

NEW 3-ARYL-2-HYDROXYPROPIONIC ACID DERIVATIVE III

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Field of invention

The present invention relates to a novel 3-aryl-2-hydroxypropionic acid derivative, to a process and intermediate for preparing such a compound, having the utility in clinical conditions associated with insulin resistance, to methods for its therapeutic use and to pharmaceutical compositions containing it.

Background of the invention

15 Insulin resistance, defined as reduced sensitivity to the actions of insulin in the whole body or individual tissues such as skeletal muscle, myocardium, fat and liver prevail in many individuals with or without diabetes mellitus. The insulin resistance syndrome, IRS, refers to a cluster of manifestations including insulin resistance with accompanying hyperinsulinemia, possibly non insulin dependent diabetes mellitus (NIDDM); arterial
20 hypertension; central (visceral) obesity; dyslipidemia observed as deranged lipoprotein levels typically characterized by elevated VLDL (very low density lipoproteins) and reduced HDL (high density lipoproteins) concentrations and reduced fibrinolysis.

Recent epidemiological research has documented that individuals with insulin resistance
25 run a greatly increased risk of cardiovascular morbidity and mortality, notably suffering from myocardial infarction and stroke. In non-insulin dependent diabetes mellitus these atherosclerosis related conditions cause up to 80% of all deaths.

In clinical medicine there is at present only limited awareness of the need to increase the insulin sensitivity in IRS and thus to correct the dyslipidemia which is considered to cause the accelerated progress of atherosclerosis.

- 5 Furthermore there is at present no pharmacotherapy available to adequately correct the metabolic derangements associated with IRS. To date, the treatment of NIDDM has been focused on correction of the deranged control of carbohydrate metabolism associated with the disease. Stimulation of endogenous insulin secretion by means of secretagogues, like sulphonylureas, and if necessary administration of exogenous insulin are methods
- 10 frequently used to normalize blood sugar but that will, if anything, further enhance insulin resistance and will not correct the other manifestations of IRS nor reduce cardiovascular morbidity and mortality. In addition such treatment involves a significant risk of hypoglycemia with associated complications.
- 15 Other therapeutic strategies have focused on aberrations in glucose metabolism or absorption, including biguanides, such as methformin, or glucosidase inhibitors, such as acarbose. Although these agents have been efficacious to a degree, their limited clinical effect is associated with side effects.
- 20 A novel therapeutic strategy involves the use of insulin sensitizing agents, such as the thiazolidinediones, which, at least in part, mediate their effects via an agonistic action on nuclear receptors. Ciglitazone is the prototype in this class. In animal models of IRS these compounds seem to correct insulin resistance and the associated hypertriglyceridaemia and hyperinsulinemia, as well as hyperglycemia in diabetes, by improving insulin sensitivity
- 25 via an effect on lipid transport and handling, leading to enhanced insulin action in skeletal muscle, liver and adipose tissue.

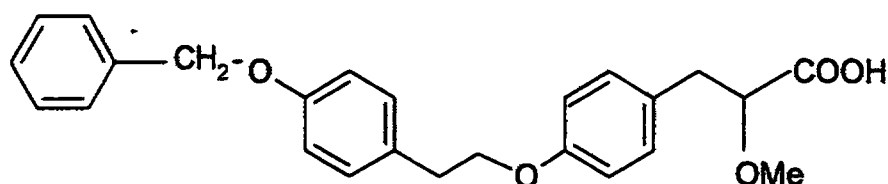
Ciglitazone as well as later described thiazolidinediones in clinical development either have been discontinued reportedly due to unacceptable toxicity or show inadequate

potency. Therefore there is a need for new and better compounds with insulin sensitizing properties.

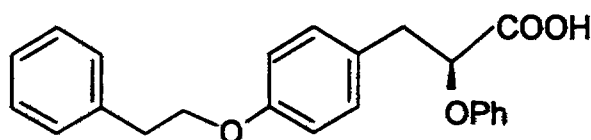
Prior art

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Compounds of the formula



10 and



and certain derivatives thereof disclosed in US 5 306 726 and WO 91/19702 are said to be
15 useful as hypoglycemic and hypocholesterolemic agents, and in US 5 232 945 said to be
useful in the treatment of hypertension.

AU 650 429 discloses structurally related compounds, but claimed to have different
properties: diuretic, antihypertensive, platelets anti-aggregating and anti-lipoxygenase
20 properties.

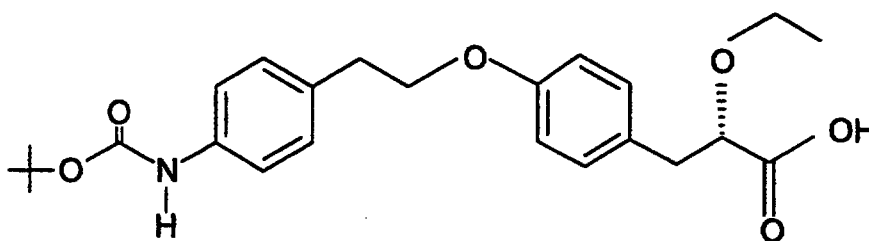
EP 139 421 discloses compounds having the ability to lower blood lipid and blood sugar
levels. Among these compounds is troglitazone, a compound that has reached the market
for treatment of NIDDM or decreased glucose tolerance.

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Description of the invention

It has now surprisingly been found that the novel compound

- 5 3-{4-[2-(4-*tert*-Butoxycarbonylaminophenyl)ethoxy]phenyl}-(S)-2-ethoxy propanoic acid
having the formula I



- 10 is effective in conditions associated with insulin resistance.

The invention also relates to pharmaceutically acceptable salts, solvates, such as hydrates, and crystalline forms of the compound of the formula I.

- 15 In the present specification the expression "pharmaceutically acceptable salts" is intended to define but is not limited to such salts as the alkali metal salts (e.g. sodium, lithium and potassium), alkaline earth metal salts (e.g. calcium, barium and magnesium), aluminium, zinc and bismuth salts, ammonium salts, salts with basic amino acids, such as arginine, lysine, and salts with organic amines such as ethanolamine, ethylenediamine,
20 triethanoleamine, benzylphenethylamine, diethylamine, tromethamine, benzathine, chloroprocaine, choline, meglumine, procaine, clemizole and piperazine.

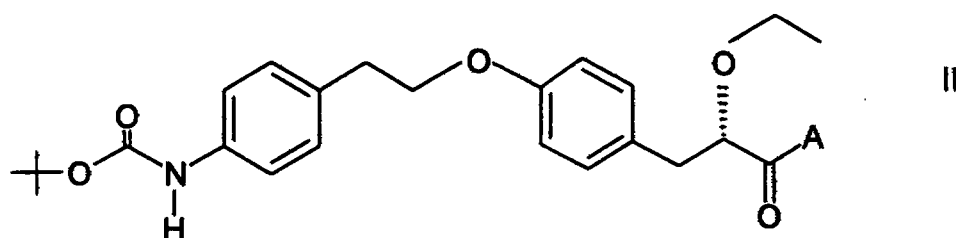
- Throughout the specification and the appended claims, a given chemical formula or name shall encompass all pharmaceutically acceptable salts thereof, crystalline forms and
25 solvates thereof such as for instance hydrates.

Methods of preparation

The compound of the invention may be prepared as outlined below according to any of
 5 methods A-H. However, the invention is not limited to these methods, the compound may
 also be prepared as described for structurally related compounds in the prior art.

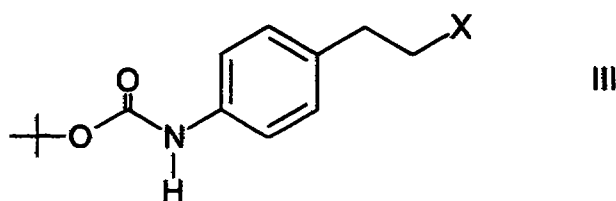
A. The compound of the formula I of the invention can be prepared by converting a
 compound of formula II

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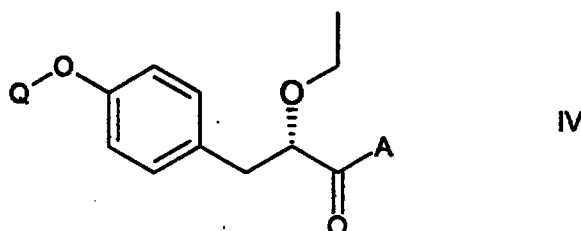


wherein A is $-OR^P$, wherein R^P is a protective group, e.g. ethyl, or A is a chiral auxiliary
 group, such as a chiral amine, e.g. (R)-phenylglycinol, a chiral alcohol, such as menthol or a
 15 chiral oxazolidinone, such as (S)-4-benzyl-2-oxazolidinone. The conversion can be
 performed as a hydrolysis which can be either acidic or basic and performed according to
 standard methods known to anyone skilled in the art or as described in the experimental
 part.

20 B. The compound of the formula I or the formula II wherein A is a chiral auxiliary group or
 $-OR^P$ and R^P is as defined above, can be prepared by reacting a compound of the formula
 III



wherein X is -OH or a leaving group such as a sulfonate or a halogen, with a compound of the formula IV



wherein Q is H and A is a chiral auxiliary group, -OH or -OR^P, and R^P is as defined above.

The reaction can be performed either by an alkylation reaction or a Mitsunobu reaction.

- 10 In an alkylation reaction the leaving group X can be a sulfonate such as mesylate, nosylate, tosylate, or a halogen, such as bromine or iodine. The compounds of formula III and IV, in approximately equimolar amounts or with an excess of either compound, are heated to reflux temperature in an inert solvent, such as isopropanol or acetonitrile, in the presence of a base, such as potassium carbonate or cesium carbonate.

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The mixture is refluxed for the necessary time, typically between 0.5 h to 24 h, the work up procedure usually includes filtration, for removal of solid salt, evaporation, neutralisation (when A = -OH) and extraction with water and an organic solvent such as dichloromethane, ethyl acetate, or diethyl ether. The crude product is purified if desired
20 e.g. by recrystallization or by standard chromatographic methods.

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The Mitsunobu reaction can be carried out according to standard methods or as described in for example Tsunoda T., Yamamiya Y., Ito S., Tetrahedron Letters, 34, 1639-1642 (1993) or O. Mitsunobu, Synthesis, 1981, p.1. When using a Mitsunobu reaction A can not
25 be -OH.

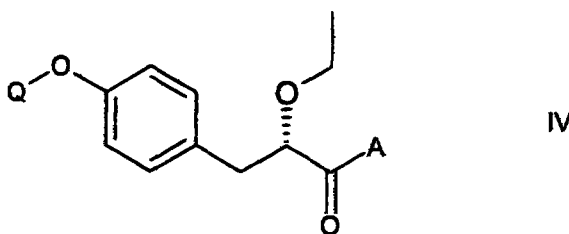
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In a typical Mitsunobu reaction a compound of formula III, wherein the group X is a hydroxyl group, and a compound of formula IV are mixed, in approximately equimolar amounts or with an excess of either compound, in an inert solvent, such as chloroform, dichloromethane, or tetrahydrofuran. A slight molar excess, 1-4 equivalents, of an azodicarboxylate, such as DEAD or ADDP and a phosphine (1-4 equivalents), such as tributylphosphine or triphenylphosphine are added and the reaction is stirred at a temperature high enough - for example room temperature - and a time long enough (1-24 hours) to obtain product, which can be worked up with standard literature methods and if desired purified, e.g. by standard chromatographic methods.

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The compound of formula III can be prepared by standard procedures known to anyone skilled in the art, from commercially available starting materials or as described in the experimental section.

15 The compound of formula IV wherein Q is H and A is a chiral auxiliary group, -OH or -OR^P, wherein R^P is as defined above, can be prepared as described below in the experimental part, or by converting a compound of formula IV



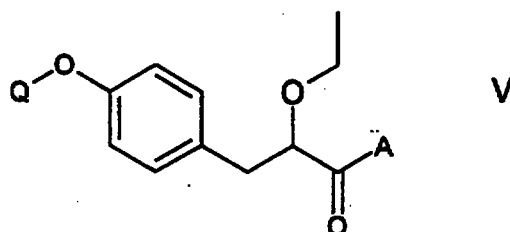
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wherein Q is R^q, wherein R^q is a protective group, e.g. benzyl, and A is a chiral auxiliary group, -OH or -OR^P, wherein R^P is as defined above.

C. The compound of formula II, wherein A is a chiral auxiliary group, and the compound of formula IV, wherein A is a chiral auxiliary group and Q is hydrogen or R^q, wherein R^q

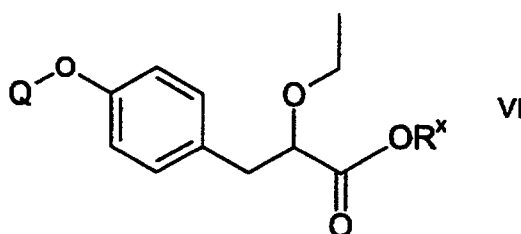
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is as defined above and, can be prepared by diastereoisomeric separation of the compound of the formula V



wherein A is a chiral auxiliary group, Q is hydrogen, $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ or R^q , wherein R^q is as defined above. The separation of the diastereomers can be performed either by crystallization or by chromatography. The chromatographic separation can be performed as described in the experimental part.

The compound of formula V wherein A is a chiral auxiliary group, Q is hydrogen, $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ or R^q , wherein R^q is as defined above, can be prepared by converting a compound of formula VI



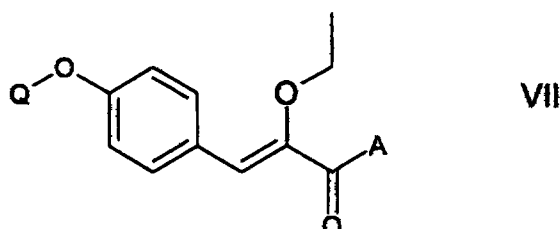
wherein Q is hydrogen, $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ or R^q and R^x is hydrogen or R^p , wherein R^q and R^p are as defined above, for example by reacting it with a chiral amine or a chiral alcohol.

The compound of formula V when A is a chiral amine can be prepared by reacting a compound of formula VI with a chiral amine such as (R)-phenyl glycinol for example in the presence of a peptide coupling system (e.g. EDC, DCC, HBTU, TBTU, PyBop or

oxalylchloride in DMF), an appropriate base (e.g. pyridine, DMAP, TEA or DiPEA) and a suitable organic solvent (e.g. dichloromethane, acetonitrile or DMF) in accordance to methods well known to those skilled in the art or as described in the examples.

- 5 The compound of formula V when A is a chiral alcohol can be prepared in the same way using a chiral alcohol, such as menthol, instead of a chiral amine, or by the mix-anhydride method with pivaloyl chloride and the lithium salt of the chiral alcohol.

The compound of formula V wherein A is a chiral auxiliary group and Q is hydrogen,
 10 $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ or R^q , wherein R^q is as defined above, and the compound of formula VI, wherein Q is hydrogen, $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ or R^q and R^x is hydrogen or R^p , wherein R^q and R^p are as defined above, can be prepared by reduction of a compound of formula VII



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wherein A is a chiral auxiliary group, $-\text{OH}$, or $-\text{OR}^p$, wherein R^p is as defined above and Q is hydrogen, $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ or R^q , wherein R^q is as defined above, and if
 20 desired followed by removal of protecting groups.

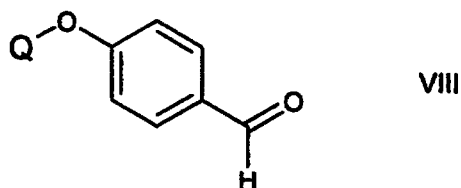
The reduction of the olefin may be carried out using a wide variety of reducing methods known to reduce carbon-carbon double bonds, such as catalytic hydrogenation in the presence of an appropriate catalyst, or hydrogen transfer reagents such as diethyl-2,5-dimethyl-1,4-dihydropyridine-3,5-dicarboxylate.

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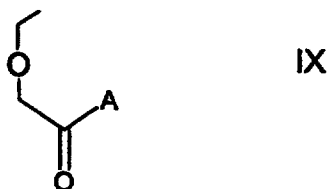
The catalytic hydrogenation can be performed in alcohol, cellosolves, protic polar organic solvents, ethers, lower alifatic acids, and particularly in methanol, ethanol, methoxyethanol, dimethylformamide, tetrahydrofuran, dioxane, dimethoxyethane, ethyl acetate or acetic acid either used alone or in mixture. Examples of the catalysts used
 5 include palladium black, palladium on charcoal, platinum oxide or Wilkinson's catalyst. This reaction can be performed at different temperatures and pressures depending on the reactivity of the aimed reaction.

In case of hydrogen transfer reaction with diethyl-2,5-dimethyl-1,4-dihydropyridine-3,5-
 10 dicarboxylate the reaction can be conducted by mixing equimolar amounts of reactants and warming the mixture to melting (140-250°C) under inert atmosphere or under vacuum.

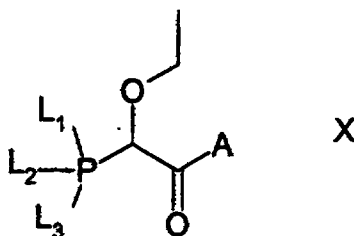
The compound of formula VII wherein A is a chiral auxiliary group, -OH, or -OR^P, wherein R^P is as defined above and Q is hydrogen, -CH₂CH₂Ph-4-NHCOO^tBu or R^Q,
 15 wherein R^Q is as defined above, can be prepared by a condensation reaction, such as a Knoevenagel or Wittig type reaction, of a carbonyl compound of the formula VIII



20 wherein Q is hydrogen, -CH₂CH₂Ph-4-NHCOO^tBu or R^Q, wherein R^Q is as defined above, with a compound of the formula IX



in which formula A is a chiral auxiliary group, -OH, -OR^P, wherein R^P is as defined above, or the formula X



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in which A is a chiral auxiliary group, or -OR^P, wherein R^P is as defined above, L¹ = L² = L³ are phenyl or L¹ = L² are Oalkyl and L³ is = O, and, if desired, followed by removal of protecting groups, by an arylation reaction as described in for example Cacchi S., Ciattini P. G., Morera E., Ortar G., Tetrahedron Letters, 28 (28) 1987, pp 3039-3042.

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In the condensation step, approximately equimolar amounts of reactants are mixed in the presence of a base, to provide the olefin compound. This step may be carried out in the presence of an inert solvent or in the absence of a solvent at a temperature between -20°C and the melting point for the mixture. It might be necessary to add a dehydrating agent in order to obtain the olefinic compound.

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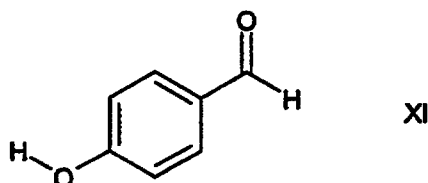
In a typical such reaction the compounds of formula VIII and formula IX are mixed in a solvent such as tetrahydrofuran. Anhydrous potassium *tert*-butoxide is slowly added at low temperature i.e. -20°C. The reaction is quenched with acetic acid. The crude product is isolated, redissolved in toluene and refluxed with *p*-toluenesulfonic acid in a Dean-Stark apparatus. The solution is cooled and the product is isolated and purified according to standard methods (see Groger T., Waldmann E., Monatsh Chem 89, 1958, p 370).

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The condensation step could also be performed as a Wittig-type reaction (see for example Comprehensive Organic Synthesis vol. 1 p. 755-781 Pergamon Press) or as described in the experimental part.

In a typical such reaction, approximately equimolar amounts of reactants of formula VIII and formula X, are stirred in the presence of a base such as tetramethylguanidine or potassium carbonate in a 1-5 fold molar excess. This step may be carried out in the presence of an inert solvent such as dichloromethane or acetonitrile and at a suitable temperature ($-10^{\circ}\text{C} + 60^{\circ}\text{C}$) and at a time long enough.

- 10 The compound of the formula VIII when Q is $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ can be prepared by coupling a compound of the formula III wherein X is $-\text{OH}$ or a leaving group such as a sulfonate or a halogen, with a compound of the formula XI

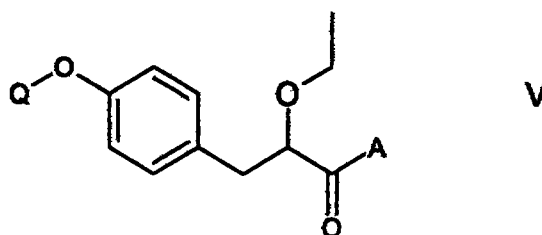


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When X is a leaving group such as a sulfonate or a halogen, the reaction may be performed as an alkylation reaction and when X is $-\text{OH}$, as a Mitsunobu reaction as described above.

- 20 D. The compound of formula I or formula II wherein A is $-\text{OR}^{\text{P}}$ and R^{P} is as defined above and the compound of formula IV wherein A is $-\text{OH}$ or $-\text{OR}^{\text{P}}$ and Q is H or R^{Q} , wherein R^{P} and R^{Q} are as defined above can be prepared by enantiomeric separation, such as chiral chromatography of the compound of the formula V

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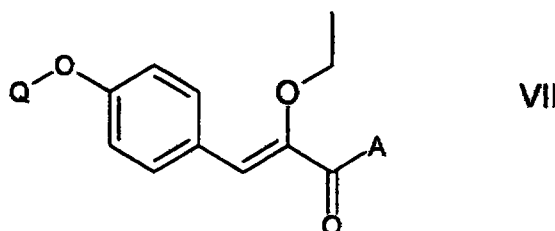


wherein A is -OH or -OR^P, Q is H, -CH₂CH₂Ph-4-NHCOO^tBu or R^Q wherein R^P and R^Q are as defined above.

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E. The compound of the formula I or the formula II wherein A is a chiral auxiliary group, or -OR^P, wherein R^P is as defined above, and the compound of formula IV wherein A is a chiral auxiliary group, -OH, or -OR^P, wherein R^P is as defined above and Q is hydrogen or R^Q, wherein R^Q is as defined above and, can be prepared by asymmetric reduction of a

10 compound of the formula VII



wherein A is a chiral auxiliary group, -OH, or -OR^P, wherein R^P is as defined above and Q is hydrogen, -CH₂CH₂Ph-4-NHCOO^tBu or R^Q, wherein R^Q is as defined above.

The asymmetric reduction can be carried out using a wide variety of reducing methods which are known to reduce carbon-carbon double bonds such as catalytic hydrogenation in the presence of an appropriate chiral catalyst such as Rh-BINAP or [Et-DuPHOS-Rh(COD)] or catalytic hydrogenation with an appropriate catalyst, such as palladium on charcoal using the chiral auxiliary group to induce the asymmetry.

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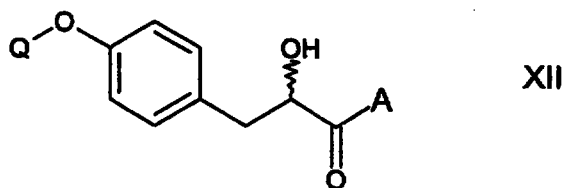
The catalytic hydrogenation can be carried out in a wide variety of solvents, such as alcohol, cellosolves, protic polar organic solvents, ethers, lower alifatic acids, and

particularly in methanol, ethanol, methoxyethanol, dimethylformamide, tetrahydrofuran, dioxane, dimethoxyethane, ethyl acetate or acetic acid, either used alone or in a mixture. The reaction can proceed at different temperatures and pressures depending on the reactivity of the aimed reaction.

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F. The compound of the formula I or the formula II, wherein A is a chiral auxiliary group, or $-OR^P$, wherein R^P is as defined above, and the compound of formula IV wherein A is a chiral auxiliary group, $-OH$, or $-OR^P$, wherein R^P is as defined above and Q is hydrogen or R^Q , wherein R^Q is as defined above, can be prepared by converting a compound of the

10 formula XII

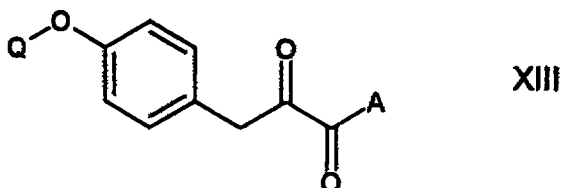


wherein A is a chiral auxiliary group, $-OH$, or $-OR^P$, wherein R^P is as defined above, and
 15 Q is hydrogen, $-CH_2CH_2Ph-4-NHCOO^tBu$ or R^Q , wherein R^Q is as defined above, with the required stereochemistry, dependent on the reaction conditions used.

The reaction may be carried out as an alkylation reaction, using a variety of alkylating agents, such as ethyl halide or diethyl sulfate (see for example Benedict D.R., Bianchi
 20 T.A., Cate L.A., Synthesis (1979), pp. 428-429, Barluenga J., Alonso-Cires L., Campos P.J., Asensio G., Synthesis, 1983, p. 53-55, Bull Chem Soc Jpn, 1986, 59, 2481, S. Patai, The Chemistry of the Ether Linkage, Wiley-Interscience NY, 1967, 445-498 or Survey of Organic Synthesis vol 1, Wiley-Interscience 1970, NY, p. 285-328).

25 The compound of formula XII wherein A is a chiral auxiliary group, $-OH$, or $-OR^P$, wherein R^P is as defined above, and Q is hydrogen, $-CH_2CH_2Ph-4-NHCOO^tBu$ or R^Q ,

wherein R^9 is as defined above, can be prepared by asymmetric reduction of a compound of the formula XIII



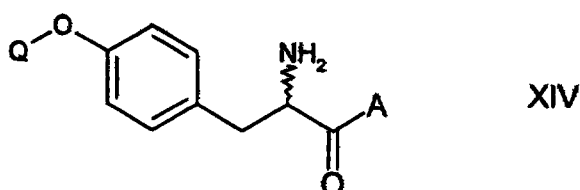
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wherein A is a chiral auxiliary group, -OH, or -OR^P, wherein R^P is as defined above, and Q is hydrogen, -CH₂CH₂Ph-4-NHCOO^tBu or R^Q, wherein R^Q is as defined above.

- 10 The asymmetric reduction may be performed by using a wide variety of reducing methods which are known to reduce ketones enantioselectively (see Flynn G.A., Beight D.W., Tetrahedron Letters, 29(4), 1988, pp. 423-426).

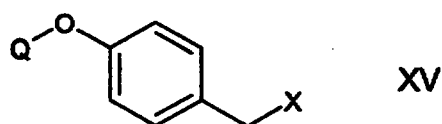
The compound of formula XII wherein A is a chiral auxiliary group and Q is hydrogen, -CH₂CH₂Ph-4-NHCOO^tBu or R^q, wherein R^q is as defined above, may also be prepared by induced chiral reduction of a compound of formula XIII, wherein A is a chiral auxiliary group and Q is hydrogen, -CH₂CH₂Ph-4-NHCOO^tBu or R^q, wherein R^q is as defined above (see Xiang Y.B., Snow K., Belley M., J. Org. Chem., 1993, 58, pp 993-994).

- 20 The compound of formula XII, wherein A is a chiral auxiliary group, -OH or -OR^P, wherein R^P is as defined above, and Q is hydrogen, -CH₂CH₂Ph-4-NHCOO^tBu or R^Q, wherein R^Q is as defined above, can be prepared by converting a compound of the formula XIV

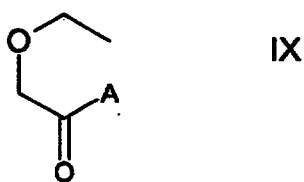


wherein A is a chiral auxiliary group, -OH or -OR^P, wherein R^P is as defined above, and Q is hydrogen, -CH₂CH₂Ph-4-NHCOO^tBu or R^Q, wherein R^Q is as defined above, with the
 5 required stereochemistry, dependent on the reaction conditions used (see for example K. Koga, C.C. Wu and S. Yamada, Tetrahedron Letters, no. 25, 1971, p 2283-2286 , Kunz H., Lerchen H-G., Tetrahedron Letters, 28 (17) 1987, pp.1873-1876).

G. The compound of formula II, wherein A is a chiral auxiliary group, and the compound
 10 of formula IV wherein A is a chiral auxiliary group and Q is R^Q, wherein R^Q is as defined above, can be prepared by reacting a compound of formula XV



15 wherein X is a leaving group, such as a halogen or a sulfonate, and Q is -CH₂CH₂Ph-4-NHCOO^tBu or R^Q, wherein R^Q is as defined above, with a compound of the formula IX

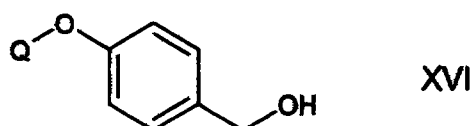


20 wherein A is a chiral auxiliary group.

In the alkylation step the compound of formula XV is reacted with a compound of formula IX in the presence of one or more bases such as potassium carbonate, triethylbenzylammonium chloride, sodium hydride, LDA, butyllithium or LHMDS in a
 25 reaction inert solvent such as acetonitrile, DMF or dichloromethane at a suitable temperature and time. The reaction can be carried out using standard methods known in the

litterature. (see for example Pearsson W.H., Cheng M.C., J. Org. Chem., 51 (19) 1986, 3746-3748, Myers A.G., Yang B.H., Gleason J.L., J. Am. Chem. Soc. 1994, 116, pp 9361-9362, Negrete G.R., Konopelski J.P., Tetrahedron Assymetry, 2, 2, pp. 105-108, 1991, Davies S.G., Sanganee H.J., Tetrahedron Assymetry, 6, 3, pp. 671-674, 1995, Hulin B.,
 5 Newton L.S., Lewis D.M., Genereux P.E., Gibbs E.M., Clark D.A. J. Med.Chem. 39, 3897-3907 (1996) and Savignac M., Durand J-O, Genet J-P, Tetrahedron Assymetry, 5, 4, pp.717-722, 1994).

The compound of formula XV wherein X is a leaving group, such as a halogen or a
 10 sulfonate, and Q is $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ or R^q , wherein R^q is as defined above, can be prepared from a compound of formula XVI



15 wherein Q is $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ or R^q , wherein R^q is as defined above, using standard methods known to anyone skilled in the art.

The compound of formula XVI wherein Q is $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ or R^q , wherein R^q is as defined above, can be prepared by reduction of a compound of formula VIII,
 20 wherein Q is $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ or R^q , wherein R^q is as defined above, by standard methods known to anyone skilled in the art.

H. The compound of the invention of formula I and the compound of formula IV, wherein A is $-\text{OH}$ and Q is hydrogen or R^q , wherein R^q is as defined above, can be prepared by
 25 resolution of the racemate thereof and, if desired, followed by neutralization.

The resolution can be performed by separative crystallization of a salt consisting of the racemate of, either the compound of the invention of formula I, or the compound of formula IV, and a chiral base, such as quinine, in an inert solvent such as ethyl acetate or

toluene (see for example Duhamel P., Duhamel L., Danvy D., Plaquevent J. C., Giros B., Gros C., Schwartz J.C., Lecomte J.M., US 5136076, Stephani R., Cesare V., J. Chem. Ed., 10, 1997, p. 1226 and Yamamoto M., Hayashi M., Masaki M., Nohira H., Tetrahedron Assymetry, 2, 6, pp. 403-406, 1991).

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The compounds of the invention may be isolated from their reaction mixtures using conventional techniques.

10

Persons skilled in the art will appreciate that, in order to obtain the compounds of the invention in an alternative and in some occasions, more convenient manner, the individual process steps mentioned hereinbefore may be performed in different order, and/or the individual reactions may be performed at different stage in the overall route (i.e. chemical transformations may be performed upon different intermediates to those associated hereinbefore with a particular reaction).

15

In any of the preceeding methods of preparation A-H, where necessary, hydroxy, amino or other reactive groups may be protected using a protecting group, R^P or R^q as described in the standard text "Protective groups in Organic Synthesis", 2nd Edition (1991) by Greene and Wuts. The protecting group R^P or R^q may also be a resin, such as Wang resin or 2-chlorotriyl chloride resin. The protection and deprotection of functional groups may take place before or after any of the reaction steps described hereinbefore. Protecting groups may be removed in accordance to techniques which are well known to those skilled in the art.

25

The expression "inert solvent" refers to a solvent which does not react with the starting materials, reagents, intermediates or products in a manner which adversely affects the yield of the desired product.

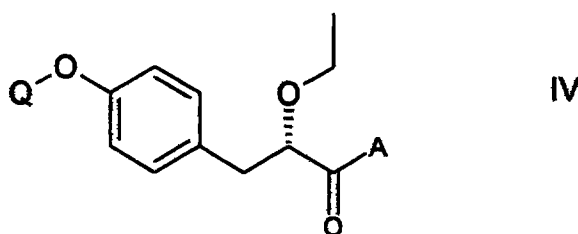
30

Unless otherwise stated or indicated the term chiral auxiliary group denotes a chiral group, such as a chiral alcohol or amine, for instance (-)-menthol, (+)-isomenthol, (-)-norneol,

(R)-2-phenyl glycinol, (S)-2-phenyl glycinol, (R)-4-phenyl-2-oxazolidinone or (S)-4-benzyl-2-oxazolidinone, which chiral group when connected to a carbonyl group can easily be cleaved to the corresponding acid.

5 Intermediates

a) When preparing the compound of the formula I of the invention an intermediate of the formula IV

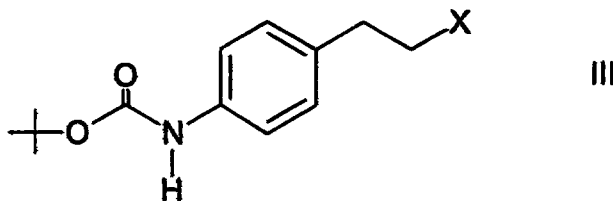


10

wherein Q is hydrogen and A is -OH or -OR^P, wherein R^P is a protective group, e.g. ethyl, or A is a chiral auxiliary group, such as a chiral amine, e.g. (R)-phenylglycinol, or a chiral alcohol such as menthol, or a chiral oxazolidinone, such as (S)-4-benzyl-2-oxazolidinone, is particularly useful. It is prepared as described above. Under the same heading its use as intermediate for the preparation of the end compound of the invention is described.

15

b) When preparing the compound of the formula I of the invention an intermediate of the formula III



20

wherein X is -OH or a leaving group, such as a sulfonate or a halogen, is particularly useful. It is prepared as described above. Under the same heading its use as intermediate for the preparation of the end product of the invention is described.

Pharmaceutical preparations

The compound of the invention will normally be administered via the oral, parenteral, intravenous, buccal, rectal, vaginal, transdermal and/or nasal route and/or via inhalation, in the form of pharmaceutical preparations comprising the active ingredient either as a free acid, or a pharmaceutical acceptable organic or inorganic base addition salt, in a pharmaceutically acceptable dosage form. Depending upon the disorder and patient to be treated and the route of administration, the compositions may be administered at varying doses.

The compound of the invention may also be combined with other therapeutic agents which are useful in the treatment of disorders associated with the development and progress of atherosclerosis such as hypertension, hyperlipidemias, dyslipidemias, diabetes and obesity.

Suitable daily doses of the compound of the invention in therapeutical treatment of humans are about 0.005-5 mg/kg body weight, preferably 0.01-0.5 mg/kg body weight.

According to a further aspect of the invention there is thus provided a pharmaceutical formulation including the compound of the invention, or pharmaceutically acceptable derivatives thereof, in optional admixture with pharmaceutically acceptable adjuvants, diluents and/or carriers.

Pharmacological properties

The present compound of formula (I) will be adapted for prophylaxis and/or treatment of clinical conditions associated with reduced sensitivity to insulin (insulin resistance) and associated metabolic disorders. These clinical conditions will include, but will not be limited to, abdominal obesity, arterial hypertension, hyperinsulinaemia, hyperglycaemia (non insulin dependent diabetes mellitus (NIDDM)) and the dyslipidaemia (plasma lipoprotein disturbances) characteristically appearing with insulin resistance. This

dyslipidaemia, also known as the atherogenic lipoprotein profile of phenotype B, is characterised by moderately elevated non-esterified fatty acids, elevated very low density lipoproteins (VLDL) triglycerides, low high density lipoproteins (HDL) cholesterol and the presence of small, dense, low density lipoproteins (LDL). Treatment with the present
5 compound is expected to lower the cardiovascular morbidity and mortality associated with atherosclerosis. These cardiovascular disease conditions include macro-angiopathies causing myocardial infarction, cerebrovascular disease and peripheral arterial insufficiency of the lower extremities. Because of their insulin sensitizing effect the compound of formula (I) is also expected to reduce the progress of clinical conditions associated with
10 chronic hyperglycaemia in diabetes like the micro-angiopathies causing renal disease and retinal damage. Furthermore the compound may be useful in treatment of various conditions outside the cardiovascular system associated with insulin resistance like the polycystic ovarian syndrome. The compound of the invention is a non-toxic insulin sensitizing agent with surprisingly good therapeutic effect and pharmacokinetic properties
15 and without undesirable weight gain.

General Experimental Procedures

¹H NMR and ¹³C NMR measurements were performed on a BRUKER ACP 300 and
20 Varian UNITY plus 400 and 500 spectrometers, operating at ¹H frequencies of 300, 400 and 500 MHz respectively, and at ¹³C frequencies of 75, 100 and 125 MHz respectively.

Unless otherwise stated, chemical shifts are given in ppm with the solvent as internal standard.

25

Example 1. 3-{4-[2-(4-*tert*-Butoxycarbonylamino)phenyl]ethoxy}phenyl)-(S)-2-ethoxypropanoic acid.

30 a) 3-(4-Benzoyloxyphenyl)-2-ethoxyacrylic acid ethyl ester

Tetramethylguanidine (33 g; 0.286 mole) was added to a solution of 4-benzyloxybenzaldehyde (59.1 g; 0.278 mole) and 101.8 g; 0.237 mole) (1,2-dieoxy-2-oxyethyl) (triphenyl) phosphonium chloride in dichloromethane (600 ml) at 0°C. After stirring at room temperature over night, the solvent was evaporated *in vacuo*. The residue was dissolved in diethyl ether, insoluble material was filtered off and the filtrate was evaporated. The residue was stirred over night with sodium bisulfite (saturated water solution) and diethyl ether. The solid material was filtered off, the filtrate was extracted with diethyl ether, dried (magnesium sulfate) and the solvent was evaporated *in vacuo*. Purification of the crude product by flash chromatography and crystallization in isopropanol gave 66.8 g (yield 86.3 %) of 3-(4-benzyloxyphenyl)-2-ethoxyacrylic acid ethyl ester.

¹³C-NMR (125 MHz; CDCl₃): δ 14.4, 15.6, 61.0, 67.5, 70.0, 114.8, 124.0, 126.7, 127.5, 128.1, 128.6, 131.7, 136.7, 143.1, 159.2, 165.0.

(b) 2-Ethoxy-3-(4-hydroxyphenyl)propanoic acid ethyl ester

3-(4-Benzyloxyphenyl)-2-ethoxyacrylic acid ethyl ester (62 g; 0.19 mole) was hydrogenated in ethyl acetate (400 ml) at atmospheric pressure using Pd/C (10 %) as catalyst. The mixture was filtered through celite and evaporated *in vacuo* to give 45.6 g (yield 100 %) of 2-ethoxy-3-(4-hydroxyphenyl)propanoic acid ethyl ester.

¹H-NMR (600 MHz; CDCl₃): δ 1.17 (t, 3H, J=7 Hz), 1.23 (t, 3H, J=7 Hz), 2.95 (d, 2H, J=6.6 Hz), 3.35-3.42 (m, 1H), 3.58-3.64 (m, 1H), 4.0 (t, 1H, J=6.6 Hz), 4.17 (q, 2H, J=7 Hz), 5.97 (s, 1 OH), 6.74 (dm, 2H, J=8.5 Hz, unresolved), 7.08 (dm, 2H, J=8.5 Hz, unresolved).

¹³C-NMR (125 MHz; CDCl₃): δ 14.0, 14.8, 38.3, 61.0, 66.1, 80.3, 115.1, 128.2, 130.3, 154.8, 173.0.

(c) 4-(2-Hydroxyethyl)phenylcarbamic acid *tert*-butyl ester

Di-*tert*-Butyl dicarbonate (7.95 g; 36 mmole) was added to a mixture of *p*-aminophenethyl
alcohol (5 g; 36 mmole) in tetrahydrofuran at 0° C. After stirring at room temperature over
night, the solvent was evaporated *in vacuo* to give 8 g (yield 94 %) of 4-(2-
hydroxyethyl)phenylcarbamic acid *tert*-butyl ester.

¹H-NMR (400 MHz; DMSO-d₆): δ 1,5 (s, 9H), 2,65 (dd, 2H), 3,55 (dd, 2H), 4,6 (bs, 1
OH), 7,1 (unresolved, 2H), 7,35 (unresolved, 2H), 9,1 (s, 1 NH).

¹³C-NMR (100 MHz; DMSO-d₆): δ 28.3, 38.6, 62.5, 78.9, 118.3, 129.1, 133.2, 136.6,
153.0.

(d) 3-{4-[2-(4-*tert*-Butoxycarbonylamino)phenyl]ethoxy}phenyl}-2-ethoxypropanoic acid
ethyl ester

4-(2-Hydroxyethyl)phenylcarbamic acid *tert*-butyl ester (1.03 g; 4.34 mmole) and 2-
ethoxy-3-(4-hydroxyphenyl)propanoic acid ethyl ester (1.03 g; 4.34 mmole) were
dissolved in dichloromethane under argon at room temperature. Azodicarbonyl
dipiperidine (1.65 g; 6.5 mmole) and thereafter triphenylphosphine (1.37 g; 5.2 mmole)
were added. After stirring at room temperature for 6 hours the solvent was evaporated *in*
vacuo. Purification by chromatography on silica gel using heptan:ethyl acetate (2:1) as
eluant gave 1.78 g (yield 89%) of 3-{4-[2-(4-*tert*-butoxycarbonylamino)phenyl]ethoxy}-
phenyl}-2-ethoxypropanoic acid ethyl ester.

¹H-NMR (400 MHz; CDCl₃): δ 1.17 (t, 3H, J=7 Hz), 1.23 (t, 3H, J=7 Hz), 1.53 (s, 9H),
2.94-2.97 (m, 2H), 3.03 (t, 2H, J=7.1 Hz), 3.31-3.40 (m, 1H), 3.56-3.65 (m, 1H), 3.95-4.0
(m, 1H), 4.11 (t, 2H, J=7.1 Hz), 4.17 (q, 2H, J=7 Hz), 6.60 (s, 1NH), 6.81 (dm, 2H, J=8.3
Hz, unresolved), 7.15 (dm, 2H, J=8.3 Hz, unresolved), 7.20 (dm, 2H, J=8.3 Hz,
unresolved), 7.31 (dm, 2H, J=8.3 Hz, unresolved).

¹³C-NMR (100 MHz; CDCl₃): δ 14.1, 15.0, 28.3, 35.0, 38.4, 60.7, 66.1, 68.6, 80.26, 80.32, 114.3, 118.7, 128.2, 129.4, 130.3, 132.8, 136.7, 152.8, 157.5, 172.4.

(e) 3-{4-[2-(4-*tert*-Butoxycarbonylamino)phenyl]ethoxy}phenyl}-2-ethoxypropanoic acid

5

Lithium hydroxide hydrate (77 mg; 1.85 mmole) in water (5.5 ml) was slowly added to a solution of 3-{4-[2-(4-*tert*-butoxycarbonylamino)phenyl]ethoxy}phenyl}-2-ethoxypropanoic acid ethyl ester (0.77 g; 1.68 mmole) in tetrahydrofuran (7.6 ml). After stirring at room temperature for 4 hours the reaction mixture was kept in a freezer for 4 days. Tetrahydrofuran was removed by evaporation *in vacuo*. More water was added and the mixture was acidified with hydrochloric acid to pH 1. The product was extracted with ethyl acetate, washed twice with water, dried (sodium sulfate), filtered and the solvent was evaporated *in vacuo* to give 0.716 g of 3-{4-[2-(4-*tert*-butoxycarbonylamino)phenyl]ethoxy}phenyl}-2-ethoxypropanoic acid.

15

¹H-NMR (400 MHz; CDCl₃): δ 1.18 (t, 3H, J=7 Hz), 1.54 (s, 9H), 2.93-3.10 (m, 4H), 3.36-3.45 (m, 1H), 3.60-3.69 (m, 1H), 4.02-4.07 (m, 1H), 4.12 (t, 2H, J=7 Hz), 6.83 (dm, 2H, J=8.8 Hz, unresolved), 7.15-7.23 (m, 4H), 7.27-7.34 (m, 2H), 10.28 (bs, 1H).

¹³C-NMR (100 MHz; CDCl₃): δ 15.0, 28.3, 35.2, 38.0, 66.7, 68.8, 79.9, 80.7, 114.6, 119.1, 129.0, 129.4, 130.4, 133.1, 136.8, 153.2, 157.8, 175.3.

20

(f) 3-{4-[2-(4-*tert*-Butoxycarbonylamino)phenyl]ethoxy}phenyl}-(S)-2-ethoxypropanoic acid.

25 The enantiomers of 3-{4-[2-(4-*tert*-butoxycarbonylamino)phenyl]ethoxy}phenyl}-2-ethoxypropanoic acid was separated with chiral preparative HPLC (Chiralpak AD 250x20 mm) using heptane, isopropanol and trifluoroacetic acid (80/20/0.5) as mobile phase giving 3-{4-[2-(4-*tert*-butoxycarbonylamino)phenyl]ethoxy}phenyl}-(S)-2-ethoxypropanoic acid as a pure enantiomer.

¹H-NMR (600 MHz; CDCl₃): δ 1.17 (t, 3H), 1.51 (s, 9H), 2.93 (dd, 1H), 3.02 (t, 2H), 3.07 (dd, 1H), 3.42-3.47 (m, 1H), 3.55-3.6 (m, 1H), 4.04 (dd, 1H), 4.1 (t, 2H), 6.5 (bs, 1H), 6.8 (d, 2H), 7.13 (d, 2H), 7.19 (d, 2H), 7.28 (d, 2H).

5 ¹³C-NMR (100 MHz; CD₃OD): δ 15.3, 28.7, 36.1, 39.3, 67.1, 69.9, 80.7, 81.3, 115.4, 120.0, 130.3, 130.7, 131.4, 134.2, 138.8, 155.4, 159.1, 176.0.

Example 2: 3-{4-[2-(4-*tert*-Butoxycarbonylamino)phenyl]ethoxy}phenyl)-(S)-2-ethoxypropanoic acid.

10

a) 3-(4-Benzyloxyphenyl)-2-ethoxypropanoic acid ethyl ester

3-(4-Benzyloxyphenyl)-2-ethoxyacrylic acid ethyl ester (described in Example 1a) (0.5 g; 1.5 mmole) was hydrogenated at atmospheric pressure using rhodium on charcoal as
15 catalyst (5%, 50 mg) in methanol (20 ml). The crude product was purified by chromatography using heptane:ethyl acetate (5:1) as eluent to give 50 mg (yield 10%) of 3-(4-benzyloxyphenyl)-2-ethoxypropanoic acid ethyl ester.

¹H NMR (300 MHz; CDCl₃): δ 7.47-7.30 (m, 5H), 7.17 (d, J=8.8, 2H), 6.91 (d, J=8.8 Hz, 2H), 5.06 (s, 2H), 4.17 (q, J=7.2 Hz, 2H), 3.98 (t, J=6.6 Hz, 1H), 3.61 (dq, J=8.9 and 6.8 Hz, 1H), 3.36 (dq, J=8.9 and 6.8 Hz, 1H), 2.97 (d, J=6.6 Hz, 2H), 1.22 (t, J=7.2 Hz, 3H), 1.18 (t, J=6.8 Hz, 3H).

¹³C NMR (75 MHz; CDCl₃): δ 172.6, 157.6, 137.1, 130.4, 129.5, 128.6, 127.9, 127.5, 114.6, 80.4, 70.0, 66.2, 60.8, 38.5, 15.1, 14.2.

25

b) 3-(4-Benzyloxyphenyl)-2-ethoxypropanoic acid

Lithium hydroxide hydrate (7.4 g; 177 mmole) dissolved in water (150 ml) was added to a solution of 3-(4-benzyloxyphenyl)-2-ethoxypropanoic acid ethyl ester (23.25 g; 70.8
30 mmole) in dioxan (150 ml). After stirring at room temperature over night dioxan was

evaporated *in vacuo*, water was added and the mixture was washed with diethyl ether. The water phase was acidified with hydrochloric acid (1 M) and the crude product was extracted with ethyl acetate, washed with water and brine, dried and the solvent was evaporated *in vacuo* to give 21.1 g (yield 99.2 %) of 3-(4-benzyloxyphenyl)-2-ethoxypropanoic acid.

¹H NMR (300 MHz; CDCl₃): δ 1.15 (t, 3H), 2.9-3.1 (m, 2H), 3.35-3.45 (m, 1H), 3.6-3.7 (m, 1H), 3.95-3.41 (m, 1H), 5.05 (s, 2H), 6.95 (d, 2H), 7.2 (d, 2H), 7.25-7.5 (m, 5H).

¹³C NMR (75 MHz; CDCl₃): δ 15.0, 38.1, 66.6, 70.0, 79.9, 114.7, 127.5, 128.0, 128.6,

129.3, 130.5, 137.1, 157.7, 176.3.

c) 3-(4-Benzyloxyphenyl)-(S)-2-ethoxy-N-(2-hydroxy-(R)-1-phenylethyl)propanoic amide

EDC (2.03 g; 10.61 mmole), diisopropylethylamine (1.84 ml, 10.61 mmole) and HOBt x H₂O (1.43 g; 10.61 mmole) were added to a solution of 3-(4-benzyloxyphenyl)-2-ethoxypropanoic acid (2.92 g, 9.74 mmole) in dry dichloromethane (30 ml) on an ice-bath. After 30 minutes the ice-bath was removed and (R)-phenylglycinol (1.46 g, 10.61 mmole) was added. After stirring at room temperature over night ethyl acetate (100 ml) was added and the solution was washed with potassium hydrogensulfate (1 M), saturated sodium bicarbonate solution, sodium carbonate solution and brine. The organic phase was dried (sodium sulfate), filtered and the solvent was evaporated *in vacuo*. The crude product was purified by chromatography on silica gel using ethyl acetate:heptan to give 1.5 g (yield 37 %) of 3-(4-benzyloxyphenyl)-(S)-2-ethoxy-N-(2-hydroxy-(R)-1-phenylethyl)propanoic amide and 1.25 g (yield 31 %) of 3-(4-benzyloxyphenyl)-(R)-2-ethoxy-N-(2-hydroxy-(R)-1-phenylethyl)propanoic amide.

¹H NMR (400 MHz; CDCl₃): δ 7.43-7.27 (m, 8H), 7.22 (d, J=8.3 Hz, 4H), 7.13 (d, NH, J=7.8 Hz, 1H), 6.96 (d, J=8.3 Hz, 1H), 5.08 (s, 2H), 5.01 (m, 1H), 3.99 (dd, J=6.8 and 3.9 Hz, 1H), 3.69 (m, 2H), 3.50 (q, J=6.8 Hz, 2H), 3.15 (dd,

J=14.2 and 3.9 Hz, 1H), 2.97 (dd, J=14.2 and 6.8 Hz, 1H), 2.94 (m, OH, 1H),
1.16 (t, J=6.8 Hz, 3H).

¹³C NMR (100 MHz; CDCl₃): δ 172.3, 157.5, 138.9, 137.0, 130.7, 129.4,
128.6, 128.4, 127.7, 127.6, 127.3, 126.5, 114.4, 81.0, 69.8, 66.3, 66.0, 55.3,
37.8, 15.1.

d) 3-(4-Benzyloxyphenyl)-(S)-2-ethoxypropanoic acid

3-(4-Benzyloxyphenyl)-(S)-2-ethoxy-*N*-(2-hydroxy-(*R*)-1-phenylethyl)propanoic amide
(8.9 g; 21.22 mmole) was hydrolyzed with concentrated sulfuric acid (27 ml) in water (104
ml) and dioxane (104 ml) at 90° C for 5 hours. The reaction mixture was poured onto water
(220 ml) and extracted with ethyl acetate. The organic phase was washed with brine, dried
(sodium sulfate) and the solvent was evaporated *in vacuo* to give 6.85 g of a mixture of 3-
(4-benzyloxyphenyl)-2-(S)-ethoxypropanoic acid and (S)-2-ethoxy-3-(4-hydroxyphenyl)-
propanoic acid, which was used without further purification.

¹H NMR (400 MHz; CDCl₃): δ 7.47-7.30 (m, 5H), 7.19 (d, J=8.8, 2H), 6.93 (d, J=8.8 Hz,
2H), 5.10 (s, 2H), 4.06 (dd, J=7.8 and 4.4 Hz, 1H), 3.64 (dq, J=9.8 and 6.8 Hz, 1H), 3.44
(dq, J=9.8 and 6.8 Hz, 1H), 3.09 (dd, J=14.2 and 4.4 Hz, 1H), 2.98 (dd, J=14.2 and 7.8 Hz,
1H), 1.19 (t, J=6.8 Hz, 3H).

e) 3-(4-Benzyloxyphenyl)-(S)-2-ethoxypropanoic acid ethyl ester

Hydrogen chloride (g) was bubbled through a solution of 3-(4-benzyloxyphenyl)-2-(S)-
ethoxypropanoic acid (6.85 g) in ethanol (400 ml). Thionyl chloride (2 ml, 27.4 mmole)
was slowly added and the reaction mixture was refluxed for 2 hours. The solvent was
evaporated *in vacuo* to give 8 g of a mixture of 3-(4-benzyloxyphenyl)-(S)-2-
ethoxypropanoic acid ethyl ester and (S)-2-ethoxy-3-(4-hydroxyphenyl)propanoic acid
ethyl ester which was used without further purification.

¹H NMR (300 MHz; CDCl₃): δ 7.47-7.30 (m, 5H), 7.17 (d, J=8.8, 2H), 6.91 (d, J=8.8 Hz, 2H), 5.06 (s, 2H), 4.17 (q, J=7.2 Hz, 2H), 3.98 (t, J=6.6 Hz, 1H), 3.61 (dq, J=8.9 and 6.8 Hz, 1H), 3.36 (dq, J=8.9 and 6.8 Hz, 1H), 2.97 (d, J=6.6 Hz, 2H), 1.22 (t, J=7.2 Hz, 3H), 1.18 (t, J=6.8 Hz, 3H).

5 ¹³C NMR (75 MHz; CDCl₃): δ 172.6, 157.6, 137.1, 130.4, 129.5, 128.6, 127.9, 127.5, 114.6, 80.4, 70.0, 66.2, 60.8, 38.5, 15.1, 14.2.

f) (S)-2-Ethoxy-3-(4-hydroxyphenyl)propanoic acid ethyl ester

10 3-(4-Benzyloxyphenyl)-(S)-2-ethoxypropanoic acid ethyl ester was hydrogenated at atmospheric pressure for 2 hours in ethyl acetate using Pd/C as catalyst. Purification by chromatography on silica gel using toluene:ethyl acetate as eluant gave 3.83 g (yield in 3 steps 76 %) of (S)-2-ethoxy-3-(4-hydroxyphenyl)propanoic acid ethyl ester.

15 ¹H-NMR (400 MHz; CDCl₃): δ 1.18 (t, 3H, J=6.8 Hz), 1.24 (t, 3H, J=7 Hz), 2.96 (d, 2H, J=6.5 Hz), 3.34-3.43 (m, 1H), 3.57-3.66 (m, 1H), 4.00 (t, 1H, 6.5 Hz), 4.18 (q, 2H, J=7 Hz), 5.30 (s, 1 OH), 6.74 (dm, 2H, J=8.5 Hz, unresolved), 7.10 (dm, 2H, J=8.5 Hz, unresolved).

¹³C-NMR (100 MHz; CDCl₃): δ 14.2, 15.0, 38.4, 60.9, 66.2, 80.4, 115.1, 129.0, 130.5,
20 154.5, 172.7.

(g) 2-[4-(*tert*-Butoxycarbonylamino)phenyl]ethylmethanesulfonate

4-(2-Hydroxyethyl)phenylcarbamic acid *tert*-butylester (described in Example 1 (c)) (2.46
25 g; 10.38 mmole) was dissolved in dichloromethane (21 ml). Triethylamine (2.17 ml; 15.6 mmole) was added and the mixture was stirred for 20 min and then cooled on an ice-bath. Methanesulphonyl chloride (1.25 g, 10.9 mmole) was added slowly. The reaction mixture was stirred for 3.5 hours and the formed precipitate was filtered off. The filtrate was evaporated and the residue redissolved in ethyl acetate. A new precipitate was formed and
30 filtered off and the filtrate evaporated. Chromatography on silica using heptane: ethyl

acetate (2:1, 1:1) gave 3 g (100 % yield) of 2-[4-(*tert*-butoxycarbonylamino)phenyl]-ethylmethanesulfonate

¹H-NMR (400 MHz; CDCl₃): δ 1.52 (s, 9H), 2.87 (s, 3H), 3.01 (t, 2H), 4.39 (t, 2H), 7.16
5 (d, 2H, J=8.45 Hz), 6.45 (bs, 1H), 7.33 (d, 2H, J=8.45 Hz)

¹³C-NMR (100 MHz; CDCl₃): δ 28.2, 34.8, 37.1, 70.2, 80.3, 118.6, 129.2, 130.5, 137.3, 152.6.

10 (h) 3-{4-[2-(4-*tert*-Butoxycarbonylamino)phenyl]ethoxy}phenyl}-(S)-2-ethoxypropanoic acid ethyl ester

2-[4-(*tert*-Butoxycarbonylamino)phenyl]ethylmethanesulfonate (52.9 g; 0.168 mmole), (S)-2-ethoxy-3-(4-hydroxyphenyl)propanoic acid ethyl ester (40 g; 0.168 mmole) and
15 potassium carbonate (69.5 g; 0.503 mmole) were mixed in acetonitrile (1200 ml) and refluxed over night. Another portion of 2-[4-(*tert*-butoxycarbonylamino)phenyl]-ethylmethanesulfonate (2.5 g; 7.9 mmole) was added. The reaction mixture was refluxed for 8 more hours then filtered. Evaporation of the filtrate gave 76.6 g 3-{4-[2-(4-*tert*-butoxycarbonylamino)phenyl]ethoxy}phenyl}-(S)-2-ethoxypropanoic acid ethyl ester.

20

This batch of 3-{4-[2-(4-*tert*-butoxycarbonylamino)phenyl]ethoxy}phenyl}-(S)-2-ethoxypropanoic acid ethyl ester (76.6 g) was combined with another batch of 3-{4-[2-(4-*tert*-butoxycarbonylamino)phenyl]ethoxy}phenyl}-(S)-2-ethoxypropanoic acid ethyl ester (74.1 g) and flash chromatographed on silica using first toluene and then methanol as eluant.
25 This gave a main fraktion of 80 g ester which was split in two portions of 40 g each and chromatographed on silica using toluene: ethyl acetate (2-5 %) as eluant. This procedure gave 69.9 g of pure 3-{4-[2-(4-*tert*-butoxycarbonylamino)phenyl]ethoxy}phenyl}-(S)-2-ethoxypropanoic acid ethyl ester.

¹H-NMR (400 MHz; CDCl₃): δ 1.16 (t, 3H), 1.22 (t, 3H), 1.51 (s, 9H), 2.94 (d, 2H), 3.02 (t, 2H), 3.31-3.38 (m, 1H), 3.55-3.63 (m, 1H), 3.95 (t, 1H), 4.10 (t, 2H), 4.16 (q, 2H), 6.45 (bs, 1H), 6.8 (d, 2H), 7.13 (d, 2H), 7.19 (d, 2H), 7.29 (d, 2H).

- 5 (i) 3-{4-[2-(4-*tert*-Butoxycarbonylaminophenyl)ethoxy]phenyl}-(S)-2-ethoxypropanoic acid

3-{4-[-(*tert*-Butoxycarbonylaminophenyl)ethoxy]phenyl}-(S)-2-ethoxypropanoic acid ethyl ester (27 g; 0.06 mmole) was dissolved in THF (250 ml), and water (250 ml) was
10 added during stirring followed by addition of lithium hydroxide hydrate (3.75 g; 0.089 mmole) dissolved in a small amount of water. The reaction mixture was stirred at room temperature over night and then concentrated by evaporation. The residue was washed once with ethyl acetate. The water phase was acidified upon cooling with hydrochloric acid (2M) and extracted with ethyl acetate. The organic phase was washed with brine dried with
15 magnesium sulfate and evaporated. The residue was redissolved in dichloromethane and chromatography on silica using a gradient system of dichloromethane: methanol (0-100 %) gave 21.3 g (83 % yield) 3-{4-[2-(4-*tert*-butoxycarbonylaminophenyl)ethoxy]phenyl}-(S)-2-ethoxypropanoic acid.

20 ¹H-NMR (600 MHz; CDCl₃): δ 1.17 (t, 3H), 1.51 (s, 9H), 2.93 (dd, 1H), 3.02 (t, 2H), 3.07 (dd, 1H), 3.42-3.47 (m, 1H), 3.55-3.6 (m, 1H), 4.04 (dd, 1H), 4.1 (t, 2H), 6.5 (bs, 1H), 6.8 (d, 2H), 7.13 (d, 2H), 7.19 (d, 2H), 7.28 (d, 2H).

¹³C-NMR (100 MHz; CD₃OD): δ 15.3, 28.7, 36.1, 39.3, 67.1, 69.9, 80.7, 81.3, 115.4,
25 120.0, 130.3, 130.7, 131.4, 134.2, 138.8, 155.4, 159.1, 176.0.

Biological activity

The biological activity of the compound of the invention was tested in obese diabetic mice of the Umeå ob/ob strain. Groups of mice received the test compound by gavage once daily for 7 days. On the last day of the experiment the animals were anesthetized 2h after dose in a non-fed state and blood was collected from an incised artery. Plasma was analyzed for concentration of glucose, insulin and triglycerides. A group of untreated obese diabetic mice of the same age served as control. The weight of the mice was measured before and after the experiment and the obtained weight gain was compared to the weight gain of the control animals. The individual values for glucose, insulin and triglyceride levels of the mice from the test group were expressed as the percent rage of the corresponding values from the control group.

The desired "therapeutic effect" was calculated as the average percent reduction of the three variables glucose, insulin and triglycerides below the levels in the control animals. The therapeutic effect of the tested compounds according to the invention was compared to the same effect in the prior art compound troglitazone, administered by gavage in the oral dose of 100 µmol/kg for 7 days.

The superior effects of the tested compound according to the invention compared to that of troglitazone when given in the same oral dose demonstrate the increased potency and efficiency of the claimed compound.

Abbreviations

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NIDDM	non insulin dependent diabetes mellitus
VLDL	very low density lipoproteins
HDL	high density lipoproteins
IRS	insulin resistance syndrom
PPAR	peroxisome proliferator activated receptor

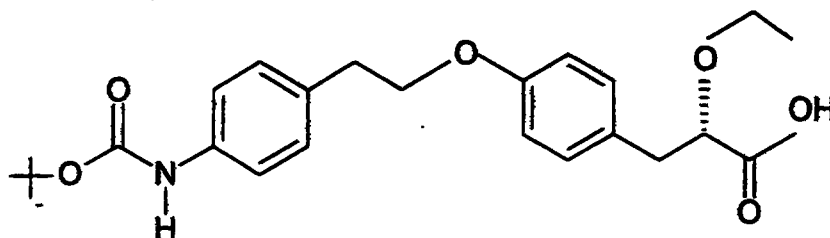
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	DEAD	diethyl azodicarboxylate
	ADDP	azodicarbonyl dipiperidine
	EDC	1-(3-dimethylaminopropyl)-3-ethylcarbodiimide
	EDCxHCl	1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride
5	DCC	dicyclohexylcarbodiimide
	HBTU	O-benzotriazol-1-yl-N,N,N',N'-tetramethyluronium hexafluorophosphate
	TBTU	O-benzotriazol-1-yl-N,N,N',N'-tetramethyluronium tetrafluoroborate
	PyBop	benzotriazole-1-yl-oxy-tris-pyrolidino-phosphonium hexafluorophosphate
	DMF	dimethylformamide
10	DMAP	4-dimethylaminopyridine
	TEA	triethylamine
	DiPEA	diisopropylethylamine
	BINAP	2,2'-bis(diphenylphosphino)-1,1'-binaphthyl
	COD	cyclooctadiene
15	LDA	lithium diisopropylamide
	LHMDS	lithium hexamethyldisilylamine
	TLC	thin layer chromatography
	THF	tetrahydrofuran
	Pd/C	palladium on charcoal
20	HOBt x H2O	1-hydroxybenzotriazole-hydrate
	m	multiplet
	t	triplet
	s	singlet
	d	doublet
25	q	quartet
	qvint	quintet
	br	broad
	dm	multiplet of doublet
	rac	racemate

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CLAIMS

1. A compound having the formula



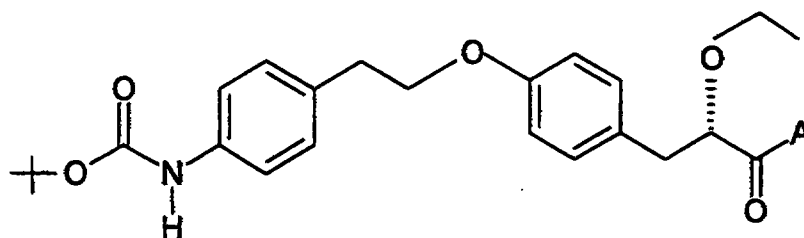
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and pharmaceutically acceptable salts, solvates, and crystalline forms thereof.

2. A process for the preparation of a compound according to claim 1, characterized by

10

a) converting a compound of the formula II



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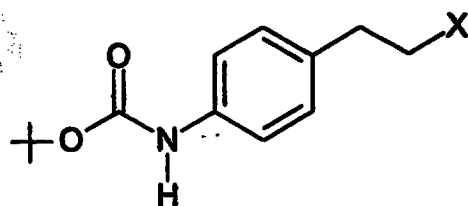
wherein A is a chiral auxiliary group or $-OR^P$, wherein R^P is a protective group, or

b) reacting a compound of the formula III

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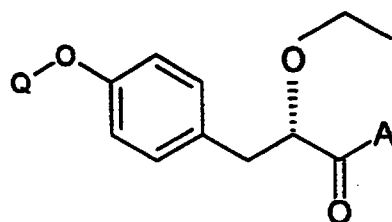
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III



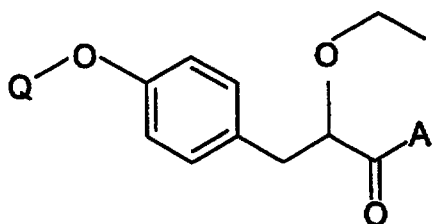
with a compound of the formula IV



IV

in which formula A is -OH, a chiral auxiliary group or the group -OR^p, wherein R^p is a protective group, X is -OH or a leaving group and Q is H, whereafter, if necessary, hydrolysing the obtained compound, or

c) diastereoisomerically separating a compound of the formula V



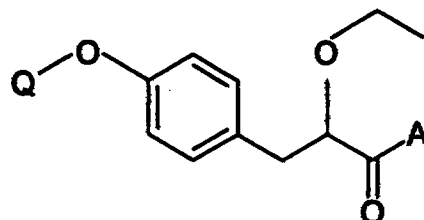
V

wherein Q is -CH₂CH₂Ph-4-NHCOO^tBu and A is a chiral auxiliary group whereafter, hydrolysing the obtained compound, or

d) enantiomerically separating a compound of the formula V

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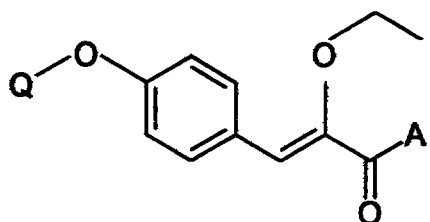
V



wherein Q is $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ and A is $-\text{OH}$ or $-\text{OR}^P$, wherein R^P is a protective group, whereafter, if necessary, hydrolysing the obtained compound, or

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e) asymmetrically reducing a compound of the formula VII



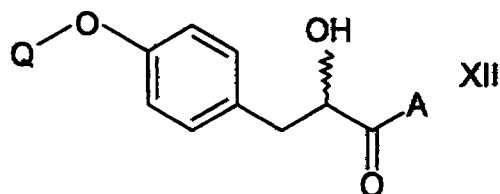
VII

10

wherein Q is $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ and A is $-\text{OH}$, a chiral auxiliary group or the group $-\text{OR}^P$, wherein R^P is a protective group, whereafter, if necessary, hydrolysing the obtained compound, or

15

f) alkylating a compound of the formula XII



XII

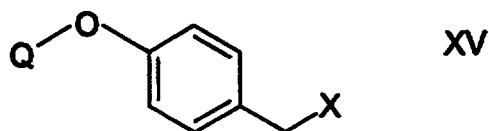
wherein Q is $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ and A is $-\text{OH}$, a chiral auxiliary group or the group $-\text{OR}^P$, wherein R^P is a protective group, whereafter, if necessary, hydrolysing the obtained compound, or

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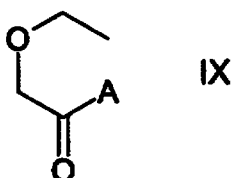
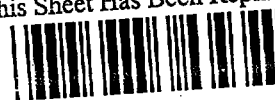
g) reacting a compound of the formula XV



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with a compound of the formula IX

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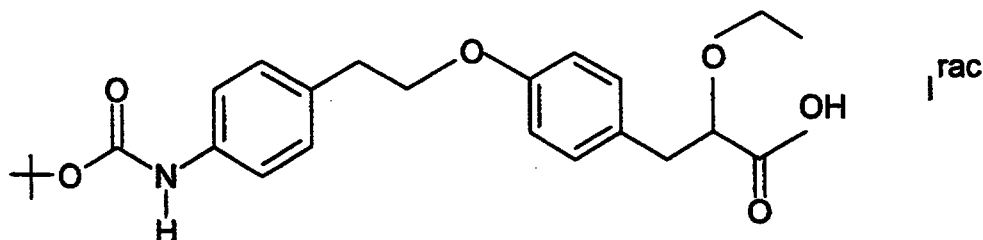


10

in which formulas X is a leaving group, Q is $-\text{CH}_2\text{CH}_2\text{Ph}-4\text{-NHCOO}^t\text{Bu}$ and A is a chiral auxiliary group used to induce chirality in the compound whereafter, hydrolysing the obtained compound, or

15

h) resolving a racemate of the formula I^{rac}

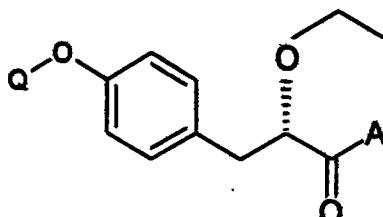


whereafter, if desired, the compound obtained according to any of methods a)-h) is converted to a pharmaceutically acceptable salt and/or a solvate, such as a hydrate thereof.

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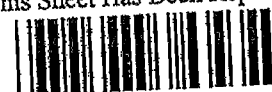


3. A compound of the formula IV



IV

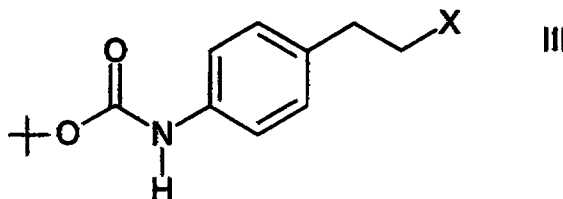
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5 wherein Q is hydrogen and A is -OH, a chiral auxiliary group or the group -OR^P, wherein R^P is a protective group.

4. A compound according to claim 3 wherein the formula IV A is -OH or -Oalkyl.

10 5. A compound of the formula III



III

wherein X is -OH or a leaving group.

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6. A compound according to claim 5, wherein in formula III X is -OH.

7. A compound according to claim 1 for use in therapy.

20 8. A pharmaceutical formulation containing a compound according to claim 1 as active ingredient optionally together with a pharmaceutically acceptable carrier, adjuvant and/or diluent.



9. The use of a compound according to claim 1 in the manufacture of a medicament for the prophylaxis and/or treatment of clinical conditions associated with insulin resistance.
10. A method for the prophylaxis and/or treatment of clinical conditions associated with insulin resistance wherein a therapeutically active amount of a compound according to claim 1 is administered to a mammal in the need of such prophylaxis and/or treatment.
11. A method according to claim 10 wherein the prophylaxis and/or treatment of clinical conditions associated with insulin resistance is the prophylaxis and/or treatment of dyslipidaemia in such conditions.
12. A method according to claim 10 wherein the prophylaxis and/or treatment of clinical conditions associated with insulin resistance is the prophylaxis and/or treatment of hyperglycaemia in non insulin dependent diabetes mellitus.
13. A pharmaceutical formulation for use in the prophylaxis and/or treatment of clinical conditions associated with insulin resistance wherein the active ingredient is a compound according to claim 1.

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