 15 minutes. The mixture was then treated dropwise within 4 minutes at -50°C with a solution of 9.147 g of trans-4-pentylcyclohexanecarbonitrile in 45 ml of absolute tetrahydrofuran (rinsing with 6 ml of absolute tetrahydrofuran) and the resulting mixture was stirred for a further 15 minutes. Thereafter, the mixture was treated dropwise within 10 minutes at -50°C with a solution of 11.022 g of 4-(2-bromoethyl)cyclohexanecarbonitrile in 45 ml of absolute tetrahydrofuran. The yellow solution obtained was stirred for a further 1.5 hours at -50°C and for 1.5 hours at room temperature and then poured into 1 l of saturated ammonium chloride solution and extracted with diethyl ether. The organic phases were washed with water, dried over sodium sulphate and freed from solvent in vacuo. The yellow, semi-solid residue (16.5 g) was dissolved in hexane/methylene chloride (vol. 9:1) and chromatographed on silica gel with hexane/methylene chloride (with an increasing amount of methylene chloride). There were thus obtained 8.870 g of 4-[2r-(trans-4-pentyl-cis-1 -cyano-cyclohexyl)ethyl]-1-cyclohexanecarbonitrile as a yellowish oil. There were subsequently eluted with methylene chloride 3.415 g of 1-[2-(trans-4-cyanocyclohexyl)ethyl]-4'-α-pentyl-1,1' -ethylenedi-1α-cyclohexanecarbonitrile which had a m.p. of 158.9-159.5°C after recrystallization from diethyl ether/hexane.

The following compound was manufactured in an analogous manner:

1'-(4'-Pentenyl)-4 α -pentyl-1,4' α -ethylenedi-1 α -cyclohexanecarbonitrile; m.p. 109.7°C.

Example 9

A solution of 1.214 g of diisopropylamine in 99 ml of absolute tetrahydrofuran was treated dropwise within 2 minutes with 7.33 ml of a 1.6M solution of butyl lithium in hexane while stirring and gassing with nitrogen at -73°C to -70°C. The mixture was stirred for a further 15 minutes at this temperature and then treated dropwise at -50°C within 3 minutes with a solution of 3.144 g of 4-[2r-(trans-4-(4-pentenyl)-cis-1-cyanocyclohexyl)ethyl]-1-cyclohexanecarbonitrile (cis/trans mixture) in 9 ml of absolute tetrahydrofuran (rinsing with 5 ml of absolute tetrahydrofuran). The yellowish solution was stirred for a further 15 minutes at -50°C, treated dropwise within 4 minutes with a solution of 1.358 g of 4-bromo-1-butene in 9 ml of absolute tetrahydrofuran and the reddish solution obtained was stirred for a further 1.5 hours at -50°C and then for 1.5 hours at room temperature. The reaction mixture was poured into 200 ml of saturated ammonium chloride solution and extracted with diethyl ether. The organic phases were washed with water, dried over sodium sulphate and freed from solvent in vacuo. The yellow, solid residue (3.805 g) was chromatographed on silica gel in toluene. Toluene eluted 2.36 g of colourless, crystalline 1'-(3-butenyl)-4 α -(4-pentenyl)-1,4' α -ethylenedi-1 α -cyclohexanecarbonitrile. Recrystallization from diethyl ether/hexane gave pure product with m.p. 106.1°C.

The 4-[2r-(trans-4-(4-pentenyl)-cis-1-cyanocyclohexyl)ethyl]-1-cyclohexanecarbonitrile used as the starting material was prepared as follows:

a) A suspension of 101.9 g of methoxymethyl-triphenylphosphonium chloride in 910 ml of absolute diethyl ether was treated with 35.5 g of solid potassium t-butyrate while stirring and gassing with nitrogen at room temperature and the mixture was stirred for a further 1 hour. The mixture was then treated dropwise within 18 minutes at 2°C with a solution of 32.7 g of 3-(4-cyanocyclohexyl)propionaldehyde in 250 ml of absolute diethyl ether, the resulting mixture was stirred for 1.5 hours at room temperature and freed from solvent in vacuo. The brown residue was taken up in methylene chloride and the solution was washed with water, dried over sodium sulphate and evaporated in vacuo. The brown, solid residue was partially freed from triphenylphosphine oxide by recrystallization from toluene/hexane and the filtrate was chromatographed on silica gel in hexane/toluene. Hexane/toluene, toluene and toluene/acetone eluted 33.80 g of 4-

-(4-methoxy-3-butenyl)cyclohexanecarbonitrile as a yellowish liquid.

b) A mixture of 16.178 g of 4-(4-methoxy-3-butenyl)cyclohexanecarbonitrile, 125 ml of tetrahydrofuran and 31 ml of 2N hydrochloric acid was heated to reflux for 30 minutes while stirring and gassing with nitrogen. After cooling the reaction mixture was poured into 290 ml of water and extracted with methylene chloride. The organic phases were washed with water, dried over sodium sulphate and freed from solvent in vacuo. There were obtained 14.3 g of 4-(4-cyanocyclohexyl)butyraldehyde as a yellow oil.

c) A suspension of 42.8 g of methyl-triphenylphosphonium bromide in 530 ml of absolute t-butyl methyl ether was treated with 13.5 g of solid potassium t-butyrate while stirring and gassing with nitrogen at room temperature and the mixture was stirred for a further 1 hour. The yellow reaction mixture was then treated dropwise within 35 minutes with a solution of 14.3 g of 4-(4-cyanocyclohexyl)butyraldehyde in 133 ml of absolute t-butyl methyl ether and the resulting mixture was stirred for a further 2.5 hours at room temperature. The reaction mixture was subsequently freed from solvent in vacuo at 50°C. The residue was taken up in 300 ml of methanol/water (vol. 6:4) and the solution was extracted once with 310 ml of hexane and twice with 150 ml of hexane each time. The hexane extracts were washed once with methanol/water (vol. 6:4) and twice with water and then dried over sodium sulphate. After removing the solvent in vacuo there was obtained 4-(4-pentenyl)cyclohexanecarbonitrile.

d) A solution of 4.712 g of diisopropylamine in 382 ml of absolute tetrahydrofuran was treated dropwise within 3 minutes with 28.2 ml of a 1.6M solution of butyl lithium in hexane while stirring and gassing with nitrogen at -73°C to -70°C and the mixture was stirred for a further 15 minutes at this temperature. The mixture was then treated dropwise at -50°C within 5 minutes with a solution of 6.9 g of 4-(4-pentenyl)cyclohexanecarbonitrile in 34 ml of absolute tetrahydrofuran (rinsing with 5 ml of absolute tetrahydrofuran) and the resulting mixture was stirred for a further 15 minutes. The mixture was subsequently treated dropwise at -50°C within 9 minutes with a solution of 8.411 g of 4-(2-bromoethyl)cyclohexanecarbonitrile in 34 ml of absolute tetrahydrofuran. The reaction mixture was stirred for a further 1.5 hours at -50°C and for 1.5 hours at room temperature and then poured into 750 ml of saturated ammonium chloride solution and extracted with diethyl ether. The organic phases were washed with water, dried over sodium sulphate and freed from solvent in vacuo. The yellow oily residue (13.2 g) was dissolved in hexane/methylene chloride (vol. 9:1) and chromatographed

on silica gel in hexane/methylene chloride. Hexane/methylene chloride eluted 6.30 g of 4-[2r-(trans-4-(4-pentenyl)-cis-1-cyanocyclohexyl)ethyl]-1-cyclohexanecarbonitrile as a yellow oil. Methylene chloride subsequently eluted 2.925 g of 1-[2-(trans-4-cyanocyclohexyl)ethyl]-4'α-(4-pentenyl)-1,1'-ethylenedi-1α-cyclohexanecarbonitrile; m.p. 148.6-149.2°C after recrystallization from acetone/hexane.

The following compound was manufactured in an analogous manner;

1'-Butyl-4α-(4-pentenyl)-1,4'α-ethylenedi-1α-cyclohexanecarbonitrile; m.p. 112.9°C.

Example 10

A solution of 1.939 g of 4-butylphenol and 0.258 g of 4-(dimethylamino)pyridine in 87 ml of absolute tetrahydrofuran was treated while stirring with a magnetic stirrer with a solution of 2.675 g of 4-cis-cyano-4-(3-butenyl)-cyclohexanecarboxylic acid (containing 11% 4-trans-cyano isomer) in 43 ml of absolute methylene chloride and subsequently with 3.197 g of dicyclohexylcarbodiimide. The reaction mixture was stirred for 5 hours at room temperature and then suction filtered. The precipitate was rinsed with methylene chloride and the filtrate was concentrated in vacuo. The residual, yellow oil (5.488 g) was chromatographed on silica gel in hexane/toluene (vol. 1:1). Toluene/hexane (vol. 1:1), toluene and toluene/acetone (vol. 99:1) eluted 4-cis-cyano-4-(3-butenyl)cyclohexanecarboxylic acid 4-butylphenyl ester as colourless crystals. By recrystallization from diethyl ether/hexane there was obtained pure product with m.p. 59.1°C.

The 4-cis-cyano-4-(3-butenyl)cyclohexanecarboxylic acid used as the starting material was obtained as follows:

A solution of 8.998 g of diisopropylamine in 360 ml of absolute tetrahydrofuran was treated dropwise within 6 minutes with 54.5 ml of a 1.6M solution of butyl lithium in hexane while stirring and gassing with nitrogen at -73°C to -65°C and the mixture was stirred for a further 15 minutes at -70°C. The mixture was then treated dropwise at -50°C within 7 minutes with a solution of 5.7 g of 4-cyanocyclohexanecarboxylic acid in 40 ml of absolute tetrahydrofuran (rinsing with 10 ml of absolute tetrahydrofuran). The reddish suspension was stirred for a further 15 minutes at -50°C and subsequently treated dropwise within 9 minutes with a solution of 5.025 g of 4-bromo-1-butene in 35 ml of absolute tetrahydrofuran (rinsing with 10 ml of absolute tetrahydrofuran). The reddish, clear solution was stirred for a further 1.5 hours

at -50°C and for 1.5 hours at room temperature, then poured into 500 ml of water and extracted with diethyl ether. The organic phases were washed three times with 250 ml of water each time and discarded. The aqueous phases were combined, made Congo-acid with semi-concentrated hydrochloric acid and extracted with methylene chloride. The methylene chloride phases were washed with water and dried over sodium sulphate. After removing the solvent in vacuo at 50°C there were obtained 7.003 g of 4-cis-cyano-4-(3-butenyl)cyclohexanecarboxylic acid (containing 11% 4-trans-cyano isomer) as a yellow, solid product.

The following compounds were manufactured in an analogous manner:

4-cis-Cyano-4-(3-butenyl)cyclohexanecarboxylic acid 4-ethoxyphenyl ester; m.p. (C-N) 57.2°C, cl.p. (N-I) 68.1°C.

4-cis-cyano-4-butylcyclohexanecarboxylic acid 4-allyloxyphenyl ester; m.p. (C-I) 77.2°C, cl.p. (N-I) 61.0°C.

4-cis-cyano-4-(3-butenyl)cyclohexanecarboxylic acid 4-trans-(4-butylphenyl)cyclohexyl ester; m.p. (C-N) 67.4°C, cl.p. (N-I) 102.5°C.

4-cis-cyano-4-(3-butenyl)cyclohexanecarboxylic acid 4-trans-butylcyclohexyl ester; m.p. (C-I) 20.5°C, cl.p. (N-I) -1.5°C.

Example 11

A solution of 2.277 g of 4-cis-cyano-4-(3-butenyl)-cyclohexanol and 0.254 g of 4-(dimethylamino)pyridine in 50 ml of absolute methylene chloride was treated while stirring with a magnetic stirrer with a suspension of 2.110 g of 4-ethoxybenzoic acid in 100 ml of absolute methylene chloride and subsequently with 3.145 g of dicyclohexylcarbodiimide. The reaction mixture was stirred for a further 2.5 hours at room temperature and left to stand overnight. The precipitate was filtered off under suction and rinsed with methylene chloride. The filtrate was concentrated in vacuo. The residual, yellow, semi-solid product (6.8 g) was dissolved in methylene chloride and the solution was treated with 30 g of silica gel and evaporated. The residue was suspended in toluene/hexane (vol. 1:1) and added to a column containing silica gel in toluene/hexane (vol. 1:1). Toluene/hexane, toluene and toluene/acetone eluted 4-ethoxybenzoic acid 4-cis-cyano-4-(3-butenyl)cyclohexyl ester as a colourless, crystallizing oil. Recrystallization from diethyl ether/hexane gave pure product with m.p. 85.4°C.

The 4-cis-cyano-4-(3-butenyl)cyclohexanol used as the starting material was prepared as follows:

a) A mixture of 1.13 g of 4-acetoxycyclohexanecarboxylic acid and 250 ml of thionyl chloride was left to stand for 1 hour at room temperature and then boiled under reflux for 2 hours. Excess thionyl chloride was distilled off and the residue was freed from residual thionyl chloride in vacuo. The 4-acetoxycyclohexanecarboxylic acid chloride obtained (139.1 g) was treated with 500 ml of absolute methylene chloride and the mixture was added dropwise to 2.5 l of methylene chloride which was saturated with ammonia gas and which was cooled to -10°C . Ammonia gas was introduced into the reddish suspension while stirring for a further 2 hours. The reaction mixture was subsequently freed as much as possible from methylene chloride in vacuo at 50°C . The reddish residue was treated with 500 ml of water and extracted with methylene chloride. The organic extracts were washed with saturated sodium chloride solution, dried over sodium sulphate and evaporated in vacuo. The residue (109 g) was suspended in 500 ml of diethyl ether. The suspension was stirred for 30 minutes at room temperature and then suction filtered. The residue was washed with diethyl ether and dried, whereby 94 g of crude 4-acetoxycyclohexanecarboxylic acid amide were obtained.

b) A suspension of 68.8 g of crude 4-acetoxycyclohexanecarboxylic acid amide in 200 ml of absolute pyridine was treated with 78.7 g of benzenesulphonyl chloride while stirring and the mixture was left to stand overnight. Thereafter, the reaction mixture was poured on to 830 ml of ice-water and 415 ml of concentrated hydrochloric acid and extracted with diethyl ether. The ether extract was washed with water, dried over sodium sulphate and evaporated in vacuo, whereby 59.5 g of crude 4-acetoxycyclohexanecarbonitrile were obtained as a brownish liquid.

c) A solution of 18.74 g of crude 4-acetoxycyclohexanecarbonitrile in 52 ml of toluene was treated with a solution of 6.65 g of sodium hydroxide in 45 ml of water while stirring and gassing with nitrogen and the mixture was stirred for a further 5 hours. The reaction mixture was subsequently extracted with methylene chloride and the organic phases were washed with saturated sodium chloride solution, dried over sodium sulphate and evaporated. The residual, brownish oil (14.6 g) was dissolved in toluene and separated by chromatography on silica gel. Toluene/acetone mixtures eluted, besides 6.9 g of apolar byproducts, 7.5 g of 4-hydroxycyclohexanecarbonitrile (cis/trans mixture) as a colourless oil.

d) A solution of 19.1 g of 4-hydroxycyclohexanecarbonitrile in 250 ml of absolute diethyl ether was treated with 21.2 g of dihydropyran and 1.5 g of p-toluenesulphonic acid and the mixture was left to stand overnight. The reaction mixture was subsequently poured on to a mixture

of 100 ml of 3N sodium hydroxide solution and 100 g of ice, the ether phase was separated and the aqueous phase was extracted with methylene chloride. The combined organic phases were washed with saturated sodium chloride solution, dried over sodium sulphate and freed from solvent in vacuo. The crude tetrahydropyranyl ether obtained (39.5 g) was dissolved in toluene and filtered through a column containing aluminium oxide in toluene (rinsing with toluene/diethyl ether). There were obtained 32.5 g of the tetrahydropyranyl ether of 4-hydroxycyclohexanecarbonitrile (cis/trans mixture).

e) A solution of 7.111 g of diisopropylamine in 575 ml of absolute tetrahydrofuran was treated dropwise within 5 minutes with 42.7 ml of a 1.6M solution of butyl lithium in hexane while stirring and gassing with nitrogen at -73°C and the mixture was stirred for a further 15 minutes at -70°C. The mixture was then treated dropwise at -50°C within 4 minutes with a solution of 12.238 g of the tetrahydropyranyl ether of 4-hydroxycyclohexanecarbonitrile in 43 ml of absolute tetrahydrofuran (rinsing with 14 ml of absolute tetrahydrofuran) and the yellow solution was stirred for a further 15 minutes at -50°C. The reaction mixture was subsequently treated dropwise at -50°C within 8 minutes with a solution of 7.898 g of 4-bromo-1-butene in 43 ml of absolute tetrahydrofuran (rinsing with 14 ml of absolute tetrahydrofuran). The yellow reaction solution was stirred for a further 1.5 hours at -50°C and for 1.5 hours at room temperature, then poured into 640 ml of saturated ammonium chloride solution and extracted with diethyl ether. The organic phases were washed with water, dried over sodium sulphate and freed from solvent in vacuo. The residual yellow oil (15.2 g) was dissolved in 145 ml of tetrahydrofuran, the solution was treated with 50 ml of 1N hydrochloric acid and left to stand overnight. The mixture was subsequently treated with 47.5 ml of 1N sodium hydroxide solution and freed from tetrahydrofuran in vacuo. The emulsion obtained was extracted with methylene chloride. The organic phases were washed with saturated sodium chloride solution, dried over sodium sulphate and freed from solvent in vacuo. The residual yellow oil (13.9 g) was dissolved in toluene and separated by chromatography on silica gel in toluene. Toluene/acetone eluted firstly 2.78 g of non-polar impurities and then 7.59 g of 4-cis-cyano-4-(3-butenyl)cyclohexanol as a colourless liquid with b.p. (0.3 mbar) 120°C.

The following compounds were manufactured in an analogous manner:

4"-Pentyl-p-terphenylcarboxylic acid 4-cis-cyano-4-(3-butenyl)cyclohexyl ester; m.p. (C-N) 154.4°C, cl.p. (N-I) 272°C,

4-trans-(4'-pentylbiphenyl)cyclohexanecarboxylic acid 4-cis-cyano-4-(3-butenyl)cyclohexyl ester; m.p. (C-N) 127.8°C, cl.p. (N-I) 225°C.

4-pentylbenzoic acid 4-cis-cyano-4-(3-butenyl)cyclohexyl ester; m.p. (C-I) 71.2°C,

4'-pentyl-4-biphenylcarboxylic acid 4-cis-cyano-4-(3-butenyl)cyclohexyl ester; m.p. (C-N) 89.8°C, cl.p. (N-I) 129.7°C,

4-trans-pentylcyclohexanecarboxylic acid 4-cis-cyano-3-(3-butenyl)cyclohexyl ester; m.p. (C-I) 74.9°C,

4-trans-(4-pentylphenyl)cyclohexanecarboxylic acid 4-cis-cyano-4-(3-butenyl)cyclohexyl ester; m.p. (C-I) 87.2°C; cl.p. (N-I) 66.5°C.

Claims

No English translation of the claims is provided herewith since the Letters Patent already contain an English version of the claims.

