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(54) **METHOD**

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(57) **ABSTRACT**

(21) Appl. No.: **10/502,191**

Process for preparing 3-[(4S)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinolin-4-yl]benzonitrile, pharmaceutical compositions containing the compound and methods of treatment using the same.

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METHOD

FIELD OF THE INVENTION

[0001] This invention relates to the synthesis of compounds useful as smooth muscle relaxants in mammals and particularly to the synthesis of compounds useful for treating overactive bladder in mammals and particularly in humans.

BACKGROUND

[0002] Inappropriate smooth muscle activation is believed to be involved in many conditions and diseases including, hypertension, asthma, peripheral vascular disease, right heart failure, congestive heart failure, angina, ischemic heart disease, cerebrovascular disease, renal colic, disorders associated with kidney stones, irritable bowel syndrome, male-pattern baldness, premature labor, impotence, peptic ulcers, overactive bladder and urinary incontinence.

[0003] Processes for the synthesis of 1,4-dihydropyridines have been described in U.S. Pat. Nos. 5,455,253 and 5,622,964 and in PCT publication WO 95/28388.

DESCRIPTION OF THE INVENTION

[0004] We have discovered a new process by which 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid may be prepared with improved yield and greater purity. Advantageously, the process is suitable for implementation on an industrial scale.

[0005] In the invented process, an ester of 4,4,4-trifluoro-3-oxobutanoate is reacted with 1,3-cyclohexanedione and 3-cyanobenzaldehyde to form an ester of 4-(3-cyanophenyl)-2-hydroxy-5-oxo-2-(trifluoromethyl)-1,2,3,4,5,6,7,8-octahydroquinoline-3-carboxylate. The 4-(3-cyanophenyl)-2-hydroxy-5-oxo-2-(trifluoromethyl)-1,2,3,4,5,6,7,8-octahydroquinoline-3-carboxylate ester is dehydrated to form a urethane, which is an ester of 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate. The urethane is de-esterified to form 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid.

[0006] A variety of esters have been found to be suitable for use in the invented process.

[0007] One aspect of the invention is a process to prepare the racemic acid from esters by cleavage with Wilkinson's catalyst.

[0008] Another aspect of the invention is a process to prepare the racemic acid from isoprenol or geraniol esters by acid cleavage without the need for Wilkinson's catalyst.

[0009] Yet another aspect of the invention is a process to prepare the racemic acid from para-nitrobenzyl esters by cleavage with Pd(0)/H₂.

[0010] A particular aspect of the invention is a method of making 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid, comprising: a) reacting an ester of 4,4,4-trifluoro-3-oxobutanoate with 1,3-cyclohexanedione and 3-cyanobenzaldehyde to form an ester of 4-(3-cyanophenyl)-2-hydroxy-5-oxo-2-(trifluoromethyl)-1,2,3,4,5,6,7,8-octahydroquinoline-3-carboxylate; b) dehydrating said ester of 4-(3-cyanophenyl)-2-hydroxy-5-oxo-2-(trifluoromethyl)-1,2,3,4,5,6,7,8-octahydroquinoline-

3-carboxylate to form an ester of 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate, and c) de-esterifying said ester of 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate to form 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid. In this aspect of the invention in particular step a) is performed in ethanol in the presence of ammonium acetate; step b) is achieved with p-toluenesulfonic acid in n-butyl acetate, and step c) is achieved with chlorotris(triphenylphosphine)rhodium.

[0011] Another particular aspect of the invention is a method of making 3-[(4S)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinolin-4-yl]benzonitrile, comprising: a) reacting an ester of 4,4,4-trifluoro-3-oxobutanoate with 1,3-cyclohexanedione and 3-cyanobenzaldehyde to form an ester of 4-(3-cyanophenyl)-2-hydroxy-5-oxo-2-(trifluoromethyl)-1,2,3,4,5,6,7,8-octahydroquinoline-3-carboxylate; b) dehydrating said ester of 4-(3-cyanophenyl)-2-hydroxy-5-oxo-2-(trifluoromethyl)-1,2,3,4,5,6,7,8-octahydroquinoline-3-carboxylate to form an ester of 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate; c) de-esterifying said ester of 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate to form 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid; d) resolving racemic 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid by co-crystallization of said 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid with (1S)-1-phenylethyl-1-amine; e) recovering (1S)-1-phenylethyl-1-aminium (4S)-4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate; f) decarboxylating said (4S)-4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate, and g) recovering 3-[(4S)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinolin-4-yl]benzonitrile. In this aspect of the invention in particular step e) is achieved by crystallization from ethanol; step f) is achieved by decarboxylation with 1-methylpyrrolidone, and step g) is achieved by crystallization from acetonitrile.

[0012] Yet another particular aspect of the invention is 3-[(4S)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinolin-4-yl]benzonitrile made as described herein or a pharmaceutically-acceptable salt thereof.

[0013] Still another particular aspect of the invention is the use of a compound made as described herein for preparation of a medicament.

[0014] Yet a further particular aspect of the invention is a pharmaceutical composition comprising a compound made as described herein together with at least one pharmaceutically-acceptable excipient or diluent.

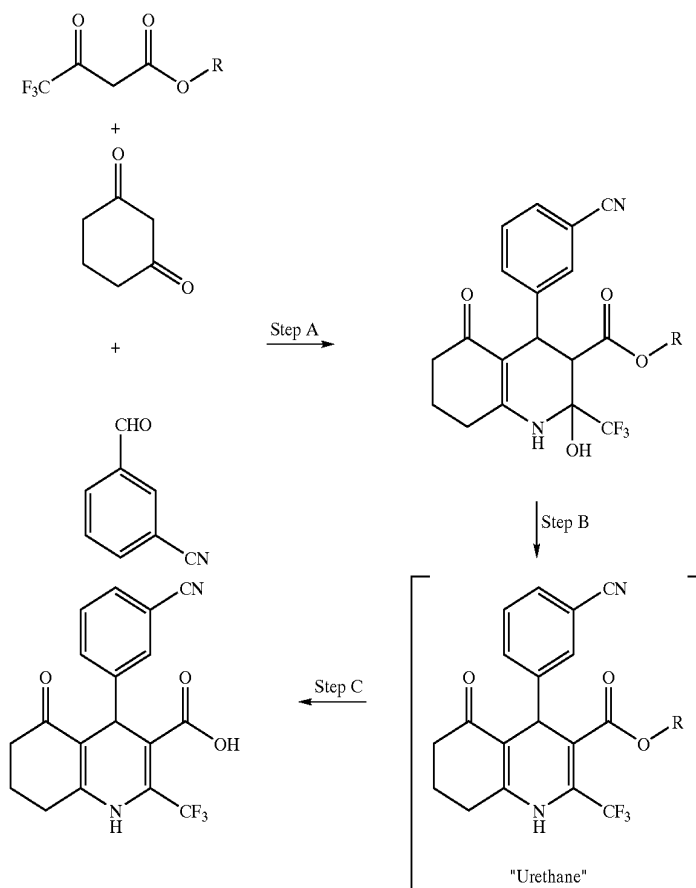
[0015] 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid is a potent opener of K-ATP channels of smooth muscle tissues. Such channels are found in human bladder smooth muscle (i.e., detrusor). Functional selectivity studies indicate little or no interaction with other ion channels or receptors. The compound initiates a robust cellular hyperpolarization that causes detrusor muscle relaxation. The antispasmodic activ-

ity of the compound is dose-dependent and is competitively antagonized by the K-ATP channel blocker, glibenclamide.

[0016] Accordingly, another aspect of the invention is a method of treating a disease or condition that results from inappropriate smooth muscle activation comprising administering a therapeutically effective amount of a compound made as described herein.

[0019] The process of the invention is illustrated in Scheme I wherein Step A is performed by refluxing in a lower alcohol solvent in the presence of ammonium acetate; Step B is performed at a temperature and in a solvent with an acid suitable for effecting the dehydration of a substituted octahydroquinoline, and Step C is performed in the presence of a catalyst and a suitable nucleophile

Scheme I:



[0017] A particular aspect of the invention is a method for treating a disease or condition selected from hypertension, asthma, peripheral vascular disease, right heart failure, congestive heart failure, angina, ischemic heart disease, cerebrovascular disease, renal colic, disorders associated with kidney stones, irritable bowel syndrome, male-pattern baldness, premature labor, impotence, peptic ulcers, overactive bladder or urinary incontinence that result from or involve inappropriate smooth muscle activation another aspect of the invention is a method for treating a disease or condition that results from or involves inappropriate smooth muscle activation with a compound prepared by the described process.

[0018] Yet a more particular method of the invention is a method for treating overactive bladder or urinary incontinence with a compound made as described herein or a pharmaceutically-acceptable salt thereof.

[0020] Suitable solvents for the performance of Step A are methanol, ethanol or propanol. Suitable solvents for performing Step B are toluene or butyl acetate heated to an elevated temperature in the presence of para-toluene sulfonic acid, acetic acid, methane sulfonic acid or trifluoroacetic acid. A suitable catalyst for performing Step C is palladium(0) on carbon 10 under atmospheric pressure hydrogen at ambient temperature, or in methanol with ammonium formate under reflux; or, Wilkinson's catalyst in water, ethanol and acetic acid. R is as defined in Scheme 3 in Example 2, below.

[0021] Particular conditions and solvents for carrying out Steps A, B and C are described in the Examples.

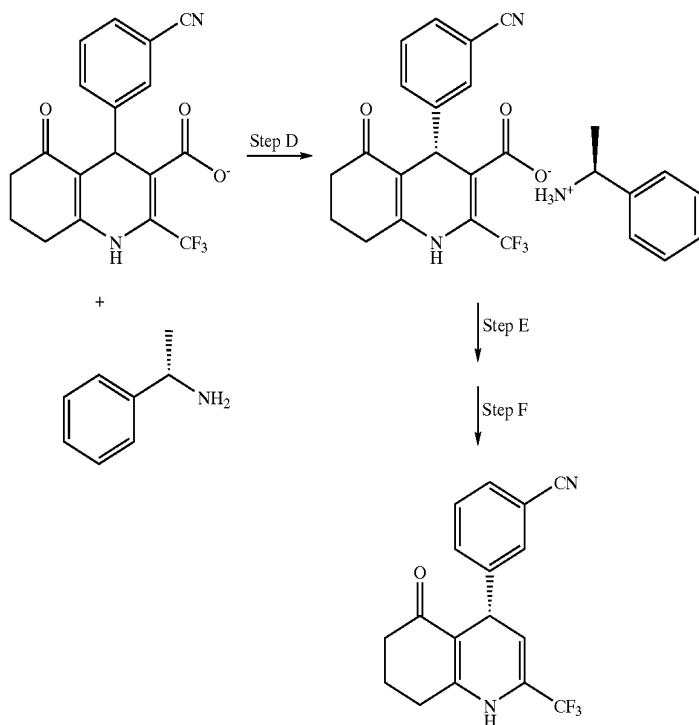
[0022] Resolution of Racemate:

[0023] Racemic 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid is

resolved by co-crystallizing 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid with (1S)-1-phenylethyl-1-amine. (1S)-1-phenylethyl-1-aminium (4S)-4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate is crystallized from a suitable solvent and the (4S) compound is decarboxylated and recovered by recrystallization.

[0024] The process for resolution of the racemate and preparation of 3-[(4S)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinolin-4-yl]benzonitrile is illustrated in Scheme II.

Scheme II:



[0025] Suitable solvents for performing the crystallization of Step D of Scheme II are substantially anhydrous solvents. Step E is performed with a solvent suitable to permit a temperature of 95° C. to be achieved. Step F is performed in a solvent suitable to afford crystallization of the product.

[0026] Particular solvents for Step D are absolute ethanol. IMS and iso-propanol/toluene mixtures; a solvent suitable for carrying out Step E is 1-methylpyrrolidone, and in Step F the product can be crystallized from acetonitrile or methanol.

[0027] Particular conditions and solvents for carrying out Steps D, E and F are described in the Examples.

[0028] Other solvents suitable for carrying out each of the reactions described herein will be apparent to those of skill in the art upon an appreciation of the processes described herein.

[0029] Abbreviations Used Herein:

NH ₄ OAc:	Ammonium acetate
EtOH:	Ethanol
pTSA:	p-Toluenesulfonic acid
BuOAc:	Butyl acetate
IMS:	Industrial Methylated Spirits
i-PrOH:	iso-Propanol
MTBE:	Methyl tert-butyl ether
NMP:	1-Methylpyrrolidone
MeCN:	Acetonitrile

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RhCl(PPh ₃) ₃	Chlorotris(triphenylphosphine)rhodium, (Wilkinson's catalyst)
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[0030] Experimental Procedures:

EXAMPLE 1

Preparation of Allyl 4-(3-cyanophenyl)-2-hydroxy-5-oxo-2-trifluoromethyl-1,2,3,4,5,6,7,3-octahydroquinoline-3-carboxylate

[0031] A slurry of 3-cyanobenzaldehyde and ammonium acetate was prepared in ethanol at ambient temperature. To the slurry a solution of 1,3-cyclohexanedione in ethanol was added at a constant rate. Allyl 4,4,4-trifluoro-3-oxobutanoate was added at a constant rate, followed by ammonium acetate and ethanol. The reaction was heated to reflux and main-

tained at reflux. Excess ethanol was removed by distillation under vacuum and water was added. The mixture was then cooled to ambient temperature, filtered, washed with water and MTBE. The title compound was obtained by drying in vacuo to constant weight.

Preparation of 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid

[0032] Allyl 4-(3-cyanophenyl)-2-hydroxy-5-oxo-2-(trifluoromethyl)-1,2,3,4,5,6,7,8-octahydroquinoline-3-carboxylate was stirred in n-butyl acetate with pTSA at 125° C. The reaction was cooled, filtered under reduced pressure, the organic phase recovered and washed with water to remove pTSA. Water, ethanol and acetic acid were added to the solution of allyl 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate. Wilkinson's catalyst (chlorotris(triphenylphosphine)rhodium) was added to the batch and the mixture degassed with sub-surface nitrogen for 30 minutes. The mixture was heated to 70-75° C. for 3-5 hours under a constant flow of nitrogen and then cooled to 20° C. to form the racemic acid. The title compound was extracted into 2 M NaOH and the aqueous phase was washed with butyl acetate. The aqueous phase is recharged to the vessel and methanol was added followed by 2 M HCl added slowly. The mixture was stirred and the product collected by filtration under reduced pressure, washed with water, dried by suction and dried in vacuo to constant weight.

Preparation of 3-[(4S)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinolin-4-yl]benzonitrile

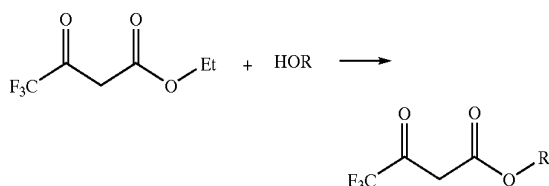
[0033] 4-(3-Cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid was co-crystallized with (1S)-1-phenylethyl-1-amine from absolute ethanol or to form (1S)-1-phenylethyl-1-aminium (4S)-4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate as shown in Scheme II. The carboxylate was de-carboxylated by treatment with 1-methylpyrrolidone at 95° C. and the title compound recrystallized from acetonitrile.

EXAMPLE 2

Preparation of Esters of
4,4,4-trifluoro-3-oxobutanoate

[0034] Esters of 4,4,4-trifluoro-3-oxobutanoate suitable for use in the process described in Scheme I were prepared as shown in Scheme 3.

Scheme 3:



[0035] wherein HOR is selected from allyl alcohol, isoprenol, geraniol, cinnamyl alcohol or para-nitrobenzylalcohol.

[0036] To perform the reaction, ethyl 4,4,4-trifluoro-3-oxobutanoate is heated with the appropriate alcohol. Transesterification is driven by providing an excess of the alcohol reagent over the ester and by removal of the formed ethanol by distillation.

EXAMPLE 3

[0037] Isoprenol and geraniol derived esters prepared essentially as described in Example 2, were dehydrated and the ester cleaved under acidic conditions in the presence of para-toluene sulfonic acid to afford the racemic acid.

[0038] Accordingly, another aspect of the invention is a process to prepare the racemic acid from isoprenol or geraniol esters by acid cleavage without the need for Wilkinson's catalyst.

EXAMPLE 4

[0039] Cinnamyl ester prepared essentially as described in Example 2 was shown to form a corresponding urethane compound upon dehydration.

EXAMPLE 5

[0040] Para-nitrobenzyl ester prepared essentially as described in Example 2 was dehydrated and the ester cleaved by Pd(0)/H₂ to afford the racemic acid.

[0041] Accordingly, another aspect of the invention is a process to prepare the racemic acid from para-nitrobenzyl esters by cleavage with Pd(0)/H₂.

We claim:

1. A method of making 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid, comprising:

- reacting an ester of 4,4,4-trifluoro-3-oxobutanoate with 1,3-cyclohexanedione and 3-cyanobenzaldehyde to form an ester of 4-(3-cyanophenyl)-2-hydroxy-5-oxo-2-(trifluoromethyl)-1,2,3,4,5,6,7,8-octahydroquinoline-3-carboxylate;
- dehydrating said ester of 4-(3-cyanophenyl)-2-hydroxy-5-oxo-2-(trifluoromethyl)-1,2,3,4,5,6,7,8-octahydroquinoline-3-carboxylate to form an ester of 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate, and
- de-esterifying said ester of 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate to form 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid.

2. The method of claim 1, wherein:

step a) is performed in ethanol in the presence of ammonium acetate;

step b) is achieved with p-toluenesulfonic acid in n-butyl acetate, and

step c) is achieved with chlorotris(triphenylphosphine)rhodium.

3. A method of making 3-[(4S)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinolin-4-yl]benzonitrile, comprising:

- a) reacting an ester of 4,4,4-trifluoro-3-oxobutanoate with 1,3-cyclohexanedione and 3-cyanobenzaldehyde to form an ester of 4-(3-cyanophenyl)-2-hydroxy-5-oxo-2-(trifluoromethyl)-1,2,3,4,5,6,7,8-octahydroquinoline-3-carboxylate;
 - b) dehydrating said ester of 4-(3-cyanophenyl)-2-hydroxy-5-oxo-2-(trifluoromethyl)-1,2,3,4,5,6,7,8-octahydroquinoline-3-carboxylate to form an ester of 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate;
 - c) de-esterifying said ester of 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate to form 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid;
 - d) resolving racemic 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid by co-crystallization of said 4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylic acid with (1S)-1-phenylethyl-1-amine;
 - e) recovering (1S)-1-phenylethyl-1-aminium (4S)-4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate;
 - f) decarboxylating said (4S)-4-(3-cyanophenyl)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate, and
 - g) recovering 3-[(4S)-5-oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinolin-4-yl]benzonitrile.
4. The method according to claim 3, wherein:
step e) is achieved by crystallization from ethanol;
step f) is achieved by decarboxylation with 1-methylpyrrolidone, and
step g) is achieved by crystallization from acetonitrile.
 5. 3-[(4S)-5-Oxo-2-(trifluoromethyl)-1,4,5,6,7,8-hexahydroquinolin-4-yl]benzonitrile made by the method of claim 3 or a pharmaceutically-acceptable salt thereof.
 6. Use of a compound according to claim 5 for preparation of a medicament.
 7. A pharmaceutical composition comprising a compound according to claim 5 together with at least one pharmaceutically-acceptable excipient or diluent.
 8. A method of treating a disease or condition that results from inappropriate smooth muscle activation comprising administering a therapeutically effective amount of a compound according to claim 5.
 9. The method according to claim 8, wherein said disease or condition is selected from hypertension, asthma, peripheral vascular disease, right heart failure, congestive heart failure, angina, ischemic heart disease, cerebrovascular disease, renal colic, disorders associated with kidney stones, irritable bowel syndrome, male-pattern baldness, premature labor, impotence, peptic ulcers, overactive bladder or urinary incontinence that result from or involve inappropriate smooth muscle activation.
 10. The method according to claim 8, wherein said disease or condition is overactive bladder or urinary incontinence.
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