SPECIFICATION ACCEPTED AND AMENDMENTS ALLOWED 27-2-90

COMMONWEALTH of AUSTRALIA

PATENTS ACT 1952

596798

APPLICATION FOR A STANDARD PATENT

584-57/86

I
We BEECHAM GROUP p.l.c.,
of Beecham House,
Great West Road,
Brentford, middlesex TW8 9BD,
ENGLAND

hereby apply for the grant of a Standard Patent for an invention entitled:

"PYRANO [3,2-c] PYRIDINE DERIVATIVES"

which is described in the accompanying ~~provisional~~ complete specification.

Details of basic application(s):—

Number	Convention Country	Date
8514538	GREAT BRITAIN	8th June, 1985
8527713	GREAT BRITAIN	9th November, 1985

AUSTRALIAN PATENT OFFICE

The address for service is care of DAVIES & COLLISON, Patent Attorneys, of 1 Little Collins Street, Melbourne, in the State of Victoria, Commonwealth of Australia.

Dated this 21st day of November 19 89

To: THE COMMISSIONER OF PATENTS

.....
(a member of the firm of DAVIES & COLLISON for and on behalf of the Applicant).

AU/1

COMMONWEALTH OF AUSTRALIA
PATENTS ACT 1952
DECLARATION IN SUPPORT OF CONVENTION
APPLICATION FOR A PATENT

- 6 JUN 1986

In support of the Application made for a patent for an invention entitled:
ACTIVE COMPOUNDS

I Ronald Smither of Beecham House, Great West Road, Brentford, Middlesex, TW8 9BD, England
do solemnly and sincerely declare as follows:-

1. I am authorised by Beecham Group p.l.c. the applicant for the patent to make this declaration on its behalf.

2. John Morris Evans,
Geoffrey Stemp,
Frederick Cassidy

Residing at:
'Cata', Old House Lane, Roydon, Essex CM19 5DJ, England;
107 Rundells, Harlow, Essex CM18 7HD, England; and
12 Peterswood, Harlow, Essex CM18 7RJ, England; respectively.

~~A~~/All British Subject(s)

~~is~~/are the actual inventor(s) of the invention and the facts upon which the applicant is entitled to make the application are as follows:-

by virtue of the employment of the actual inventor(s) by Beecham Group p.l.c., the applicant would, if a patent were granted upon an application made by the said actual inventor(s), be entitled to have the patent assigned to it.

3. The basic application(s) as defined by Section 141 of the Act ~~was~~/were made in United Kingdom by Beecham Group p.l.c. as follows:
Great Britain Patent Appln. No. 8514538 filed on 8th June 1985
Great Britain Patent Appln. No. 8527713 filed on 9th November 1985

4. The basic application(s) referred to in the paragraph 3 of this Declaration ~~was~~/were the first application(s) made in a Convention country in respect of the invention the subject of the application.

Declared at Brentford, Middlesex, England

this 1st day of May 1986

R. Smither

R.Smither, as Attorney for and on behalf of the said Beecham Group p.l.c.

Witness: S. Monk

(12) PATENT ABRIDGMENT (11) Document No. AU-B-58457/86
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 596798

(54) Title
ANTIHYPERTENSIVE PYRANO(3,2-C) PYRIDINES

International Patent Classification(s)
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A61K 031/495 C07D 491/107 C07D 491/153

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8514538	08.06.85	GB UNITED KINGDOM
8527713	09.11.85	GB UNITED KINGDOM

(43) Publication Date : 11.12.86

(44) Publication Date of Accepted Application : 17.05.90

(71) Applicant(s)
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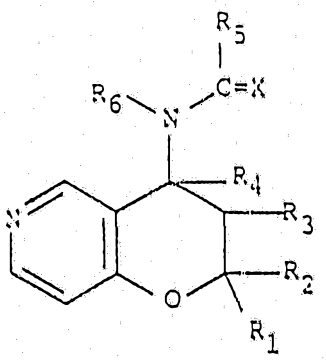
(72) Inventor(s)
JOHN MORRIS EVANS; GEOFFREY STEMP; FREDERICK CASSIDY

(74) Attorney or Agent
DAVIES & COLLISON, MELBOURNE

(57) The present invention relates to novel pyranopyridines having pharmacological activity, to a process and intermediates for preparing them, to pharmaceutical compositions containing them, and to their use in the treatment of mammals.

CLAIM

1. A compound of formula (I) or a pharmaceutically acceptable salt thereof:



(I)

wherein:

one of R_1 and R_2 is hydrogen or C_{1-4} alkyl and the other is C_{1-4} alkyl or R_1 and R_2 together are C_{2-5} polymethylene;

either R_3 is hydrogen, hydroxy, C_{1-6} alkoxy or C_{1-7} acyloxy and R_4 is hydrogen or R_3 and R_4 together are a bond;

R_5 is hydrogen; C_{1-6} alkyl optionally substituted by up to three halo atoms, by hydroxy, C_{1-6} alkoxy, C_{1-6} alkoxycarbonyl, carboxy or amino optionally substituted by one or two independent C_{1-6} alkyl groups or disubstituted by C_{4-5} polymethylene; C_{2-6} alkenyl; amino optionally substituted by a C_{1-6} alkyl or C_{1-6} alkenyl group or by a C_{1-6} alkanoyl group optionally substituted by up to three halo atoms, by a phenyl group optionally substituted by C_{1-6} alkyl, C_{1-6} alkoxy or halogen; or aryl or heteroaryl, either being optionally substituted by one or more groups or atoms selected from the class of C_{1-6} alkyl, C_{1-6} alkoxy, hydroxy, halogen, trifluoromethyl, nitro, cyano, C_{1-12} carboxylic acyl, or amino or aminocarbonyl optionally substituted by one or two C_{1-6} alkyl groups; or (when X is O), R_5 is selected from the class of carboxy, C_{1-6} alkoxycarbonyl, or aminocarbonyl optionally substituted by one or two C_{1-6} alkyl groups; and

R_6 is hydrogen or C_{1-6} alkyl; or

R_5 and R_6 together are $-CH_2-(CH_2)_n-Z-(CH_2)_m-$ wherein m and n are 0 to 2 such that m + n is 1 or 2 and Z is CH_2, O, S or NR wherein R is hydrogen, C_{1-9} alkyl, C_{2-7} alkanoyl, phenyl C_{1-4}-alkyl, naphthylcarbonyl, phenylcarbonyl or benzyl-carbonyl optionally substituted in the phenyl or naphthyl ring by one or two of C_{1-6} alkyl, C_{1-6} alkoxy or halogen; or R is heteroarylcarbonyl;

X is oxygen or sulphur; or

R_5, R_6, X and N together are tetrahydroisoquinolinone or tetrahydroisoquinolin-thione optionally substituted in the phenyl ring as defined for R above;

the nitrogen-containing group in the 4-position being trans to the R_3 group when R_3 is hydroxy, C_{1-6} alkoxy or C_{1-7} acyloxy.

11. A pharmaceutical composition comprising a compound according to any one of claims 1 to 7 or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable carrier.

12. A method of treatment and/or prophylaxis of disorders associated with the respiratory system by the administration of an effective amount of a compound according to any one of claims 1 to 8 to a patient in need of such treatment or prophylaxis.

COMMONWEALTH OF AUSTRALIA

PATENT ACT 1952

596798

COMPLETE SPECIFICATION

(Original)

FOR OFFICE USE

Class Int. Class

Application Number: 58457/86.
Lodged:

Complete Specification Lodged:
Accepted:
Published:

Priority:

Related Art:

This document contains the amendments made under Section 49 and is correct for printing.

Name of Applicant: BEECHAM GROUP p.l.c.

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Actual Inventor(s): John Morris EVANS
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Address for Service: DAVIES & COLLISON, Patent Attorneys,
1 Little Collins Street, Melbourne, 3000.

Complete Specification for the invention entitled:

~~"ACTIVE COMPOUNDS"~~
Pyrano [3,2-C] Pyridine Derivatives

The following statement is a full description of this invention, including the best method of performing it known to us :-

AUSTRALIAN PATENT OFFICE

B1855/1947

~~ACTIVE COMPOUNDS~~

Pyrano [3,2-c] Pyridine Derivatives

The present invention relates to novel pyranopyridines having pharmacological activity, to a process and intermediates for preparing them, to pharmaceutical compositions containing them, and to their use in the treatment of mammals.

European Patent Publications 76075, 91748, 93535, 95316, 107423, 120426, 120427, 126311 and 126367 disclose classes of compounds that are described as having blood pressure lowering activity or anti-hypertensive activity.

A structurally distinct class of compounds has now been discovered which are pyranopyridines substituted in the 4-position by a cyclic or acyclic amide, the nitrogen atom of the amide moiety being bonded directly to the carbon atom in the 4-position. Such pyranopyridines have been found to have blood pressure lowering activity, useful in the treatment of hypertension. In addition, these compounds are believed to be K^+ channel activators which indicates that they are of potential use in the treatment of disorders associated with smooth muscle contraction of the gastro-intestinal tract, respiratory system, uterus or urinary tract. Such disorders include peptic ulcers, irritable bowel syndrome and diverticular disease, reversible airways obstruction and asthma; premature labour; and incontinence. They are also indicated as of potential use in the treatment of cardiovascular disorders other than hypertension, such as congestive heart failure, angina, peripheral vascular disease and cerebral vascular disease.

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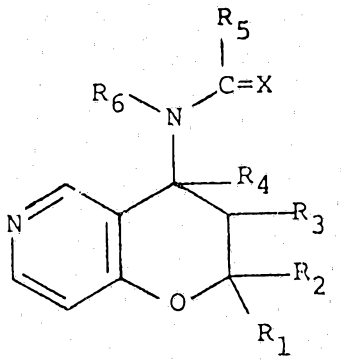
Accordingly, the present invention provides a compound of formula (I) or a pharmaceutically acceptable salt thereof:



(I)

wherein:

one of R_1 and R_2 is hydrogen or C_{1-4} alkyl and the other is C_{1-4} alkyl or R_1 and R_2 together are C_{2-5} polymethylene;

either R_3 is hydrogen, hydroxy, C_{1-6} alkoxy or C_{1-7} acyloxy and R_4 is hydrogen or R_3 and R_4 together are a bond;

R_5 is hydrogen; C_{1-6} alkyl optionally substituted by up to three halo atoms, by hydroxy, C_{1-6} alkoxy, C_{1-6} alkoxycarbonyl, carboxy or amino optionally substituted by one or two independent C_{1-6} alkyl groups or disubstituted by C_{4-5} polymethylene; C_{2-6} alkenyl; amino optionally substituted by a C_{1-6} alkyl or C_{1-6} alkenyl group or by a C_{1-6} alkanoyl group optionally substituted by up to three halo atoms, by a phenyl group optionally substituted by C_{1-6} alkyl, C_{1-6} alkoxy or halogen; or aryl or heteroaryl, either being optionally substituted by one or more groups or atoms selected from the class of C_{1-6} alkyl, C_{1-6} alkoxy, hydroxy, halogen, trifluoromethyl, nitro, cyano, C_{1-12}

carboxylic acyl, or amino or aminocarbonyl optionally substituted by one or two C_{1-6} alkyl groups; or (when X is O), R_5 is selected from the class of carboxy, C_{1-6} alkoxycarbonyl, or aminocarbonyl optionally substituted by one or two C_{1-6} alkyl groups; and

R_6 is hydrogen or C_{1-6} alkyl; or

R_5 and R_6 together are $-CH_2-(CH_2)_n-Z-(CH_2)_m-$ wherein m and n are 0 to 2 such that m + n is 1 or 2 and Z is CH_2, O, S or NR wherein R is hydrogen, C_{1-9} alkyl, C_{2-7} alkanoyl, phenyl C_{1-4}-alkyl, naphthylcarbonyl, phenylcarbonyl or benzyl-carbonyl optionally substituted in the phenyl or naphthyl ring by one or two of C_{1-6} alkyl, C_{1-6} alkoxy or halogen; or R is heteroarylcarbonyl;

X is oxygen or sulphur; or

R_5, R_6, X and N together are tetrahydroisoquinolinone or tetrahydroisoquinolin-thione optionally substituted in the phenyl ring as defined for R above;

the nitrogen-containing group in the 4-position being trans to the R_3 group when R_3 is hydroxy, C_{1-6} alkoxy or C_{1-7} acyloxy.

Preferably, R_1 and R_2 are both C_{1-4} alkyl, in particular both methyl.

When R_3 is C_{1-6} alkoxy and R_4 is hydrogen, preferred examples of R_3 include methoxy and ethoxy, of which methoxy is more preferred. When R_3 is C_{1-7} acyloxy and R_4 is hydrogen, a preferred class of R_3 is unsubstituted carboxylic acyloxy, such as unsubstituted aliphatic acyloxy. However, it is more preferred that

R_3 and R_4 together are a bond, or that R_3 and R_4 are both hydrogen, or, in particular, that R_3 is hydroxy and R_4 is hydrogen.

Examples of R_5, when C_{1-6} alkyl, include methyl, ethyl and n- and iso-propyl. Preferably such R_5 is methyl.

A sub-group of R_5, when C_{1-6} alkyl substituted by halogen is C_{1-6} alkyl substituted by fluoro, chloro or bromo. Examples thereof include methyl or ethyl terminally substituted by one, two or three fluoro, chloro or bromo.

Examples of R_5, when C_{1-6} alkyl substituted by hydroxy, include methyl or ethyl terminally substituted by hydroxy.

A sub-group of R_5, when C_{1-6} alkyl substituted by C_{1-6} alkoxy is C_{1-6} alkyl substituted by methoxy or ethoxy. Examples thereof include methyl or ethyl terminally substituted by methoxy or ethoxy.

A sub-group of R_5, when C_{1-6} alkyl substituted by C_{1-6} alkoxycarbonyl is C_{1-6} alkyl substituted by methoxycarbonyl or ethoxycarbonyl. Examples thereof include methyl or ethyl terminally substituted by methoxycarbonyl or ethoxycarbonyl.

Examples of R_5, when C_{1-6} alkyl substituted by carboxy include methyl or ethyl terminally substituted by carboxy.

Examples of R_5 when alkyl substituted by amino optionally substituted by one or two independent C_{1-6} alkyl groups include a group $(CH_2)_nNR_9R_{10}$ where n is 1 to 6, and R_9 and R_{10} are each independently hydrogen or

C_{1-6} alkyl or together are C_4 or C_5 polymethylene. Examples of n include 1 and 2, in particular 1. Preferably R_9 and R_{10} are each independently selected from hydrogen and methyl.

Examples of R_5, when C_{2-6} alkenyl include vinyl, prop-1-enyl, prop-2-enyl, 1-methylvinyl, but-1-enyl, but-2-enyl, but-3-enyl, 1-methylenepropyl, or 1-methylprop-2-enyl, in both their E and Z forms where stereoisomerism exists.

Examples of R_5 when amino optionally substituted as hereinbefore defined include an amino optionally substituted by a methyl, ethyl, propyl, butyl, allyl or trichloroacetyl group or by a phenyl group optionally substituted by one methyl, methoxy or chloro group or atom, in particular amino, methylamino, and phenylamino optionally substituted in the phenyl ring by one methyl, methoxy or chloro group or atom.

Examples of R_5 when aryl include phenyl and naphthyl, of which phenyl is preferred.

A sub-group of R_5 heteroaryl or heteroaryl for an R moiety in Z, is 5- or 6-membered monocyclic or 9- or 10-membered bicyclic heteroaryl of which 5- or 6-membered monocyclic heteroaryl is preferred. In addition, 5- or 6-membered monocyclic or 9- or 10-membered bicyclic heteroaryl preferably contains one, two or three heteroatoms which are selected from the class of oxygen, nitrogen and sulphur and which, in the case of there being more than one heteroatom, are the same or different.

Examples of 5- or 6-membered monocyclic heteroaryl containing one, two or three heteroatoms which are selected from the class of oxygen, nitrogen and sulphur include furyl, thienyl, pyrryl, oxazolyl, thiazolyl, imidazolyl and thiadiazolyl, and pyridyl, pyridazyl, pyrimidyl, pyrazyl and triazyl. Preferred examples of such groups include furanyl, thienyl, pyrryl and pyridyl, in particular 2- and 3-furyl, 2- and 3-pyrryl, 2- and 3-thienyl, and 2-, 3- and 4-pyridyl.

Examples of 9- or 10-membered bicyclic heteroaryl containing one, two or three heteroatoms which are selected from the class of oxygen, nitrogen and sulphur include benzofuranyl, benzothienyl, indolyl and indazolyl, quinolyl and isoquinolyl, and quinazonyl. Preferred examples of such groups include 2- and 3-benzofuryl, 2- and 3-benzothienyl, and 2- and 3-indolyl, and 2- and 3-quinolyl.

Preferably, the number of groups or atoms for optional substitution of aryl or heteroaryl is one, two, three or four.

Preferred examples of the groups or atoms for optional substiution of aryl or heteroaryl include methyl, methoxy, hydroxy, chloro, fluoro, nitro or cyano, most preferably fluoro.

A sub-group of R_5 is phenyl or naphthyl or a 5- or 6-membered monocyclic or a 9- or 10-membered bicyclic heteroaryl, the phenyl, naphthyl or heteroaryl group being optionally substituted by one, two, three or four groups or atoms selected from the class of C_{1-6} alkyl, C_{1-6} alkoxy, halogen, trifluoromethyl, nitro or cyano.

A preferred subgroup of phenyl optionally substituted as hereinbefore defined is phenyl, 4-substituted phenyl, 3-substituted phenyl, 2-substituted phenyl, 2,4, 2,6 and 3,4-disubstituted phenyl and 3,4,5-trisubstituted phenyl.

A preferred sub-group of 5- or 6-membered monocyclic or 9- or 10-membered bicyclic heteroaryl optionally substituted as hereinbefore defined is unsubstituted or mono-substituted 5- or 6-membered monocyclic or 9- or 10-membered bicyclic heteroaryl, in particular unsubstituted 5- or 6-membered monocyclic or 9- or 10-membered bicyclic heteroaryl.

When X is O, examples of R_5 also include carboxyl, methoxycarbonyl, ethoxycarbonyl, aminocarbonyl, methylamino-carbonyl and dimethylaminocarbonyl.

R_5 and R_6, when together are $-CH_2-(CH_2)_n-Z-(CH_2)_m-$ as defined the resulting radical substituting the pyranopyridine in the 4-position is preferably either pyrrolidonyl or piperidonyl. Other examples of 4-substituents when R_5 and R_6 are joined together include those described in EP-A-107423.

When Z is other than CH_2, m is often 0 or 1 and n is often 0 or 1. Suitable examples of R when Z is NR include hydrogen, methyl, ethyl, n- and iso-propyl, n-, sec- and tert- butyl, benzyl, phenylcarbonyl or benzylcarbonyl optionally substituted in the phenyl ring by methyl, methoxy, chloro or bromo; furylcarbonyl, thienylcarbonyl, pyrrolylcarbonyl or indolylcarbonyl. Preferably R is hydrogen, methyl, n-butyl, acetyl, benzyl, benzylcarbonyl, phenylcarbonyl or furylcarbonyl. Most preferably R is hydrogen.

Preferred examples of R_5 and R_6 are R_5 is methyl or halophenyl, such as 2- or 4-fluorophenyl and R_6 hydrogen and R_5 and R_6 together are C_3 or C_4 polymethylene.

Preferably, X is oxygen.

Examples of a pharmaceutically acceptable salt of a compound of formula (I), when the compound contains a salifiable substituent which is an optionally substituted amino group, include acid addition salts such as the hydrochloride and hydrobromide salts. Such a salifiable group may be within an R_5 group. A carboxy group within R_5 may also be salified to form metal salts, such as alkali metal salts, or optionally substituted ammonium salts.

It will also be appreciated that the pyridine in the compound of formula (I) is also salifiable, to give pyridine salts with acids, such as those with HCl and HBr. Alternatively, internal salts such as the N-Oxide may be formed by per-acid oxidation of the corresponding compound of formula (I).

The compounds of formula (I) may also exist as solvates such as hydrates and the invention extends to these; such solvates are included wherever a compound of formula (I) is herein referred to.

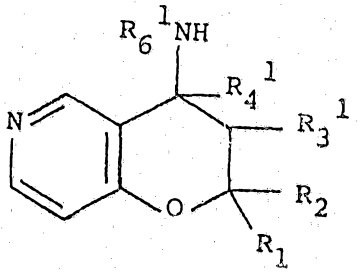
The compounds of formula (I), wherein R_3 is hydrogen, hydroxy, C_{1-6} alkoxy or C_{1-7} acyloxy and R_4 is hydrogen, are asymmetric, and, therefore, can exist in the form of optical isomers.

The present invention extends to all such isomers individually and as mixtures, such as racemates.

Examples of compounds of formula (I) include the compounds prepared in the Examples hereinafter.

The present invention also provides a process for the preparation of a compound of formula (I) or a pharmaceutically acceptable salt thereof, which comprises;

i) acylating a compound of formula (II):



(II)

wherein, R_1 and R_2 are as hereinbefore defined, R_3^1 is hydroxy, C_{1-6} alkoxy or C_{1-7} acyloxy, R_4^1 is hydrogen and R_6^1 is hydrogen or C_{1-6} alkyl, the R_6^1NH group being trans to the R_3^1 group,

a) with an acylating agent of formula (III):

$$R_8\text{-}CO\text{-}L_1 \qquad \text{(III)}$$

wherein L_1 is a leaving group, and R_8 is hydrogen, C_{1-6} alkoxycarbonyl, C_{1-6} alkyl optionally substituted by halogen, hydroxy, C_{1-6} alkoxy, C_{1-6} alkoxycarbonyl, carboxy or amino optionally substituted as hereinbefore defined for R_5, C_{2-6} alkenyl or optionally substituted aryl or heteroaryl as hereinbefore defined for R_5, or a group convertible to R_5 as hereinbefore defined, and thereafter, when R_6 is hydrogen and R_8 is $Y(CH_2)_z$—,

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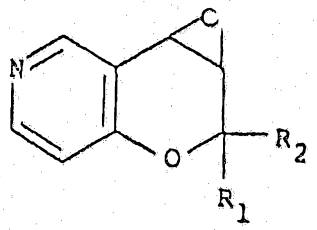
where z is 3 or 4 and Y is a leaving group, cyclising the resultant compound;

b) with a compound of formula (IV)

$$X=C=N.R_{11} \qquad (IV)$$

wherein R_{11} is hydrogen, C_{1-6} alkyl, C_{1-6} alkenyl, C_{1-6} alkanoyl optionally substituted by up to three halo atoms, or phenyl optionally substituted by C_{1-6} alkyl, C_{1-6} alkoxy or halogen; and X is oxygen or sulphur, and thereafter when R_{11} is hydrogen, optionally converting R_{11}; or

ii) where, in the resultant compound of formula (I), R_5 and R_6 are joined together or R_5 is aminocarbonyl, reacting a compound of formula (V):



(V)

wherein R_1 and R_2 are as hereinbefore defined, with a compound of formula (VI):

$$R_{13}NHCOR_{12} \qquad (VI)$$

wherein R_{13} is R_6 as defined and R_{12} is aminocarbonyl; R_{12} and R_{13} together are $-CH_2-(CH_2)_n-Z-(CH_2)_m-$ or $R_{13}NHCOR_{12}$ is tetrahydroisoquinolinone;

optionally converting R_3 in the resulting compound into another R_3; in the case where R_3 and R_4 in the resulting compound are hydroxy and hydrogen respectively, optionally dehydrating the compound to give another compound wherein R_3 and R_4 together are a bond, and optionally reducing the resulting compound wherein R_3 and R_4 together are a bond, to give another compound wherein R_3 and R_4 are each hydrogen; and optionally thiating the R_6-N-CO-R_5 group in the resulting compound to give a compound wherein X is sulphur; and optionally forming a pharmaceutically acceptable salt thereof.

In the process variant i) a) acylation of a compound of formula (II) with an acylating agent of formula (III), the leaving group L_1 is a group that is displaceable by a primary or secondary amino nucleophile. Examples of such a group include C_{1-4} alkanoyloxy, and halogen, such as chloro and bromo or hydroxy. When the leaving group L_1 is either of these examples, the acylating agent of formula (III) is either an acid anhydride or an acid halide. When it is an acid anhydride, it may be a mixed or simple anhydride. If it is a mixed anhydride, it may be prepared <u>in situ</u> from a carboxylic acid and an acid halide, although this is less preferred than using the halide itself. When L_1 is hydroxy, conventional coupling methods using dicyclohexylcarbodiimide are suitable.

In process variant i) a), when R_5 in the desired compound of formula (I) is an R_5 optionally substituted amino-substituted alkyl group as hereinbefore defined, it is preferred that R_8 is a group convertible to the R_5 substituted alkyl group as hereinbefore defined, in particular that it is C_{1-6} alkyl substituted by halo, especially bromo. The R_8 halo substituent in the

resultant compound of process variant i) a) may be converted to an R_5 substituent which is amino optionally substituted as hereinbefore defined by a conventional amination reaction with ammonia or a corresponding alkyl- or dialkylamine. When R_8 is C_{1-6}alkoxycarbonyl, this may be converted to R_5 is carboxy by conventional hydrolysis.

Less favourably R_8 may be C_{1-6} alkyl substituted by protected amino, protected C_{1-6} alkylamino or amino substituted by two independent C_{1-6} alkyl groups, it being necessary to protect the R_8 amino function in process variant i) a).

When the acylating agent of formula (III) is an acid anhydride, the acylation of the compound of formula (II) may be carried out in the presence of an acid acceptor, such as sodium acetate, optionally using the anhydride as the solvent.

When the acylating agent of formula (III) is an acid halide, the acylation of the compound of formula (II) is, preferably, carried out in a non-aqueous medium, such as dichloromethane, in the presence of an acid acceptor, such as triethylamine, trimethylamine, or calcium, potassium or sodium carbonate.

When the acylating agent of formula (III) is an acid the acylation of a compound of formula (II) is conveniently performed in the presence of a dehydrating agent, such as dicyclohexyldicarbodiimide in an inert solvent, such as dimethylformamide at a temperature of 0°C to ambient.

When R_3^1 in a compound of formula (II) is hydroxy, there is a risk of a side-reaction between the

hydroxy group and the acylating agent of formula (III). However, the reaction may be carried out under controlled conditions such that only the amine, R_6^1NH- is acylated, for example, by using a C_{2-9} acyloxy group as the leaving group L_1, in the acylating agent of formula (III) in the manner as previously described for an acid anhydride, and/or effecting the reaction at relatively low temperature, e.g. at below 10°C. Alternatively R_3^1 may be C_{1-7} acyloxy in a compound of formula (II), although less preferably if R_3 in the resultant compound of formula (I) is to be hydroxy, and, after reaction with the acylating agent of formula (III), be converted into hydroxy, as described hereinafter.

When R_8 is $Y(CH_2)_z$ where the variables are as hereinbefore defined, the leaving group Y is a group that is displaceable by a secondary amino nucleophile adjacent to a carbonyl function. A preferred example is chloro.

The cyclisation reaction when R_8 is $Y(CH_2)_z$ where the variables are as hereinbefore defined is preferably carried out in an inert solvent such as dimethylformamide.

In process variant i) b), when R_{11} in a compound of formula (IV) is C_{1-6} alkyl, C_{1-6} alkanoyl optionally substituted as hereinbefore defined, or phenyl optionally substituted as hereinbefore defined, the reaction between the compounds of formulae (II) and (IV) is, preferably, carried out in a solvent, such as methylene chloride, at below room temperature, in particular below 10°C.

When R_{11} is hydrogen, the reaction between the compounds of formulae (II) and (IV) is, preferably, carried out using a corresponding alkali metal cyanate or thiocyanate, for example that of sodium or potassium, in an optionally methanolic aqueous medium acidified with a mineral acid, such as dilute hydrochloric acid. A slightly elevated temperature such as 50 to 90°C is apt.

In the process variant ii) reaction of a compound of formula (V) with a compound of formula (VI), it is particularly preferred that the reaction is carried out under basic conditions so as to facilitate the formation of the anion of the compound of formula (VI), for example, in the presence of sodium hydride.

The reaction of the compounds of formulae (II) with (III) or (IV) results in a compound of formula (I) wherein R_3 is hydroxy, C_{1-6} alkoxy or C_{1-7} acyloxy, whereas the reaction of the compounds of formulae (V) and (VI) results in a compound of formula (I) wherein R_3 is hydroxy. Examples of an optional conversion of R_3 in a compound of formula (I) into another R_3 are generally known in the art. For example, when R_3 is hydroxy, it may be alkylated using an alkyl iodide in an inert solvent, such as toluene, in the presence of a base, such as potassium hydroxide, or it may be acylated using a carboxylic acid chloride or anhydride in a non-hydroxylic solvent in the presence of an acid acceptor. Alternatively, when R_3 is C_{1-7} acyloxy or C_{1-6} alkoxy, it may be converted into hydroxy by conventional hydrolysis or dealkylation respectively.

The optional dehydration of the resulting compound of formula (I), wherein R_3 and R_4 are hydroxy and hydrogen respectively, into another compound of formula (I),

wherein R_3 and R_4 together are a bond, may be carried out under conventional dehydration conditions, for example, by using a dehydrating agent, such as sodium hydride, in an inert solvent, such as dry tetrahydrofuran, at reflux temperature.

The optional reduction of the resulting compound of formula (I), wherein R_3 and R_4 together are a bond, into another compound of formula (I), wherein R_3 and R_4 are each hydrogen, may be carried out by hydrogenation using a catalyst of palladium on charcoal.

The optional thiation of the R_6-N-CO-R_5 group in a compound of formula (I) to give another compound of formula I, wherein X is sulphur, is, preferably, carried out with conventional thiation agents, such as hydrogen sulphide, phosphorous pentasulphide and Lawesson's reagent (p-methoxyphenylthiophosphine sulphide dimer). The use of hydrogen sulphide and phosphorous pentasulphide may lead to side-reactions and, therefore, the use of Lawesson's reagent is preferred.

The thiation reaction conditions are conventional for the thiation agent employed. For example, the use of hydrogen sulphide is, preferably, acid catalysed by, for example, hydrogen chloride in a polar solvent, such as acetic acid or ethanol. The preferred use of Lawesson's reagent is, preferably, carried out under reflux in a dry solvent, such as toluene or methylene chloride.

The optional formation of a pharmaceutically acceptable salt may be carried out conventionally. It should be appreciated that formation of an N-Oxide by oxidation may affect other substituents and appropriate

modification of reaction conditions and/or protection will be taken where necessary.

A compound of formula (II) may be prepared by reacting a compound of formula (V), as defined hereinbefore, with a compound of formula (VII):

$$R_6^1NH_2 \qquad \text{(VII)}$$

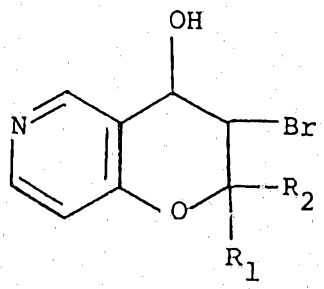
wherein R_6^1 is as defined hereinbefore; and optionally converting R_3^1 hydroxyl in the resulting compound of formula (II) into another R_3^1.

The reaction is normally carried out in a solvent, such as a C_{1-4} alcohol, in particular methanol, ethanol or propanol at an ambient or an elevated temperature, for example 12 to 100°C. The reaction proceeds particularly smoothly if carried out in ethanol under reflux.

The resulting compound of formula (II) may be removed from the reaction mixture by removal of the solvent, for example, by evaporation under reduced pressure. Any epoxide impurity may be removed conventionally, for example by chromatography.

The optional conversion of the hydroxy group for R_3^1 in the resulting compound of formula (II) into a C_{1-6} alkoxy or C_{1-7} acyloxy group may be carried out as described hereinbefore in relation to the corresponding conversion of R_3 in a compound of formula (I).

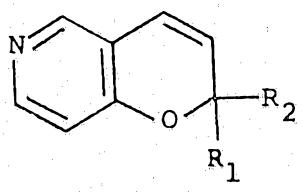
A compound of formula (V) may be prepared by reacting a compound of formula (VIII):



(VIII)

wherein R_1 and R_2 are as hereinbefore defined, the bromine atom being trans to the hydroxy group, with a base, such as potassium hydroxide, in a solvent, such as ether or aqueous dioxan. It is preferred that the compound of formula (V) is used directly in the reaction with (VI).

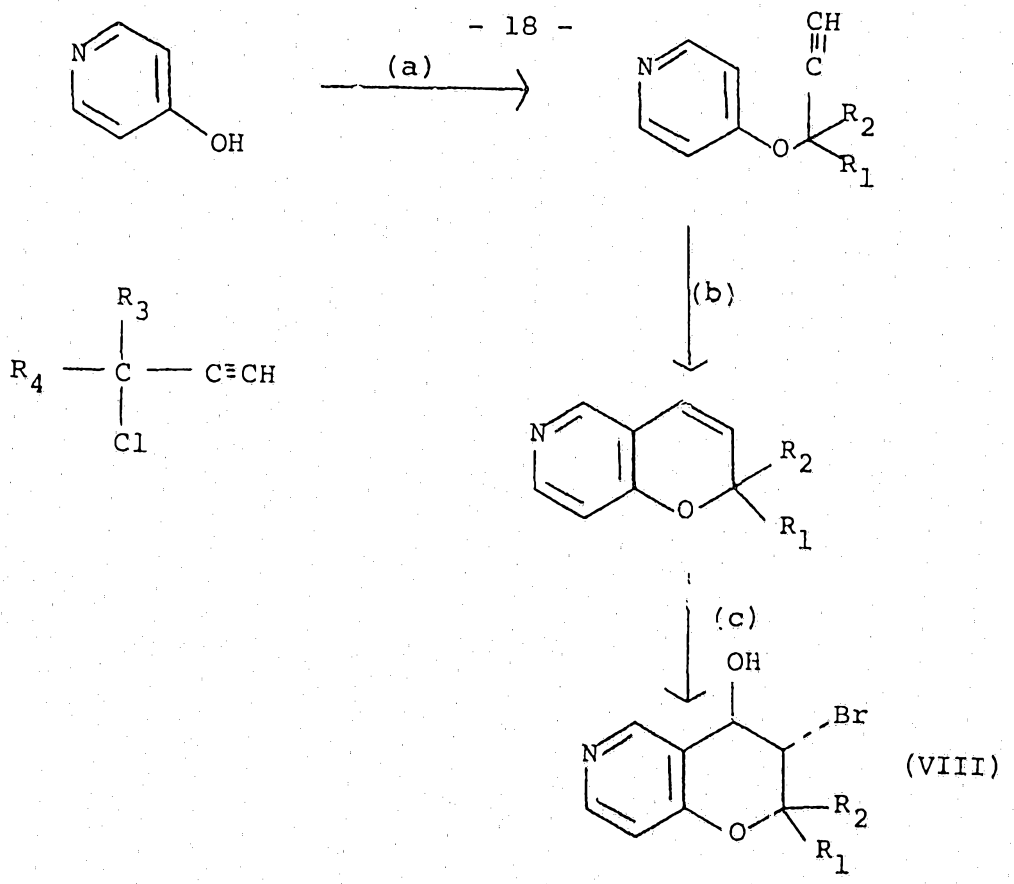
A compound of formula (VIII) may be prepared by reacting a compound of formula (IX):



(IX)

wherein R_1 and R_2 are as hereinbefore defined, with N-bromosuccinimide in a solvent, such as aqueous dimethyl sulphoxide.

A compound of formula (VIII) may be prepared in accordance with analogous processes to those described in the aforementioned European publications, i.e. by the process depicted below:



(VIII)

(a) Room temperature; NaOH/40% benzyltrimethyl-ammonium hydroxide in methanol;

(b) Heat in o-dichlorobenzene;

(c) N-bromosuccinimide/dimethylsulphoxide/water;

As mentioned previously, some of the compounds of formula (I) may exist in optically active forms, and the processes of the present invention produce mixtures of such forms. The individual enantiomers may be resolved by conventional methods.

It is preferred that the compounds of formula (I) are isolated in substantially pure, pharmaceutically acceptable form.

The intermediates of formulae (II), (V), (VIII) or (IX) are believed to be novel and represent part of the present invention. The intermediates of formulae (III), (IV), (VI) or (VII) are known and may be prepared in accordance with an appropriate known process.

As mentioned previously, the compounds of formula (I) have been found to have blood-pressure lowering activity. They are therefore useful in the treatment of hypertension. They may also be of potential use in the treatment of other disorders hereinbefore described.

The present invention accordingly provides a pharmaceutical composition which comprises a compound of formula (I) or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable carrier. In particular, the present invention provides an anti-hypertensive pharmaceutical composition which comprises an anti-hypertensive effective amount of a compound of formula (I) or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable carrier.

The compositions are preferably adapted for oral administration. However, they may be adapted for other modes of administration, for example parenteral administration for patients suffering from heart failure. Other alternative modes of administration include sublingual or transdermal administration. A composition may be in the form of a spray, aerosol or other conventional method for inhalation, for treating asthma.

The compositions may be in the form of tablets, capsules, powders, granules, lozenges, suppositories, reconstitutable powders, or liquid preparations, such as oral or sterile parenteral solutions or suspensions.

In order to obtain consistency of administration it is preferred that a composition of the invention is in the form of a unit dose.

Unit dose presentation forms for oral administration may be tablets and capsules and may contain conventional excipients such as binding agents, for example syrup, acacia, gelatin, sorbitol, tragacanth, or polyvinylpyrrolidone; fillers, for example lactose, sugar, maize-starch, calcium phosphate, sorbitol or glycine; tabletting lubricants, for example magnesium stearate; disintegrants, for example starch, polyvinylpyrrolidone, sodium starch glycollate or microcrystalline cellulose; or pharmaceutically acceptable wetting agents such as sodium lauryl sulphate.

The solid oral compositions may be prepared by conventional methods of blending, filling or tabletting. Repeated blending operations may be used to distribute the active agent throughout those compositions employing large quantities of fillers. Such operations are of course conventional in the art. The tablets may be coated according to methods well known in normal pharmaceutical practice, in particular with an enteric coating.

Oral liquid preparations may be in the form of, for example, emulsions, syrups, or elixirs, or may be presented as a dry product for reconstitution with

water or other suitable vehicle before use. Such liquid preparations may contain conventional additives such as suspending agents, for example sorbitol, syrup, methyl cellulose, gelatin, hydroxyethylcellulose, carboxymethylcellulose, aluminium stearate gel, hydrogenated edible fats; emulsifying agents, for example lecithin, sorbitan monooleate, or acacia; non-aqueous vehicles (which may include edible oils), for example almond oil, fractionated coconut oil, oily esters such as esters of glycerine, propylene glycol, or ethyl alcohol; preservatives, for example methyl or propyl p-hydroxybenzoate or sorbic acid and if desired conventional flavouring or colouring agents.

For parenteral administration, fluid unit dosage forms are prepared utilizing the compound and a sterile vehicle, and, depending on the concentration used, can be either suspended or dissolved in the vehicle. In preparing solutions the compound can be dissolved in water for injection and filter sterilized before filling into a suitable vial or ampoule and sealing. Advantageously, adjuvants such as a local anaesthetic, a preservative and buffering agents can be dissolved in the vehicle. To enhance the stability, the composition can be frozen after filling into the vial and the water removed under vacuum. Parenteral suspensions are prepared in substantially the same manner, except that the compound is suspended in the vehicle instead of being dissolved, and sterilization cannot be accomplished by filtration. The compound can be sterilized by exposure to ethylene oxide before suspending in the sterile vehicle. Advantageously, a surfactant or wetting agent is included in the composition to facilitate uniform distribution of the compound.

The compositions may contain from 0.1% to 99% by weight, preferably from 10-60% by weight, of the active material, depending on the method of administration.

The present invention further provides a method of prophylaxis or treatment of hypertension in mammals including man, which comprises administering to the suffering mammal an anti-hypertensive effective amount of a compound of formula (I) or a pharmaceutically acceptable salt thereof.

An effective amount will depend on the relative efficacy of the compounds of the present invention, the severity of the hypertension being treated and the weight of the sufferer. However, a unit dose form of a composition of the invention may contain from 1 to 100 mg of a compound of the invention and more usually from 2 to 50 mg, for example 5 to 25 mg such as 6, 10, 15 or 20mg. Such compositions may be administered from 1 to 6 times a day, more usually from 2 to 4 times a day, in a manner such that the daily dose is from 5 to 200 mg for a 70 kg human adult and more particularly from 10 to 100 mg.

No toxicological effects are indicated at the aforementioned dosage ranges.

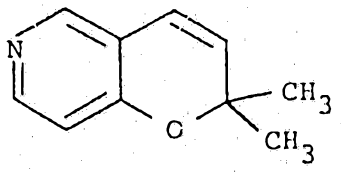
The present invention further provides a compound of formula (I) or a pharmaceutically acceptable salt thereof for use in the treatment or prophylaxis of hypertension.

The following descriptions relate to the preparation of intermediates and the following examples relate to the preparation of compounds of formula (I).

All temperatures therein are in °C.

Description 1

2,2-Dimethyl-2H-pyrano[3,2-c]pyridine

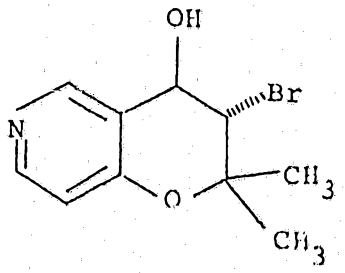


(D1)

p-Hydroxypyridine (32.0 g), 40% benzyltrimethylammonium hydroxide in MeOH (50.7 g) and 3-methyl-3-chlorobut-1-yne (37.4 g) were dissolved in CH_2Cl_2 (150 mL). To this stirred solution was added NaOH pellets (14.5 g) dissolved in H_2O (150 mL) and the resulting mixture stirred vigorously at room temperature for 3.75 days. The layers were separated and the aqueous layer further extracted with $CHCl_3$. The combined organic layers were evaporated and the resulting brown oil was taken up in Et_2O and washed with 10% NaOH solution, H_2O and brine before drying over anh. $MgSO_4$. Filtration and evaporation yielded an orange oil (21.0 g) which was boiled in o-dichlorobenzene under N_2 for 1 h. Evaporation of the solvent and distillation gave the title pyranopyridine (9.2 g): bp 110°C/0.18 mmHg; NMR ($CDCl_3$) δ 1.47 (s, 6H)
5.67 (d, J=10, 1H)
6.37 (d, J=10, 1H)
6.67 (d, J=6, 1H)
8.17 (s, 1H)
8.28 (d, J=6, 1H)

Description 2

Trans-3-Bromo-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c] pyridin-4-ol

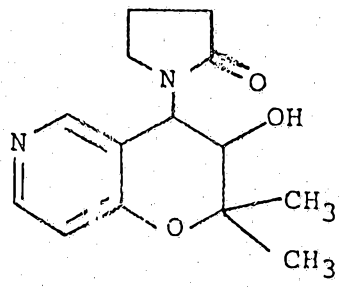


(D2)

To the pyranopyridine (4.0 g) of description 1 dissolved in DMSO (60 mL) and H_2O (40 mL) was added NBS (5.3 g) in one portion with vigorous stirring at room temperature. After an additional 90 min of stirring the mixture was poured into H_2O (70 mL) containing HCl to pH 2. Extraction with EtOAc, was followed by basification of the aqueous layer to pH 9 with aqueous $NaHCO_3$ and further extraction with EtOAc. Both organic extracts were washed with H_2O (pH 7) and brine before drying over anh. $MgSO_4$. The combined extracts were filtered and evaporated and triturated with pentane to give the bromohydrin (2.27 g) as a pale yellow solid. A small portion was recrystallised from EtOAc-pentane: mp 140-141°C; NMR ($CDCl_3$) δ 1.46 (s, 3H), 1.65 (s, 3H), 4.14 (d, J=9, 1H), 5.03 (d, J=9, 1H) overlapped by 5.08 (s, 1H exchangeable with D_2O), 6.77 (d, J=6, 1H), 8.35 (d, J=6, 1H), 8.62 (s, 1H).

Example 1

Trans-3,4-Dihydro-2,2-dimethyl-4-(2-oxopyrrolidin-1-yl) 2H-pyrano[3,2-c]pyridin-3-ol



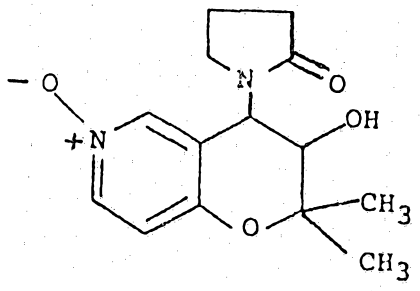
(E1)

The bromohydrin of description 2 (1.2 g) and KOH pellets (1.2 g) were stirred in Et_2O (200 mL) at room temperature for 20 h. Filtration and evaporation gave a crude epoxide (0.78 g) which was used directly, without purification, in the next stage.

The epoxide (0.43 g) was added to a solution of 2-pyrrolidinone (0.22 mL) in dry DMSO (10 mL) containing 80% NaH (80 mg), and the reaction mixture stirred under N_2 for 24 h at room temperature. Water (100 mL) was added cautiously to the reaction mixture and the aqueous layer extracted with EtOAc. The aqueous layer was basified to pH 14 with aqueous KOH and extracted with EtOAc. The organic extract was washed with H_2O (at pH 7) and brine and dried over anh. $MgSO_4$. Filtration and evaporation gave a solid (0.22 g) which was chromatographed (chromatotron, 2mm silica gel, gradient elution with $CHCl_3$ ->20% MeOH/$CHCl_3$) and recrystallised from EtOAc to give the title compound (74 mg): mp 253°C; mass spectrum (EI) M^+ at m/z 262.1316. Calcd. for $C_{14}H_{18}N_2O_3$; 262.1313.

Example 2

Trans-3,4-Dihydro-2,2-dimethyl-4-(2-oxopyrrolidin-1-yl)-2H-pyrano[3,2-c]pyridin-3-ol oxide (E2)



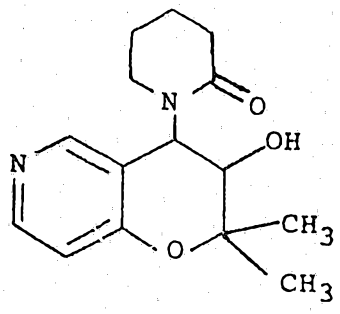
(E2)

The compound of example 1 (102mgm) and m-chloroperbenzoic acid (134mgm) were heated under reflux in chloroform (10mL) for 2hr. The reaction mixture was cooled and evaporated and the resulting gum was chromatographed (chromatotron; chloroform ->10% methanol-chloroform in a gradient elution), and chromatographically homogenous fractions were combined and recrystallised from ethyl acetate-methanol to give the N-oxide of (E2) as a solid (54mgm) of m.p. 284-285°C.

Mass spectrum (E.I.) M^+ at m/z 278.1255. $C_{14}H_{18}N_2O_4$ requires 278.1243.

Example 3

Trans-3,4-Dihydro-2,2-dimethyl-4-(2-oxopiperidin-1-yl)-2H-pyrano[3,2-c]pyridin-3-ol (E3)



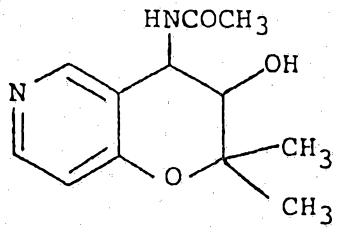
(E3)

The bromohydrin of description 2 was treated in a similar manner to that described in example 1, and the crude epoxide used directly as follows.

The epoxide (0.95g) in dimethyl sulphoxide (15mL) was added to a solution of δ-valerolactam (0.64g) and 80% NaH (0.18g) in dimethyl sulphoxide (10mL) and the mixture stirred for 18 hours under nitrogen. Water was added cautiously to the reaction mixture and the pH adjusted to 12 with sodium hydroxide, and the solution saturated with sodium chloride. Extraction with ethyl acetate, gave a crude product which was chromatographed (chromatotron; chloroform ->25% methanol-chloroform in a gradent elution) to give the required product (0.03g) as a solid. Further extraction of the aqueous layer with chloroform, and distillation of the co-extracted dimethyl sulphoxide gave more crude product which was chromatographed as above to give a further batch of the required material (0.355g). Solids were combined and recrystallised from ethyl acetate to give the compound of example 3 as colourless crystals (0.232g); m.p. 241-243°C. IR (KBr disc): 3500-3100; 1610cm^{-1}.

Example 4

Trans-4-Acetylamino-3,4-dihydro-2,2-dimethyl-2H-pyrano-[3,2-c]pyridin-3-ol (E4)



(E4)

Crude epoxide (1.48g, prepared as described in example 1) was treated with 0.88 ammonia solution (15mL) in ethanol (30mL) during 31 hours. Evaporation gave a crude aminoalcohol (1.56g) as a foam.

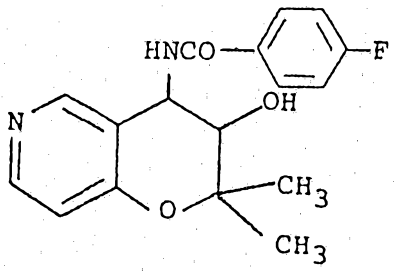
A portion of this aminoalcohol (0.71g), triethylamine (0.51mL) and dichloromethane (25mL) were stirred at 0°C. Acetyl chloride (0.26mL) was added to this solution, and the mixture stirred for a further 1 hour. The organic layer was washed with water. The aqueous extract was made basic with sodium carbonate and saturated with sodium chloride and extracted with chloroform. The organic layer was dried, filtered and evaporated to leave a solid (0.48g) which was recrystallised from ethyl acetate to furnish the compound of example 4 as a white solid (0.274g) of m.p. 208-210°C.

NMR ($CDCl_3$) δ

1.28 (s, 3H)
1.49 (s, 3H)
2.08 (s, 3H)
3.62 (d, J=10Hz, 1H)
5.03 (d, J=10Hz, 1H)
6.79 (d, J=6Hz, 1H)
8.18 (m, 2H)

Example 5

Trans-4-(4-fluorobenzoylamino)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol (E5)



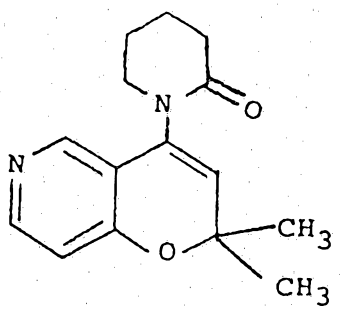
(E5)

Crude aminoalcohol (0.85g, prepared as described in example 4) was treated in an identical manner to that described in example 4, with p-fluorobenzoyl chloride.

Chromatography of the crude product (0.654g) using a gradient elution technique (chromatotron; chloroform - methanol) gave the required material which was recrystallised from ethyl acetate-methanol as a crystalline white solid (64mg) of m.p. 254-255°C.
Anal. Found: C, 64.29; H, 5.35; N, 8.77;
$C_{17}H_{17}N_2O_3F$ req: C, 64.55; H, 5.42; N, 8.86.

Example 6

2,2-Dimethyl-4-(2-oxopiperidin-1-yl)-2H-pyrano[3,2-c] pyridine (E6)



(E6)

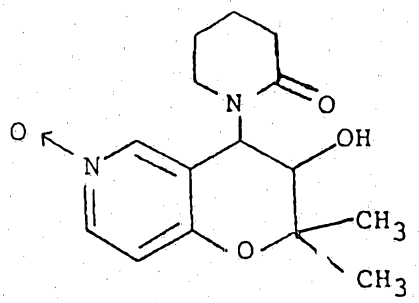
The compound of example 3 (0.40g) and 80% NaH (0.088g) were heated under reflux in dry xylene (35 mL) under nitrogen for 2.5h. A few drops of water were added cautiously and the solution evaporated to give a yellow gum (0.60g) which was chromatographed (chromototron; chloroform ->25% MeOH-chloroform in a gradient elution) to give a crude product (0.147g) which was recrystallised from ethyl acetate-pentane to give the title compound (0.086g) as colourless crystals mp 108-113°C.

NMR $CDCl_3$ δ

1.52 (s, 6H)
1.94 (brs, 4H)
2.56 (brs, 2H)
3.49 (m, 2H)
5.59 (s, 1H)
6.72 (d, J=5.5Hz, 1H)
8.05 (s, 1H)
8.26 (d, J=5.5Hz, 1H)

Example 7

Trans-3,4-dihydro-2,2-dimethyl-4-(2-oxopiperidin-1-yl)-2H-pyrano[3,2-c]pyridin-3-ol oxide (E7)

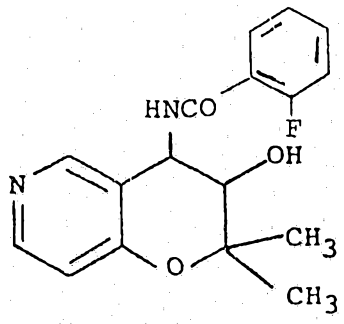


(E7)

The compound of example 3 was treated with m-chloroperbenzoic acid as described in the preparation of the oxide of example 2, to give the N-oxide (E7) as a solid of m.p. 290-291°C from ethyl acetate-methanol.

Example 8

Trans-4-(2-fluorobenzoylamino)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol (E8)



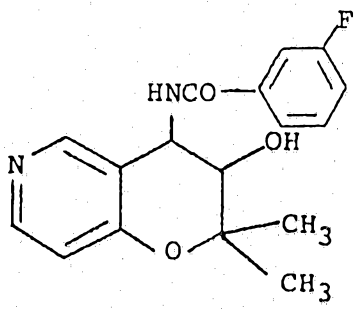
(E8)

The crude aminoalcohol (0.97g, prepared as described in example 4) was added to a solution of dicyclohexylcarbodiimide (1.027g), hydroxybenzotriazole (0.657g) and 2-fluorobenzoic acid (0.7g) in dry dimethylformamide (20 mL) at 0°C. The reaction mixture was allowed to attain room temperature, and was stirred for 3 days. The mixture was filtered and evaporated, and the residue chromatographed on silica gel. Elution with 10% methanol-chloroform mixture and recrystallisation from ethyl acetate-methanol furnished the product of example 8 (345 mg) of m.p. 254°C.

NMR (CD_3OD) δ 1.33 (s, 3H)
1.53 (s, 3H)
3.81 (d, J=9Hz, 1H)
5.27 (d, J=9Hz, 1H)
6.83 (d, J=6Hz, 1H)
7.10 - 7.93 (series of m, 4H)
8.23 (d, J=6Hz, 1H)
8.36 (s, 1H)

Example 9

Trans-4-(3-fluorobenzoylamino)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol (E9)

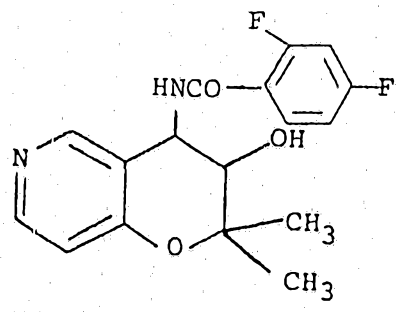


(E9)

The compound of this example was prepared in a similar manner, employing 3-fluorobenzoic acid, to that described in example 8. Recrystallisation from ethyl acetate-methanol gave the product of m.p. 259-261°C.
Mass Spectrum (E.I.).
M^+ at m/z 316.1220. $C_{17}H_{17}N_2O_3F$ requires 316.1223.

Example 10

Trans-4-(2,4-difluorobenzoylamino)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol (E10)



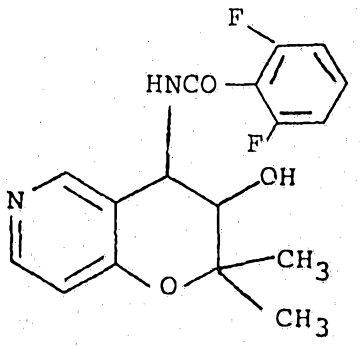
(E10)

The compound of this example was prepared in a similar manner, employing 2,4-difluorobenzoic acid, to the compound of example 8. Recrystallisation from ethyl acetate gave the compound of example 10 of m.p. 235-237°C.

NMR (CD_3OD) δ 1.37 (s, 3H)
1.57 (s, 3H)
3.84 (d, J=10Hz, 1H)
5.30 (d, J=10Hz, 1H)
6.85 (d, J=6Hz, 1H)
7.14 (irregular t, J=8Hz, 2H)
7.87 (q, J=8Hz, 1H)
8.23 (d, J=6Hz, 1H)
8.36 (s, 1H)

Example 11

Trans-4-(2,6-difluorobenzoylamino)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol (E11)



(E11)

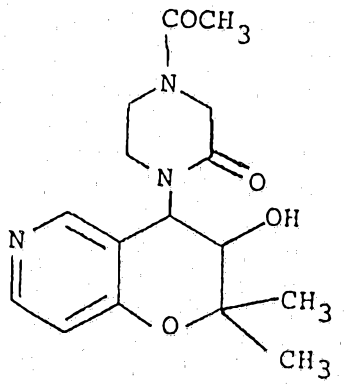
The compound of this example was prepared in a similar manner, employing 2,6-difluorobenzoic acid, to the compound of example 8. Recrystallisation from ethyl acetate-methanol furnished the compound of example 11 as a solid of m.p. 256°C.

Anal. Found: C,61.17; H,4.55; N,8.29%.

$C_{17}H_{16}N_2O_3F_2$ require: C,61.07; H,4.82; N,8.38%.

Example 12

Trans-4-(N-acetyl-2-oxopiperazin-1-yl)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol (E12)



(E12)

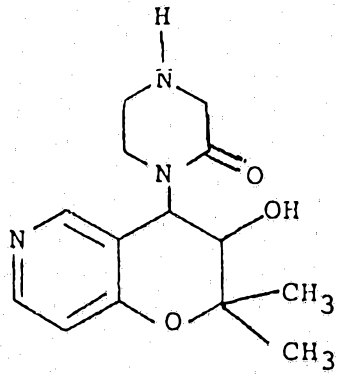
The epoxide (2.5g, the preparation of which was described in example 1) and 4-acetylpiperazin-2-one (2.7g) were stirred in dimethyl sulphoxide (30 mL). Sodium hydride (0.57g, 80% dispersion in oil) was added in portions to the solution at room temperature under nitrogen. The reaction mixture was stirred at room temperature for an additional 6 h. Water (25 mL) was added cautiously to the solution and the mixture extracted several times with chloroform. The organic extracts were washed with H_2O and brine, and dried over anhydrous $MgSO_4$. The solution was filtered and evaporated and the residual gum chromatographed on silica gel. Elution with 5% methanol-chloroform gave the product which was recrystallised from ethyl acetate -methanol to give the compound of example 12 (0.36g) as a solid of m.p. 215-217°C.

Anal. Found: C,60.24; H,6.59; N,13.16%.

$C_{16}H_{21}N_3O_4$ requires: C,60.18; H,6.63; N,13.16%.

Example 13

Trans-4-(2-oxopiperazin-1-yl)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol (E13)



(E13)

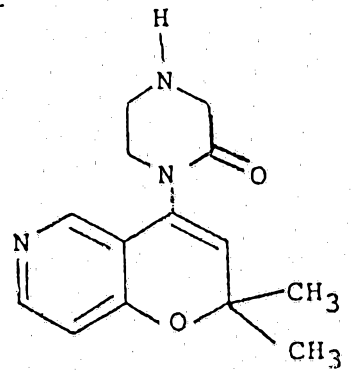
The compound of example 12 (0.64g) was heated under reflux in 5N HCl (6mL) and ethanol (10 mL) for 2 hours. The solution was cooled, partially evaporated and basified with KOH pellets. The mixture was evaporated to dryness, and taken up in hot ethyl acetate and filtered. Evaporation of solvent gave a residue which was recrystallised twice from ethyl acetate-methanol to give the compound of example 13 as a crystalline solid (156 mg) of m.p. 198-199°C.

Mass spectrum (E.I.) $(M+H)^+$ at m/z 278.1512.

$C_{14}H_{20}O_3N_3$ requires 278.1504.

Example 14

2,2-dimethyl-4-(2-oxopiperazin-1-yl)-2H-pyrano[3,2-c] pyridine (E14)



(E14)

The compound of example 13 was treated in a similar manner to the compound of example 3 during the preparation of the compound of example 6, to furnish the title compound (E14) as a solid of m.p. 109-111°C after chromatography (chromatotron; elution with 15% methanol-chloroform).

PHARMACOLOGICAL DATA

Blood Pressure Lowering Activity

Systolic blood pressures were recorded by a modification of the tail cuff method described by I.M. Claxton, M.G. Palfreyman, R.H. Poyser, R.L. Whiting, European Journal of Pharmacology, 37, 179 (1976). A W+W BP recorder, model 8005 was used to display pulses. Prior to all measurements rats were placed in a heated environment (33.5 ± 0.5°C) before transfer to a restraining cage. Each determination of blood pressure was the mean of at least 6 readings. Spontaneously hypertensive rats (ages 12-18 weeks) with systolic blood pressures >180 mmHg were considered hypertensive.

Compound of Example 1	Time Post Dose Hrs	% Change in Systolic Blood Pressure
6 Rats Dose 1 mg/kg po	1 2	-39 ± 7 -29 ± 4
Initial Blood Pressure 238±7 mmHg	4 6	-17 ± 4 -12 ± 4
	24	-15 ± 3

The other compounds of the Examples were tested and found to be active in the above test.

Bronchodilator Activity - Guinea Pig Asphyxic Collapse Model in-vivo

This model is based on the method described by Herxheimer (Br.J.Pharm.50, 314 (1974)]. Conscious guinea pigs (Dunkin-Hartley strain, 500-700g body weight) were placed individually into a Perspex chamber of approximately 8 litres capacity, and the animals were challenged with an histamine aerosol. The standard histamine aerosol was generated using a Monaghan 675 ultrasonic nebulizer (power setting 7) from a 5 x 10^{-6}m solution of histamine diphosphate in distilled water. After obtaining satisfactory aerosol generation, the aerosol was passed into the chamber for 10 seconds and the time was recorded from introduction of the aerosol until the guinea pig collapsed (termed asphyxic collapse). In this way, the mean time to asphyxic collapse for a group of guinea pigs was determined.

Compounds were administered orally to groups of animals (number = N) and the degree of protection against histamine-induced asphyxic collapse was determined by the percentage increase in mean time to asphyxic collapse of a compound-treated group over that for asphyxic collapse for control groups. Compound-treated animals that did not collapse were considered to be 100% protected.

Compounds were administered in 1% methyl cellulose at a concentration of 5mg/kg (1ml/kg body weight) and the animals were challenged with the standard histamine aerosol after 30 min.

The significance of any increase in the mean asphyxic collapse time of a compound-treated group of animals over that of a vehicle-treated control group was determined using Student's ''t'' test.

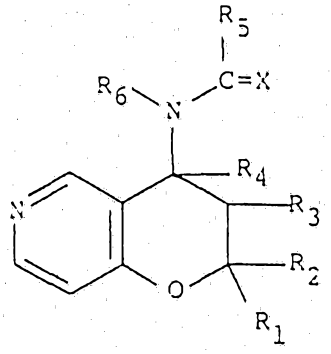
The results were as follows:

Compound	Dose (p.o.)	N	Mean Collapse time (sec)
example 3	5 mg/kg	5	193.0 ± 7.0*
Control		5	67.8 ± 6.1

*p<0.001 (Student's t-test).

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A compound of formula (I) or a pharmaceutically acceptable salt thereof:



(I)

wherein:

one of R_1 and R_2 is hydrogen or C_{1-4} alkyl and the other is C_{1-4} alkyl or R_1 and R_2 together are C_{2-5} polymethylene;

either R_3 is hydrogen, hydroxy, C_{1-6} alkoxy or C_{1-7} acyloxy and R_4 is hydrogen or R_3 and R_4 together are a bond;

R_5 is hydrogen; C_{1-6} alkyl optionally substituted by up to three halo atoms, by hydroxy, C_{1-6} alkoxy, C_{1-6} alkoxycarbonyl, carboxy or amino optionally substituted by one or two independent C_{1-6} alkyl groups or disubstituted by C_{4-5} polymethylene; C_{2-6} alkenyl; amino optionally substituted by a C_{1-6} alkyl or C_{1-6} alkenyl group or by a C_{1-6} alkanoyl group optionally substituted by up to three halo atoms, by a phenyl group optionally substituted by C_{1-6} alkyl, C_{1-6} alkoxy or halogen; or aryl or heteroaryl, either being optionally substituted by one or more groups or atoms

selected from the class of C_{1-6} alkyl, C_{1-6} alkoxy, hydroxy, halogen, trifluoromethyl, nitro, cyano, C_{1-12} carboxylic acyl, or amino or aminocarbonyl optionally substituted by one or two C_{1-6} alkyl groups; or (when X is O), R_5 is selected from the class of carboxy, C_{1-}, alkoxycarbonyl, or aminocarbonyl optionally substituted by one or two C_{1-6} alkyl groups; and

R_6 is hydrogen or C_{1-6} alkyl; or

R_5 and R_6 together are $-CH_2-(CH_2)_n-Z-(CH_2)_m-$ wherein m and n are 0 to 2 such that m + n is 1 or 2 and Z is CH_2, O, S or NR wherein R is hydrogen, C_{1-9} alkyl, C_{2-7} alkanoyl, phenyl C_{1-4}-alkyl, naphthylcarbonyl, phenylcarbonyl or benzyl-carbonyl optionally substituted in the phenyl or naphthyl ring by one or two of C_{1-6} alkyl, C_{1-6} alkoxy or halogen; or R is heteroarylcarbonyl;

X is oxygen or sulphur; or

R5, R6, X and N together are tetrahydroisoquinolinone or tetrahydroisoquinolin-thione optionally substituted in the phenyl ring as defined for R above;

the nitrogen-containing group in the 4-position being trans to the R_3 group when R_3 is hydroxy, C_{1-6} alkoxy or C_{1-7} acyloxy.

2. A compound according to claim 1 wherein R_1 and R_2 are both methyl.

3. A compound according to claim 1 or 2 wherein R_3 is hydroxy and R_4 is hydrogen, or R_3 and R_4 together are a bond.

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4. A compound according to any one of claims 1 to 3 wherein R_5 and R_6 are joined to form $-CH_2-(CH_2)_n-Z-(CH_2)_m-$ as defined in claim 1.

5. A compound according to any one of claims 1 to 4 wherein R_5 is methyl or R_5 is phenyl or amino either being optionally substituted as defined in claim 1; and R_6 is methyl, ethyl or hydrogen.

6. Trans-3,4-Dihydro-2,2-dimethyl-4-(2-oxopyrrolidin-1-yl)2H-pyrano[3,2-c]pyridin-3-ol,

trans-3,4-dihydro-2,2-dimethyl-4-(2-oxopiperidin-1-yl)-2H-pyrano[3,2-c]pyridin-3-ol,

trans-4-acetylamino-3,4-dihydro-2,2-dimethyl-2H-pyrano-[3,2-c]pyridin-3-ol,

trans-4-(4-fluorobenzoylamino)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol,

2,2-dimethyl-4-(2-oxopiperidin-1-yl)-2H-pyrano[3,2-c] pyridine,

trans-4-(2-fluorobenzoylamino)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol,

trans-4-(3-fluorobenzoylamino)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol,

trans-4-(2,4-difluorobenzoylamino)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol,

trans-4-(2,6-difluorobenzoylamino)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol,

trans-4-(N-acetyl-2-oxopiperazin-1-yl)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol,

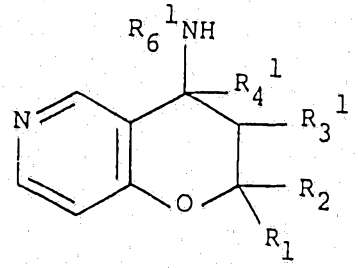
trans-4-(2-oxopiperazin-1-yl)-3,4-dihydro-2,2-dimethyl-2H-pyrano[3,2-c]pyridin-3-ol, or

2,2-dimethyl-4-(2-oxopiperazin-1-yl)-2H-pyrano-[3,2-c]pyridin-3-ol; or a pharmaceutically acceptable salt of any of the foregoing.

7. An N-oxide of a compound ~~according to~~ of formula (I) as defined in any one of claims 1 to 6.

8. A process for the preparation of a compound according to claim 1 or a pharmaceutically acceptable salt thereof, which comprises;

i) acylating a compound of formula (II):



wherein , R_1 and R_2 are as hereinbefore defined, R_3^1 is hydroxy, C_{1-6} alkoxy or C_{1-7} acyloxy, R_4^1 is hydrogen and R_6^1 is hydrogen or C_{1-6} alkyl, the R_7^1NH group being trans to the R_3^1 group,

a) with an acylating agent of formula (III):

$$R_8\text{-}CO\text{-}L_1 \qquad \text{(III)}$$

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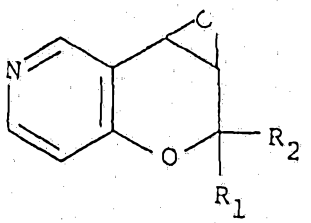
wherein L_1 is a leaving group, and R_8 is hydrogen, C_{1-6} alkoxycarbonyl, C_{1-6} alkyl optionally substituted by halogen, hydroxy, C_{1-6} alkoxy, C_{1-6} alkoxycarbonyl, carboxy or amino optionally substituted as hereinbefore defined for R_5, C_{2-6} alkenyl or optionally substituted aryl or heteroaryl as hereinbefore defined for R_5, or a group convertible to R_5 as hereinbefore defined, and thereafter, when R_6 is hydrogen and R_8 is $Y(CH_2)_z-$, where z is 3 or 4 and Y is a leaving group, cyclising the resultant compound;

b) with a compound of formula (IV)

$$X=C=N.R_{11} \qquad (IV)$$

wherein R_{11} is hydrogen, C_{1-6} alkyl, C_{1-6} alkenyl, C_{1-6} alkanoyl optionally substituted by up to three halo atoms, or phenyl optionally substituted by C_{1-6} alkyl, C_{1-6} alkoxy or halogen; and X is oxygen or sulphur, and thereafter when R_{11} is hydrogen, optionally converting R_{11}; or

ii) where, in the resultant compound of formula (I), R_5 and R_6 are joined together or R_5 is aminocarbonyl, reacting a compound of formula (V):



(V)

wherein R_1 and R_2 are as hereinbefore defined, with a compound of formula (VI):

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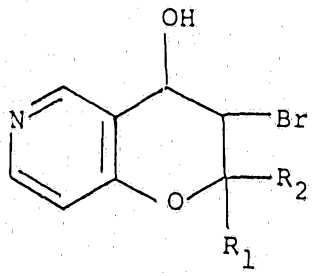
$R_{13}NHCOR_{12}$ (VI)

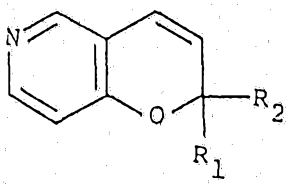
wherein R_{13} is R_6 as defined and R_{12} is aminocarbonyl; R_{12} and R_{13} together are $-CH_2-(CH_2)_n-Z-(CH_2)_m-$ or $R_{13}NHCOR_{12}$ is tetrahydroisoquinolinone;

optionally converting R_3 in the resulting compound into another R_3; in the case where R_3 and R_4 in the resulting compound are hydroxy and hydrogen respectively, optionally dehydrating the compound to give another compound wherein R_3 and R_4 together are a bond, and optionally reducing the resulting compound wherein R_3 and R_4 together are a bond, to give another compound, wherein R_3 and R_4 are each hydrogen; and optionally thiating the $R_6-N-CO-R_5$ group in the resulting compound to give a compound wherein X is sulphur; and optionally forming a pharmaceutically acceptable salt thereof.

9. A compound of formula (II) ~~or (V)~~ as defined in claim 8, or a compound of formula (VIII) or (IX):



(VIII)



(IX)

10. 2,2-Dimethyl-2H-pyrano[3,2-c]pyridine, or

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trans-3-bromo-3,4-dihydro-2,2-dimethyl-2H-pyrano-[3,2-c] pyridin-4-ol.

11. A pharmaceutical composition comprising a compound according to any one of claims 1 to 7 or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable carrier.

12. A method of treatment and/or prophylaxis of disorders associated with the respiratory system by the administration of an effective amount of a compound according to any one of claims 1 to 8 to a patient in need of such treatment or prophylaxis.

13. A method of treatment or prophylaxis of hypertension by the administration of an effective amount of a compound according to any one of the claims 1 to 8 to a patient in need of such treatment or prophylaxis.

14. Compounds of Formula (I), methods for their manufacture or pharmaceutical compositions containing them, substantially as hereinbefore described with reference to the Examples.

DATED THIS 25th January, 1990
DAVIES & COLLISON
Fellows Institute of Patent
Attorneys of Australia.
Patent Attorneys for the Applicant

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