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APPROVAL PACKAGE FOR:

APPLICATION NUMBER

21-184

Administrative Documents

1.4 PATENT INFORMATION/CERTIFICATION

The following patent information has been recorded for the Active Pharmaceutical Ingredient, tazarotene and the finished dosage form for the approved gel formulation, Tazorac® (tazarotene topical gel) 0.05%, 0.1%.

Copies of the documentation is attached.

<u>Reference</u>	<u>Date</u>	<u>Subject</u>
Patent Number 5,032,341	June 11, 1991	Compounds having a di-substituted acetylene moiety and retinoic acid-like activity
Patent Number 5,089,509	February 18, 1992	Di-substituted acetylenes bearing heteroaromatic and heterobicyclic groups having retinoid-like activity
Federal Register, Vol. 64, No. 97,	May 20, 1999	Determination of regulatory review period for purposes of patent extension; Tazorac®

I certify that the patent and patent extension information in the New Drug Application is, to the best of my knowledge and belief, factually true and correct.



Peter A. Kresel, MS, MBA
Senior Vice President,
Global Regulatory Affairs, Allergan



Date

United States Patent [19]

[11] Patent Number: 5,023,341

Chandraratna

[45] Date of Patent: Jun. 11, 1991

[54] COMPOUNDS HAVING A DISUBSTITUTED ACETYLENE MOIETY AND RETINOIC ACID-LIKE BIOLOGICAL ACTIVITY

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[21] Appl. No.: 409,477

[22] Filed: Sep. 19, 1989

[51] Int. Cl.⁵ C07D 335/06

[52] U.S. Cl. 549/23

[58] Field of Search 546/164; 549/23

[56] References Cited

U.S. PATENT DOCUMENTS

4,739,098 4/1988 Chandraratna 560/8
4,810,804 3/1989 Chandraratna 514/311

FOREIGN PATENT DOCUMENTS

0176034 4/1986 European Pat. Off. .
3706060 9/1987 Fed. Rep. of Germany .

OTHER PUBLICATIONS

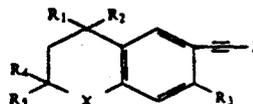
A General Synthesis of Terminal and Internal Arylalkynes by the Palladium-Catalyzed Reaction of Alkynylzinc Reagents with Aryl Halides, by Anthony O. King and Ei-ichi Negishi, *J. Org. Chem.* 43 1978, p. 358.
A Convenient Synthesis of Ethynylarenes and Die-

thynylarenes, by S. Takahashi, Y. Kuroyama, K. Sonogashira, N. Hagihara, *Synthesis* 1980, pp. 627-630.
Conversion of Methyl Ketones into Thermal Acetylenes and (E)-Trisubstituted Olefins of Terpenoid Origin, by Ei-ichi, Anthony O. King, and William L. Klima, *J. Org. Chem.* 45 1980, p. 2526.

Primary Examiner—Frederick E. Waddell
Assistant Examiner—Raymond Covington
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[57] ABSTRACT

Disubstituted acetylene thiochroman containing derivatives of the formulae below wherein the symbols have the following meanings; R₁, R₂, R₃, R₄ and R₅ are hydrogen or lower alkyl groups (of 1-6 carbons) where R₁, R₂, R₃, R₄ and R₅ may be identical or different from one another) X is S



9 Claims, No Drawings

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ON ORIGINAL

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COMPOUNDS HAVING A DISUBSTITUTED ACETYLENE MOIETY AND RETINOIC ACID-LIKE BIOLOGICAL ACTIVITY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is directed to the preparation of compounds which have retinoic acid-like biological activity. More specifically, the present invention is directed to processes and intermediates which result in the synthesis of disubstituted acetylene compounds having retinoic acid-like activity.

2. Related Art

European Patent Application 176034A (published Apr. 2, 1986) discloses tetrahydronaphthalene compounds having an olefinic moiety wherein three olefinic units from the acid-containing moiety of retinoic acid are replaced by an ethynylphenyl functionality. These compounds have retinoic acid-like biological activity.

U.S. Pat. No. 4,810,804 (issued on Mar. 7, 1989) based on an application of the same inventor and assigned to the same assignee as the present application, discloses such disubstituted acetylene compounds wherein one of the substituents of the acetylene (ethyne) group is a substituted phenyl group, and the second substituent is a substituted or unsubstituted chromanyl, thiochromanyl or tetrahydroquinolinyl group. The compounds disclosed and claimed in U.S. Pat. No. 4,810,804 have retinoic acid-like biological activity.

Several co-pending applications of the present inventor, which applications are assigned to the assignee of the present which application, are directed to further types of disubstituted acetylene compounds wherein one substituent of the acetylene (ethyne) moiety is a substituted phenyl or a substituted heteroaryl group, and the other substituent is a substituted unsubstituted chromanyl, thiochromanyl or tetrahydroquinolinyl group. The disubstituted acetylene compounds described and claimed in the aforesaid co-pending applications have significant retinoic acid-like activity.

Retinoic acid-like activity has been generally recognized in the art to be associated with useful biological activity. Specifically, compounds having retinoic acid-like activity are useful as regulators of cell proliferation, and particularly as agents for treating dermatoses, such as acne, Darier's disease, psoriasis, ichthyosis, eczema, atopic dermatitis and epithelial cancers, for treating arthritic diseases and other immunological disorders (e.g. lupus erythematosus) for promoting wound healing, for treating dry eye syndrome and for reversing the effects of sun damage to skin.

With respect to the synthetic processes of the present invention which involve either the formation of an acetylenic (ethynyl) function in the compounds of the invention, or the coupling of the compounds of the invention which already have the ethynyl function, with a halogen substituted phenyl or heteroaryl group, the following article comprise background information: A General Synthesis of Terminal and Internal Arylalkynes by the Palladium-Catalyzed Reaction of Alkynylzinc Reagents with Aryl Halides by Anthony O King and Ei-ichi Negishi, *J. Org. Chem.* 43 1978 p 358; Conversion of Methyl Ketones into Terminal Acetylenes and (E)-Trisubstituted Olefins of Terpenoid Origin by Ei-ichi, Anthony O. King, and William L. Klima, *J. Org. Chem.* 45 1980 p.2526, and A Convenient Synthesis of Ethynylarenes and Diethynylarenes by S. Takahashi, Y.

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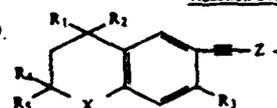
Kuroyama, K. Sonogashira, N. Hagihara, *Synthesis* 1980 p 627-630.

SUMMARY OF THE INVENTION

The present invention is directed to a novel process for making the biologically active and useful disubstituted acetylene compounds having as one of the substituents a substituted or unsubstituted chromanyl, thiochromanyl or tetrahydroquinolinyl group. In another aspect, the present invention covers intermediate compounds which are utilized in the process to make the aforementioned biologically active disubstituted acetylenes.

Specifically, in accordance with the present invention the 6-thiochromanyl-ethyne, 6-chromanyl-ethyne and 6-tetrahydroquinolinyl-ethyne compounds of Formula 1, or their suitable metal salts are reacted with a suitable halogensubstituted phenyl or heteroaryl compound of Formula 2 to provide the compounds of Formula 3. The compounds of Formula 3 either have useful retinoic acid-like activity or are readily converted by routine organic synthetic steps (such as esterification, deesterification, homologation, oxidation, reduction, amide formation or the like) to compounds having the retinoic acid-like activity. (Formulae 1, 2 and 3 are incorporated in Reaction Scheme 1).

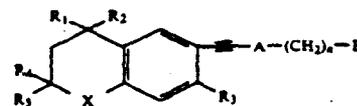
Reaction Scheme 1



Formula 1



Formula 2



Formula 3

In Formula 1, 2, and 3, R₁, R₂, R₃, R₄ and R₅ are hydrogen or lower alkyl groups (of 1-6 carbons) where R₁, R₂, R₃, R₄ and R₅ may be identical or different from one another) X is S, O or NR' where R' is hydrogen or lower alkyl. Z represents hydrogen or a metal ion capable of forming a salt with the ethynyl moiety of the molecule, X' is a leaving group such as a halogeno group, A is phenyl, or heteroaryl such as pyridithienyl, furyl, pyridazinyl, pyrimidinyl, pyrazinyl, thiazolyl or oxazolyl, n is an integer between 0 to 5, and B is H, -COOH or a pharmaceutically acceptable salt, ester or amide thereof, -CH₂OH or an ether or ester derivative, or -CHO or an acetal derivative, or -COR₁ or a ketal derivative where is an alkyl, cycloalkyl or alkenyl group containing 1 to 5 carbons.

The reaction shown in Reaction Scheme 1, i.e. the coupling between the compounds of Formula 1 and the compounds of Formula 2, is conducted, in accordance with the invention in the presence of cuprous iodide and in the further presence of Pd(PQ)₃Cl₂ (Q is phenyl) or similar complex when Z is and in the presence of

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$\text{Pd}(\text{PQ})_4$ (Q is phenyl) or similar complex when Z is a metal ion, such as ZnCl^+ .

The compounds set forth in Formula 1, comprise another aspect of the present invention. These compounds are useful as intermediates for the synthesis of the biologically active and useful retinoic acid-like compounds of Formula 3.

When the preferred compounds of Formula 1 are reacted with compounds of Formula 2, then, in the resulting compounds of Formula 3 the X, R_1 , R_2 , R_3 , R_4 and R_5 substituents are defined as for compounds 1 through 9.

The reaction conditions for the coupling of compounds of Formula 1 with the compounds of Formula 2, in accordance with the present invention, as well as the processes for synthesizing the compounds of Formula 1, are explained in the ensuing description of Specific Embodiments and examples.

GENERAL EMBODIMENTS

Definitions

The term "ester" as used here refers to and covers any compound falling within the definition of that term as classically used in Organic chemistry. Where B (of Formulae 1 and 2) is $-\text{COOH}$, this term covers the products derived from treatment of this function with alcohols. Where the ester is from compounds where B is $-\text{CH}_2\text{OH}$, this term covers of the formula $-\text{CH}_2\text{OOCR}$ where R is any substituted or unsubstituted aliphatic, aromatic or aliphatic-aromatic group.

Preferred esters are derived from the saturated aliphatic alcohols or acids of ten or fewer carbon atoms or the cyclic or saturated aliphatic cyclic alcohols and acids of 5 to 10 carbon atoms. Particularly preferred aliphatic esters are those derived from lower alkyl acids or alcohols. Here, and where ever else used, lower alkyl means having 1-6 carbon atoms. Also preferred are the phenyl or lower alkylphenyl esters.

Amide has the meaning classically accorded that term in organic chemistry. In this instance it includes the unsubstituted amides and all aliphatic and aromatic mono- and di-substituted amides. Preferred amides are the mono- and di-amides amides derived from the saturated aliphatic radicals of ten or fewer carbon atoms or the cyclic or saturated aliphatic-cyclic radicals of 5 to 10 carbon atoms. Particularly preferred amides are those derived from lower alkyl amines. Also preferred are mono- and di-substituted amides derived from the phenyl or lower alkylphenyl amines. Unsubstituted amides are also preferred.

Acetals and ketals include the radicals of $-\text{CK}$ where K is $(-\text{OR})_2$. Here, R is lower alkyl. Also, K may be $-\text{OR}_1\text{O}-$ where R_1 is lower alkyl of 2-5 carbon atoms, straight chain or branched.

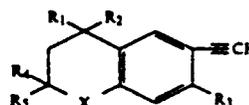
A pharmaceutically acceptable salt may be prepared for any compound made in accordance with this invention, provided the compound has a functionality capable of forming such salt, for example an acid or an amine functionality. A pharmaceutically acceptable salt may be any salt which retains the activity of the parent compound and does not impart any deleterious or untoward effect on the subject to which it is administered and in the context in which it is administered.

Such a salt may be derived from and organic or inorganic acid or base. The salt may be a mono or polyvalent ion. Of particular interest where the acid function is concerned are the inorganic ions, sodium, potassium, calcium, and magnesium. Organic amine salts may be

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made with amines, particularly ammonium salts such as mono-, di- and trialkyl amines or ethanol amines. Salts may also be formed with caffeine, tromethamine and similar molecules. Where there is a nitrogen sufficiently basic as to be capable of forming acid addition salts, such may be formed with any inorganic or organic acids or alkylating agent such as methyl iodide. Preferred salts are those formed with inorganic acids such as hydrochloric sulfuric acid or phosphoric acid. Any of a number of organic acids such as mono-, di- or tri-acid may also be used.

The compounds which are preferably utilized in the synthetic process of the present invention to introduce the substituted chromanyl, substituted thiochromanyl, and substituted tetrahydroquinolinyl moiety as one of the substituents of the ethyne portion of the biologically active compounds, and which therefore are the preferred intermediates in accordance with the invention, are shown in Formula 4.



Formula 4

- These preferred compounds and intermediates are:
- Compound 1 X=S; $\text{R}_1=\text{R}_2=\text{CH}_3$; $\text{R}_3=\text{R}_4=\text{R}_5=\text{H}$
 - Compound 2 X=S; $\text{R}_1=\text{R}_2=\text{R}_3=\text{CH}_3$; $\text{R}_4=\text{R}_5=\text{H}$
 - Compound 3 X=S; $\text{R}_1=\text{R}_2=\text{R}_4=\text{R}_5=\text{CH}_3$; $\text{R}_3=\text{H}$
 - Compound 4 X=O; $\text{R}_1=\text{R}_2=\text{CH}_3$; $\text{R}_3=\text{R}_4=\text{R}_5=\text{H}$
 - Compound 5 X=O; $\text{R}_1=\text{R}_2=\text{R}_4=\text{R}_5=\text{CH}_3$; $\text{R}_3=\text{H}$
 - Compound 6 X=NH; $\text{R}_1=\text{R}_2=\text{CH}_3$; $\text{R}_3=\text{R}_4=\text{R}_5=\text{H}$
 - Compound 7 X=NH; $\text{R}_1=\text{R}_2=\text{R}_4=\text{R}_5=\text{CH}_3$; $\text{R}_3=\text{H}$
 - Compound 8 X=S; $\text{R}_1=\text{R}_2=\text{R}_3=\text{R}_4=\text{R}_5=\text{CH}_3$
 - Compound 9 X=O; $\text{R}_1=\text{R}_2=\text{R}_3=\text{R}_4=\text{R}_5=\text{CH}_3$
 - 4,4-dimethyl-6-ethynylthiochroman (Compound 1)
 - 4,4,7-trimethyl-6-ethynylthiochroman (Compound 2)
 - 2,2,4,4-tetramethyl-6-ethynylthiochroman (Compound 3)
 - 4,4-dimethyl-6-ethynylchroman (Compound 4)
 - 2,2,4,4-tetramethyl-6-ethynylchroman (Compound 5)
 - 4,4-dimethyl-6-ethynyl-1,2,3,4-tetrahydroquinoline (Compound 6)
 - 2,2,4,4-tetramethyl-6-ethynyl-1,2,3,4-tetrahydroquinoline (Compound 7)
 - 2,2,4,4,7-pentamethyl-6-ethynylthiochroman (Compound 8)
 - 2,2,4,4,7-pentamethyl-6-ethynylchroman (Compound 9)

The metal (preferably zinc) salts of the preferred compounds are also preferred as intermediates in the process of the invention.

Generally speaking the compounds of Formula 1, or their (such as zinc) salts preferably the Compounds of Formula 4 (or their salts), are reacted with the compounds of Formula 2 to provide the compounds of Formula 3.

When the preferred compounds of Formula 4 are reacted with compounds of Formula 2, then, in the resulting compounds of Formula 3 the X, R_1 , R_2 , R_3 , R_4 and R_5 substituents are defined as for Compounds 1 through 9.

The reaction conditions for the coupling of compounds of Formula 1 with the compounds of Formula 2, in accordance with the present invention as well as the processes for synthesizing the compounds of Formula 1,

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are explained in the ensuing description of Specific Embodiments and Examples.

With respect to biological activity of the compounds of Formula 3 made in accordance with the process of the present invention (utilizing the intermediates of the invention in the process) the following is noted.

The retinoic acid like activity of these compounds was confirmed through the classic measure of retinoic acid activity involving the effects of retinoic acid on ornithine decarboxylase. The original work on the correlation between retinoic acid and decrease in cell proliferation was done by Verma & Bourwell, *Cancer Research*, 1977, 37, 2196-2201. That reference discloses that ornithine decarboxylase (ODC) activity increased precedent to polyamine biosynthesis. It has been established elsewhere that increases in polyamine synthesis can be correlated or associated with cellular proliferation. Thus, if ODC activity could be inhibited, cell hyperproliferation could be modulated. Although all causes for ODC activity increase are unknown, it is known that 12-O-tetradecanoylphorbol-13-acetate (TPA) induces ODC activity. Retinoic acid inhibits this induction of ODC activity by TPA. The compounds of this invention also inhibit TPA induction of ODC as demonstrated by an assay essentially following the procedure set out in *Cancer Res.* 35, 1662-1670, 1975.

By way of example of retinoic acid-like activity it is that in the assay conducted essentially in accordance with the method of Verman & Boutwell, *ibid.* the following examples of compounds made in accordance with the process of the present invention (Compounds 10, 11 and 12) attained an 80% inhibition of TPA induced ODC activity at the following concentrations (IC₅₀):

Compound	IC ₅₀ conc (nmols)
10	0.69
11	0.13

Compounds 10, 11 and 12 are characterized with reference to Formula 3 as follows:

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Compound 10 X=S R₁=R₂=R₄=R₅=CH₃; R₃=H.
A-(CH₂)_n-B=ethyl 6-nicotinate

Compound 11 X=O R₁=R₂=R₄=R₅=CH₃; R₃=H.
A-(CH₂)_n-B=ethyl 6-nicotinate.

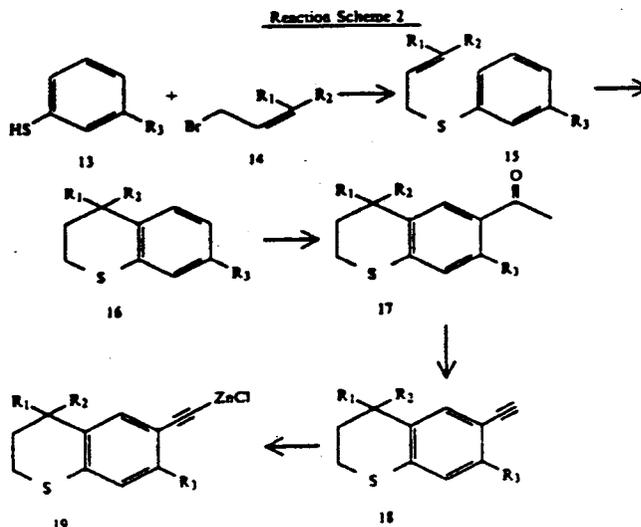
Compound 12 X=O R₁=R₂=R₃=R₄=R₅=CH₃.
A-(CH₂)_n-B=ethyl 6-nicotinate.

In view of their retinoic acid-like activity the of Formula 3 may be administered systematically or for treatment of a variety of conditions, as is indicated in the introductory section of the present application for patent. For a detailed description of the modes of administration, of various pharmaceutical formulations and dosages in the treatment of mammals (including humans) with the compounds of Formula 3, reference is made to U.S. Pat. No., 4,810,804, the specification of which is incorporated herein by reference.

Specific Embodiments

The compounds of the invention which are defined in Formula 1, and which serve as key intermediates in the process steps of the invention to make the compounds of Formula 3, can by a number of different synthetic chemical pathways. To illustrate this invention, there is here outlined a series of steps which have been proven to provide the compounds of Formulae 1 and 3 when such synthesis is followed in fact and in spirit. The synthetic chemist will readily appreciate that the conditions set out here are specific embodiments which can be generalized to any and all of the compounds represented by Formulae 1 and 3. Furthermore, the synthetic chemist will readily appreciate that the herein described synthetic steps may be varied and or adjusted by those skilled in the art without departing from the scope and spirit of the invention. Moreover, it should be understood that some of the steps and processes utilized in the hereinbelow given examples of the compounds of Formula 1, are novel and innovative on their own right. Such novel steps are described here in sufficient detail to enable the ordinary artisan to duplicate such steps:

With reference to the compounds of Formula 1, Reaction Scheme 2 illustrates an example of their synthesis when X=S and R₄ and R₅ are both hydrogen.



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Thus, with reference to Reaction Scheme 2, a thiophenol 13 which may be substituted with the R₃ substituent (defined above as hydrogen or lower alkyl) in the 3 position is alkylated, preferably under strongly basic conditions such as NaOH in a polar solvent (acetone, room temp.) with the Compound 14, which is either 1-bromo-3-methyl-2-butene (R₁ and R₂ are methyl, available from Aldrich) or a derivative thereof where either R₁ and R₂ or both are lower alkyl other than methyl. The resulting alkylated thiophenol (sulfide, Compound 15) is thereafter ring closed under Friedel Crafts or like conditions, typically by refluxing in an inert solvent such as benzene or toluene, in the presence of phosphorous pentoxide and phosphoric acid. The resulting thiochroman 16, made in accordance with Reaction Scheme 2, has no substituents in the 2 position, and preferably in accordance with this reaction scheme R₁ and R₂ are methyl and R₃ is hydrogen.

Compound 16 is acetylated under Friedel Crafts conditions, the like, preferably with acetyl chloride (AlCl₃, CH₂Cl₂, reflux) to provide the 6-acetyl-thiochroman 17. The acetyl function of Compound 17 is converted into an acetylenic (ethynyl) function by means of lithium diisopropylamide, or a similar base, at reduced temperature. An intermediate derived from Compound 17 (presumably a lithium salt of the corresponding enol, not shown on Reaction Scheme 2) is esterified by treatment with diethylchlorophosphate (or the like) and is again reacted at reduced temperature (e.g. -78 degrees C.) with lithium diisopropylamide, to form the triple bond (presumably by an elimination reaction) and to yield the 6-ethynylthiochroman derivative (Compound 18).

It is noted at this point that the present invention is not intended to be limited or bound by the above-mentioned and other theories of reaction mechanisms. Brief description of of reaction mechanisms (where applicable) are given to further enable and facilitate the work of a skilled artisan in the field to modify and adjust the synthetic conditions to fit particular specific intermediates and to make the several compounds of the invention, without departing from the scope and spirit of the invention.

The 6-ethynyl-thiochroman 18 is either utilized directly in the coupling reaction indicated in Reaction Scheme 1, or is converted to a metal (zinc) salt (Compound 19) before the coupling step.

Generally speaking the zinc chloride salts (Compounds 19) are prepared under conditions which exclude water and oxygen. dry, ether-type solvent such as dialkyl ether or a cyclic ether such as a furan or pyran, particularly a tetrahydrofuran, may be used as the solvent. A solution of compound 18 is first prepared under an inert atmosphere (argon or nitrogen) and then a strong base such as n-butyl lithium is added (in about a 10% molar excess). This reaction is begun at a reduced temperature of between -10 degrees and +10 degrees C., preferably about 0 degrees C. The reaction mixture stirred for a short period, between 30 minutes and 2 hours, then treated with about a 10% molar excess of fused zinc chloride dissolved in the reaction solvent. This mixture is stirred for an additional 1-3 hours at about the starting temperature, then the temperature is increased to about ambient temperature for 10-40 minutes.

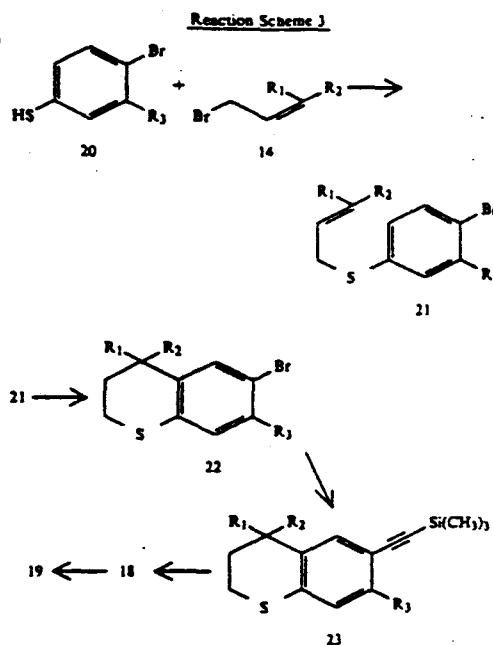
The foregoing general description for the preparation of the ZnCl salts symbolized by Compound 19, are also applicable, with such modifications which will be readily apparent to the skilled artisan in the field, to the

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preparation of all ZnCl salts corresponding to Formula 1.

Reaction Scheme 3 shows another method for preparing the compounds of Formula 1 when X=S and R₄ and R₅ hydrogen. The synthetic sequence shown in Reaction Scheme 3 is preferably (but not exclusively) used when R₃ is not hydrogen. In contrast the reactions shown in Reaction Scheme 2 are preferably (but not exclusively) used when R₃ is hydrogen.

Thus, with reference to Reaction Scheme 3 and 4-bromothiophenol (Compound 20) (which is preferably alkyl substituted in the 3-position) is alkylated with Compound 14. The resulting 4-bromo phenyl sulfides 21 are ring closed under conditions analogous to the ring closure of Compounds 15 described in connection with Reaction Scheme 2.



To introduce the acetylene (ethyne) portion into the molecule, the substituted 6-bromothiochroman 22 is reacted with trimethylsilylacetylene in the presence of cuprous iodide and a suitable catalyst, typically having the formula Pd(PQ)₂Cl₂ (Q is phenyl). The reaction is typically conducted in the presence of bis(triphenylphosphine) palladium (II) catalyst, an acid acceptor, (such as triethylamine) under an inert gas (argon) atmosphere, by heating in a sealed tube. The resulting 6-trimethylsilylethynylthiochroman, is as Compound 23 in Reaction Scheme 3.

As is further shown on Reaction Scheme 3, the trimethylsilyl moiety is removed from the 6-trimethylsilylethynyl-thiochroman 23 in the next synthetic step, to provide the ring substituted 6-ethynyl-thiochroman derivative (Compound 18). The latter reaction is conducted under basic conditions, preferably under an inert gas atmosphere.

The 6-ethynyl-thiochroman 18 can be utilized directly in the coupling reaction set forth in Reaction

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Scheme 1, or prior to coupling can be converted to the corresponding ZnCl salt, as is described above.

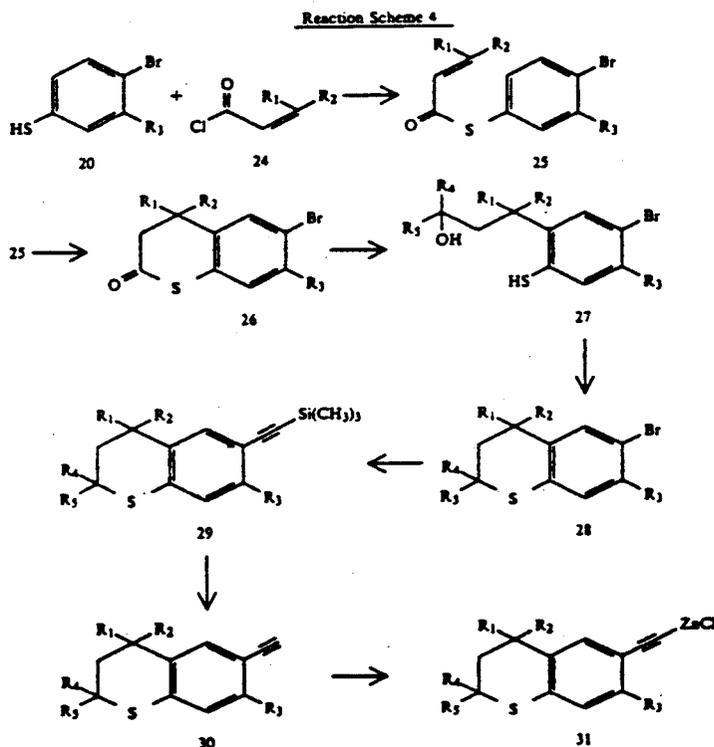
Reaction Scheme 4 shows preparation of the compounds corresponding to Formula 1 where X=S and at least one of the R₄ and R₅ groups is lower alkyl, preferably where R₄ and R₅ are both lower alkyl, and still more preferably where R₄ and R₅ are identical with one another.

Thus, with specific reference to Reaction scheme 4, the 2 substituted (preferably 2,2 di-substituted) 6-ethynyl thiochromans can be prepared as follows. The 4-bromo-thio-phenol (Compound 20) is acylated with an acylating agent such as an chloride (Compound 24) derived from an appropriately substituted acrylic acid. The acylation is conducted in an inert solvent (such as tetrahydrofuran) in the presence of strong base (for example sodium hydride). The resulting thioester (Compound 25)

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stood by those skilled in the art that depending on the relative molecular ratios of the Grignard reagent and of the oxothiochroman compound (Compound 26), and also depending on the reaction conditions, the primary products of the reaction may be derivatives where either one or two alkyl groups have been introduced through the Grignard reaction. When the Grignard reagent (such as methylmagnesium bromide) is in excess, the thiochromane ring is opened and the tertiary alcohol derivative of the 4-bromo thiophenol (Compound 27) is formed.

Ring closure of the thiophenol derivative (Compound 27) which has the desired R₁, R₂, R₃, R₄ and R₅ substituents, is affected by heating in acidic conditions, preferably by heating compound 27 in aqueous acid. The resulting 6-bromothiochroman which bears the desired alkyl (or hydrogen) substituents, R₁, R₂, R₃, R₄ and R₅, is shown as Compound 28 in Reaction Scheme



which contains the olefinic bond of the acrylic acid moiety is ring closed in the presence of a Friedel Crafts type catalyst (such as aluminum chloride) by stirring in a suitable solvent such as methylene chloride. The resulting 2-oxo-6-bromothiochromane (compound 26) is usually isolated in crystalline form.

The R₄ and/or R₅ substituents (both of which cannot be hydrogen when the steps of Reaction Scheme 4 are used) and which preferably are identical with one another (for example both are methyl) are introduced by treating the 2-oxo-6-bromothiochromane (Compound 26) with a Grignard reagent, bearing the alkyl substituents R₄ and R₅ (such as methylmagnesium bromide when R₄ and R₅ are methyl). It will be readily under-

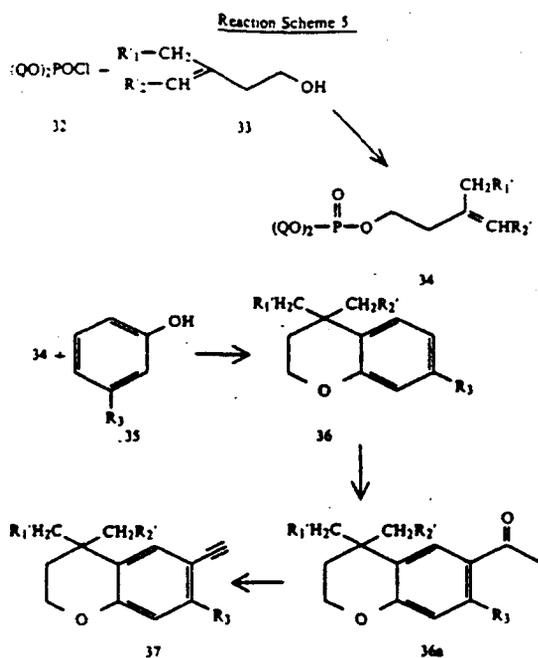
The 6-bromothiochromans 28 (which differs from the 6-bromothiochromans 22 only in that in Compound 28 the 2 position of the thiochroman ring is substituted) is converted to the 6-(2-trimethylsilyl)ethynyl derivative 29, and thereafter into the 6-ethynyl derivative 30, (and further if desired into the ZnCl salts 31) in reaction steps which are analogous to the corresponding steps described in connection with Reaction Scheme 3.

Turning now to compounds of Formula 1 where X=O and where R₄ and R₅ are H, (that is turning to chromans substituted in the 4, and possibly in the 7 position) the compounds can be as indicated in Reaction Scheme 5.

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In Reaction Scheme 5 Q is phenyl and R₁' and R₂' are hydrogen or lower alkyl having 1 to 5 carbons, and R₃ is defined as above in connection with Formula 1. The reaction sequence is hereinafter further described for the preferred case where R₁' and R₂' and R₃ are all hydrogen, i.e. for the synthesis of 4,4-dimethyl-6-ethynylchroman (Compound 4).

With reference to Reaction Scheme 5, the phosphate (Compound 34) is prepared from the corresponding diphenyl chlorophosphate 32 is prepared from the corresponding diphenyl chlorophosphate 32 and 3-methyl-3-butene-1-ol (Compound 33, R₁' and R₂' are both H) available from Aldrich, or prepared by means known in the art. It is preferred to prepare Compound 34 by dissolving the alcohol 33 in about a 10% excess of pyridine or the like under an inert atmosphere cooled to approximately -10 degrees to 10 degrees C. This solution is then added drop-wise, under an inert atmosphere, to a solution of diphenyl chlorophosphate 32, in about an equal amount of the reaction solvent. About a 2-5% molar excess of diphenyl chlorophosphate 22 relative to the alcohol 33 is employed. The atmosphere may be argon, nitrogen, or another inert gas. The mixture is heated at reflux for between 1 and 5 hours, preferably about 3, to effect the reaction. The product is then recovered by conventional means. The diphenyl phosphate ester (Compound 34) is then reacted with a phenol 35 to effect formation of chroman (Compound 36). For example, phenol 35 (or R₃ substituted phenol) is added to a flask already containing stannic chloride under argon which has been cooled to between -10 degrees to 10 degrees C. After thorough mixing of this

combination for about 15 minutes to an hour at the reduced temperature, the phosphate 34 is added at the reduced temperature. Both of these steps are carried out under an inert atmosphere such as argon or nitrogen. When the addition of the phosphate 34 is completed, the mixture is stirred at about ambient temperature for up to 24 hours. Then the reaction is quenched with a dilute solution of aqueous alkali metal base or the like. The product is recovered by extraction and other conventional means.

The acetylenic (ethynyl) function is introduced into the 4,4-disubstituted (and optionally 7-substituted) chroman Compound 36 in a sequence of reaction steps which are described in Reaction Scheme 2 in connection with the analogous thiochroman compounds. Thus, a 6-acetylation chromane (Compound 36a) is first obtained, by acetylation with acetyl chloride, and thereafter the acetyl group is converted to the ethynyl group through treatment with lithium diisopropylamide, dialkyl chlorophosphate and another treatment with lithium diisopropylamide.

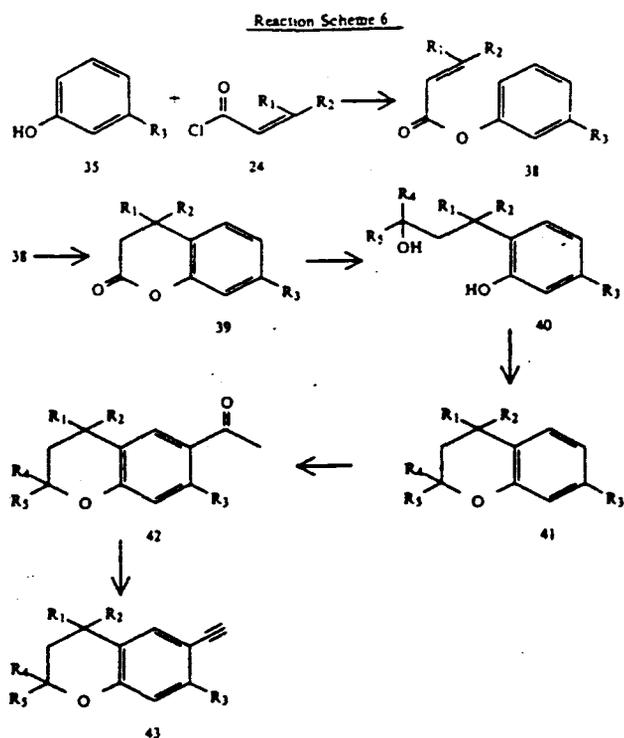
Compound 4 (or its analogs where R₃ is lower alkyl and/or where the 2,2 substituents have 2-6 carbons) can also be converted to the corresponding ZnCl salt (not shown in Reaction Scheme 5) prior to a coupling reaction with compounds of Formula 2.

Reaction Scheme 6 discloses, in general terms, the preparation of compounds of Formula 1 where X=O and R₄ and R₅ both are not hydrogen. In other words Reaction Scheme 6 discloses the preparation of 2 substituted, and preferably of 2,2-disubstituted 6-ethynyl chromanes.

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Thus, in accordance with Reaction Scheme 6, phenol, or a phenol substituted in the 3 (meta) position by an alkyl substituent (R_3) (Compound 35) is acylated with an acylating agent, such as the acid chloride (Compound 24) derived from an appropriately substituted acrylic acid. In Reaction Scheme 6, just as in Reaction Scheme 4, the R_1 and R_2 substituents of the target compounds are introduced through this acrylic acid derivative 24. The acylation with the acid chloride 24 is preferably conducted in the presence of a strong base (e.g. sodium hydride) in an inert solvent (such as tetrahydrofuran). The resulting substituted phenyl-acrylate is shown in Reaction Scheme 6 as Compound 38.

The substituted phenyl-acrylate 38 is ring closed under Friedel Crafts type reaction conditions ($AlCl_3$ catalyst, in an inert solvent, such as methylene chloride) to provide the 2-oxo-chroman compound (Compound 39) which bears, in the 4-position, the R_1 and R_2 substituents and in the 6-position the R_3 substituent (as applicable). Just like the analogous 2-oxo-thiochroman 26 in Reaction Scheme 4, the 2-oxo-chroman 39 of Reaction Scheme 6 is treated with a Grignard reagent to introduce the R_4 and R_5 substituents. As it was noted out above, in this Reaction Scheme R_4 and R_5 both cannot be hydrogen, and in the preferred embodiments R_4 and R_5 are identical, for example both are methyl or ethyl. When R_4 and R_5 are methyl, the Grignard reagent is preferably methylmagnesium chloride (dissolved in tetrahydrofuran, THF). A solution of Compound 39 in a suitable solvent, for example in dry diethylether is added to this Grignard reagent. The resulting phenol containing a tertiary alcohol side chain, (that is a mole-

cule in which the chroman ring had been opened) is shown in Reaction Scheme 6 as Compound 40.

Compound 40 which already has the desired R_1 , R_2 , R_3 , R_4 and R_5 substituents, is ring closed under acidic conditions, (e.g. by heating in aqueous sulfuric acid) to provide the chroman derivative (Compound 41). It should be noted that up this point in the synthetic sequence similar or analogous steps are involved for making both the 2,2-disubstituted thiochroman (Reaction Scheme 4) and the 2,2-disubstituted chroman derivatives (Reaction Scheme 6), the only difference being that in Reaction Scheme 6 the starting phenol derivative does not have a halogen (such as a bromo) substituent.

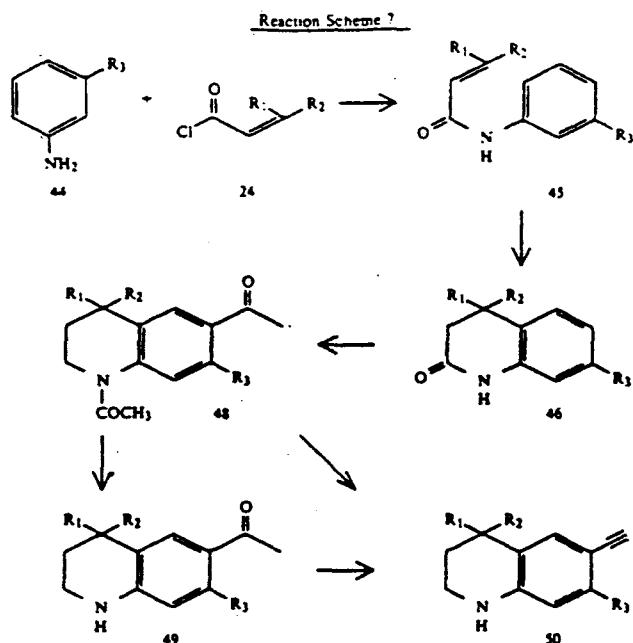
As is further disclosed in Reaction Scheme 6, the ethynyl group is introduced into the 2-substituted (preferably 2,2-disubstituted) chroman in a sequence of steps which is analogous to the steps described in Reaction Scheme 2 for introducing the ethynyl function into 4-substituted thiochromans. 6-Ethynylchroman 43 can also be utilized directly in the coupling reaction with compounds of Formula 2, or can be converted to a suitable metal, preferably $ZnCl_2$ salt, in the manner described above.

Compounds of Formula 1 where X is NR' (R' is H or lower alkyl) and R_4 and R_5 are both hydrogen can be made in accordance with Reaction Scheme 7. The reaction sequence of Scheme 7 is hereinafter described with primary emphasis to a preferred embodiment where R' is hydrogen, R_1 and R_2 (of Formula 1) are both methyl, and R_3 is hydrogen. Thus, with reference to Reaction Scheme 7, the tetrahydroquinoline

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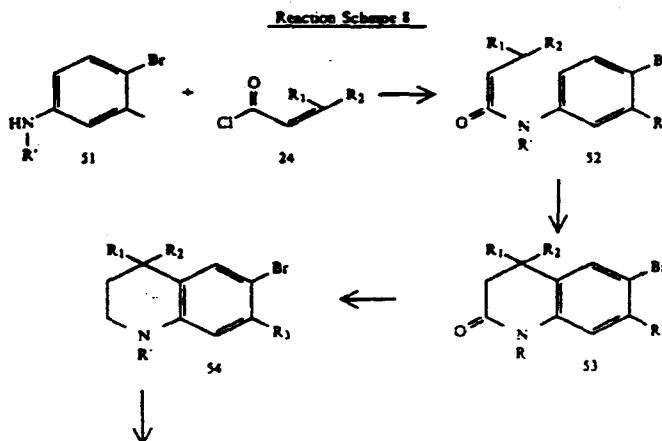


moiety, that is where X is nitrogen, is made in part by the method described in European patent application No. 0130795 published Sept. 1, 1985. First, Compound 24, 3-methylcrotonoyl chloride (when R₁ and R₂ are both methyl) is reacted with aniline 44 to obtain the amide 45. This amide 45 is then cyclized using aluminum chloride in the absence of solvent to give Compound 46. Lithium aluminum hydride or another acceptable reducing agent of similar type is then used to reduce the 2-oxo-1,2,3,4-tetrahydroquinoline 46, preferably in inert solvent such as diethyl ether. The resulting amine 47 is then acetylated using acetyl chloride in a polar solvent such as pyridine followed by acetylation in the presence of aluminum chloride to give Com-

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pound 48. Compound 48 is then subjected to base hydrolysis to give the secondary amine 49.

The 6-acetyl group of Compound 49 is thereafter converted into an ethynyl group in the manner described above for analogous transformation of 6-acetyl chromans or 6-acetyl thiochromans. The 6-ethynyl 1,2,3,4-tetrahydroquinoline (Compound 50) may be coupled directly or as the corresponding ZnCl salts, with compounds of Formula 2.

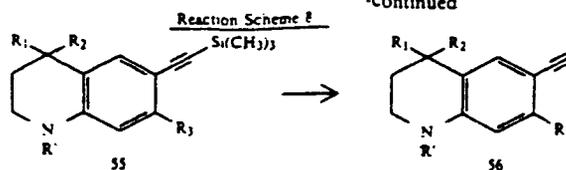
Alternatively compounds of Formula 1 where X= is NR', R₄ and R₅ are H, can also be prepared by the synthetic sequence outlined in Reaction Scheme 8 (R₁ and R₂ preferably are methyl). Reaction Scheme 8 will be self-explanatory to those skilled in the art in light of the analogous reactions disclosed in the present specification (R₃ is defined as above for Formula 1).



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The compounds of Formula 2 are coupled in accordance with the present invention with the compounds of Formula 1 to provide the biologically active compounds of Formula 3. The compounds of Formula 2 per se, are not new, and can be made in accordance with well known procedures, or by such adaptation of well known procedures which are within the skill of the practicing synthetic organic chemist.

In accordance with one preferred embodiment of the invention, group A of Formula 2 is a phenyl group, X' is halogen, preferably bromine or iodine. Ethyl-4-iodobenzoate is one preferred example of a reagent in accordance with Formula 2, used in coupling with the compounds of Formula 1. Other examples, where A is phenyl, are: ethyl 4-iodophenylacetate, ethyl 4-iodophenylpropionate, ethyl 4-iodo-phenylbutanoate, ethyl 4-iodo-phenylpentanoate. Reagents in accordance with Formula 2 where the X' and (CH₂)_n-B substituents respectively are in meta or ortho position on the phenyl ring, can also be used in the process of the invention. Moreover, the group characterized as B in Formula 2 may be a suitably protected or unprotected alcohol, aldehyde, ketone, amide, or such other functionality as is set forth in the definition of the group B of Formula 2. The preparation of such compounds in accordance with Formula 2, suitable for coupling with compounds of Formula 1, will be within the skill of the practicing organic chemist in light of the present disclosure.

When group A of Formula 2 is heteroaryl then examples of preferred reagents are: ethyl 6-chloronicotinate; ethyl 2-(2-chloropyrid-5-yl)acetate; ethyl 5-(2-chloropyrid-5-yl)pentanoate; ethyl 2-(2-iodofur-5-yl)acetate; ethyl 5-(2-iodofur-5-yl)pentanoate; ethyl 2-(2-iodothien-5-yl)acetate; ethyl 5-(2-iodothien-5-yl)pentanoate; ethyl 2-(3-chloropyridazin-6-yl) acetate; ethyl 5-(3-chloropyridazin-6-yl)pentanoate; and the corresponding chloro, or other halo, substituted pyrimidinyl or pyrazinyl analogues of such esters. In this series also, the B grouping of the compound of Formula 2 can be protected or unprotected alcohol, aldehyde, ketone, amide or other group, set forth in connection with Formula 2.

It is also within the scope of the present invention to Couple compounds of Formula 1 with compounds of Formula 2, and thereafter subject the resulting molecule (particularly that portion thereof which is derived from the reagent of Formula 2) to such routine synthetic transformations as a blocking and deblocking, homologation, reduction or oxidation, ester formation, saponification, and the like, which results in the formation of further analogs within the scope of Formula 3 and retinoic acid-like biological activity.

With respect to the novel coupling reaction of the process of the present invention, the following is noted. The coupling is affected typically in the presence of cuprous iodide, a suitable catalyst, typically of the formula Pd(PQ)₂Cl₂ and an acid acceptor, such as trieth-

ylamine, by heating in a sealed tube under an inert gas (argon) atmosphere.

Alternatively, the compound of Formula 1 is first converted to a salt (preferably ZnCl salt) for the coupling. exemplary generalized process for preparing ZnCl salts of the compounds of Formula 1 (where Z is converted from H to ZnCl) is described above in connection with Compounds 19.

Coupling of the ZnCl salts of the 6-thiochromanyl, 6-chromanyl and 6-(1,2,3,4-tetrahydroquinolinyl)-ethyne compounds with compounds of Formula 2, is conducted in the presence of Pd(PQ)₂ catalyst (Q is phenyl). For further details of the conditions of these reactions, reference is made to the following detailed procedures which describe the preparation of specific compounds.

SPECIFIC EXAMPLES

Phenyl-3-methylbut-2-enylsulfide (Compound 60)

A mixture of 14.91 g (135.324 mmol) of thiophenol and 5.5 g (137.5 mmol) of NaOH in 100 ml acetone was heated at reflux for 2.5 hours and then treated dropwise with a solution of 20 g (134.19 mmol) of 1-bromo-3-methyl-2-butene in 20 ml acetone. This solution was refluxed for 40 hours and then stirred at room temperature for 24 hours. Solvent was then removed in vacuo and the residue was taken up in water and extracted with 3x50 ml ether. Ether extracts were combined and washed with 3x30 ml of 5% NaOH solution, then water, saturated NaCl solution and dried (MgSO₄). Solvent was then removed in vacuo and the residue further purified by Kugelrohr distillation (80 degrees C., 0.75 mm) to give the title compound as a pale yellow oil. PMR (CDCl₃) δ 1.57 (3H, s), 1.69 (3H, s), 3.52 (2H, d, J=7.7 Hz), 5.29 (1H, t, J=7.7 Hz), 7.14 (1H, t, J=7.0 Hz), 7.24 (2H, t, J=7.0 Hz), 7.32 (2H, d, J=7.0 Hz).

Proceeding in a similar manner, but substituting for thiophenol the appropriate 3-alkylthiophenol, the following compounds can be prepared:

3-methylphenyl-3-methylbut-2-enylsulfide;
3-ethylphenyl-3-methylbut-2-enylsulfide;
3-propylphenyl-3-methylbut-2-enylsulfide;
3-butylphenyl-3-methylbut-2-enylsulfide;
3-pentylphenyl-3-methylbut-2-enylsulfide; and
3-hexylphenyl-3-methylbut-2-enylsulfide.

4-Dimethylthiochroman (Compound 61)

To a solution of 15.48 g (86.824 mmol) of phenyl-3-methylbut-2-enylsulfide (Compound 60) in 160 ml benzene were added successively 12.6 g (88.767 mmol) of phosphorus pentoxide and 11 ml of 85% phosphoric acid. This solution was refluxed with vigorous stirring under argon for 20 hours, then cooled to room temperature. The supernatant organic layer was decanted and the syrupy residue extracted with 3x50 ml ether. Organic fractions were combined and washed with water, saturated NaHCO₃ and saturated NaCl solutions and then dried (MgSO₄). Solvent was removed in vacuo and

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the residue purified by kugelrohr distillation (80 degrees C., 0.5mm) to give the title compound as a pale yellow oil. PMR (CDCl₃): δ 1.30 (6H, s), 1.90-1.95 (2H, m), 2.95-3.00 (2H, m), 6.96-7.00 (2H, m), 7.04-7.07 (1H, m), 7.30-7.33 (1H, m).

This method can be used to make 7-position alkyl analogues as exemplified by the following compounds:
4,4,7-trimethylthiochroman (Compound 2)
4,4-dimethyl-7-ethylthiochroman;
4,4-dimethyl-7-propylthiochroman;
4,4-dimethyl-7-butylthiochroman; and
4,4-dimethyl-7-hexylthiochroman.

4,4-Dimethyl-6-acetylthiochroman (Compound 62)

A solution of 114.3 g (80.21 mmol) of 4,4-dimethylthiochroman (Compound 61) and 6.76 g (86.12 mmol) of acetyl chloride in 65 ml benzene was cooled in an ice bath and treated dropwise with 26.712 g (102.54 mmol) of stannic chloride. The mixture was stirred at room temperature for 12 hours, then treated with 65 ml water and 33 ml conc. hydrogen chloride and heated at reflux for 0.5 hours. After being cooled to room temperature, the organic layer was separated and the aqueous layer extracted with 5 x 50 ml benzene. The recovered organic fractions were combined and washed with 5% sodium carbonate, water, saturated NaCl and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; 5% ethyl acetate in hexanes) followed by kugelrohr distillation (150 degrees C., 0.7 mm) to give the title compound as a pale yellow oil. PMR (CDCl₃): δ 1.35 (6H, s), 1.92-1.98 (2H, m), 2.54 (3H, s), 3.02-3.08 (2H, m), 7.13 (1H, d, J=8.6 Hz), 7.58 (1H, dd, J=8.6 Hz, 2Hz), 7.99 (1H, d, J=2Hz).

This procedure serves to acetylate all the compounds which can be made by the process given for the preparation of Compound 61.

4,4-Dimethyl-ethynylthiochroman (Compound 1)

To a solution of 1.441 g (14.2405 mmol) of isopropylamine in 30 ml dry tetrahydrofuran under argon at -78 degrees C. was added dropwise 9ml of 1.6M (14.4 mmol) n-butyl lithium in hexane. After stirring this solution at -78 degrees C. for 1 hour, it was treated dropwise with a solution 2.95 g (13.389 mmol) of 4,4-dimethyl-6-acetylthiochroman (Compound 62) in 5 ml of dry tetrahydrofuran. After another hour of stirring at -78 degrees C., the solution was treated with 2.507 g (14.53 mmol) of diethyl chlorophosphate and brought to room temperature, where it was stirred for 3.75 hours. This solution was then transferred using a double ended needle to a solution of lithium diisopropylamide [prepared using 2.882 g (28.481 mmol) of diisopropylamine and 18 ml of 1.6M (28.8 mmol) n-butyllithium in hexane] in 60 ml dry tetrahydrofuran at -78 degrees C. The cooling bath was removed and the solution stirred at room temperature for 15 hours, then quenched with water and acidified to pH 1 with 3N hydrogen chloride. The mixture was extracted with 5 x 50 ml pentane and the combined organic fractions washed with 3N hydrogen chloride, water, saturated NaHCO₃ and saturated NaCl, then dried (MgSO₄). Solvent was then removed in vacuo, and the residue purified by kugelrohr distillation (100 degrees C., 0.7mm) to give the title compound as a pale yellow solid. PMR (CDCl₃): δ 1.34 (6H, s), 1.94-1.99 (2H, m), 3.04-3.08 (3H, m), 7.06 (1H, d, J=8.4 Hz), 7.17 (1H, dd, J=8.4 Hz, 2.1 Hz), 7.51 (1H, d, J=2.1 Hz).

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Similarly, the acetyl group of all compounds prepared similar to the preparation of Compound 62, can be converted to an ethynyl function.

4,4-dimethyl-6-ethynylthiochroman ZnCl (Compound 63) and ethyl 4-(4,4-dimethylthiochroman-6-yl-ethynyl) benzoate (Compound 64)

Reaction vessels used in this procedure were flame dried vacuum and all operations carried out in an oxygen-free, argon or nitrogen atmosphere. To a solution of 533.9 mg (2.6389 mmol) of 4,4-dimethyl-6-ethynylthiochroman (Compound 1) in 4ml of dry tetrahydrofuran at 0 degrees C. was added dropwise 1.7 ml of 1.6M (2.72 mmol) n-butyl lithium in hexane. This was stirred at 0 degrees C. for 10 minutes and at room temperature for 15 minutes, cooled again to 0 degrees C. and then treated with a solution of 410 mg (3.005 mmol) of fused ZnCl₂ in 4 ml dry tetrahydrofuran using a double ended needle. Thereafter, the solution was stirred at 0 degrees C. for 45 minutes, then at room temperature for 20 minutes to give compound 63. This product was not isolated but further used as follows: A solution of 724.4 mg (2.6243 mmol) of ethyl 4iodobenzoate in 4 ml dry tetrahydrofuran was transferred by double ended needle into a suspension of 520 mg (0.45 mmol) of tetrakis-triphenylphosphine palladium in 5 ml dry tetrahydrofuran and stirred at room temperature for 20 minutes, then treated by double ended needle with the solution of the alkynyl zinc chloride prepared above. This mixture was stirred at room temperature for 18 hours, then quenched with ice and 30 ml 3N hydrogen chloride. Product was recovered by extraction with 3 x 75 ml ether. Ether fractions were combined and washed successively with saturated NaHCO₃ and saturated NaCl solutions and dried (MgSO₄). Solvent was removed in vacuo and the residue purified by flash chromatography (silica; 5% ethyl acetate in hexane) followed by HPLC (Whatman Partisil M-9 10/50; 4% ethyl acetate in hexane) to give ethyl 4-(4,4-dimethylthiochroman-6-yl-ethynyl) benzoate (Compound 64) as a colorless oil. PMR (CDCl₃): δ 1.36 (6H), 1.42 (3H, t, J=7 Hz), 1.93-1.99 (2H, m), 3.03-3.08 (2H, m), 4.40 (2H, q, J=7 Hz), 7.09 (1H, d, J=8.4 Hz), 7.22 (1H, dd, J=8.4 Hz, 2.1 Hz), 7.56 (1H, d, J=2.1 Hz), 7.59 (2H, d, J=7.8 Hz), 8.04 (2H, d, J=7.8 Hz).

(3-Methyl-4-bromo-phenyl)-3-methylbut-2-enylsulfide (Compound 65)

To a stirred solution of 9.52 g (68 mmol) of 3-methyl-4-bromo-thiophenol in 80 ml of acetone was added 2.86 g (68 mmol) of powdered sodium hydroxide and mixture stirred until dissolution was complete. The reaction mixture was then heated to reflux, and then treated with a solution of 11.26 g (68 mmol) of 4-bromo-2-methyl-2-butene in 20 ml of acetone. The mixture was heated at reflux for a further 0.5 h, cooled to room temperature and the solvent removed in vacuo. The residue was taken up in 35 ml of water and extracted with ether. The ether extracts were combined and washed successively with water and saturated NaCl solution and then (MgSO₄). The solvent was removed in vacuo and the residue kugelrohr distilled (140-145 degrees C., 0.2 mm) to give the title compound as a colorless oil. PMR (CDCl₃): δ 1.58 (3H, s), 1.70 (3H, s), 2.33 (3H, s), 3.49 (2H, d, J=7.8 Hz), 5.26 (1H, t, J=7.8 Hz), 6.98 (1H, dd, J=8.3 Hz, 2.3 Hz), 7.7 (1H, d, J=2.3 Hz), 7.38 (1H, d, J=8.3 Hz).

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4,4,7-Trimethyl-6-bromothiochroman (Compound 66)

To 40 g of a vigorously stirred mixture of 10% phosphorous pentoxide in methane-sulfonic acid was added slowly 6.0 g (28.8 mmol) of (3-methyl-4-bromophenyl)-3-methylbut-2-enyl-sulfide (Compound 65). The mixture was stirred at room temperature for a further 2 h and was then poured onto ice. The mixture was extracted with 2 x 40 ml of ether and the combined ether extracts were washed successively with water and saturated NaCl solution and then dried. The solvent was removed in vacuo and the residue kugelrohr distilled (130 degrees C.; 0.07 mm) to give the title compound as a viscous oil. PMR (CDCl₃): δ 1.28 (6H, s) 1.84-1.93 (2H, m), 2.26 (3H, s), 2.95-3.03 (2H, m), 6.94 (1H, s), 7.46 (1H, s).

4,4,7-Trimethyl-6-trimethylsilylethynyl-thiochroman (Compound 67)

A mixture of 624 mg (3.0 mmol) of 4,4,7-trimethyl-6-bromothiochroman (Compound 66) 314 mg (3.2 mmol) of trimethylsilyl acetylene, 40 mg (0.21 mmol) of cuprous iodide, 80 mg (0.11 mmol) of bis (triphenylphosphine) palladium (II) chloride and 1 ml of triethylamine was degassed under nitrogen and heated in a sealed tube at 85 degrees C. for 15 h. The mixture was then treated with a further 20 mg (0.11 mmol) of cuprous iodide and 40 mg (0.06 mmol) of the palladium (II) catalyst. The mixture was then heated under a nitrogen atmosphere in the sealed tube at 100 degrees C. for a further 64 h. The triethylamine was then removed under vacuum and the residue purified by flash chromatography (silica; hexanes) to give the title compound as a yellow oil. PMR (CDCl₃): δ 0.28 (9H, s), 1.30 (6H, s), 1.88-1.97 (2H, m), 2.33 (3H, s), 2.97-3.05 (2H, m), 6.92 (1H, s), 7.43 (1H, s).

4,4,7-Trimethyl-6-ethynyl-Thiochroman (Compound 2)

A mixture of 380 mg (1.69 mmol) of trimethylsilyl (4,4,7-trimethyl-thiochroman-6-yl) ethyne, (Compound 67) 4 ml of isopropanol and 2.5 ml of aqueous 1N potassium hydroxide was degassed under nitrogen and stirred at room temperature for 16 h. The mixture was concentrated under vacuum and extracted with 2 x 10 ml of ether. The ether extracts were combined and washed successively with water and saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo to give the title compound as a yellow oil. PMR (CDCl₃): δ 1.31 (6H, s), 1.88-1.96 (2H, m), 2.35 (3H, s), 3.00-3.08 (2H, m), 3.25 (1H, s), 6.94 (1H, s), 7.47 (1H, s).

S-(4-bromophenyl) 3,3-dimethylthioacrylate (Compound 69)

To an ice bath cooled solution of 1.92 g (80 mmol) of NaH (obtained from a 60% suspension in mineral oil by 3 x 15 ml hexane wash) in 30 ml of dry THF was added slowly under argon a solution of 15.1 g (80 mmol) of 4-bromothiophenol in 60 ml of dry THF over 1 h. The mixture was stirred at 0 degrees C. for a further 30 min and then treated with a solution of 10.1 g (85 mmol) of dimethylacryloyl chloride in 30 ml of dry THF. The cooling bath was then removed and the mixture then stirred at room temperature for 40 h. The reaction mixture was poured into 200 ml of water containing 2 ml of glacial acetic acid and the organic layer was separated. The organic layer was washed with 2 x 75 ml of water and then dried (MgSO₄). The solvent was removed in vacuo to give the title compound as a yellow oil. PMR

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(CDCl₃): δ 1.91 (3H, s), 2.14 (3H, s), 6.03-6.06 (1H, m), 7.28 (2H, d, J=8.6 Hz), 7.53 (2H, d, J=8.6 Hz).

4,4-Dimethyl-6-bromo-2-oxo-thiochroman (Compound 70)

To a stirred, ice-cooled suspension of 15.9 g (119 mmol) of aluminum chloride in 140 ml of methylene chloride was added under nitrogen, a solution of 21.64 g (79.9 mmol) of S-(4-bromophenyl) 3,3-dimethyl-thioacrylate (Compound 69) in 100 ml of methylene chloride. The mixture was then stirred at room

for 72 h and then poured into 250 g of an ice and brine mixture. The mixture was extracted with methylene chloride and the combined organic extracts were washed with saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue recrystallized from hexanes to give the title compound as white crystals. PMR (CDCl₃): δ 1.40 (6H, s), 2.67 (2H, s), 7.31-7.40 (3H, m). MS exact mass, m/e 269.9714 (calcd. for C₁₁H₁₁ SOBr, 269.9714).

4-Bromo-2-(1,1,3-trimethyl-3-hydroxybutyl) thiophenol (Compound 71)

To 3.49 g (32.8 mmol) of lithium perchlorate was added under argon 35 ml of 3.0M (105 mmol) methyl magnesium bromide in ether. The above mixture was treated dropwise with stirring with a solution of 2.961 g (10.926 mmol) of 4,4-dimethyl-6-bromo-2-oxo-thiochroman (Compound 70) and the reaction mixture was then heated at reflux for 70 h. The reaction mixture was then allowed to cool and poured onto a mixture of 100 g of ice and 8 ml of conc. H₂SO₄. The organic layer was separated and the aqueous layer was extracted with 2 x 25 ml ether. The organic layers were combined and washed successively with 2 x 25 ml of saturated NaHCO₃ solution, 25 ml of water and 25 ml of saturated NaCl solution and then dried (MgSO₄). The solvent was removed in-vacuo and the residue purified by flash chromatography to give the title compound as pale yellow oil. PMR (CDCl₃): δ 1.05 (6H, s), 1.52 (6H, s), 2.30 (2H, s), 3.71 (1H, s), 7.22 (1H, dd, J=8.5 Hz, 2.1 Hz), 7.28 (1H, d, J=8.5 Hz), 7.35 (1H, d, J=2.1 Hz).

Using ethyl magnesium bromide, instead of methyl magnesium bromide, provides the corresponding 4-bromo-2-(1,1 dimethyl 3-ethyl-3-hydroxypropyl)-thiophenol.

2,2,4,4-Tetramethyl-6-bromothiochroman (Compound 72)

A mixture of 500 mg (1.49 mmol) of 4-bromo-2-(1,1,3-trimethyl-3-hydroxybutyl) thiophenol (Compound 71) and 8 ml of 20 percent aqueous H₂SO₄ was heated at reflux for 24 h. The mixture was extracted with hexanes, the organic extracts were combined and washed successively with water, saturated NaHCO₃, water again, saturated NaCl and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; hexanes) to give the title compound as a colorless oil. PMR (CDCl₃): δ 1.35 (6H s) 1.40 (6H, s), 1.93 (2H, s), 7.17 (1H, dd, J=8.4 Hz, 2.1 Hz), 7.23 (1H, d, J=8.4 Hz), 7.26 (1H, d, J=2.1 Hz). MS exact mass, m/e 284.0221 (calcd. for C₁₃H₁₇ S Br, 284.0234).

2,2,4,4-Tetramethyl-6-trimethylsilylethynyl-thiochroman (Compound 73)

A solution of 600 mg (2.11 mmol) of 2,2,4,4-tetramethyl-6-bromothiochroman (Compound 72) in 1.5

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ml of triethylamine was placed in a heavy-walled tube and degassed and then treated under argon with 1.4 g (14.3 mmol) of trimethylsilylacetylene and a powdered mixture of 75 mg (0.39 mmol) of cuprous and 150 mg (0.21 mmol) of bis(triphenyl) nylphosphine) palladium (II) chloride. The reaction mixture was degassed again, then placed under argon and the tube was sealed. The mixture was heated at 100 degrees C. for 24 h, allowed to cool to room temperature and then treated with a further 1.4 g (14.3 mmol) of trimethylsilylacetylene and a powdered mixture of 75 mg (0.39 mmol) of cuprous iodide and 150 mg (0.21 mmol) of bis(triphenylphosphine) palladium (II) chloride. The mixture was then degassed, placed under argon and then heated in the sealed tube at 100 degrees C. for 96 h. The mixture was cooled to room temperature and extracted with 3 x 10 ml of ether. The organic extracts were combined, washed successively with 25 ml of water and 25 ml of saturated sodium chloride solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; hexanes followed by 3% ethyl acetate in hexanes) to give the title compound as a yellow, crystalline solid. PMR (CDCl₃): δ 0.23 (9H, s), 1.36 (6H, s), 1.39 (6H, s), 1.94 (2H, s), 7.17 (1H, dd, J=8.2 Hz, 1.8 Hz), 7.25 (1H, d, J=1.8 Hz), 7.30 (1H, d, J=8.2 Hz). MS exact mass, m/1 302.1519 (calcd. for C₁₅H₂₆ S Si, 382.1524).

2,2,4,4-Tetramethyl-6-ethynylthiochroman (Compound 3)

To a solution of 527.6 mg (1.75 mmol) of 2,2,4,4-tetramethyl-6-trimethylsilyl-ethynylthiochroman (Compound 73) in 4 ml of isopropanol was added, under argon, 4 ml of 1N KOH solution. The reaction mixture was stirred at room temperature for 20 h and the isopropanol was then removed under vacuum. The residue was extracted with ether and the combined ether extracts were washed successively with water and saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo to give the title compound as a yellow oil. PMR (CDCl₃): δ 1.34 (6H, s), 1.37 (6H, s), 1.91 (2H, s), 2.99 (1H, s), 7.17 (1H, dd, J=8.1 Hz, 1.8 Hz), 7.26 (1H, d, J=1.8 Hz), 7.30 (1H, d, J=8.1 Hz). MS exact mass, m/e 230.1122 (calcd. for C₁₅H₁₈S, 230.1129)

Diphenyl-3-methyl-3-buten-1-yl phosphate (Compound 75)

To an ice-cooled solution of 12.2 g (141.65 mmol) of 3-methyl-3-buten-1-ol (Aldrich) and 1.9 g (150.44 mmol) of pyridine in 100ml of tetrahydrofuran was added dropwise under argon a solution of 38.5 g (143.21 mmol) of diphenyl chlorophosphate (Compound 32) in 100ml of tetrahydrofuran. The mixture was heated at reflux for 3 hours and then cooled and filtered. The filtrate was concentrated in vacuo and the residue dissolved in 400ml of 1:1 ether and hexane and then washed with 2 x 200 ml water, 75 ml saturated NaCl solution and dried (MgSO₄). The solvent was removed in vacuo to give the title compound as a pale yellow oil. PMR (CDCl₃): δ 1.69 (3H, s), 2.37 (2H, t, J=7 Hz), 4.32 (2H, q, J=7 Hz), 4.72 (1H, s), 4.80 (1H), 7.10-7.35 (10H, m).

4,4-Dimethylchroman (Compound 76)

To a dry, ice-cooled flask containing 34.95 g (0.134 mol) of stannic chloride was added quickly under argon 63.0 g (0.669 mol) of phenol. The mixture was stirred at

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0 degrees C. for 0.5 hour and then treated with 43.0 g (0.135 mol) of diphenyl-3-methyl-3-buten-1-yl phosphate (Compound 75), followed by a 5 ml carbon disulfide rinse. The mixture was stirred at room temperature for 21 hours and then quenched by pouring onto 700 g ice and 1 liter of 1.5N NaOH. The mixture was extracted with 1 x 600 ml and 2 x 300 ml ether. The combined ether fractions were washed with 2N NaOH, saturated NaCl and dried (MgSO₄). Solvent was removed in vacuo and the residue purified by flash chromatography (silica; 2% ether in hexane) to give the title compound as a colorless oil. PMR (CDCl₃): δ: 1.34 (6H), 1.80-1.85 (2H, m), 4.15-4.20 (2H, m), 6.80 (1H, dd, J=8.1 Hz, 1.5 Hz), 6.87 (1H, td, J=8.1 Hz, 1.5 Hz), 7.07 (1H, td, J=8.1 Hz, 1.5 Hz), 7.26 (1H, dd, J=8.1 Hz, 1.5 Hz).

In a similar manner, but substituting the corresponding 3 alkylphenol for phenol, there may be prepared the following compounds:

4,4,7-trimethylchroman;

4,4-dimethyl-7-ethylchroman;

4,4-dimethyl-7-propylchroman; and

4,4-dimethyl-7-pentylchroman.

4,4-Dimethyl-6-acetylchroman (Compound 77)

To a stirred solution of 7.94 g (48.9425 mmol) of 4,4-dimethylchroman (Compound 76) in 70 ml of nitromethane was added under argon 4.0 g (50.96 mmol) of acetyl chloride followed by 6.8 g (51 mmol) of aluminum chloride. This was stirred at room temperature for 5.5 hours and then cooled in an ice bath and treated slowly with 70 ml of 6N hydrogen chloride. The resultant mixture was stirred at room temperature for 10 minutes and then treated with 100 ml ether and the organic layer separated. The organic layer was washed with water, saturated NaHCO₃ and saturated NaCl solutions and dried (MgSO₄). Solvent was removed in vacuo and the residue purified by flash chromatography (silica; 10% ethyl acetate in hexanes). This was followed by kugelrohr distillation (95-100 degrees C.; 0.15 mm) to give the title compound as a colorless oil. PMR (CDCl₃): δ 1.40 (6H), 1.95-2.00 (2H, m), 2.58 (3H), 4.25-4.30 (2H, m), 6.83 (1H, d, J=8.0 Hz), 7.62 (1H, dd, J=8.0 Hz, 1.5 Hz), 8.00 (1H, d, J=1.5 Hz).

Proceeding in the same manner, the other chroman made similar to Compound 76, are converted to their respective acetyl analogs.

4,4-Dimethyl-6-ethynylchroman (Compound 4)

To a solution of 2.47 g (24.41 mmol) of diisopropylamine in 40 ml dry tetrahydrofuran under argon at -78 degrees C. was added dropwise 15.2ml of 1.6M (24.32 mmol) n-butyl lithium in hexane. This mixture was stirred at -78 degrees C. for 1 hour and then treated dropwise with a solution of 4.98 g (24.38 mmol) of 4,4-dimethyl-6-acetylchroman (Compound 77) in 1 ml dry of tetrahydrofuran. After stirring at -78 degrees C. for 1 hour, the solution was treated with 4.2 g (24.36 mmol) of diethyl chlorophosphate. The cooling bath was then removed and the reaction mixture stirred at room temperature for 2.75 hours. This solution was then transferred using a double ended needle to a solution of lithium diisopropyl amide [prepared using 4.95 g (48.92 mmol) of diisopropylamine and 30.5 ml of 1.6M (48.8 mmol) n-butyllithium in hexane] in 80 ml dry tetrahydrofuran -78 degrees C. The cooling bath was removed and mixture stirred at room temperature for 18 hours then quenched with 50 ml water and 25 ml of 3N hydrogen chloride. The mixture was extracted with

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2 × 100 ml and 3 × 50 ml of pentane and the combined organic fractions washed with 3N hydrogen chloride, water, saturated NaHCO₃ and saturated NaCl solutions and then dried (MgSO₄). Solvent was then removed in vacuo and the residue purified by flash chromatography (silica; 10% ethyl acetate in hexane) followed by kugelrohr distillation (70 degrees C.; 0.35mm) to give the title compound as a colorless crystalline solid. PMR (CDCl₃): δ 1.33 (6H), 1.81-1.86 (2H, m), 3.00 (1H, s), 4.19-4.24 (2H, m), 6.75 (1H, d, J=8.5 Hz), 7.22 (1H, dd, J=8.5 Hz, 2.3 Hz), 7.44 (1H, d, J=2.3 Hz).

Using this method, the acetyl derivatives, made similar to Compound 77, are converted to the ethynyl form.

4,4-dimethyl-6-ethynylchroman ZnCl (compound 79)
and ethyl 4-(4,4-dimethylchroman-6-yl-ethynyl)
benzoate (compound 80)

Reaction vessels used in this procedure were flame dried under vacuum and all operations were carried out in an oxygen-free, argon or nitrogen atmosphere. To a solution of 509.4 mg (2.74 mmol) of 4,4-dimethyl-6-ethynyl chroman (Compound 78) in 4 ml of dry tetrahydrofuran at 0 degrees C. was added dropwise 1.72 ml of 1.6M (2.75 mmol) of n-butyl lithium in hexane. Stirring was commenced at 0 degrees C. for 30 minutes and at room temperature for 15 minutes, after which the solution was cooled again to 0 degrees C. and then treated with a solution of 380 mg (2.79 mmol) of fused zinc chloride in 5 ml of dry tetrahydrofuran using a double ended needle. The resulting solution was stirred at 0 degrees C. for 1 hour and then at room temperature for 15 minutes to give Compound 79.

This product was not isolated but further used as follows: A solution of 628.6 mg (2.74 mmol) of ethyl 4-bromobenzoate in 4 ml of dry tetrahydrofuran was transferred by double ended needle into a suspension of 380 mg (0.33 mmol) tetrakis(triphenylphosphine) palladium in 5 ml dry tetrahydrofuran and stirred at room temperature for 15 minutes, then treated by double ended needle with the solution of alkylnyl zinc chloride prepared above. The mixture was stirred at room temperature for 20 hours and then quenched with ice and 30 ml of 3N hydrogen chloride. The mixture was then extracted with 3 × 75 ml ether and ether extracts were combined and washed successively with saturated NaHCO₃ and saturated NaCl solutions and then dried (MgSO₄). Solvent was removed in vacuo and the residue further purified by flash chromatography (silica; 10% ethyl acetate in hexane) to obtain ethyl 4-(4,4-dimethylchroman-6-yl-ethynyl) benzoate (Compound 80) as a white solid. PMR (CDCl₃): δ 1.36 (6H), 1.42 (3H, t, J=7.3 Hz), 1.82-1.86 (2H, m), 4.21-4.25 (2H, m), 4.40 (2H, q, J=7.3 Hz), 6.79 (1H, d, J=8.1 Hz), 7.28 (1H, dd, J=8.1 Hz, 2.2 Hz), 7.50 (1H, d, J=2.2 Hz), 7.58 (2H, d, J=8.7 Hz), 8.03 (2H, J=8.7 Hz).

Phenyl 3,3-dimethylacrylate (Compound 81)

To an ice bath cooled solution of 1.29 g (54 mmol) of NaH (obtained from a 60% suspension in mineral oil by 3 × 10 ml hexane wash) in 20 ml of dry THF was added slowly under oxygen a solution of 5 g (53 mmol) of phenol in 50 ml of dry THF. The mixture was then treated with a solution of 7 g (59 mmol) of dimethylacryloyl chloride in 300 ml of dry THF. The cooling bath was then removed and the mixture was stirred for a further 2.5 h. The reaction mixture was then poured into 150 ml of water containing 1 ml of glacial acetic acid. The mixture was extracted with 150 ml ether and

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the ether extract washed with saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; 5% ether in hexanes) to give the title compound as a yellow oil. PMR (CDCl₃): δ 1.99 (3H, s), 2.24 (3H, s), 5.93 (1H, broad s), 7.10 (2H, d, J=7.8 Hz) 7.22 (1H, t, J=7.8 Hz), 7.38 (2H, t, J=7.8 Hz).

4,4-Dimethyl-2-oxo-chroman (Compound 82)

To a stirred, ice-cooled suspension of 10.4 g (78 mmol) of aluminum chloride in 160 ml of methylene chloride was added slowly under argon a solution of 7 g (39.8 mmol) of phenyl 3,3-dimethylacrylate (Compound 81) in 40 ml of methylene chloride. The cooling bath was removed and the mixture stirred a further 42 h. The mixture was poured into a mixture of and brine and the organic layer separated. The aqueous layer was extracted with methylene chloride and the organic extracts were combined and washed with saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; 10% ether in hexane) to give the title compound as a colorless oil. PMR (CDCl₃): δ 1.30 (6H, s), 2.56 (2H, s), 7.06 (1H, dd, J=8.0 Hz, 1.4 Hz), 7.16 (1H, td, J=8.0 Hz, 1.4 Hz), 7.26 (1H, td, J=8.0 Hz, 1.7 Hz), 7.33 (1H, dd, J=8.0 Hz, 1.7 Hz). MS exact mass, m/e 176.0852 (calcd. for C₁₁H₁₂O₂, 176.0837).

2-(1,1,3-Trimethyl-3-hydroxybutyl)phenol (Compound 83)

To 11 ml of 3.0 M (33 mmol) methyl magnesium chloride in THF, cooled in an ice bath, was added, under nitrogen a solution of 1.96 g (11.1 mmol) of 4,4-dimethyl-2-oxo-chroman (Compound 82) in 35 ml of dry ether. The cooling bath was then removed and the mixture stirred at room temperature for 72 h. The reaction mixture was then poured onto a mixture of 100 g of ice and 3 ml of conc. H₂SO₄ and stirred until the magnesium salts were dissolved. The organic layer was separated and the aqueous layer extracted with 2 × 50 ml of ether. organic layers were combined and washed successively with water, saturated NaHCO₃ and saturated NaCl solutions and then dried (MgSO₄). The solvent was removed in vacuo and the residue was purified by flash chromatography (silica; 20% ethyl acetate in hexanes) to give the title compound as a pale yellow solid. PMR (CDCl₃): δ 1.13 (6H, s), 1.48 (6H, s), 1.89 (1H, s), 2.23 (2H, s), 6.60 (1H, dd, J 7.9 Hz, 1.4 Hz), 6.83 (1H, s), 6.84 (1H, td, J=7.9 Hz, 1.4 Hz), 7.07 (1H, td, J=7.9 Hz, 1.6 Hz), 7.31 (1H, dd, J=7.9 Hz, 1.6 Hz). MS exact mass, m/1 20.1458 (calcd. for C₁₃H₂₀O₂, 208.1464).

2,2,4,4-Tetramethyl-chroman (Compound 84)

A mixture of 2.98 g (14.3 mmol) of 2-(1,1,3-trimethyl-3-hydroxybutyl) phenol (Compound 83) and 40 ml of 20% aqueous H₂SO₄ was heated at reflux, under nitrogen, for 4 h. The mixture was stirred at room temperature for a further 72 h and then diluted with 50 ml of water. The mixture was extracted with 3 × 20 ml of hexanes. The organic extracts were then combined and washed successively with water and saturated NaCl solution and then dried (MgSO₄). The solvent was then removed in vacuo to give the title compound as a colorless oil. PMR (CDCl₃): δ 1.36 (6H, s), 1.37 (6H, s), 1.83 (2H, s), 6.71 (1H, dd, J=8.2 Hz, 1.5 Hz) 6.92 (1H, td, J=8.2 Hz, 1.5 Hz), 7.09 (1H, td, J=8.2 Hz, 1.5 Hz), 7.29 (1H, dd, J=8.2 Hz, 1.5 Hz).

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2,2,4,4-Tetramethyl-6-acetyl-chroman (Compound 85)

To an ice bath cooled solution of 2 g (10.53 mmol) of 2,2,4,4-tetramethylchroman (Compound 84) in 25 ml of nitromethane was added, under nitrogen, 941 mg (11.99 mmol) of acetyl chloride followed by 1.59 g (11.92 mmol) of aluminum chloride. The cooling bath was then removed and the mixture stirred at room temperature for 16 h. The mixture was then cooled again in an ice bath and treated with 25 ml of conc. HCl. The mixture was then filtered and the residue washed with methylene chloride. The filtrate was concentrated in vacuo and the resultant residue was purified by flash chromatography (silica; 10% ethyl acetate in hexanes) to give the title compound as a yellow oil. PMR (CDCl₃): δ 1.38 (6H, s), 1.39 (6H, s), 1.87 (2H, s), 2.56 (3H, s), 6.83 (1H, d, J=8.7 Hz), 7.71 (1H, dd, J=8.7 Hz, 2.1 Hz), 7.98 (1H, d, J=2.1 Hz). MS exact mass, m/e 232.1468 (calcd. for C₁₃H₂₀O₂, 232.1464).

2,2,4,4-Tetramethyl-6-ethynyl-chroman (Compound 5)

To a cooled (-78 degrees C.) solution of 522 mg (5.17 mmol) of diisopropylamine in 8 ml of dry THF was added slowly, under nitrogen, 3.23 ml of 1.6 M (5.17 mmol) n-butyl lithium in hexane. The mixture was stirred at -78 degrees C. for 40 minutes and then treated with a solution of 1.24 g (5.17 mmol) of 2,2,4,4-tetramethyl-6-acetylchroman (Compound 85) in 2 ml dry THF. The mixture was stirred at -78 degrees C. for a further 1 h and then treated with 895 mg (5.19 mmol) of diethylchlorophosphate. The reaction mixture was allowed to warm room temperature and transferred by double-ended needle into a solution of lithium diisopropylamide in THF at -78 degree C. [prepared as described above from 1.04 g (10.34 mmol) of diisopropylamine and 6.46 ml of 1.6 M (10.34 mmol) n-butyl lithium in hexane]. The cooling bath was removed and the mixture was stirred at room temperature for 16 h. The mixture was then treated with 10 ml of ice water and acidified to a pH of 2 with 10% HCl. The organic layer was separated and the aqueous layer was extracted with 3x30 ml of pentane. The organic extracts were combined and washed successively with 2.30 ml of dilute HCl, water, 3x30 ml of saturated NaHCO₃ solution and saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue was purified by flash chromatography (silica; 2% ethyl acetate in hexane) to give the title compound as a pale yellow oil. PMR (CDCl₃): δ 1.31 (6H, s), 1.32 (6H, s), 1.50 (2H, s), 3.00 (1H, s), 6.72 (1H, d, J=8.4 Hz), 7.20 (1H, dd, J=8.4 Hz, 2.1 Hz), 7.42 (1H, d, J=2.1 Hz). MS exact mass, m/e 214.1251 (calcd. for C₁₅H₁₈O, 214.1357).

3-Methyl-phenyl-3,3-dimethylacrylate (Compound 87)

A 60% suspension of sodium hydride (3.22 g; 81 mmol) in mineral oil was washed with 3x10 ml of hexane and then treated with 30 ml of dry THF. This mixture was cooled in an ice-bath and then treated with a solution of 8.6 g (79.5 mmol) of m-cresol in 80 ml of dry THF. The reaction mixture was stirred for 10 min and then treated with a solution of 10.5 g (88.5 mmol) of dimethylacryloyl chloride in 40 ml of dry THF. The reaction mixture was stirred at room temperature for 96 h and then poured into a mixture of 150 ml of water and 1 ml of glacial acetic acid. The mixture was stirred for 10 min and the organic layer was separated. The aqueous layer was extracted with 2x5 ml of ether. The

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organic layers were combined and washed successively with water and saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue was purified by flash chromatography (silica; 10% ethyl acetate in hexane) to give the title compound as a pale yellow oil. PMR (CDCl₃): δ 1.95 (3H, d, J=1.3 Hz), 2.21 (3H, d, J=2 Hz), 2.34 (3H, s), 5.90 (1H, broad s), 6.86-6.93 (2H, m), 7.01 (1H, d, J=7.2 Hz), 7.24 (1H, t, J=7.2 Hz).

2-(1,1,3-Trimethyl-3-hydroxybutyl) 5-methyl-phenol (Compound 88)

To an ice-bath cooled suspension of 13 g (97.5 mmol) of aluminum chloride in 200 ml of methylene chloride was added dropwise under argon a solution of 9.0 g (47.4 mmol) of 3-methyl-phenyl-3,3-dimethylacrylate (Compound 87) in 100 ml of methylene chloride. The reaction mixture was stirred at 0 degrees C. for a further 30 min and then at room temperature for 15 h. The reaction mixture was poured into 200 ml of an ice water/salt mixture and the organic layer was separated. The aqueous layer was extracted with 50 ml of ether. The organic layers were combined and washed successively with water and saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; 5% ethyl acetate in hexane) to give an approximately 2.5:1 mixture of isomeric products, 4,4,5-trimethyl-2-oxo-chroman and 4,4,5-trimethyl-2-oxo-chroman as a pale yellow oil. To a solution of 3.8 g (20 mmol) of this mixture of isomeric 2-oxo-chromans in 60 ml of ether at 0 degrees C. was added under argon 20 ml of 3.0 M (60 mmol) of methyl magnesium bromide in ether. The reaction mixture was stirred at room temperature for 48 h and then poured onto a mixture of ice and 1 ml of conc. H₂SO₄. The organic layer was separated and the aqueous layer extracted with 2x50 ml of ether. The organic layers were combined and washed successively with water, saturated NaHCO₃ solution, water again and then saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue was purified by flash chromatography (silica; 15% ethyl acetate in hexanes) to give the title compound as a colorless oil. PMR (CDCl₃): δ 1.14 (6H, s), 1.45 (6H, s), 2.19 (3H, s), 2.21 (2H, s), 6.39 (1H, d, J=1.8 Hz), 6.67 (1H, dd, J=7.9 Hz, 1.8 Hz), 7.16 (1H, d, J=7.9 Hz), 7.44 (1H, s).

2,2,4,4,7-Pentamethyl-chroman (Compound 89)

To 2.16 g (11.7 mmol) of 2-(1,1,3-trimethyl-3-hydroxybutyl) 5-methyl-phenol (Compound 88) was added under nitrogen 50 ml of 20% aqueous sulfuric acid. The reaction mixture was heated at reflux for 13 h and then cooled. The organic layer was separated and the aqueous layer was extracted with ether. The organic extracts were combined and washed successively with water, saturated NaHCO₃ solution, water again and saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo to give the title compound as a yellow oil. PMR (CDCl₃): δ 1.32 (6H, s), 1.34 (6H, s), 1.81 (2H, s), 2.26 (3H, s), 6.63 (1H, s), 6.72 (1H, d, J=7.9 Hz), 7.15 (1H, d, J=7.9 Hz).

2,2,4,4,7-Pentamethyl-6-acetyl-chroman (Compound 90)

To an ice-bath cooled solution of 1.96 g (9.6 mmol) of 2,2,4,4,7-pentamethyl-chroman (Compound 89) in 30 ml of nitromethane was added under argon 1.059 g (13.5

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mmol) of acetyl chloride followed by 1.9 g (14.3 mmol) of aluminum chloride. The reaction mixture was stirred at room temperature for 14 h and then cooled in an ice-bath and treated with 25 ml of conc. HCl. The mixture was warmed to room temperature and diluted with ether and water. The organic layer was separated and the aqueous layer extracted with ether. The organic extracts were combined and washed successively with water, saturated NaHCO₃ solution, water again, and saturated NaCl solution, and then dried (MgSO₄). The solvent was removed in vacuo and the residue was purified by flash chromatography (silica; 5% ethyl acetate in hexanes) to give the title compound as a pale yellow oil. PMR (CDCl₃): 1.36 (6H, s), 1.37 (6H, s), 1.86 (2H, s), 2.49 (3H, s), 2.56 (3H, s), 6.65 (1H, s), 7.74 (1H, s).

2,2,4,4,7-Pentamethyl-6-ethynyl-chroman (Compound 9)

To a solution of 455 mg (4.5 mmol) of diisopropylamine in 5 ml of dry THF at -78 degrees C. was added under argon 3 ml of 1.5 M n-BuLi in hexane. The mixture was stirred at -78 degrees C. for a further 45 min and then treated with a solution of 1.07 g (4.3 mmol) of 2,2,4,4,7-pentamethyl-6-acetyl-chroman (Compound 90) in 4 ml of dry THF. The reaction mixture was stirred at -78 degrees C. for 1 h and then treated with 776 mg (4.5 mmol) of diethyl chlorophosphate. The mixture was allowed to warm to room temperature and then transferred by a double-ended needle into a solution of lithium diisopropyl amide in 10 ml dry THF at -78 degrees C. which was prepared as described above using 910 mg (9.0 mmol) of diisopropylamine and 6 ml of 1.5 M (9.0 mmol) n-BuLi in hexane. The mixture was stirred at room temperature for 15 h and then poured into 10 ml of iced water. The mixture was acidified to pH=2 with 10% HCl solution. The organic layer was separated and the aqueous layer extracted with pentane. The organic extracts were combined and washed successively with water, saturated NaHCO₃ and saturated NaCl solutions and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by Kugelrohr distillation (82 degrees C, 0.3 mm) to give the title compound as a pale yellow oil. PMR (CDCl₃): 1.32 (6H, s), 1.34 (6H, s), 1.81 (2H, s), 2.36 (3H, s), 3.18 (1H, s), 6.64 (1H, s), 7.40 (1H, s). MS exact mass, m/e 228.1520 for C₁₆H₂₀O, 228.1514).

N-(4-Bromophenyl)3,3-dimethylacrylamide (Compound 92)

To a solution of 9.48 g (80 mmol) of 3,3-dimethylacryloyl chloride in 200 ml of dry THF was added with vigorous shaking a solution of 13.76 g (80 mmol) of 4-bromoaniline in 300 ml of dry THF. The mixture was stood at room temperature for 2 h and then treated with 80 g of ice followed by 200 ml of hexane. The organic layer was separated and the aqueous layer was extracted with 2x50 ml of hexanes. The organic layers were combined and washed successively with 30 ml of water and 2x30 ml of saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by recrystallization from an ethyl acetate and hexanes mixture to give the title compound as colorless crystals. PMR (CDCl₃): 1.91 (3H, s), 2.23 (3H, s), 5.73 (1H, broad s), 7.38-7.55 (5H, m).

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4,4-Dimethyl-6-bromo-2-oxo-1,2,3,4-tetrahydroquinoline (Compound 93)

To 6.7 g (26.02 mmol) of molten N-(4-bromophenyl)3,3-dimethylacrylamide (Compound 92) (heated to 135 degrees C.) was added 4.15 g (31.09) of aluminum chloride over 25 min. The reaction mixture was stirred at 130 degrees C. for 16 h and then treated with a further 1 g (7.5 mmol) of aluminum chloride. The reaction mixture was heated at 130 degrees C. for a further 9 h and then cooled to room temperature. The reaction was then quenched by the slow addition of 100 ml of ice cold water with slight warming of flask to facilitate mixing. The mixture was extracted with 1x100 ml and 4x50 ml of ether. The organic extracts were combined and washed with 25 ml of saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; 30% ethyl acetate in hexanes) to give the title compound as a pale yellow solid. PMR (CDCl₃): 1.37 (6H, s), 2.53 (2H, s), 6.85 (1H, d, J=8.4 Hz), 7.32 (1H, dd, J=8.4 Hz, 2.1 Hz), 7.43 (1H, d, J=2.1 Hz), 10.12 (1H, broad s).

4,4-Dimethyl-6-bromo-1,2,3,4-tetrahydroquinoline (Compound 94)

To 23.5 ml of 1.0 M (23.5 mmol) lithium aluminum hydride in THF, heated to reflux under nitrogen, was added a solution of 4.95 g (19.48 mmol) of 4,4-dimethyl-6-bromo-2-oxo-1,2,3,4-tetrahydroquinoline (Compound 93) in 50 ml of dry THF and 100 ml of dry ether via a double-ended needle. The mixture was heated at reflux for 2 h and then cooled to room temperature. The reaction mixture was then quenched by the slow addition of 25 ml of water followed by 50 ml of 5% NaOH solution. The mixture was extracted with 2x25 ml of ether, the organic extracts were combined and washed successively with 25 ml each of water and saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; 15% ethyl acetate in hexanes) to give the title compound as a brown oil. PMR (CDCl₃): 1.27 (6H, s), 1.67-1.74 (2H, m), 3.23-3.32 (2H, m), 3.90 (1H, broad s), 6.33 (1H, d, J=8.4 Hz), 7.10 (1H, dd, J=8.4 Hz, 2.3 Hz), 7.25 (1H, d, J=2.3 Hz).

4,4-Dimethyl-6-trimethylsilylethynyl-1,2,3,4-tetrahydroquinoline (Compound 95)

A solution of 1.608 g (6.7 mmol) of 4,4-dimethyl-6-bromo-1,2,3,4-tetrahydroquinoline (Compound 94) in 1.5 ml of triethylamine in a heavy-walled tube was degassed under argon and then treated with 75 mg (0.39 mmol) of cuprous iodide and 150 mg (0.21 mmol) of bis(triphenylphosphine) palladium (II) chloride. The mixture was degassed again under argon, treated with 2.09 g (21.2 mmol) of trimethylsilylacetylene and the tube was sealed. The mixture was heated at 50 degrees C. for 48 h. After cooling to room temperature methylene chloride was added to the reaction mixture and the mixture filtered. The filtrate was concentrated in vacuo and the residue purified by flash chromatography (silica; 10% ethyl acetate in hexanes) to give the title compound as a yellow oil. PMR (CDCl₃): 0.20 (9H, s), 1.20 (6H, s), 1.57-1.63 (2H, m), 3.16-3.25 (2H, m), 4.02 (1H, broad s), 6.24 (1H, d, J=8.2 Hz), 7.00 (1H, dd, J=8.2 Hz, 1.8 Hz), 7.26 (1H, d, J=1.8 Hz).

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4,4-Dimethyl-6-ethynyl-1,2,3,4-tetrahydroquinoline
(Compound 6).

To a solution of 569 mg (2.21 mmol) of 4,4-dimethyl-6-trimethylsilylethynyl-1,2,3,4-tetrahydroquinoline (Compound 95) in 3 ml of isopropanol was added, under argon, 1 ml of 1N aqueous KOH solution. The reaction mixture was stirred at room temperature for 36 h and the isopropanol was removed under vacuum. The residue was extracted with ether and the ether extract was washed successively with water and saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue was purified by flash chromatography (silica; 10% ethyl acetate in hexanes) to give the title compound as a brown oil. PMR (CDCl₃): δ 1.26 (6H, s), 1.65-1.72 (2H, m), 2.96 (1H, s), 3.27-3.34 (2H, m), 6.34 (1H, d, J=8.3 Hz), 7.08 (1H, dd, J=8.3 Hz, 6 Hz), 7.33 (1H, d, J=1.6 Hz).

Ethyl 4-iodobenzoate (Compound 97)

To a suspension of 10 g (40.32 mmol) of 4-iodobenzoic acid in 100 ml absolute ethanol was added 2 ml thionyl chloride and the mixture was then heated at reflux for 3 hours. Solvent was removed in vacuo and the residue was dissolved in 100 ml ether. The ether solution was washed with saturated NaHCO₃ and saturated NaCl solutions and dried (MgSO₄). Solvent was then removed in vacuo and the residue kugelrohr distilled (100 degrees C.; 0.55 mm) to give the title compound as a colorless oil, PMR (CDCl₃): δ 1.42 (3H, t, J=7 Hz), 4.4 (2H, q, J=7 Hz), 7.8 (4H).

In the same manner, but substituting for 4-iodobenzoic acid the appropriate acid, the following compounds can be prepared:

ethyl 4-iodophenylacetate;
ethyl 3-(4-iodophenyl)propionate;
ethyl 4-(4-iodophenyl)butanoate; and
ethyl 5-(4-iodophenyl)pentanoate.

Ethyl 6-chloronicotinate (Compound 98)

A mixture of 15.75 g (0.1 mol) 6-chloronicotinic acid, 6.9 g (0.15 mol) ethanol, 22.7 g (0.11 mol) dicyclohexylcarbodiimide and 3.7 g dimethylaminopyridine in 200 ml methylene chloride was heated at reflux for 2 hours. The mixture was allowed to cool, solvent removed in vacuo and the residue subjected to flash chromatography to give the title compound as a low-melting white solid. PMR (CDCl₃): δ 1.44 (3H, t, J=6.2 Hz), 4.44 (2H, q, J=4.4 Hz), 7.44 (1H, d, J=8.1 Hz), 8.27 (1H, dd, J=8.1 Hz, 3 Hz), 9.02 (1H, d, J=3 Hz).

The foregoing procedure may be used to esterify any of other halo-substituted acids employed in the making of compounds such as:

ethyl 2-(2-chloropyrid-5-yl)acetate;
ethyl 5-(2-chloropyrid-5-yl)pentanoate;
ethyl 2-(2-iodofur-5-yl)acetate;
ethyl 5-(2-iodofur-5-yl)pentanoate;
ethyl 2-(2-iodothien-5-yl)acetate;
ethyl 5-(2-iodothien-5-yl)pentanoate;
ethyl 2-(3-chloropyridazin-6-yl)acetate;
ethyl 5-(3-chloropyridazin-6-yl)pentanoate; and the corresponding chloro, or other halo, substituted pyrimidinyl or pyrazinyl analogues of such esters.

Ethyl

6-[(4,4-dimethylthiochroman-6-yl)ethynyl]nicotinate
(Compound 99)

Reaction vessels used in this procedure were flame dried under vacuum and all operations carried out in an oxygen-free, argon or nitrogen atmosphere. To a solution of 465.7 mg (2.3019 mmol) of 4,4-dimethyl-6-ethynylthiochroman (Compound 1) in 4 ml of dry tetrahydrofuran at 0 degrees C. was added dropwise 1.5 ml of 1.6 M (2.4 mmol) n-butyllithium in hexane. This was stirred at 0 degrees C. for 10 minutes and at room temperature for 10 minutes, cooled again to 0 degrees C. and then treated with a solution of 330 mg (2.4215 mmol) of fused ZnCl₂ in 4 ml dry tetrahydrofuran using a double ended needle. Thereafter the solution was stirred at 0 degrees C. for 30 minutes, then at room temperature for 10 minutes. A solution of 426.3 mg (2.2967 mmol) of ethyl 6-chloronicotinate (Compound 98) in 4 ml dry tetrahydrofuran was transferred by double ended needle into a suspension of 430 mg (0.37 mmol) of tetrakis(triphenyl)phosphine palladium in 4 ml dry tetrahydrofuran and stirred at room temperature for 10 minutes, then treated by double ended needle with the solution of the alkynyl zinc prepared above. This mixture was stirred at room temperature for 18 hours, then quenched with 100 ml water. Product was recovered by extraction with 3 x 75 ml ether. Ether fractions were combined and washed with saturated NaCl solutions and dried (MgSO₄). Solvent was removed in vacuo and the residue purified by flash chromatography (silica; 5% ethyl acetate in hexane) followed by HPLC (Whatman Partisil M-9 10/50; 4% ethyl acetate in hexane) to give the title compound as a white solid.

PMR (CDCl₃): δ 1.36 (6H, s), 1.45 (3H, t, J=7 Hz), 1.96-2.00 (2H, m), 3.05-3.09 (2H, m), 4.45 (2H, q, J=7 Hz), 7.11 (1H, d, J=8.4 Hz), 7.29 (1H, dd, J=8.4 Hz, 2.2 Hz), 7.59 (1H, d, J=7.8 Hz), 7.66 (1H, d, J=2.2 Hz), 8.30 (1H, dd, J=7.8 Hz, 2.3 Hz), 9.22 (1H, d, J=2.3 Hz).

Alternative synthesis: Ethyl 6-[(4,4-dimethylthiochroman-6-yl)ethynyl]nicotinate (Compound 99) was also prepared as follows.

A solution of 15.4 g (76.2 mmol) of 4,4-dimethyl-6-ethynylthiochroman (Compound 1) and 14.0 g (75.5 mmol) of ethyl 6-chloronicotinate (Compound 98) in 35 ml of freshly distilled triethylamine was degassed and then treated under nitrogen with a finely powdered mixture of 1 g (5.25 mmol) of high purity cuprous iodide and 2 g (2.85 mmol) of bis(triphenyl)phosphine palladium (II) chloride. The mixture was heated under nitrogen at 55 degrees C. for 20 hours and then cooled to room temperature. The triethylamine was then removed under vacuum and the residue was diluted with 200 ml of a 1:4 mixture of ethyl acetate and hexanes. This mixture was filtered through silica and the filtrate concentrated in vacuo. The resultant residue was purified by flash chromatography (silica gel; 15% ethyl acetate in hexanes) and recrystallized from a mixture of ethyl acetate and hexanes to give the title compound as a pale yellow solid.

Ethyl

6-(4,4,7-trimethylthiochroman-6-yl)ethynyl]nicotinate
(Compound 100)

A mixture of 86 mg (0.4 mmol) of 4,4,7-trimethyl-6-ethynylthiochroman (Compound 2), 85 mg (0.46 mmol) of ethyl 6-chloronicotinate (Compound 98) and

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0.8 ml of triethylamine was degassed under nitrogen and then treated with a mixture of mg (0.05 mmol) of cuprous iodide and 20 mg (0.03 mmol) of bis(triphenylphosphine) palladium (II) chloride. The reaction mixture was heated at 55 degrees C. under a nitrogen atmosphere for 18 hours. The mixture was then extracted with 1.5 ml of 40% ethyl acetate in hexanes and purified by flash chromatography (silica; 10% ethyl acetate in hexanes) to give title compound as a yellow solid.

PMR (CDCl₃): δ 1.32 (6H, s), 1.43 (3H, t, J=7.2 Hz), 2.44 (3H, s), 3.01-3.05 (2H, m), 4.42 (2H, q, J=7.2 Hz), 6.98 (1H, s), 7.54-7.63 (2H, m), 8.27 (1H, dd, J=8.3 Hz, 2.3 Hz), 9.21 (1H, d, J=2.3 Hz).

Ethyl 6-[(4,4-dimethylchroman-6-yl)ethynyl]nicotinate (Compound 101)

Reaction vessels used in this procedure were flame dried under vacuum and all operations were carried out in an oxygen-free, argon or nitrogen atmosphere. To a solution of 509.4 mg (2.74 mmol) of 4,4-dimethyl-6-ethynylchroman (Compound 4) in 4 ml of dry tetrahydrofuran at 0 degrees C. was added dropwise 72 ml of 1.6 M (2.75 mmol) of n-butyl lithium in hexane, stirring was commenced at 0 degrees C. for 30 minutes and at room temperature for 15 minutes, after which the solution was cooled again to 0 degrees C. and then treated with a solution of 380 mg (2.79 mmol) of fused zinc chloride in 5 ml of dry tetrahydrofuran using a double ended needle. The resulting solution was stirred at 0 degrees C. for 1 hour and then at room temperature for 15 minutes. A solution of 628.6 mg (2.74 mmol) of ethyl 6-chloronicotinate (Compound 98) in 4 ml of dry tetrahydrofuran was transferred by double ended needle into a suspension of 380 mg (0.33 mmol) of tetrakis(triphenylphosphine) palladium in 5 ml dry tetrahydrofuran and the mixture was stirred at room temperature for 15 minutes and then treated by double ended needle with the solution of alkynyl zinc prepared above. The mixture was stirred at room temperature for 20 hours and then quenched with ice and 30 ml of 3N hydrogen chloride. The mixture was extracted with 3x75 ml ether and ether extracts were combined and washed successively with saturated NaHCO₃ and saturated NaCl and then dried (MgSO₄). Solvent was removed in vacuo and the residue further purified by flash chromatography (silica; 10% ethyl acetate in hexane) to give the title compound as a yellow solid.

PMR (CDCl₃): δ 1.36 (6H, s), 1.44 (3H, t, J=7.1 Hz), 1.83-1.87 (2H, m), 4.22-4.26 (2H, m), 4.44 (2H, q, J=7.1 Hz), 6.80 (1H, d, J=7.6 Hz), 7.35 (1H, d, J=8.9 Hz), 7.58 (1H, d, J=7.6 Hz), 7.60 (1H, m), 8.28 (1H, d, J=8.9 Hz), 9.21 (1H, s).

Ethyl

6-[(2,2,4,4-tetramethyl-thiochroman-6-yl)ethynyl]nicotinate (Compound 102)

A solution of 232 mg (1.01 mmol) of 2,2,4,4-tetramethyl-6-ethynylthiochroman (Compound 3) and 190 mg (1.03 mmol) of ethyl 6-Chloro-nicotinate (Compound 98) in 2 ml of triethylamine was placed in a heavy-walled glass tube, degassed, placed under argon and then treated with a powdered mixture of 53 mg (0.28 mmol) of cuprous iodide and 84 mg (0.12 mmol) of bis(triphenylphosphine) palladium (II) chloride. The mixture was degassed again, placed under argon and the tube was sealed. The reaction mixture was heated at 55 degrees C. for 60 h and then cooled to room temperature. The mixture was treated with water and ether and

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the organic layer was separated. The aqueous layer was extracted with ether. The organic layers were then combined and washed with saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the resultant residue was purified by flash chromatography (silica; 10% ethyl acetate in hexanes) to give the title compound as a dark yellow oil. PMR (CDCl₃): δ 1.32-1.43 (15H, m), 1.92 (2H, s), 4.38 (2H, q, J=7.1 Hz), 7.28 (1H, dd, J=8.3 Hz, 1.8 Hz), 7.32-7.38 (2H, m), 7.53 (1H, d, J=8.3 Hz), 8.24 (1H, dd, J=8.2 Hz, 2.2 Hz), 9.16 (1H, d, J=2.2 Hz). MS exact mass, m/e 379.1594 (calcd. for C₂₃H₂₅NO₂S, 379.1606).

Ethyl

6-[(2,2,4,4-tetramethylchroman-6-yl)ethynyl]nicotinate (Compound 103)

A solution of 233 mg (1.09 mmol) of 2,2,4,4-tetramethyl-6-ethynylchroman (Compound 5) and 209 mg (1.09 mmol) of ethyl 6-chloronicotinate (Compound 98) in 1 ml of triethylamine was degassed and then treated under argon with a powdered mixture of 50 mg (0.26 mmol) of cuprous iodide and 100 mg (0.14 mmol) of bis(triphenylphosphine) palladium (II) chloride. The reaction mixture was heated under argon at 55 degrees C. for 80 h and then cooled to room temperature. The triethylamine was then removed under vacuum and the residue purified by flash chromatography (silica; 5% ethyl acetate in hexanes) to give the title compound as a yellow oil. PMR (CDCl₃): δ 1.36 (12H, s), 1.42 (3H, t, J=7.2 Hz), 1.85 (2H, s), 4.37 (2H, q, J=7.2 Hz), 6.79 (1H, d, J=4 Hz), 7.34 (1H, dd, J=8.4 Hz, 2.1 Hz), 7.56 (1H, d, J=8.7 Hz), 7.60 (1H, d, J=2.1 Hz), 8.27 (1H, dd, J=8.7 Hz, 2.4 Hz), 9.19 (1H, d, J=2.4 Hz). MS exact mass, m/e 363.1837 (calcd. for C₂₃H₂₅O₃N, 363.1834).

Ethyl-6-[(2,2,4,4-pentamethyl-6-chromanyl)ethynyl]nicotinate (Compound 104)

A solution of 300 mg (1.316 mmol) of 2,2,4,4,7-pentamethyl-6-ethynyl-chroman (Compound 9) and 245.6 mg (1.3276 mmol) of ethyl 6-chloro-nicotinate (Compound 98) in 2 ml of triethylamine was placed in a pressure tube and a stream of nitrogen was bubbled through the solution for 15 min. The tube was then flushed with argon and a finely ground mixture of 100 mg (0.1425 mmol) of bis (triphenylphosphine) palladium (II) chloride and 50 mg (0.2625 mmol) of cuprous iodide was added to the solution. The pressure tube was then sealed and the reaction mixture heated at 60 degrees C. for 72 h. The mixture was cooled to room temperature and the triethylamine removed under vacuum. The residue was purified by flash chromatography (silica; 10% ethyl acetate in hexane) to give the title compound as a yellow solid. PMR (CDCl₃): δ 1.37 (6H, s), 1.38 (6H, s), 1.44 (3H, t, J=7.2 Hz), 1.85 (2H, s), 2.49 (3H, s), 4.43 (2H, q, J=7.2 Hz), 6.70 (1H, s), 7.55-7.61 (2H, m), 8.28 (1H, dd, J=8.2 Hz, 2.1 Hz), 9.22 (1H, d, J=2.1 Hz). MS exact mass, m/e 377.1982 (calcd. for C₂₄H₂₇O₃N, 377.1991).

Ethyl 4-[(2,2,4,4,7-pentamethylchroman-6-yl)ethynyl]benzoate (Compound 105)

Nitrogen was bubbled for 15 min through a solution of 200 mg (0.877 mmol) of 2,2,4,4,7-pentamethyl-6-ethynylchroman (Compound 9) and 245.3 mg (0.888 mmol) of ethyl 4-iodobenzoate (Compound 97) in 2 ml of triethylamine. The mixture was then placed under an argon atmosphere and treated with a finely ground mixture of 50 mg (0.2625 mmol) of cuprous iodide and

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100 mg (0.1425 mmol) of bis(triphenylphosphine) palladium (II) chloride. The reaction vessel was then fitted with a reflux condenser and the mixture was heated at 55 degrees C. under argon for 72 hours. The triethylamine was then removed under vacuum and the residue purified by flash chromatography (silica, 5% ethyl acetate in hexane) to give the title compound as a yellow oil. PMR (CDCl₃): δ 1.32 (12H, s), 1.37 (3H, t, J=7.0 Hz), 1.80 (2H, s), 2.40 (3H, s), 4.36 (2H, q, J=7.0 Hz), 6.66 (1H, s), 7.42 (1H, s), 7.54 (2H, d, J=8.6 Hz), 7.99 (2H, d, J=8.6 Hz). MS exact mass, m/e 376.2 038 (calcd. for C₂₅H₂₂O₃, 376.2038).

4-[(2,2,4,4-tetramethylchroman-6-yl-ethynyl]benzoate
Compound 106)

A solution of 233 mg (1.088 mmol) of 2,2,4,4-tetramethyl-6-ethynyl-chroman (Compound 9) and 308 mg (1.087 mmol) of ethyl 4-iodo-benzoate (Compound 97) in 1 ml of triethylamine was placed in a heavy-walled tube and degassed under argon. The mixture was treated with a finely ground mixture of 50 mg (0.263 mmol) of cuprous iodide and 100 mg (0.142 mmol) of bis(triphenylphosphine) palladium (II) chloride and the tube was then sealed. The reaction mixture was then heated at 55 degrees C. for 48 hours. The triethylamine was removed in vacuo and the residue was purified by flash chromatography (silica, 5% ethyl acetate in hexane) to give the title compound as yellow oil. PMR (CDCl₃): δ 1.33 (6H, s), 1.34 (6H, s), 1.37 (3H, t, J=7.2 Hz), 1.83 (2H, s), 4.35 (2H, q, J=7.2 Hz), 6.75 (1H, d, J=8.4 Hz), 7.24 (1H, dd, J=8.4 Hz, 2.1 Hz), 7.46 (1H, d, J=2.1 Hz), 7.54 (2H, d, J=8.1 Hz), 7.99 (2H, d, J=8.1 Hz) MS exact mass, m/e 362.1880 (calcd. for C₂₄H₂₆O₃, 362.1881).

Ethyl

4-[(2,2,4,4-tetramethyl-thiochroman-6-yl)-ethynyl]
benzoate (Compound 107)

A solution of 110.7 mg (0.481 mmol) of 2,2,4,4-tetramethyl-6-ethynylthiochroman (Compound 3) and 142.3 mg (0.516 mmol) of ethyl 4-iodobenzoate (Compound 97) in 2 ml of triethylamine was placed in a heavy walled glass tube and degassed under argon. The mixture was then treated with a finely ground mixture of 42 mg (0.221 mmol) of cuprous iodide and 63 mg (0.09 mmol) of bis (triphenylphosphine) palladium (II) chloride. The reaction mixture was degassed under argon again and the tube was sealed. The mixture was stirred at room temperature for 40 hours. The triethylamine was removed under vacuum and the residue purified by flash chromatography (silica, 3% ethyl acetate in hexanes) to give the title compound as a pale yellow solid. PMR (CDCl₃): δ 1.37-1.42 (15H, m), 1.96 (2H, s), 4.38 (2H, q, J=7.0 Hz), 7.25 (1H, dd, J=8.2 Hz, 1.8 Hz), 7.33 (1H, d, J=1.8 Hz), 7.37 (1H, d, J=8.2 Hz), 7.65 (2H, d, J=8.6 Hz), 8.01 (2H, d, J=8.6 Hz). MS exact mass, m/e 378.1636 (calcd. for C₂₄H₂₆O₂S, 378.1636).

Ethyl

4-(4,4-dimethyl-1,2,3,4-tetrahydroquinoline-6-yl)-
ethynyl]benzoate (Compound 108)

Nitrogen gas was bubbled for 15 minutes through a solution of 145mg (0.7838 mmol) of 4,4-dimethyl-6-ethynyl-1,2,3,4-tetrahydroquinoline (Compound 6) and 220 mg (0.797 mmol) of ethyl 4-iodobenzoate (Com-

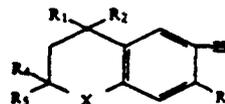
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pound 97) in 2 ml of triethylamine placed in a heavy-walled tube. The solution was then treated with a finely ground mixture of 31 mg (0.163 mmol) of cuprous iodide and 62 mg (0.088 mmol) of bis (triphenylphosphine) palladium (II) chloride. The tube was then flushed with argon and sealed. The reaction mixture was at 55 degrees C. for 72 h. The mixture was allowed to cool and then treated with 1 ml of triethylamine. The mixture was further treated with a ground mixture of 15 mg (0.079 mmol) cuprous iodide and 30 mg (0.003 mmol) of bis(triphenylphosphine) palladium (II) chloride. The tube was flushed with argon and sealed and the mixture was heated at 55 degrees C. for a further 24 h. The mixture was cooled and treated with ether and water and the organic layer was separated. The aqueous layer was extracted with ether and the combined organic extracts were washed successively with water saturated NaCl solution and then dried (MgSO₄). The solvent was removed in-vacuo and the residue was purified by flash chromatography (silica; 10% ethyl acetate in hexane) to give the title compound as a yellow oil. PMR (CDCl₃): δ 1.31 (6H, s), 1.40 (3H, t, J=7.2 Hz), 1.68-1.78 (2H, m), 3.32-3.40 (2H, m), 4.17 (1H, broad s), 4.38 (2H, q, J=7.2 Hz), 6.41 (1H, d, J=8.2 Hz), 7.15 (1H, dd, J=8.2 Hz, 1.9 Hz), 7.39 (1H, d, H=1.9 Hz), 7.54 (2H, d, J=8.4 Hz), 8.00 (2H, d, J=8.4 Hz). MS exact mass, m/e 333 1729 (calcd. for C₂₂H₂₃O₂N, 333.1728).

Several modifications of the above described compounds and processes, and application of the herein disclosed processes to numerous compounds beyond the specific examples forth above, may be practiced by those skilled in the art without departing from the scope and spirit of the present invention. Therefore, the scope of the present invention should be interpreted solely from the following claims, as such claims are read in light of the present disclosure.

What is claimed is:

1. A compound of the formula,



wherein

X is S, and each of independently

R₁, R₂, R₃, R₄ and R₅ is hydrogen or lower alkyl having 1 to 6 carbon, or a salt thereof.

2. The compound of claim 1 wherein R₄ and R₅ both are hydrogen.

3. The compound of claim 2 wherein R₁ and R₂ both are methyl.

4. The compound of claim 3 wherein R₃ is methyl.

5. The compound of claim 3 wherein R₃ is hydrogen.

6. The compound of claim 1 wherein R₄ and R₅ both are methyl.

7. The compound of claim 6 wherein R₁ and R₂ both are methyl.

8. The compound of claim 7 wherein R₃ is methyl.

9. The compound of claim 7 wherein R₃ is hydrogen.

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100 mg (0.1425 mmol) of bis(triphenylphosphine) palladium (II) chloride. The reaction vessel was then fitted with a reflux condenser and the mixture was heated at 55 degrees C. under argon for 72 hours. The triethylamine was then removed under vacuum and the residue purified by flash chromatography (silica, 5% ethyl acetate in hexane) to give the title compound as a yellow oil. PMR (CDCl₃): δ 1.32 (12H, s), 1.37 (3H, t, J=7.0 Hz), 1.80 (2H, s), 2.40 (3H, s), 4.35 (2H, q, J=7.0 Hz), 6.66 (1H, s), 7.42 (1H, s), 7.54 (2H, d, J=8.6 Hz), 7.99 (2H, d, J=8.6 Hz). MS exact mass, m/e 376.2038 (calcd. for C₂₅H₂₈O₃, 376.2038).

4-[(2,2,4,4-tetramethylchroman-6-yl)ethynyl]benzoate
Compound 96

A solution of 233 mg (1.088 mmol) of 2,2,4,4-tetramethyl-6-ethynyl-chroman (Compound 9) and 308 mg (1.087 mmol) of ethyl 4-iodobenzoate (Compound 97) in 1 ml of triethylamine was placed in a heavy-walled tube and degassed under argon. The mixture was treated with a finely ground mixture of 50 mg (0.263 mmol) of cuprous iodide and 100 mg (0.142 mmol) of bis(triphenylphosphine) palladium (II) chloride and the tube was then sealed. The reaction mixture was then heated at 55 degrees C. for 48 hours. The triethylamine was removed in vacuo and the residue was purified by flash chromatography (silica, 5% ethyl acetate in hexane) to give the title compound as yellow oil. PMR (CDCl₃): δ 1.33 (6H, s), 1.34 (6H, s), 1.37 (3H, t, J=7.2 Hz), 1.83 (2H, s), 4.35 (2H, q, J=7.2 Hz), 6.75 (1H, d, J=8.4 Hz), 7.24 (1H, dd, J=8.4 Hz, 2.1 Hz), 7.46 (1H, d, J=2.1 Hz), 7.54 (2H, d, J=8.1 Hz), 7.99 (2H, d, J=8.1 Hz). MS exact mass, m/e 362.1880 (calcd. for C₂₄H₂₆O₃, 362.1881).

Ethyl

4-[(2,2,4,4-tetramethylthiochroman-6-yl)ethynyl]benzoate (Compound 107)

A solution of 110.7 mg (0.481 mmol) of 2,2,4,4-tetramethyl-6-ethynylthiochroman (Compound 3) and 142.3 mg (0.516 mmol) of ethyl 4-iodobenzoate (Compound 97) in 2 ml of triethylamine was placed in a heavy walled glass tube and degassed under argon. The mixture was then treated with a finely ground mixture of 42 mg (0.221 mmol) of cuprous iodide and 63 mg (0.09 mmol) of bis(triphenylphosphine) palladium (II) chloride. The reaction mixture was degassed under argon again and the tube was sealed. The mixture was stirred at room temperature for 40 hours. The triethylamine was removed under vacuum and the residue purified by flash chromatography (silica, 5% ethyl acetate in hexane) to give the title compound as a pale yellow solid. PMR (CDCl₃): δ 1.37-1.42 (12H, m), 1.96 (2H, s), 4.38 (2H, q, J=7.0 Hz), 7.25 (1H, dd, J=8.2 Hz, 1.8 Hz), 7.33 (1H, d, J=1.8 Hz), 7.37 (1H, d, J=8.2 Hz), 7.65 (2H, d, J=8.6 Hz), 8.01 (2H, d, J=8.6 Hz). MS exact mass, m/e 378.1636 (calcd. for C₂₄H₂₆O₂S, 378.1633).

Ethyl

4-(4,4-dimethyl-1,2,3,4-tetrahydroquinoline-6-yl)ethynyl]benzoate (Compound 108)

Nitrogen gas was bubbled for 15 minutes through a solution of 145mg (0.7838 mmol) of 4,4-dimethyl-6-ethynyl-1,2,3,4-tetrahydroquinoline (Compound 6) and 220 mg (0.797 mmol) of ethyl 4-iodobenzoate (Com-

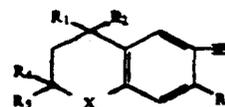
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pound 97) in 2 ml of triethylamine placed in a heavy-walled tube. The solution was then treated with a finely ground mixture of 31 mg (0.163 mmol) of cuprous iodide and 62 mg (0.088 mmol) of bis(triphenylphosphine) palladium (II) chloride. The tube was then flushed with argon and sealed. The reaction mixture was at 55 degrees C. for 72 h. The mixture was allowed to cool and then treated with 1 ml of triethylamine. The mixture was further treated with a ground mixture of 15 mg (0.079 mmol) cuprous iodide and 30 mg (0.003 mmol) of bis(triphenylphosphine) palladium (II) chloride. The tube was flushed with argon and sealed and the mixture was heated at 55 degrees C. for a further 24 h. The mixture was cooled and treated with ether and water and the organic layer was separated. The aqueous layer was extracted with ether and the combined organic extracts were washed successively with water saturated NaCl solution and then dried (MgSO₄). The solvent was removed in-vacuo and the residue was purified by flash chromatography (silica, 10% ethyl acetate in hexane) to give the title compound as a yellow oil. PMR (CDCl₃): δ 1.31 (6H, s), 1.40 (3H, t, J=7.2 Hz), 1.68-1.78 (2H, m), 3.32-3.40 (2H, m), 4.17 (1H, broad s), 4.38 (2H, q, J=7.2 Hz), 6.41 (1H, d, J=8.2 Hz), 7.15 (1H, dd, J=8.2 Hz, 1.9 Hz), 7.39 (1H, d, H=1.9 Hz), 7.54 (2H, d, J=8.4 Hz), 8.00 (2H, d, J=8.4 Hz). MS exact mass, m/e 333.1729 (calcd. for C₂₂H₂₃O₂N, 333.1728).

Several modifications of the above described compounds and processes, and application of the herein disclosed processes to numerous compounds beyond the specific examples forth above, may be practiced by those skilled in the art without departing from the scope and spirit of the present invention. Therefore, the scope of the present invention should be interpreted solely from the following claims, as such claims are read in light of the present disclosure.

What is claimed is:

1. A compound of the formula,



wherein

- X is S, and each of independently
- R₁, R₂, R₃, R₄ and R₅ is hydrogen or lower alkyl having 1 to 6 carbons, or a salt thereof.
- 2. The compound of claim 1 wherein R₄ and R₅ both are hydrogen.
- 3. The compound of claim 2 wherein R₁ and R₂ both are methyl.
- 4. The compound of claim 3 wherein R₃ is methyl.
- 5. The compound of claim 3 wherein R₃ is hydrogen.
- 6. The compound of claim 1 wherein R₄ and R₅ both are methyl.
- 7. The compound of claim 6 wherein R₁ and R₂ both are methyl.
- 8. The compound of claim 7 wherein R₃ is methyl.
- 9. The compound of claim 7 wherein R₃ is hydrogen.

US005089509A

United States Patent [19]
Chandraratna

[11] Patent Number: 5,089,509
[45] Date of Patent: Feb. 18, 1992

[54] DISUBSTITUTED ACETYLENES BEARING
HETEROAROMATIC AND
HETEROBICYCLIC GROUPS HAVING
RETINOID LIKE ACTIVITY

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[21] Appl. No.: 326,191
[22] Filed: Mar. 20, 1989

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 246,037, Sep. 15, 1988,
abandoned.
[51] Int. Cl.³ A61K 31/335; A61K 31/38;
C07D 413/06; C07D 413/12
[52] U.S. Cl. 514/337; 514/247;
514/269; 514/255; 514/432; 514/444; 514/456;
514/461; 514/863; 544/238; 544/333; 544/376;
549/13; 549/23; 549/60; 549/398; 549/425;
549/426; 549/427; 546/269; 546/274
[58] Field of Search 546/269, 274; 514/337,
514/863

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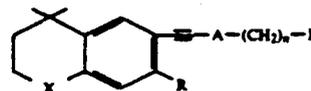
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Primary Examiner—Johann Richter
Attorney, Agent, or Firm—Gabor L. Szekeres; Martin A.
Voet; Robert J. Baran

[57] ABSTRACT

Retinoid-like activity is exhibited by compounds of the
formula



where X is S, O, or NR' where R' is hydrogen or lower
alkyl; R is hydrogen or lower alkyl; A is pyridyl, thi-
enyl, furyl, pyridazinyl, pyrimidinyl or pyrazinyl; n is
0-2; and B is H, —COOH or a pharmaceutically accept-
able salt, ester or amide thereof, —CH₂OH or an ether
or ester derivative, or —CHO or an acetal derivative, or
—COR₁ or a ketal derivative where R₁ is
—(CH₂)_mCH₃; where m is 0-4, or a pharmaceutically
acceptable salt thereof.

19 Claims, No Drawings

APPEARS THIS WAY
ON ORIGINAL

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**DISUBSTITUTED ACETYLENES BEARING
HETEROAROMATIC AND HETEROBICYCLIC
GROUPS HAVING RETINOID LIKE ACTIVITY**

This is a continuation-in-part of pending U.S. application Ser. No. 07/246,037 filed Sept. 15, 1988 now abandoned.

BACKGROUND

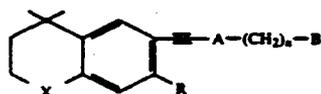
This invention relates to novel compounds having retinoid-like activity. More specifically, the invention relates to compounds having an ethynylheteroaromatic acid portion and a second portion which is a tetrahydroquinolinyl, thiocromanyl, or chromanyl group. The acid function may also be converted to an alcohol, aldehyde or ketone or derivatives thereof, or may be reduced to $-\text{CH}_3$.

RELATED ART

Carboxylic acid derivatives useful for inhibiting the degeneration of cartilage of the general formula 4-(2-(4,4-dimethyl-6-X)-2-methylvinyl)benzoic acid where X is tetrahydroquinolinyl, chromanyl or thiocromanyl are disclosed in European Patent Application 0133795 published Jan. 9, 1985. See also European Patent Application 176034A published Apr. 2, 1986 where tetrahydronaphthalene compounds having an ethynylbenzoic acid group are disclosed.

SUMMARY OF THE INVENTION

This invention covers compounds of formula I



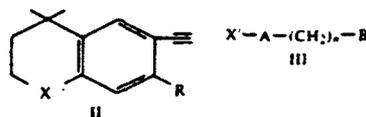
wherein X is S, O, or NR' where R' is hydrogen or lower alkyl; R is hydrogen or lower alkyl; A is pyridinyl, thienyl, furyl, pyridazinyl, pyrimidinyl or pyrazinyl; n is 0-2; and B is H, $-\text{COOH}$ or a pharmaceutically acceptable salt, ester or amide thereof, $-\text{CH}_2\text{OH}$ or an ether or ester derivative, or $-\text{CHO}$ or an acetal derivative, or $-\text{COR}_1$ or a ketal derivative where R_1 is $-(\text{CH}_2)_m\text{CH}_3$ where m is 0-4.

In a second aspect, this invention relates to the use of the compounds of formula I for treating dermatoses, such as acne, Darier's disease, psoriasis, ichthyosis, eczema, atopic dermatitis and epithelial cancers. These compounds are also useful in the treatment of arthritic diseases and other immunological disorders (e.g., lupus erythematosus), in promoting wound healing, in treating dry eye syndrome and in reversing the effects of sun damage to skin.

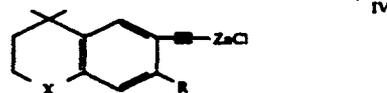
This invention also relates to a pharmaceutical formulation comprising a compound of formula I in admixture with a pharmaceutically acceptable excipient.

In another aspect, this invention relates to the process for making a compound of formula I which process comprises reacting a compound of formula II with a compound of formula III in the presence of cuprous iodide and $\text{Pd}(\text{PQ})_2\text{Cl}_2$ or a similar complex where the two formulas are represented by graphics II and III

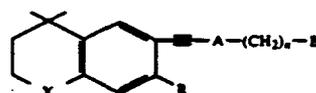
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where X' is a halogen, preferably I; n and A are the same as defined above; and B is H, or a protected acid, alcohol, aldehyde or ketone, giving the corresponding compound of formula I; or to the process of making a compound of formula I which consists of reacting a zinc salt of formula IV with a compound of formula III in the presence of $\text{Pd}(\text{PQ})_2$ (Q is phenyl) or a similar complex,



giving the corresponding compound of formula I; or homologating a compound of the formula



where n is 0-1 to give an acid of formula I; or converting an acid of formula I to a salt; or forming an acid addition salt; converting an acid of formula I to an ester; or converting an acid of formula I to an amide; or reducing an acid of formula I to an alcohol or aldehyde; or converting an alcohol of formula I to an ether or ester; or oxidizing an alcohol of formula I to an aldehyde; or converting an aldehyde of formula I to an acetal; or converting a ketone of formula I to a ketal.

GENERAL EMBODIMENTS

Definitions

The term "ester" as used here refers to and covers any compound falling within the definition of that term as classically used in organic chemistry. Where A is $-\text{COOH}$, this term covers the products derived from treatment of this function with alcohols. Where the ester is derived from compounds where A is $-\text{CH}_2\text{OH}$, this term covers compounds of the formula $-\text{CH}_2\text{OOCR}$ where R is any substituted or unsubstituted aliphatic, aromatic or aliphatic-aromatic group.

Preferred esters are derived from the saturated aliphatic alcohols or acids of ten or fewer carbon atoms or the cyclic or saturated aliphatic cyclic alcohols and acids of 5 to 10 carbon atoms. Particularly preferred aliphatic esters are those derived from lower alkyl acids and alcohols. Here, and where ever else used, lower alkyl means having 1-6 carbon atoms. Also preferred are the phenyl or lower alkylphenyl esters.

Amide has the meaning classically accorded that term in organic chemistry. In this instance it includes

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the unsubstituted amides and all aliphatic and aromatic mono- and di-substituted amides. Preferred amides are the mono- and di-substituted amides derived from the saturated aliphatic radicals of ten or fewer carbon atoms or the cyclic or saturated aliphatic-cyclic radicals of 5 to 10 carbon atoms. Particularly preferred amides are those derived from lower alkyl amines. Also preferred are mono- and di-substituted amides derived from the phenyl or lower alkylphenyl amines. Unsubstituted amides are also preferred.

Acetals and ketals includes the radicals of the formula —CK where K is (—OR)₂. Here, R is lower alkyl. Also, K may be —OR₁O— where R₁ is lower alkyl of 2-5 carbon atoms, straight chain or branched.

A pharmaceutically acceptable salt may be prepared for any compound of this invention having a functionality capable of forming such salt, for example an acid amine functionality. A pharmaceutically acceptable salt may be any salt which retains the activity of the parent compound and does not impart any deleterious or untoward effect on the subject to which it is administered and in the context in which it is administered.

Such a salt may be derived from any organic or inorganic acid or base. The salt may be a mono or polyvalent ion. Of particular interest where the acid function is concerned are the inorganic ions, sodium, potassium, calcium, and magnesium. Organic amine salts may be made with amines, particularly ammonium salts such as mono-, di- and trialkyl amines or ethanol amines. Salts may also be formed with caffeine, tromethamine and similar molecules. Where there is a nitrogen sufficiently basic as to be capable of forming acid addition salts, such may be formed with any inorganic or organic acids or alkylating agent such as methyl iodide. Preferred salts are those formed with inorganic acids such as hydrochloric acid, sulfuric acid or phosphoric acid. Any of a number of simple organic acids such as a mono-, di- or tri-acid may also be used.

The preferred compounds of this invention are those where the ethynyl group and the B group are attached to the 2 and 5 positions respectively of a pyridine ring (the 6 and 3 positions in the nicotinic acid nomenclature being equivalent to the 2/5 designation in the pyridine nomenclature) or the 5 and 2 positions respectively of a thiophene group respectively; A is O; and B is —COOH, an alkali metal salt or organic amine salt, or a lower alkyl ester, or —CH₂OH and the lower alkyl esters and ethers thereof, or —CHO and acetal derivatives thereof.

The most preferred compounds are:

- ethyl 6-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)-nicotinate;
- 6-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)nicotinic acid;
- 6-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)nicotinic acid;
- ethyl 6-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)nicotinate;
- ethyl 6-(2-(4,4,7-trimethylthiochroman-6-yl)ethynyl)-nicotinate;
- ethyl 6-(2-(4,4-dimethyl-1,2,3,4-tetrahydroquinolin-6-yl)ethynyl)nicotinate;
- ethyl 5-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)thiophene-2-carboxylate.
- 6-(2-(4,4-dimethylthiochroman-6-yl)-ethynyl)-3-pyridylmethanol; and
- 2-(2-(4,4-dimethylthiochroman-6-yl)-ethynyl)-5-pyridinecarboxaldehyde.

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The compounds of this invention may be administered systemically or topically, depending on such considerations as the condition to be treated, need for site-specific treatment, quantity of drug to be administered, and similar considerations.

In the treatment of dermatoses, it will generally be preferred to administer the drug topically, though in certain cases such as treatment of severe cystic acne, oral administration may also be used. Any common topical formulation such as a solution, suspension, gel, ointment, or salve and the like may be used. Preparation of such topical formulations are well described in the art of pharmaceutical formulations as exemplified, for example, *Remington's Pharmaceutical Science*, Edition 17, Mack Publishing Company, Easton, Pa. For topical application, these compounds could also be administered as a powder or spray, particularly in aerosol form.

If the drug is to be administered systemically, it may be conected as a powder, pill, tablet or the like, or as a syrup or elixir for oral administration. For intravenous or intraperitoneal administration, the compound will be prepared as a solution or suspension capable of being administered by injection. In certain cases, it may be useful to formulate these compounds in suppository form or as an extended release formulation for deposit under the skin or intermuscular injection.

Other medicaments can be added to such topical formulation for such secondary purposes as treating skin dryness, providing protection against light; other medications for treating dermatoses, preventing infection, reducing irritation, inflammation and the like.

Treatment of dermatoses or any other indications known or discovered to be susceptible to treatment by retinoic acid-like compounds will be effected by administration of the therapeutically effective dose of one or more compounds of the instant invention. A therapeutic concentration will be that concentration which effects reduction of the particular condition, or retards its expansion. In certain instances, the drug potentially could be used in a prophylactic manner to prevent onset of a particular condition. A given therapeutic concentration will vary from condition to condition and in certain instances may vary with the severity of the condition being treated and the patient's susceptibility to treatment. Accordingly, a given therapeutic concentration will be best determined at the time and place through routine experimentation. However, it is anticipated that in the treatment of, for example, acne, or other such dermatoses, that a formulation containing between 0.001 and 5 percent by weight, preferably about 0.01 to 1%, will usually constitute a therapeutically effective concentration. If administered systemically, an amount between 0.01 and 100 mg per kg body weight per day, but preferably about 0.1 to 10 mg/kg, will effect a therapeutic result in most instances.

The retinoic acid like activity of these compounds was confirmed through the classic measure of retinoic acid activity involving the effects of retinoic acid on ornithine decarboxylase. The original work on the correlation between retinoic acid and decrease in cell proliferation was done by Verma & Bourwell, *Cancer Research*, 1977, 37, 2196-2201. That reference discloses that ornithine decarboxylase (ODC) activity increased precedent to polyamine biosynthesis. It has been established elsewhere that increases in polyamine synthesis can be correlated or associated with cellular proliferation. Thus, if ODC activity could be inhibited, cell hyperproliferation could be modulated. Although all

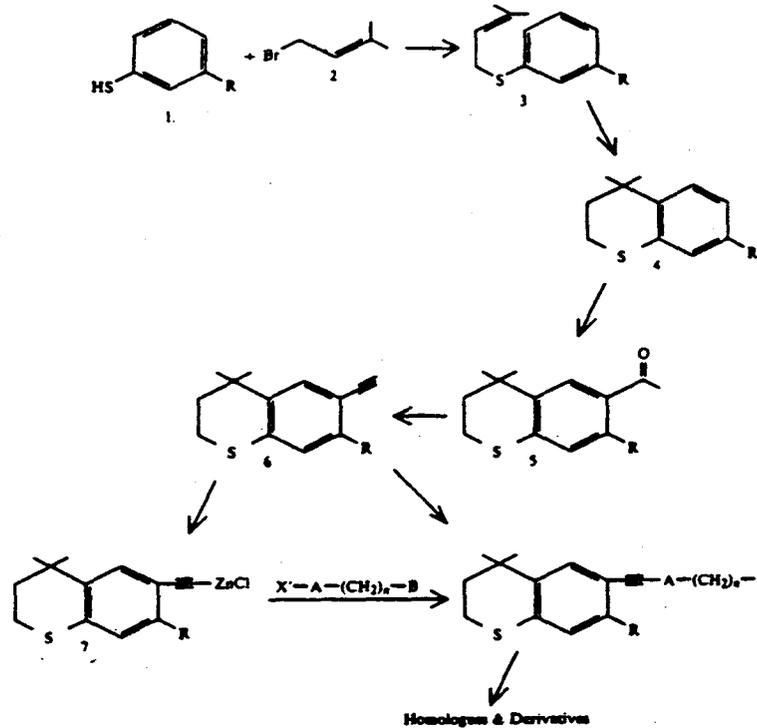
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5 causes for ODC activity increase are unknown, it is known that 12-O-tetradecanoylphorbol-13-acetate (TPA) induces ODC activity. Retinoic acid inhibits this induction of ODC activity by TPA. The compounds of this invention also inhibit TPA induction of ODC as demonstrated by an assay essentially following the procedure set out in *Cancer Res*: 1662-1670, 1975

6 pounds of formula I when such synthesis is followed in fact and in spirit. The synthetic chemist will readily appreciate that the conditions set out here are specific embodiments which can be generalized to any and all of the compounds represented by formula I.

Compounds of formula I where X is —S— are prepared as per Reaction Scheme I.

Reaction Scheme I



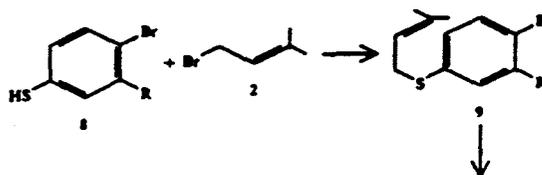
SPECIFIC EMBODIMENTS

The compounds of this invention can be made by a number of different synthetic chemical pathways. To illustrate this invention, there is here outlined a series of steps which have been proven to provide the com-

50 Here, R is hydrogen or a lower alkyl group, A is defined above, n is 0-2 and B is H, or a protected acid, alcohol, aldehyde or ketone. X' is Cl, Br or I when n is 0 but preferably is Br or I when n is 1 or 2.

Alternatively, compounds of formula I where X is —S— are prepared as per Reaction Scheme II

Reaction Scheme II



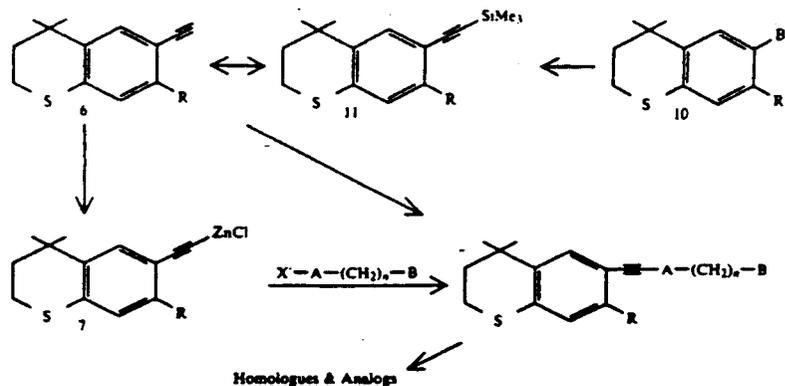
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Reaction Scheme II

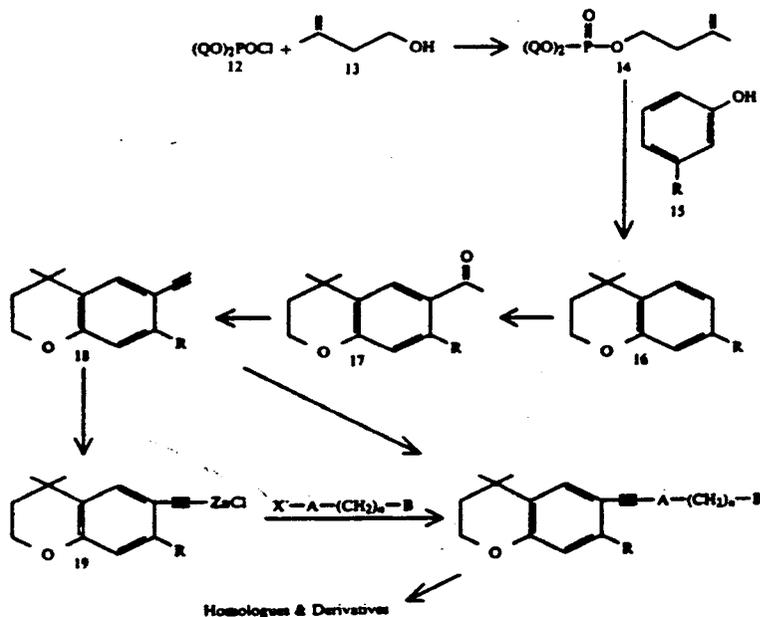


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The definitions of R, n, A, B and X' are the same here as in Reaction Scheme I.
Compounds of formula I where X is oxygen are prepared as per Reaction Scheme III.

The definitions of R, n, A, B and X' are the same here as in Scheme I.
Compounds of formula I where X is N-R' where R' is hydrogen or alkyl are prepared as per Reaction Scheme IV.

Reaction Scheme III

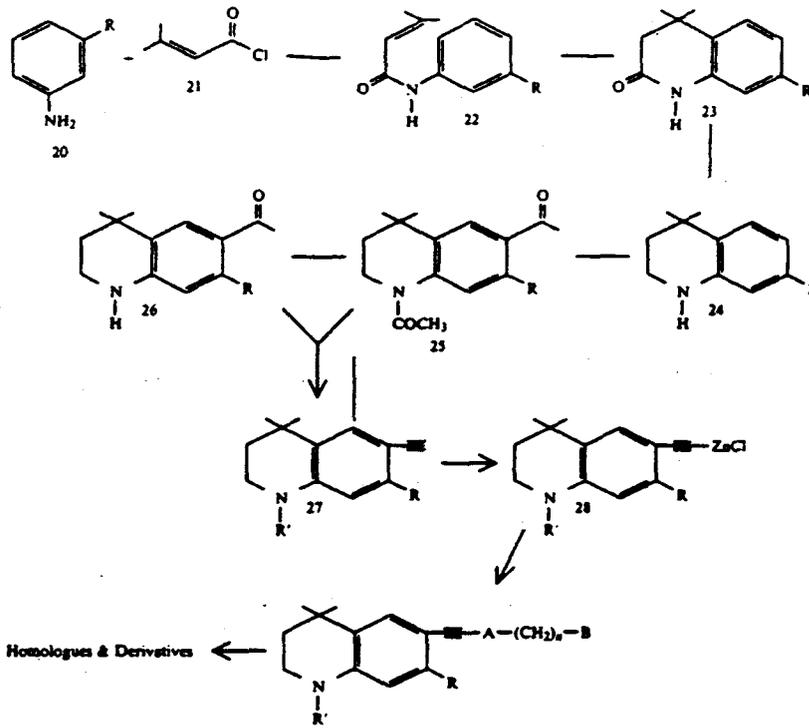


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Reaction Scheme IV

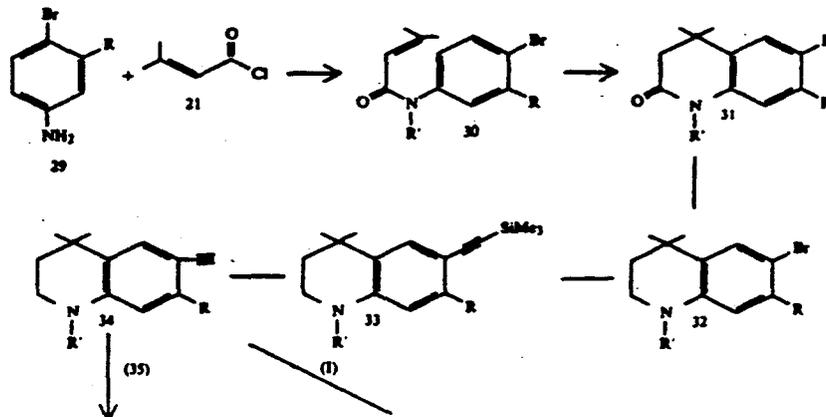


The definitions of R', n, A, B and X' are the same here as in Scheme I.

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Alternatively, the sequence of steps outlined in Reaction Scheme V will serve to make such compounds where X is N-R' and R' is H or lower alkyl.

Reaction Scheme V

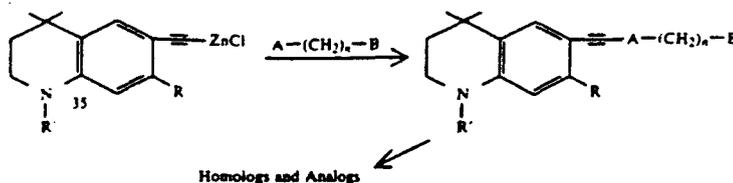


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Reaction Scheme V



A general description for making each of the compounds recited in the foregoing Reaction Schemes follows.

In Reaction Scheme I, the following generalized reaction conditions are applicable. The thiophenol of formula 1 is first treated with approximately an equimolar amount of a strong base such as an alkali metal hydroxide, preferably sodium hydroxide, in acetone at reflux. Refluxing is carried out for between 1 and 4 hours, preferably 2.5 hours, after which the solution is treated with an equimolar amount of formula 2, 1-bromo-3-methyl-2-butene (Aldrich), dissolved in acetone. Refluxing is continued for about 2 days after which the solution is stirred for another 24 hours at about room temperature effecting formation of formula 3. It is isolated by conventional means.

Ring closure is effected by treating the sulfide (compound 3), whose formation is described above, with phosphorous pentoxide in the presence of phosphoric acid under an inert atmosphere to give the thiochroman of formula 4. The sulfide is first dissolved in an inert solvent such as benzene, toluene, or the like, and then treated with a small excess of phosphorous pentoxide along with concentrated phosphoric acid. The solution is heated at reflux with stirring under an inert gas such as argon or nitrogen for up to 24 hours. The product is then recovered and purified by conventional means.

The ketone of formula 5 is obtained by treating the thiochroman with acetyl chloride in the presence of aluminum chloride. A suspension of the aluminum chloride in a polar inert solvent is prepared under an inert atmosphere and at reduced temperature, i.e., -10° to 10° C. The inert atmosphere may be argon or nitrogen, preferably argon. The reaction is conveniently carried out in a solvent such as methylene chloride. To the aluminum chloride suspension is added the thiochroman and acetyl chloride via a dropping funnel or similar device. About a 5% molar excess of acetyl chloride and 10% molar excess of aluminum chloride, relative to the thiochroman material, is used. The reaction is effected with agitation (stirring) over 0.5-4 hours at a temperature between 10° - 50° C. Preferably the reaction is effected in about 2 hours at room temperature. Then the reaction is quenched with water and/or ice, the product extracted and further purified by distillation or some other appropriate means.

The acetylenic function of formula 6 is introduced by means of lithium diisopropylamide or a similar base at reduced temperature under an inert atmosphere. The reaction is carried out in an ether-type of solvent such as dialkyl ether or a cyclic ether, for example, tetrahydrofuran, pyran or the like.

More specifically, lithium diisopropylamide is generated in situ by mixing diisopropylamine in a dry solvent such as tetrahydrofuran, which is then cooled, to between -70° and -50° C. under an inert atmosphere.

An equimolar amount of an alkyllithium compound such as n-butyl lithium in an appropriate solvent is then added at the reduced temperature and mixed for an appropriate time to permit formation of lithium diisopropylamide (LDA). The ketone of formula 5 (at least a 10% molar excess) is dissolved in the reaction solvent, the solution cooled to that of the LDA mixture, and added to that solution. After brief mixing, the solution is then treated with a dialkyl chlorophosphate, preferably diethyl chlorophosphate in about a 20% molar excess.

The reaction solution is then gradually brought to room temperature. This solution is then added to a second lithium diisopropylamide solution which is prepared in situ using dry solvent all under an inert atmosphere, preferably argon, at reduced temperature (e.g. -78° C.). Thereafter, the reaction mixture is again warmed to room temperature where it is stirred for an extended period of time, preferably between 10 and 20 hours, most preferably about 15 hours. The solution is then acidified and the product recovered by conventional means.

Formula 7 compounds are prepared under conditions which exclude water and oxygen. A dry, ether-type solvent such as dialkyl ether or a cyclic ether such as a furan or pyran, particularly a tetrahydrofuran, may be used as the solvent. A solution of formula 6 is first prepared under an inert atmosphere such as argon or nitrogen, and then a strong base such as n-butyl lithium is added (in about a 10% molar excess). This reaction is begun at a reduced temperature of between -10° and $+10^{\circ}$ C., preferably about 0° C. The reaction mixture is stirred for a short period, between 30 minutes and 2 hours, and then treated with about a 10% molar excess of fused zinc chloride dissolved in the reaction solvent. This mixture is stirred for an additional 1-3 hours at about the starting temperature, then the temperature is increased to about ambient temperature for 10-40 minutes.

Where a protected heteroaromatic compound is needed to couple with formula 7 compounds, such may be prepared from their corresponding acids, alcohols, ketones or aldehydes. These starting materials, the protected acids, alcohols, aldehydes or ketones, are all available from chemical manufacturers or can be prepared by published methods. Acids are esterified by refluxing the acid in a solution of the appropriate alcohol in the presence of thionyl chloride. Refluxing for 2-5 hours provides the desired ester. Alternatively, the acid can be condensed with the appropriate alcohol in the presence of dicyclohexylcarbodiimide and dimethylaminopyridine. The ester is recovered and purified by conventional means. Acetals and ketals are readily made by the method described in March, "Advanced Organic Chemistry," 2nd Edition. McGraw-Hill Book Company, p. 810). Alcohols, aldehydes and ketones all

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may be protected by forming respectively, ethers and esters, acetals or ketals by known methods such as those described in McOmie, Plenum Publishing Press, 1973 and *Protecting Groups*, Ed. Greene, John Wiley & Sons, 1981.

To increase the value of *n* before effecting a coupling reaction, where such compounds are not available from a commercial source, the heteroaromatics where B is —COOH are subjected to homologation by successive treatment under Arndt-Eistert conditions or other homologation procedures. These acids are then esterified by the general procedure outlined in the preceding paragraph. Alternatively, heteroaromatics where B is a different functional may also be homologated by appropriate procedures.

To effect the coupling of the thiochroman moiety with those of formula III, the halo-substituted heteroaromatic compound is dissolved in a dry reaction solvent. The heteromatic compound is used in an amount approximating the molar concentration of formula 7. This solution is introduced into a suspension of tetrakis-triphenylphosphine palladium (about a 5 to 10% molar amount relative to the reactants) in the reaction solvent at a temperature of between about —10° and +10° C. This mixture is stirred briefly, for about 15 minutes. To this just prepared mixture is then added the pre-prepared solution of formula 7, the addition being made at about room temperature. This solution is stirred for an extended period, between about 15 and 25 hours at room temperature. The reaction is then quenched with acid and the product separated and purified by conventional means to give the compounds of formula I.

An alternative means for making compounds where *n* is 1 or 2 is to subject the compounds of formula I where B is an acid or other function to homologation using the Arndt-Eistert method referred to above or other homologation procedures.

The acids and salts derived from formula I are readily obtainable from the corresponding esters. Basic saponification with an alkali metal base will provide the acid. For example, an ester of formula I may be dissolved in a polar solvent such as an alkanol, preferably under an inert atmosphere at room temperature, with about a three molar excess of base, for example, potassium hydroxide. The solution is stirred for an extended period of time, between 15 and 20 hours, cooled, acidified and the hydrolysate recovered by conventional means.

The amide may be formed by any appropriate amidation means known in the art. One way to prepare such compounds is to convert an acid to an acid chloride and then treat that compound with ammonium hydroxide or an appropriate amine. For example, the acid is treated with an alcoholic base solution such as ethanolic KOH (in approximately a 10% molar excess) at room temperature for about 30 minutes. The solvent is removed and the residue taken up in an organic solvent such as diethyl ether, treated with a dialkyl formamide and then a 10-fold excess of oxalyl chloride. This is all effected at a moderately reduced temperature between about —10° and +10° C. The last mentioned solution is then stirred at the reduced temperature for 1-4 hours, preferably 2 hours. Solvent removal provides a residue which is taken up in an inert inorganic solvent such as benzene, cooled to about 0° C. and treated with concentrated ammonium hydroxide. The resulting mixture is stirred at a reduced temperature for 1-4 hours. The product is recovered by conventional means.

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Alcohols are made by converting the corresponding acids to the acid chloride with thionyl chloride or other means (J. March, "Advanced Organic Chemistry", 2nd Edition, McGraw-Hill Book Company), then reducing the acid chloride with sodium borohydride (March, *Ibid.*, pg. 1124), which gives the corresponding alcohols. Alternatively, esters may be reduced with lithium aluminum hydride at reduced temperatures. Alkylating these alcohols with appropriate alkyl halides under Williamson reaction conditions (March, *Ibid.*, pg. 357) gives the corresponding ethers. These alcohols can be converted to esters by reacting them with appropriate acids in the presence of acid catalysts or dicyclohexylcarbodiimide and dimethylaminopyridine.

Aldehydes can be prepared from the corresponding primary alcohols using mild oxidizing agents such as pyridinium dichromate in methylene chloride (Corey, E. J., Schmidt, G., *Tet. Lett.*, 399, 1979), or dimethyl sulfoxide/oxalyl chloride in methylene chloride (Omura, K., Swern, D., *Tetrahedron*, 1978, 34, 1651).

Ketones can be prepared from an appropriate aldehyde by treating the aldehyde with an alkyl Grignard reagent or similar reagent followed by oxidation.

Acetals or ketals can be prepared from the corresponding aldehyde or ketone by the method described in March, *Ibid.*, p 810.

Compounds where B is H are prepared from the corresponding halo-heterocyclic entity preferably where the halogen is I. This halobeterocyclic compound is reacted with the ethynyl entity or the ethynyl zinc chloride entity as represented in Reaction Scheme I and as illustrated in the Examples. Halo-substituted heterocyclic compounds where B is H are commercially available or can be prepared by methods in the literature.

Compounds where X is oxygen are prepared by the steps outlined in Reaction Scheme III. The phosphate of formula 14 is prepared from the corresponding diphenyl chlorophosphate and 3-methyl-3-butene-1-ol available from Aldrich or which may be prepared by means known in the art. It is preferred to prepare formula 14 by dissolving the alcohol of formula 13 in about a 10% excess of pyridine in a polar inert solvent under an inert atmosphere cooled to approximately —10° to 10° C. This solution is then added drop-wise, under an inert atmosphere, to a solution of cooled diphenyl chlorophosphate in about an equal amount of the reaction solvent. About a 2-5% molar excess of diphenyl chlorophosphate relative to the alcohol is employed. The atmosphere may be argon, nitrogen, or another inert gas. The mixture is heated at reflux for between 1 and 5 hours, preferably about 3, to effect the reaction. The product is then recovered by conventional means.

The diphenyl phosphate ester from the preceding paragraph (formula 14) is then reacted with phenol or 3-alkylphenol to effect formation of compound 16. For example, phenol is added to a flask already containing stannic chloride under argon which has been cooled to between —10° to 10° C. After thorough mixing of this combination for about 15 minutes to an hour at the reduced temperature, the phosphate is added at the reduced temperature. Both of these steps are carried out under an inert atmosphere such as argon or nitrogen. When the addition of the phosphate is completed, the mixture is stirred at about ambient temperature for up to 24 hours. Then the reaction is quenched with a dilute solution of aqueous alkali metal base or the like. The

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product is recovered by extraction and other conventional means.

Formula 16 is then acetylated, converted to the acetylene and either the acetylene or the corresponding alkynyl zinc chloride salt coupled with the appropriate heterocycle by the steps outlined in Reaction Scheme I.

The tetrahydroquinoline moiety, that is where X is nitrogen, can be made by the steps outlined in Reaction Scheme IV in part by the method described in European Patent Application 0130795 published Sept. 1, 1985. First, 3-methylcrotonoyl chloride is reacted with aniline to obtain the amide. This amide is then cyclized using aluminum chloride in the absence of solvent. Lithium aluminum hydride or another acceptable reducing agent of similar type is then used to reduce the 2-oxo-1,2,3,4-tetrahydroquinoline, preferably in an inert solvent such as diethyl ether. This amine is then acetylated using acetyl chloride in a polar solvent such as pyridine. This protected amine is then acetylated in the presence of aluminum chloride. The acetyl function on the nitrogen may then be removed by base hydrolysis. Then the acetylated compound is converted to the acetylene and ZnCl salt as outlined in Reaction Scheme I. The acetylene or the salt is then coupled with an appropriate compound of formula III as described before to give compounds of formula I.

Reaction Scheme V sets out an alternative method for making the tetrahydroquinoline compounds illustrated in Reaction Scheme IV.

The following Examples are set out to illustrate the invention, not to limit its scope.

EXAMPLE 1

Phenyl-3-methylbut-2-enylsulfide

A mixture of 14.91 g (135.324 mmol) of thiophenol and 5.5 g (137.5 mmol) of NaOH in 100 ml acetone was heated at reflux for 2.5 hours and then treated dropwise with a solution of 20 g (134.19 mmol) of 1-bromo-3-methyl-2-butene in 20 ml acetone. This solution was refluxed for 40 hours and then stirred at room temperature for 24 hours. Solvent was then removed in vacuo, the residue taken up in water, and extracted with 3x50 ml ether. Ether extracts were combined and washed with 3x30 ml of 5% NaOH solution, then water, saturated NaCl solution and dried (MgSO₄). Solvent was then removed in vacuo and the residue further purified by kugelrohr distillation (80° C., 0.75 mm) to give the title compound as a pale yellow oil.

PMR (CDCl₃): 81.57 (3H, s), 1.69 (3H, s), 3.52 (2H, d, J~7.7 Hz), 5.29 (1H, t, J~7.7 Hz), 7.14 (1H, t, J~7.0 Hz), 7.24 (2H, t, J~7.0 Hz), 7.32 (2H, d, J~7.0 Hz).

EXAMPLE 2

4,4-Dimethylthiochroman

To a solution of 15.48 g (86.824 mmol) of phenyl-3-methylbut-2-enylsulfide (from Example 1) in 160 ml benzene were added successively 12.6 g (88.767 mmol) of phosphorus pentoxide and 11 ml of 85% phosphoric acid. This solution was refluxed with vigorous stirring under argon for 20 hours, then cooled to room temperature. The supernatant organic layer was decanted and the syrupy residue extracted with 3x50 ml ether. Organic fractions were combined and washed with water, saturated NaHCO₃ and saturated NaCl solution and then dried (MgSO₄). Solvent was removed in vacuo and the residue purified by kugelrohr distillation (80° C., 0.5 mm) to give the title compound as a pale yellow oil.

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PMR (CDCl₃): 81.30 (6H, s), 1.90-1.95 (2H, m), 2.95-3.00 (2H, m), 6.96-7.00 (2H, m), 7.04-7.07 (1H, m), 7.30-7.33 (1H, m).

This method can be used to make 7-position alkyl analogues as exemplified by the following compounds:

- 4,4,7-trimethylthiochroman;
- 4,4-dimethyl-7-ethylthiochroman;
- 4,4-dimethyl-7-propylthiochroman;
- 4,4-dimethyl-7-butylthiochroman; and
- 4,4-dimethyl-7-hexylthiochroman.

EXAMPLE 3

4,4-Dimethyl-6-acetylthiochroman

A solution of 14.3 g (80.21 mmol) of 4,4-dimethylthiochroman (from Example 2) and 6.76 g (86.12 mmol) of acetyl chloride in 65 ml benzene was cooled in an ice bath and treated dropwise with 26.712 g (102.54 mmol) of stannic chloride. The mixture was stirred at room temperature for 12 hours, then treated with 65 ml water and 33 ml conc. hydrogen chloride and heated at reflux for 0.5 hours. After being cooled to room temperature, the organic layer was separated and the aqueous layer extracted with 5x50 ml benzene. The recovered organic fractions were combined and washed with 5% sodium carbonate solution, water, saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; 5% ethyl acetate in hexanes) followed by kugelrohr distillation (150° C., 0.7 mm) to give the title compound as a pale yellow oil.

PMR (CDCl₃): 81.35 (6H, s), 1.92-1.98 (2H, m), 2.54 (3H, s), 3.02-3.08 (2H, m), 7.13 (1H, d, J~8.6 Hz), 7.58 (1H, dd, J~8.6 Hz, 2 Hz), 7.99 (1H, d, J~2 Hz).

This same method may be used to acetylate all compounds made as per Example 2.

EXAMPLE 4

4,4-Dimethyl-6-ethynylthiochroman

To a solution of 1.441 g (14.2405 mmol) of diisopropylamine in 30 ml dry tetrahydrofuran under argon at -78° C. was added dropwise 9 ml of 1.6M (14.4 mmol) n-butyllithium in hexane. After stirring this solution at -78° C. for 1 hour, it was treated dropwise with a solution of 2.95 g (13.389 mmol) of 4,4-dimethyl-6-acetylthiochroman in 5 ml of dry tetrahydrofuran. After another hour of stirring at -78° C., the solution was treated with 2.507 g (14.33 mmol) of diethyl chlorophosphate and brought to room temperature, where it was stirred for 3.75 hours. This solution was then transferred using a double ended needle to a solution of lithium diisopropylamide (prepared as above using 2.882 g (28.481 mmol) of diisopropylamine and 18 ml of 1.6M (28.8 mmol) n-butyllithium in hexane) in 60 ml dry tetrahydrofuran at -78° C. The cooling bath was removed and the solution stirred at room temperature for 15 hours, then quenched with water and acidified to pH 1 with 3N hydrogen chloride. The mixture was stirred at room temperature for 12 hours, then treated with 65 ml water and 33 ml conc. hydrogen chloride and heated at reflux for 0.5 hours. After being cooled to room temperature, the organic layer was separated and the aqueous layer extracted with 5x50 ml benzene. The recovered organic fractions were combined and washed with 5% sodium carbonate solution, water, saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; 5% ethyl acetate in hexanes)

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followed by kugelrohr distillation (150° C., 0.7 mm) to give the captioned compound as a pale yellow oil.

PMR (CDCl₃): δ1.35 (6H, s), 1.92-1.98 (2H, m), 2.54 (3H, s), 3.02-3.08 (2H, m), 7.13 (1H, d, J=8.6 Hz), 7.58 (1H, dd, J=8.6 Hz, 2 Hz), 7.99 (1H, d, J=2 Hz).

In the same manner, all acetyl-containing compounds prepared under Example 3 may be converted to their corresponding ethynyl analogues.

EXAMPLE 5

Ethyl 6-chloronicotinate

A mixture of 15.75 g (0.1 mol) 6-chloronicotinic acid, 6.9 g (0.15 mol) ethanol, 22.7 g (0.11 mol) dicyclohexylcarbodiimide and 3.7 g dimethylaminopyridine in 200 ml methylene chloride was heated at reflux for 2 hours. The mixture was allowed to cool, solvent removed in vacuo and residue subjected to flash chromatography to give the title compound as a low-melting white solid.

PMR (CDCl₃): δ1.44 (3H, t, J=6.2 Hz), 4.44 (2H, q, J=4.4 Hz), 7.44 (1H, d, J=8.1 Hz), 8.27 (1H, dd, J=8.1 Hz, 3 Hz), 9.02 (1H, d, J=3 Hz).

This procedure may be used to esterify any of the other halo-substituted acids employed in the making of these compounds such as

ethyl 2-(2-chloropyrid-5-yl)acetate;
ethyl 5-(2-chloropyrid-5-yl)pentanoate;
ethyl 2-(2-iodofur-5-yl)acetate;
ethyl 5-(2-iodofur-5-yl)pentanoate;
ethyl 2-(2-iodothien-3-yl)acetate;
ethyl 5-(2-iodothien-5-yl)pentanoate;
ethyl 2-(3-chloropyridazin-6-yl)acetate;
ethyl 5-(3-chloropyridazin-6-yl)pentanoate; and the corresponding chloro, or other halo, substituted pyrimidinyl or pyrazinyl analogues of such esters.

EXAMPLE 6

Ethyl

6-[2-(4,4-dimethylthiochroman-6-yl)ethynyl]nicotinate

Reaction vessels used in this procedure were flame dried under vacuum and all operations carried out in an oxygen-free, argon or nitrogen atmosphere. To a solution of 465.7 mg (2.3019 mmol) of 4,4-dimethyl-6-ethynyl-thiochroman in 4 ml of dry tetrahydrofuran at 0° C. was added dropwise 1.5 ml of 1.6M (2.4 mmol) n-butyllithium in hexane. This was stirred at 0° C. for 10 minutes and at room temperature for 10 minutes, cooled again to 0° C. and then treated with a solution of 330 mg (2.4215 mmol) of fused ZnCl₂ in 4 ml dry tetrahydrofuran using a double ended needle. Thereafter the solution was stirred at 0° C. for 30 minutes, then at room temperature for 10 minutes. A solution of 426.3 mg (2.2967 mmol) of ethyl 6-chloronicotinoate (from Example 5) in 4 ml dry tetrahydrofuran was transferred by double ended needle into a suspension of 430 mg (0.37 mmol) of tetrakis(triphenylphosphine) palladium in 4 ml dry tetrahydrofuran and stirred at room temperature for 10 minutes, then treated by double ended needle with the solution of the alkynylzinc prepared above. This mixture was stirred at room temperature for 18 hours, then quenched with 100 ml water. Product was recovered by extraction with 3 x 75 ml ether. Ether fractions were combined and washed with saturated NaCl solutions and dried (MgSO₄). Solvent was removed in vacuo and the residue purified by flash chromatography (silica; 5% ethyl acetate in hexane) followed by HPLC (Whatman Partisil M-9 10/50; 4% ethyl acetate in hexane) to give the title compound as a white solid.

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PMR (CDCl₃): δ1.36 (6H, s), 1.45 (3H, t, J=7 Hz), 1.96-2.00 (2H, m), 3.05-3.09 (2H, m), 4.45 (2H, q, J=7 Hz), 7.11 (1H, d, J=8.4 Hz), 7.29 (1H, dd, J=8.4 Hz, 2.2 Hz), 7.59 (1H, d, J=7.8 Hz), 7.66 (1H, d, J=2.2 Hz), 8.30 (1H, dd, J=7.8 Hz, 2.3 Hz), 9.22 (1H, d, J=2.3 Hz).

Using this method, but substituting the appropriate ethynylthiochroman from Example 4 and the appropriate halo-substituted heteroaromatic ester from Example 5, the following compounds may be prepared:

ethyl 6-(2-(4,4,7-trimethylthiochroman-6-yl)ethynyl)nicotinate;
ethyl 6-(2-(4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)nicotinate;
ethyl 6-(2-(4,4-dimethyl-7-propylthiochroman-6-yl)ethynyl)nicotinate;
ethyl 6-(2-(4,4-dimethyl-7-hexylthiochroman-6-yl)ethynyl)nicotinate;
ethyl 2-((4,4-dimethylthiochroman-6-yl)ethynyl)pyrid-5-yl)acetate;
ethyl 2-((4,4,7-trimethylthiochroman-6-yl)ethynyl)pyrid-5-yl)acetate;
ethyl 2-((4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)pyrid-5-yl)acetate;
ethyl 2-((4,4-dimethyl-7-hexylthiochroman-6-yl)ethynyl)pyrid-5-yl)acetate;
ethyl 3-(2-((4,4-dimethylthiochroman-2-yl)ethynyl)pyrid-5-yl)propionate;
ethyl 3-(2-((4,4,7-trimethylthiochroman-6-yl)ethynyl)pyrid-5-yl)propionate;
ethyl 3-(2((4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)pyrid-5-yl)propionate;
ethyl 3-(2((4,4-dimethyl-7-hexylthiochroman-6-yl)ethynyl)pyrid-5-yl)propionate;
ethyl 5-(2-((4,4-dimethylthiochroman-6-yl)ethynyl)pyrid-5-yl)pentanoate;
ethyl 5-(2-((4,4,7-trimethylthiochroman-6-yl)ethynyl)pyrid-5-yl)pentanoate;
ethyl 5-(2-((4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)pyrid-5-yl)pentanoate;
ethyl 5-(2-((4,4-dimethyl-7-hexylthiochroman-6-yl)ethynyl)pyrid-5-yl)pentanoate;
ethyl 5-(5-((4,4-dimethylthiochroman-6-yl)ethynyl)fur-2-yl)acetate;
ethyl 5-(5-((4,4,7-trimethylthiochroman-6-yl)ethynyl)fur-2-yl)acetate;
ethyl 5-(5-((4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)fur-2-yl)acetate;
ethyl 5-(5-((4,4-dimethyl-7-hexylthiochroman-6-yl)ethynyl)fur-2-yl)acetate;
ethyl 5-(5-((4,4-dimethylthiochroman-6-yl)ethynyl)fur-2-yl)pentanoate;
ethyl 5-(5-((4,4,7-trimethylthiochroman-6-yl)ethynyl)fur-2-yl)pentanoate;
ethyl 5-(5-((4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)thien-2-yl)acetate;
ethyl 5-(5-((4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)thien-2-yl)acetate;
ethyl 5-(5-((4,4-dimethyl-7-hexylthiochroman-6-yl)ethynyl)thien-2-yl)acetate;
ethyl 5-(5-((4,4-dimethylthiochroman-6-yl)ethynyl)thien-2-yl)pentanoate;
ethyl 5-(5-((4,4,7-trimethylthiochroman-6-yl)ethynyl)thien-2-yl)pentanoate;

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ethyl 5-((4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)thien-2-yl)pentanoate;
ethyl 5-((4,4-dimethyl-7-hexylthiochroman-6-yl)ethynyl)thien-2-yl)pentanoate;
ethyl 6-((4,4-dimethylthiochroman-6-yl)ethynyl)pyridazin-3-yl)acetate;
ethyl 6-((4,4,7-trimethylthiochroman-6-yl)ethynyl)pyridazin-3-yl)acetate;
ethyl 6-((4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)pyridazin-3-yl)acetate;
ethyl 6-((4,4-dimethyl-7-hexylthiochroman-6-yl)ethynyl)pyridazin-3-yl)acetate;
ethyl 5-((4,4-dimethylthiochroman-6-yl)ethynyl)pyridazin-3-yl)pentanoate;
ethyl 5-((4,4,7-trimethylthiochroman-6-yl)ethynyl)pyridazin-3-yl)pentanoate;
ethyl 5-((4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)pyridazin-3-yl)pentanoate;
ethyl 5-((4,4-dimethyl-7-hexylthiochroman-6-yl)ethynyl)pyridazin-3-yl)pentanoate;
ethyl 5-((4,4-dimethylthiochroman-6-yl)ethynyl)pyrimidin-2-yl)acetate;
ethyl 5-((4,4,7-trimethylthiochroman-6-yl)ethynyl)pyrimidin-2-yl)acetate;
ethyl 5-((4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)pyrimidin-2-yl)acetate;
ethyl 5-((4,4-dimethyl-7-hexylthiochroman-6-yl)ethynyl)pyrimidin-2-yl)acetate;
ethyl 5-((4,4-dimethylthiochroman-6-yl)ethynyl)pyrimidin-2-yl)pentanoate;
ethyl 5-((4,4,7-trimethylthiochroman-6-yl)ethynyl)pyrimidin-2-yl)pentanoate;
ethyl 5-((4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)pyrimidin-2-yl)pentanoate;
ethyl 5-((4,4-dimethyl-7-hexylthiochroman-6-yl)ethynyl)pyrimidin-2-yl)pentanoate;
ethyl 5-((4,4-dimethylthiochroman-6-yl)ethynyl)pyrazin-2-yl)acetate;
ethyl 5-((4,4,7-trimethylthiochroman-6-yl)ethynyl)pyrazin-2-yl)acetate;
ethyl 5-((4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)pyrazin-2-yl)acetate;
ethyl 5-((4,4-dimethyl-7-hexylthiochroman-6-yl)ethynyl)pyrazin-2-yl)acetate;
ethyl 5-((4,4-dimethylthiochroman-6-yl)ethynyl)pyrazin-2-yl)pentanoate;
ethyl 5-((4,4,7-trimethylthiochroman-6-yl)ethynyl)pyrazin-2-yl)pentanoate;
ethyl 5-((4,4-dimethyl-7-ethylthiochroman-6-yl)ethynyl)pyrazin-2-yl)pentanoate; and
ethyl 5-((4,4-dimethyl-7-hexylthiochroman-6-yl)ethynyl)pyrazin-2-yl)pentanoate.

Alternative synthesis: The title compound of Example 6, ethyl 6-[2-((4,4-dimethylthiochroman-6-yl)ethynyl)nicotinate, was also prepared as follows.

A solution of 15.4 g (76.2 mmol) of 4,4-dimethyl-6-ethynylthiochroman and 14.0 g (75.5 mmol) of ethyl-6-chloronicotinate in 35 ml of freshly distilled triethylamine was degassed and then treated under nitrogen with a finely powdered mixture of 1 g (5.25 mmol) of high purity cuprous iodide and 2 g (2.85 mmol) of bis(triphenylphosphine) palladium (II) chloride. The mixture was heated under nitrogen at 55° C. for 20 hours and then cooled to room temperature. The triethylamine was then removed under vacuum and the residue was diluted with 200 ml of a 1:4 mixture of ethyl acetate and hexanes. This mixture was filtered through silica and the filtrate concentrated in vacuo. The resultant residue

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was purified by flash chromatography (silica gel; 15% ethyl acetate in hexanes) and recrystallized from a mixture of ethyl acetate and hexanes to give the title compound as a pale yellow solid.

EXAMPLE 7

(3-Methyl-4-bromo-phenyl)-3-methylbut-2-enylsulfide

To a stirred solution of 9.52 g (68 mmol) of 3-methyl-4-bromothiophenol in 80 ml of acetone was added 2.86 g (68 mmol) of powdered sodium hydroxide. This mixture was stirred until the components were dissolved. The reaction mixture was then heated to reflux, and then treated with a solution of 11.26 g (68 mmol) of 4-bromo-2-methyl-2-butene in 20 ml of acetone. The mixture was heated at reflux for a further 0.5 hour, cooled to room temperature and the solvent removed in vacuo. The residue was taken up in 35 ml of water and extracted with ether. The ether extracts were combined and washed successively with water and saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue kugelrohr distilled (140°-145° C., 0.2 mm) to give the title compound as a colorless oil.

PMR (CDCl₃): 81.58 (3H, s), 1.70 (3H, s), 2.33 (3H, s), 3.49 (2H, d, J=7.8 Hz), 5.26 (1H, t, J=7.8 Hz), 6.98 (1H, dd, J=8.3 Hz, 2.3 Hz), 7.17 (1H, d J=2.3 Hz), 7.38 (1H, d, J=8.3 Hz).

EXAMPLE 8

4,4,7-Trimethyl-6-bromothiochroman

To 40 g of a vigorously stirred mixture of 10% phosphorous pentoxide in methanesulfonic acid was added slowly 6.0 g (28.8 mmol) of (3-methyl-4-bromophenyl)-3-methylbut-2-enylsulfide. The mixture was stirred at room temperature for a further 2 hours and was then poured onto ice. The mixture was extracted with 2 x 40 ml of ether and the combined ether extracts were washed successively with water and saturated NaCl solution and then dried. The solvent was removed in vacuo and the residue distilled using a kugelrohr apparatus (130° C.; 0.07 mm) to give the title compound as a viscous oil.

PMR (CDCl₃): 81.28 (6H, s) 1.84-1.93 (2H, m), 2.26 (3H, s), 2.95-3.03 (2H, m), 6.94 (1H, s), 7.46 (1H, s).

EXAMPLE 9

4,4,7-Trimethyl-6-trimethylsilylthiochroman

A mixture of 624 mg (3.0 mmol) of 4,4,7-trimethyl-6-bromothiochroman, 314 mg (3.2 mmol) of trimethylsilylacetylene, 40 mg (0.21 mmol) of cuprous iodide, 80 mg (0.11 mmol) of bis-(triphenylphosphine) palladium (II) chloride and 1 ml of triethylamine was degassed under nitrogen and heated in a sealed tube at 85° C. for 15 hours. The mixture was then treated with a further 20 mg (0.11 mmol) of cuprous iodide and 40 mg (0.06 mmol) of the palladium (II) catalyst. The mixture was then heated under a nitrogen atmosphere in the sealed tube at 100° C. for a further 64 hours. The triethylamine was then removed under vacuum and the residue purified by flash chromatography (silica; hexanes) to give the title compound as a yellow oil.

PMR (CDCl₃): 80.28 (9H, s), 1.30 (6H, s), 1.88-1.97 (2H, m), 2.33 (3H, s), 2.97-3.05 (2H, m), 6.92 (1H, s), 7.43 (1H, s).

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EXAMPLE 10

4,4,7-Trimethyl-6-ethynylthiochroman

A mixture of 380 mg (1.69 mmol) of 4,4,7-trimethyl-6-ethynylthiochroman, 4 ml of isopropanol and 2.5 ml of aqueous 1N potassium hydroxide was degassed under nitrogen and stirred at room temperature for 16 hours. The mixture was concentrated under vacuum and extracted with 2 x 10 ml of ether. The ether extracts were combined and washed successively with water and saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo to give the title compound as a yellow oil.

PMR (CDCl₃): δ 1.31 (6H, s), 1.88-1.96 (2H, m), 2.35 (3H, s), 3.00-3.08 (2H, m), 3.25 (1H, s), 6.94 (1H, s), 7.47 (1H, s).

EXAMPLE 11

Ethyl

6-[2-(4,4,7-trimethylthiochroman-6-yl)ethynyl]nicotinate

A mixture of 86 mg (0.4 mmol) of 4,4,7-trimethyl-6-ethynylthiochroman, 85 mg (0.46 mmol) of ethyl 6-chloronicotinate and 0.8 ml of triethylamine was degassed under nitrogen and then treated with a mixture of 10 mg (0.05 mmol) of cuprous iodide and 20 mg (0.03 mmol) of bis(triphenylphosphine) palladium (II) chloride. The reaction mixture was heated at 55° C. under a nitrogen atmosphere for 18 hours. The mixture was then extracted with 1.5 ml of 40% ethyl acetate in hexanes and purified by flash chromatography (silica; 10% ethyl acetate in hexanes) to give the title compound as a yellow solid.

PMR (CDCl₃): δ 1.32 (6H, s), 1.43 (3H, t, J=7.2 Hz), 2.44 (3H, s), 3.01-3.05 (2H, m), 4.42 (2H, q, J=7.2 Hz), 6.98 (1H, s), 7.54-7.63 (2H, m), 8.27 (1H, dd, J=8.3 Hz, 2.3 Hz), 9.21 (1H, d, J=2.3 Hz).

EXAMPLE 12

Ethyl

5-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)thiophene-2-carboxylate

Using the same general procedure described in the preceding Example 11, but using instead 4,4-dimethyl-6-ethynylthiochroman and ethyl 5-bromothiophene-2-carboxylate, the title compound was synthesized.

PMR (CDCl₃): δ 1.31 (6H, s), 1.36 (3H, t, J=7.5 Hz), 1.90-1.94 (2H, m), 2.99-3.03 (2H, m), 4.33 (2H, q, J=7.5 Hz), 7.04 (1H, d, J=8.1 Hz), 7.13-7.18 (2H, m), 7.50 (1H, s), 7.65 (1H, d, J=3.9 Hz).

EXAMPLE 13

Ethyl-5-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)-2-furoate

Again using the general procedure of Example 11, but using instead 4,4-dimethyl-6-ethynylthiochroman and ethyl 5-bromo-2-furoate, the title compound was synthesized.

PMR (CDCl₃): δ 1.24 (6H, s), 1.31 (3H, t, J=7.0 Hz), 1.83-1.87 (2H, m), 2.93-2.97 (2H, m), 4.30 (2H, q, J=7.0 Hz), 6.60 (1H, d, J=3.4 Hz), 6.98 (1H, d, J=8.1 Hz), 7.09-7.11 (2H, m), 7.46 (1H, d, J=1.7 Hz).

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EXAMPLE 14

Diphenyl-3-methyl-3-buten-1-yl phosphate

To an ice-cooled solution of 12.2 g (141.65 mmol) of 3-methyl-3-buten-1-ol (Aldrich) and 11.9 g (150.44 mmol) of pyridine in 100 ml of tetrahydrofuran was added dropwise under argon a solution of 38.5 g (143.21 mmol) of diphenyl chlorophosphate 93 in 100 ml of tetrahydrofuran. The mixture was heated at reflux for 3 hours and then cooled and filtered. The filtrate was concentrated in vacuo and the residue dissolved in 400 ml of 1:1 ether and hexane and then washed with 2 x 200 ml water, 75 ml saturated NaCl solution and dried (MgSO₄). The solvent was removed in vacuo to give the captioned compound as a pale yellow oil.

PMR (CDCl₃): δ 1.69 (3H, M), 2.37 (2H, t, J N7 Hz), 4.32 (2H, q, J=7 Hz), 4.72 (1H, M), 7.10-7.35 (10H, m).

EXAMPLE 15

4,4-Dimethylchroman

To a dry, ice-cooled flask containing 34.95 g (0.134 mol) of stannic chloride was added quickly under argon 63.0 g (0.669 mol) of phenol. The mixture was stirred at 0° C. for 0.5 hour and then treated with 43.0 g (0.135 mol) of diphenyl-3-methyl-3-buten-1-yl phosphate, followed by a 5 ml carbon disulfide rinse. The mixture was stirred at room temperature for 21 hours and then quenched by pouring onto 700 g ice and 1 liter of 1.5N NaOH. The mixture was extracted with 1 x 600 ml and 2 x 300 ml ether. The combined ether fractions were washed with 2N NaOH, saturated NaCl and dried (MgSO₄). Solvent was removed in vacuo and the residue purified by flash chromatography (silica; 2% ether in hexane) to give the title compound as a colorless oil.

PMR (CDCl₃): δ 1.34 (6H, M), 1.80-1.85 (2H, m), 4.15-4.20 (2H, m), 6.80 (1H, dd, J=8.1 Hz, 1.5 Hz), 6.87 (1H, td, J=8.1 Hz, 1.5 Hz), 7.07 (1H, td, J=8.1 Hz, 1.5 Hz), 7.26 (1H, dd, J=8.1 Hz, 1.5 Hz).

This method also serves to prepare the corresponding 7-alkylchroman compounds, starting with the appropriate 3-alkylphenol, for example:

- 4,4,7-trimethylchroman;
- 4,4-dimethyl-7-ethylchroman;
- 4,4-dimethyl-7-propylchroman;
- 4,4-dimethyl-7-butylchroman;
- 4,4-dimethyl-7-pentylchroman; and
- 4,4-dimethyl-7-hexylchroman.

EXAMPLE 16

4,4-Dimethyl-6-acetylchroman

To a stirred solution of 7.94 g (48.9425 mmol) of 4,4-dimethylchroman in 70 ml of nitromethane was added under argon 4.0 g (50.96 mmol) of acetyl chloride followed by 6.8 g (51 mmol) of aluminum chloride. This was stirred at room temperature for 5.5 hours and then cooled in an ice bath and treated slowly with 70 ml 6N hydrogen chloride. The resultant mixture was stirred at room temperature for 10 minutes, then treated with 100 ml ether and the organic layer separated. The organic layer was washed with water, saturated NaHCO₃ and saturated NaCl solutions and dried (MgSO₄). Solvent was removed in vacuo and the residue purified by flash chromatography (silica; 10% ethyl acetate in hexanes). This was followed by kugelrohr distillation (95°-100° C.; 0.15 mm) to give the title compound as a colorless oil.

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PMR (CDCl₃): 81.40 (6H, M), 1.95-2.00 (2H, m), 2.58 (3H, M), 4.25-4.30 (2H, m), 6.83 (1H, d, J ~ 8.0 Hz), 7.62 (1H, dd, J ~ 8.0 Hz, 1.5 Hz), 8.00 (1H, d, J ~ 1.5 Hz).

Following the same procedure and using the compounds of Example 15, the following compounds can be prepared:

- 4,4-dimethyl-6-acetyl-7-methylchroman;
- 4,4-dimethyl-6-acetyl-7-ethylchroman;
- 4,4-dimethyl-6-acetyl-7-propylchroman;
- 4,4-dimethyl-6-acetyl-7-butylchroman;
- 4,4-dimethyl-6-acetyl-7-pentylchroman; and
- 4,4-dimethyl-6-acetyl-7-hexylchroman.

EXAMPLE 17

4,4-Dimethyl-6-ethynylchroman

To a solution of 2.47 g (24.41 mmol) of diisopropylamine in 40 ml dry tetrahydrofuran under argon at -78° C. was added dropwise 15.2 ml of 1.6M (24.32 mmol) n-butyl lithium in hexane. Mixture was stirred at -78° C. for 1 hour and then treated dropwise with a solution of 4.98 g (24.38 mmol) of 4,4-dimethyl-6-acetylchroman in 4 ml of dry tetrahydrofuran. After stirring at -78° C. for 1 hour, the solution was treated with 4.2 g (24.36 mmol) of diethyl chlorophosphate. The cooling bath was then removed and mixture stirred at room temperature for 2.75 hours. This solution was then transferred using a double ended needle to a solution of lithium diisopropyl amide (prepared as per Example 4) using 4.95 g (48.92 mmol) of diisopropylamine and 30.5 ml of 1.6M (48.8 mmol) n-butyl lithium in hexane in 80 ml dry tetrahydrofuran at -78° C. The cooling bath was removed and mixture stirred at room temperature for 18 hours and then quenched with 50 ml water and 25 ml of 3N hydrogen chloride. The mixture was extracted with 2 x 100 ml and 3 x 50 ml of pentane and the combined organic fractions washed with 3N hydrogen chloride, water, saturated NaHCO₃ and saturated NaCl solution and then dried (MgSO₄). Solvent was then removed in vacuo and the residue purified by flash chromatography (silica; 10% ethyl acetate in hexane) followed by kugelrohr distillation (70° C.; 0.35 mm) to give the title compound as a colorless crystalline solid.

PMR (CDCl₃): 81.33 (6H, s), 1.81-1.86 (2H, m), 3.00 (1H, s), 4.19-4.24 (2H, m), 6.75 (1H, d, J ~ 8.5 Hz), 7.22 (1H, dd, J ~ 8.5 Hz, 2.3 Hz), 7.44 (1H, d, J ~ 2.3 Hz).

This procedure serves to convert all acetyl-containing compounds prepared as per Example 16 to their corresponding ethynyl-containing compounds.

EXAMPLE 18

Ethyl

6-[2-(4,4-dimethylchroman-6-yl)ethynyl]nicotinate

Reaction vessels used in this procedure were flame dried under vacuum and all operations were carried out in an oxygen-free, argon or nitrogen atmosphere. To a solution of 509.4 mg (2.74 mmol) of 4,4-dimethyl-6-ethynylchroman in 4 ml of dry tetrahydrofuran at 0° C. was added dropwise 1.72 ml of 1.6M (2.75 mmol) of n-butyl lithium in hexane. Stirring was commenced at 0° C. for 30 minutes and at room temperature for 15 minutes, after which the solution was cooled again to 0° C. and then treated with a solution of 380 mg (2.79 mmol) of fused zinc chloride in 5 ml of dry tetrahydrofuran using a double ended needle. The resulting solution was stirred at 0° C. for 1 hour and then at room temperature for 15 minutes. A solution of 628.6 mg (2.74 mmol) of ethyl 6-chloronicotinate in 4 ml of dry tetrahydrofuran was transferred by double ended needle into a suspen-

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sion of 380 mg (0.33 mmol) of tetrakis(triphenylphosphine) palladium in 5 ml dry tetrahydrofuran and mixture stirred at room temperature for 15 minutes and then treated by double ended needle with the solution of alkynylzinc prepared above. The mixture was stirred at room temperature for 20 hours and then quenched with ice and 30 ml of 3N hydrogen chloride. The mixture was extracted with 3 x 75 ml ether and ether extracts were combined and washed successively with saturated NaHCO₃ and saturated NaCl and then dried (MgSO₄). Solvent was removed in vacuo and the residue further purified by flash chromatography (silica; 10% ethyl acetate in hexane) to give the title compound as a yellow solid.

PMR (CDCl₃): 81.36 (6H, s), 1.44 (3H, t, J ~ 7.1 Hz), 1.83-1.87 (2H, m), 4.22-4.26 (2H, m), 4.44 (2H, q, J ~ 7.1 Hz), 6.80 (1H, d, J ~ 7.6 Hz), 7.35 (1H, d, J ~ 8.9 Hz), 7.58 (1H, d, J ~ 7.6 Hz), 7.60 (1H, M), 8.28 (1H, d, J ~ 8.9 Hz), 9.21 (1H, s).

By this method, using the appropriate precursors, the following compounds are prepared:

- ethyl 6-[2-(4,4,7-trimethylchroman-6-yl)ethynyl]nicotinate;
- ethyl 6-[2-(4,4-dimethyl-7-ethylchroman-6-yl)ethynyl]nicotinate;
- ethyl 6-[2-(4,4-dimethyl-7-propylchroman-6-yl)ethynyl]nicotinate;
- ethyl 6-[2-(4,4-dimethyl-7-hexylchroman-6-yl)ethynyl]nicotinate;
- ethyl 2-[(4,4-dimethylchroman-6-yl)ethynyl]pyrid-5-yl]acetate;
- ethyl 2-[(4,4,7-trimethylchroman-6-yl)ethynyl]pyrid-5-yl]acetate;
- ethyl 2-[(4,4-dimethyl-7-ethylchroman-6-yl)ethynyl]pyrid-5-yl]acetate;
- ethyl 2-[(4,4-dimethyl-7-hexylchroman-6-yl)ethynyl]pyrid-5-yl]acetate;
- ethyl 3-[2-(4,4-dimethylchroman-2-yl)ethynyl]pyrid-5-yl]propionate;
- ethyl 3-[2-(4,4,7-trimethylchroman-6-yl)ethynyl]pyrid-5-yl]propionate;
- ethyl 3-[2-(4,4-dimethyl-7-ethylchroman-6-yl)ethynyl]pyrid-5-yl]propionate;
- ethyl 3-[2-(4,4-dimethyl-7-hexylchroman-6-yl)ethynyl]pyrid-5-yl]propionate;
- ethyl 5-[2-(4,4-dimethylchroman-6-yl)ethynyl]pyrid-5-yl]pentanoate;
- ethyl 5-[2-(4,4,7-trimethylchroman-6-yl)ethynyl]pyrid-5-yl]pentanoate;
- ethyl 5-[2-(4,4-dimethyl-7-ethylchroman-6-yl)ethynyl]pyrid-5-yl]pentanoate;
- ethyl 5-[2-(4,4-dimethyl-7-hexylchroman-6-yl)ethynyl]pyrid-5-yl]pentanoate;
- ethyl 5-[2-(4,4-dimethylchroman-6-yl)ethynyl]fur-2-yl]acetate;
- ethyl 5-[2-(4,4,7-trimethylchroman-6-yl)ethynyl]fur-2-yl]acetate;
- ethyl 5-[2-(4,4-dimethyl-7-ethylchroman-6-yl)ethynyl]fur-2-yl]acetate;
- ethyl 5-[2-(4,4-dimethyl-7-hexylchroman-6-yl)ethynyl]fur-2-yl]acetate;
- ethyl 5-[5-(4,4-dimethylchroman-6-yl)ethynyl]fur-2-yl]pentanoate;
- ethyl 5-[5-(4,4,7-trimethylchroman-6-yl)ethynyl]fur-2-yl]pentanoate;
- ethyl 5-[5-(4,4-dimethyl-7-ethylchroman-6-yl)ethynyl]fur-2-yl]pentanoate;

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ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)ethynyl)fur-2-yl)pentanoate;
ethyl 5-(5-((4,4-dimethylchroman-6-yl)ethynyl)thien-2-yl)acetate;
ethyl 5-(5-((4,4,7-trimethylchroman-6-yl)ethynyl)thien-2-yl)acetate;
ethyl 5-(5-((4,4-dimethyl-7-ethylchroman-6-yl)ethynyl)thien-2-yl)acetate;
ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)ethynyl)thien-2-yl)acetate;
ethyl 5-(5-((4,4-dimethylchroman-6-yl)ethynyl)thien-2-yl)pentanoate;
ethyl 5-(5-((4,4,7-trimethylchroman-6-yl)ethynyl)thien-2-yl)pentanoate;
ethyl 5-(5-((4,4-dimethyl-7-ethylchroman-6-yl)ethynyl)thien-2-yl)pentanoate;
ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)ethynyl)thien-2-yl)pentanoate;
ethyl 6-(6-((4,4-dimethylchroman-6-yl)ethynyl)pyridazin-3-yl)acetate;
ethyl 6-(6-((4,4,7-trimethylchroman-6-yl)ethynyl)pyridazin-3-yl)acetate;
ethyl 6-(6-((4,4-dimethyl-7-ethylchroman-6-yl)ethynyl)pyridazin-3-yl)acetate;
ethyl 6-(6-((4,4-dimethyl-7-hexylchroman-6-yl)ethynyl)pyridazin-3-yl)acetate;
ethyl 5-(5-((4,4-dimethylchroman-6-yl)ethynyl)pyridazin-3-yl)pentanoate;
ethyl 5-(5-((4,4,7-trimethylchroman-6-yl)ethynyl)pyridazin-3-yl)pentanoate;
ethyl 5-(5-((4,4-dimethyl-7-ethylchroman-6-yl)ethynyl)pyridazin-3-yl)pentanoate;
ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)ethynyl)pyridazin-3-yl)pentanoate;
ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)ethynyl)pyrimidin-2-yl)acetate;
ethyl 5-(5-((4,4,7-trimethylchroman-6-yl)ethynyl)pyrimidin-2-yl)acetate;
ethyl 5-(5-((4,4-dimethyl-7-ethylchroman-6-yl)ethynyl)pyrimidin-2-yl)acetate;
ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)ethynyl)pyrimidin-2-yl)acetate;
ethyl 5-(5-((4,4-dimethylchroman-6-yl)ethynyl)pyrimidin-2-yl)pentanoate;
ethyl 5-(5-((4,4,7-trimethylchroman-6-yl)ethynyl)pyrimidin-2-yl)pentanoate;
ethyl 5-(5-((4,4-dimethyl-7-ethylchroman-6-yl)ethynyl)pyrimidin-2-yl)pentanoate;
ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)ethynyl)pyrimidin-2-yl)pentanoate;
ethyl 5-(5-((4,4,7-trimethylchroman-6-yl)ethynyl)pyrazin-2-yl)acetate;
ethyl 5-(5-((4,4,7-trimethylchroman-6-yl)ethynyl)pyrazin-2-yl)acetate;
ethyl 5-(5-((4,4-dimethyl-7-ethylchroman-6-yl)ethynyl)pyrazin-2-yl)acetate;
ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)ethynyl)pyrazin-2-yl)acetate;
ethyl 5-(5-((4,4,7-trimethylchroman-6-yl)ethynyl)pyrazin-2-yl)pentanoate;
ethyl 5-(5-((4,4-dimethyl-7-ethylchroman-6-yl)ethynyl)pyrazin-2-yl)pentanoate;
ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)ethynyl)pyrazin-2-yl)pentanoate; and
ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)ethynyl)pyrazin-2-yl)pentanoate.

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EXAMPLE 19

N-(4-Bromophenyl)-3,3-dimethylacrylamide

To a solution of 9.48 g (80 mmol) of 3,3-dimethylacryloyl chloride in 200 ml of dry tetrahydrofuran (THF) was added with vigorous shaking a solution of 13.76 g (80 mmol) of 4-bromoaniline in 300 ml of dry THF. The mixture stood at room temperature for 2 hours and was then treated with 80 g of ice followed by 200 ml of hexane. The organic layer was separated and the aqueous layer was extracted with 2 x 50 ml of hexanes. The organic layers were combined and washed successively with 30 ml of water and 2 x 30 ml of saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by recrystallization from an ethyl acetate and hexanes mixture to give the title compound as colorless crystals.

PMR (CDCl₃): 81.91 (3H, s), 2.23 (3H, s), 5.73 (1H, broad s), 7.38-7.55 (5H, m).

EXAMPLE 20

4,4-Dimethyl-6-bromo-2-oxo-1,2,3,4-tetrahydroquinoline

To 6.7 g (26.02 mmol) of molten N-(4-bromophenyl)3,3-dimethylacrylamide (heated to 135° C.) was added 4.15 g (31.09) of aluminum chloride over 25 minutes. The reaction mixture was stirred at 130° C. for 16 hours and then treated with a further 1 g of aluminum chloride. The reaction mixture was heated at 130° C. for a further 9 hours and then cooled to room temperature. The reaction was then quenched by the slow addition of 100 ml of ice cold water with slight warming of flask to facilitate mixing. The mixture was extracted with 1 x 100 ml and 4 x 50 ml of ether. The organic extracts were combined and washed with 25 ml of saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; 30% ethyl acetate in hexanes) to give the title compound as a pale yellow solid.

PMR (CDCl₃): 81.37 (6H, s), 2.53 (2H, s), 6.85 (1H, d, J=8.4 Hz), 7.32 (1H, dd, J=8.4 Hz, 2.1 Hz), 7.43 (1H, d, J=2.1 Hz), 10.12 (1H, broad s).

EXAMPLE 21

4,4-Dimethyl-6-bromo-1,2,3,4-tetrahydroquinoline

To 23.5 ml of 1.0M (23.5 mmol) lithium aluminum hydride in THF, heated to reflux under nitrogen, was added a solution of 4.95 g (19.48 mmol) of 4,4-dimethyl-6-bromo-2-oxo-1,2,3,4-tetrahydroquinoline in 50 ml of dry THF and 100 ml of dry diethyl ether via a double-ended needle. The mixture was heated at a reflux for 2 hours and then cooled to room temperature. The reaction mixture was then quenched by the slow addition of 25 ml of water followed by 50 ml of 5% NaOH solution. The mixture was extracted with 2 x 25 ml of ether, the organic extracts were combined and washed successively with 25 ml each of water and saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; 15% ethyl acetate in hexanes) to give the title compound as a brown oil.

PMR (CDCl₃): 81.27 (6H, s), 1.67-1.74 (2H, m), 3.23-3.32 (2H, m), 3.90 (1H, broad s), 6.33 (1H, d, J=8.4 Hz), 7.10 (1H, dd, J=8.4 Hz, 2.3 Hz), 7.25 (1H, d, J=2.3 Hz).

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EXAMPLE 22

4,4-Dimethyl-6-trimethylsilylethynyl-1,2,3,4-tetrahydroquinoline

A solution of 1.608 g (6.7 mmol) of 4,4-dimethyl-6-bromo-1,2,3,4-tetrahydroquinoline in 1.5 ml of triethylamine in a heavy-walled tube was degassed under argon and then treated with 75 mg (0.39 mmol) of cuprous iodide and 150 mg (0.21 mmol) of bis(triphenylphosphine) palladium (II) chloride. The mixture was degassed again under argon, treated with 2.09 g (21.2 mmol) of trimethylsilylacetylene and the tube was sealed. The mixture was heated at 50° C. for 48 hours. After cooling to room temperature methylene chloride was added to the reaction mixture and the mixture filtered. The filtrate was concentrated in vacuo and the residue purified by flash chromatography (silica; 10% ethyl acetate in hexanes) to give the title compound as a yellow oil.

PMR (CDCl₃): 80.20 (9H, s), 1.20 (6H, s), 1.57-1.63 (2H, m), 3.16-3.25 (2H, m), 4.02 (1H, broad s), 6.24 (1H, d, J=8.2 Hz), 7.00 (1H, dd, J=8.2 Hz, 1.8 Hz), 7.26 (1H, d, J=1.8 Hz).

EXAMPLE 23

4,4-Dimethyl-6-ethynyl-1,2,3,4-tetrahydroquinoline

To a solution of 569 mg (2.21 mmol) of 4,4-dimethyl-6-trimethylsilylethynyl-1,2,3,4-tetrahydroquinoline in 3 ml of isopropanol was added, under argon, 1 ml of 1N aqueous KOH solution. The reaction mixture was stirred at room temperature for 36 hours and the isopropanol was removed under vacuum. The residue was extracted with ether and the ether extract was washed successively with water and saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue was purified by flash chromatography (silica; 10% ethyl acetate in hexanes) to give the title compound as a brown oil.

PMR (CDCl₃): 81.26 (6H, s), 1.65-1.72 (2H, m), 2.96 (1H, s), 3.27-3.34 (2H, m), 6.34 (1H, d, J=8.3 Hz), 7.08 (1H, dd, J=8.3 Hz, 1.6 Hz), 7.33 (1H, d, J=1.6 Hz).

EXAMPLE 24

6-(2-(4,4-dimethylchroman-6-yl)ethynyl)nicotinic acid

The absolute ethanol used in this experiment was degassed by applying a vacuum while simultaneously bubbling nitrogen through it. A solution of 101.1 mg (0.30 mmol) of ethyl 6-(2-(4,4-dimethylchroman-6-yl)ethynyl)nicotinoate in 2 ml ethanol was treated under argon with 0.7 ml of a 1.81M (1.27 mmol) solution of potassium hydroxide in ethanol and water. This mixture was stirred at room temperature for 60 hours and then solvent removed in vacuo. The residue was dissolved in 25 ml of water and extracted with 25 ml of ether. The aqueous layer was acidified with glacial acetic acid and extracted with 4 x 50 ml of ether. Ether extracts were combined and washed with water, then saturated NaCl and dried (MgSO₄). Solvent was then removed in vacuo to give the title compound. PMR ((CD₃)₂CO): 81.40 (6H, s) 1.88-1.92 (2H, m), 4.26-4.30 (2H, m), 6.82 (1H, d, J=8.7 Hz), 7.37 (1H, dd, J=7.6 Hz, 2.2 Hz), 7.62 (1H, M), 7.63 (1H, d, J=8.7 Hz), 8.37 (1H, dd, J=7.6 Hz, 2.2 Hz), 9.27 (1H, d, J=2.2 Hz).

Proceeding in the same manner 6-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)nicotinic acid was prepared

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from ethyl 6-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)nicotinoate.

PMR (CDCl₃(CD₃)₂CO): 81.37 (6H, M), 1.99 (2H, m), 3.09 (2H, m), 7.10 (1H, d, J=8.1 Hz), 7.28 (1H, dd, J=8.1 Hz), 2.1 Hz), 7.64 (1H, dd, J=7.8 Hz), 1.8 Hz), 7.65 (1H, d, J=7.8 Hz, 1.5 Hz), 9.24 (1H, m).

Proceeding in the same manner, the esters prepared as per the preceding Examples may be converted to their corresponding acid.

EXAMPLE 25

6-(2-(4,4-Dimethyl-thiochroman-6-yl)ethynyl)-3-pyridylmethanol

To 3.0 ml of 1M lithium aluminum hydride (3.0 mmol) in THF, cooled to -78° C., was added dropwise over 5 min a solution of 2.0 g (5.9 mmol) of ethyl 6-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)nicotinate in 5 ml of THF. The reaction mixture was stirred at -78° C. for 40 min and then treated with 2 ml of water. The mixture was warmed to room temperature and the organic layer was separated. The aqueous layer was extracted with 3 x 10 ml of ether. The organic extracts were combined and washed successively with 1 x 10 ml of dilute HCl, 3 x 10 ml of water and 1 x 15 ml of saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; 50% ethyl acetate in hexanes) to give the title compound as a pale yellow solid.

PMR (CDCl₃): 81.33 (6H, s), 1.91-1.98 (2H, m), 3.01-3.07 (2H, m), 4.75 (2H, s), 7.08 (1H, d, J=8.2 Hz), 7.23 (1H, dd, J=8.2 Hz, 1.7 Hz), 7.46 (1H, d, J=7.9 Hz), 7.60 (1H, d, J=1.2 Hz), 7.71 (1H, dd, J=7.9 Hz, 1.2 Hz), 8.51 (1H, broad s).

EXAMPLE 26

2-(4,4-dimethyl-thiochroman-6-yl)ethynyl)-5-bromopyridine

A mixture of 6.36 g (31.5 mmol) of 4,4-dimethyl-6-ethynylthiochroman, 7.46 g (31.5 mmol) of 2,5-dibromopyridine, 122 mg (0.64 mmol) of cuprous iodide, 224 mg (0.32 mmol) of bis(triphenylphosphine) palladium (II) chloride and 70 ml of freshly distilled triethylamine was degassed under nitrogen and stirred at room temperature for 1 hour. The mixture was then treated with 180 ml of ether and 40 ml of water and the organic layer was separated. The aqueous layer was extracted with ether, the organic layers were combined and then washed with 2 x 40 ml of water, 2 x 40 ml of saturated NaCl solution and then dried (K₂CO₃). The solvent was removed in vacuo and the residue purified by flash chromatography (silica; 5% ethyl acetate in hexanes) and recrystallization from ethyl acetate and hexane to give the title compound as a pale brown solid.

PMR (CDCl₃): 81.34 (6H, s), 1.94-1.98 (2H, m), 3.04-3.08 (2H, m), 7.08 (1H, d, J=8.4 Hz), 7.23 (1H, dd, J=8.4 Hz, 1.8 Hz), 7.38 (1H, J=8.4 Hz), 7.60 (1H, d, J=1.8 Hz), 7.78 (1H, dd, J=8.4, 2.3 Hz), 8.66 (1H, d, J=2.3 Hz).

EXAMPLE 27

2-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)-5-pyridinecarboxaldehyde

To a cooled (-78° C.) solution of 358 mg (1.0 mmol) of 2-(4,4-dimethylthiochroman-6-yl)ethynyl-5-bromopyridine in 5 ml of anhydrous ether was added slowly under nitrogen 1.3 ml of 1.7M (2.21 mmol) ter-

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butyl lithium in pentane. The mixture was stirred at -78° C. for 1 h and then treated with 95 mg (1.3 mmol) of anhydrous dimethylformamide. The mixture was stirred at -78° C. for a further 0.5 hours, then warmed to 0° C. and treated with 5 ml of saturated NH₄Cl solution followed by 5 ml of ether. The organic layer was separated and the aqueous layer was extracted with ether. The organic layers were combined, washed successively with water and saturated NaCl solution and then dried (MgSO₄). The solvent was then removed in vacuo and the residue purified by flash chromatography (silica; 15% ethyl acetate in hexanes) followed by high pressure liquid chromatography (Whatman M-9 Partisil 10/50 column, 15% ethyl acetate in hexanes) to give the title compound as a pale yellow solid.

PMR (CDCl₃): 81.33 (6H, s), 1.93-1.97 (2H, m), 3.03-3.07 (2H, m), 7.08 (1H, d, J=8.2 Hz), 7.26 (1H, dd, J=8.2 Hz, 1.8 Hz), 7.63-7.65 (2H, m), 8.14 (2H, dd, J=8.0 Hz, 2.3 Hz) 9.05 (1H, d, J=2.3 Hz), 10.1 (1H, s).

EXAMPLE 28

2-[2-(4,4-Dimethylchroman-6-yl)ethynyl]-5-hydroxymethylpyridine

A 250 ml 3-necked flask is fitted with a stirrer, a dropping funnel, a nitrogen inlet and a thermometer. In the flask is placed a solution of 379.5 mg (10 mmol) of lithium aluminum hydride in 30 ml of dry diethyl ether. The solution is cooled to -65° C. under nitrogen and a solution of 3.2343 g (10 mmol) of ethyl 6-[2-(4,4-dimethylchroman-6-yl)ethyl]nicotinate in 15 ml of dry ether is added dropwise at a rate such that the temperature does not exceed -60° C. The mixture is stirred at -30° C. for 1 hour and the excess hydride is then destroyed by the addition of 300 mg (3.4 mmol) of ethyl acetate. The reaction mixture is then hydrolyzed by adding 3 ml of saturated ammonium chloride solution and allowing the temperature to rise to room temperature. The mixture is then filtered and the residue washed with ether. The ether layer is then washed with saturated sodium chloride solution, dried (MgSO₄) and then concentrated in vacuo. The residue is purified by chromatography followed by recrystallization to give the title compound.

By the same process, acids or esters of this invention may be converted to their corresponding primary alcohol.

EXAMPLE 29

2-[2-(4,4-Dimethylchroman-6-yl)ethynyl]-5-acetoxymethylpyridine

A solution of 2.81 g (10 mmol) of 2-[2-(4,4-dimethylchroman-6-yl)ethynyl]-5-hydroxymethylpyridine, 600 mg (10 mmol) of glacial acetic acid, 2.06 g (10 mmol) of dicyclohexylcarbodiimide and 460 mg (3.765 mmol) of 4-dimethylaminopyridine in 150 ml methylene chloride is stirred at room temperature for 48 hours. The reaction mixture is then filtered and the residue washed with 50 ml of methylene chloride. The filtrate is then concentrated in vacuo and the residue is purified by chromatography followed by recrystallization to give the title compound.

Proceeding in the same manner, other alcohols of this invention may be esterified.

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EXAMPLE 30

2-(2-(4,4-Dimethylchroman-6-yl)ethynyl)pyridine-5-carboxaldehyde

A solution of 1.396 g (11 mmol) of freshly distilled oxalyl chloride in 25 ml of methylene chloride is placed in a 4-necked flask equipped with a stirrer, a thermometer and two pressure-equalizing addition funnels fitted with drying tubes. The solution is cooled to -60° C. and then treated dropwise with a solution of 1.875 g (24 mmol) of dimethyl sulfoxide (distilled from calcium hydride) in 5 ml of methylene chloride over a five minute period. The reaction mixture is then stirred at -60° C. for an additional 10 minutes. A solution of 2.82 g (10 mmol) of 2-[2-(4,4-dimethylchroman-6-yl)ethynyl]-5-hydroxymethylpyridine in 10 ml of methylene chloride is then added to the reaction mixture over a period of 5 minutes. The mixture is stirred for a further 15 minutes and is then treated with 5.06 g (50 mmol) of triethylamine. The cooling bath is then removed and the mixture is allowed to warm to room temperature. Thirty ml of water is then added to the mixture and stirring is continued for a further 10 minutes. The organic layer is then separated and the aqueous layer is extracted with 20 ml of methylene chloride. The organic layers are then combined and washed successively with dilute HCl, water and dilute Na₂CO₃ solution and then dried (MgSO₄). The solution is then filtered and concentrated in vacuo and the residue is purified by chromatography followed by recrystallization to give the title compound.

Primary alcohols of this invention may be oxidized to their corresponding aldehyde by this method.

EXAMPLE 31

2-(2-(4,4-Dimethylchroman-6-yl)ethynyl)-5-(1-hydroxypropyl)pyridine

Four ml of a 3M (12 mmol) solution of ethylmagnesium bromide in ether is placed in a 3-necked flask fitted with a mechanical stirrer, a reflux condenser protected by a drying tube and a pressure-equalizing dropping funnel protected by a drying tube. The flask is cooled in an ice bath and a solution of 2.8 g (10 mmol) of 2-(2-(4,4-Dimethylchroman-6-yl)ethynyl)pyridine-5-carboxaldehyde in 10 ml of dry ether is added slowly with vigorous stirring. The cooling bath is then removed and the mixture heated at reflux for 3 hours. The mixture is then cooled in an ice-salt bath and 5 ml of saturated ammonium chloride solution added. The mixture is stirred for a further 1 hour and then filtered and the residue washed with two 10 ml portions of ether. The ether solution is then separated, dried (MgSO₄) and the ether removed in vacuo. The residue is then purified by chromatography followed by recrystallization to give the title compound.

Using the same procedure any of the other aldehydes of this invention can be converted to a secondary alcohol.

Such secondary alcohols may be converted to their corresponding ketone using the procedure recited in Example 15.

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EXAMPLE 32

2-(2-(4,4-Dimethylchroman-6-yl)ethynyl)-5-dimethoxy-methylpyridine

A round-bottomed flask is fitted with a Dean-Stark apparatus under a reflux condenser protected by a drying tube. A mixture of 3.35 g (12 mmol) of 2-(4,4-dimethylchroman-6-yl)ethynyl-pyridine-5-carboxaldehyde, 4.80 mg (15 mmol) of anhydrous methanol, 2 mg of P-toluenesulfonic acid monohydrate and 10 ml of anhydrous benzene is placed in the flask and the mixture heated at reflux under nitrogen until lower to the theoretical amount of water is collected in the Dean-Stark trap. The reaction mixture is cooled to room temperature and extracted successively with 5 ml of 10% sodium hydroxide solution and two 5 ml portions of water and then dried (MgSO₄). The solution is then filtered and the solvent removed in vacuo. The residue is purified by chromatography and then recrystallization to give the title compound.

In a similar manner, any aldehyde or ketone of this invention may be converted to an acetal or a ketal.

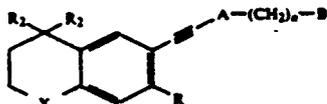
EXAMPLE 33

Preferably, these compounds may be administered topically using various formulations. Such formulation may be as follows:

Ingredient	Weight/Percent
<u>Solution</u>	
Retinoid	0.1
BHT 0.1	
Alcohol USP	58.0
Polyethylene Glycol 400 NF	41.8
<u>Gel</u>	
Retinoid	0.1
BHT 0.1	
Alcohol USP	97.8
Hydroxypropyl Cellulose	2.0

What is claimed is:

1. A compound of the formula



where X is S or O; R is hydrogen or lower alkyl; R₂ is methyl; A is pyridyl; n is 0-2; and B is H, —COOH or a pharmaceutically acceptable salt thereof, or an ester thereof with a saturated aliphatic alcohol of ten or fewer carbon atoms, or with a cyclic or saturated aliphatic cyclic alcohol of 5 to 10 carbon atoms, or with phenol or with a lower alkylphenol, or an amide or a mono or disubstituted amide thereof, the substituents on the amide being selected from a group consisting of saturated aliphatic radicals of ten or fewer carbon atoms, cyclic or saturated aliphatic cyclic radicals of 5 to 10 carbon atoms, and phenyl or lower alkylphenyl radicals, or B is CH₂OH or an ester derivative thereof derived from a saturated aliphatic acid of ten or fewer carbon atoms, or from a cyclic or saturated aliphatic cyclic acid of 5 to 10 carbon atoms, or from benzoic acid, or an ether derivative thereof derived from a saturated aliphatic radical of ten or fewer carbon atoms, or from a cyclic or saturated aliphatic cyclic radical of 5 to

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10 carbon atoms, or from phenyl or lower alkylphenyl radical, or B is —CHO or a lower alkyl acetal derivative thereof, or an acetal derivative thereof formed with a lower alkyl diol, or B is —COR₁ or a lower alkyl ketal derivative thereof, or a ketal derivative thereof formed with a lower alkyl diol, where R₁ is —(CH₂)_mCH₃; where m is 0-4, or a pharmaceutically acceptable salt of the compound defined in said formula.

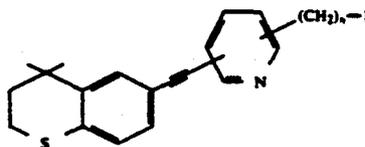
2. A compound of claim 1 where X is S, R is hydrogen, and n is 0 or 1.

3. A compound of claim 2 where B is —COOH or a pharmaceutically acceptable salt, lower alkyl ester or mono- or di-lower alkyl amide thereof.

4. Ethyl 6-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)nicotinate.

5. 6-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)nicotinic acid or a pharmaceutically acceptable salt thereof.

6. A compound of the formula



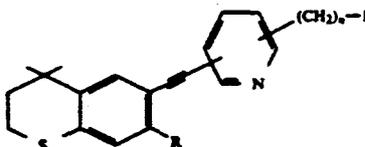
where n is 0 or 1 and where B is —CH₂OH or a lower alkyl ether or lower alkyl acid ester thereof.

7. A compound of claim 6 which is 6-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)-3-pyridylmethanol.

8. A compound of claim 2 where B is —CHO or an acetal derivative thereof.

9. A compound of claim 8 which is 2-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)-5-pyridinecarboxaldehyde.

10. A compound of the formula



where R is lower alkyl, n is 0 or 1, and B is H, —COOH or a pharmaceutically acceptable salt thereof, or an ester thereof with a saturated aliphatic alcohol of ten or fewer carbon atoms, or with a cyclic or saturated aliphatic cyclic alcohol of 5 to 10 carbon atoms, or with phenol or with a lower alkylphenol, or an amide or a mono or di-substituted amide thereof, the substituents on the amide being selected from a group consisting of saturated aliphatic radicals of ten or fewer carbon atoms, cyclic or saturated aliphatic cyclic radicals of 5 to 10 carbon atoms, and phenyl or lower alkylphenyl radicals, or B is CH₂OH or an ester derivative thereof derived from a saturated aliphatic acid of ten or fewer carbon atoms, or from a cyclic or saturated aliphatic cyclic acid of 5 to 10 carbon atoms, or from benzoic acid, or an ether derivative thereof derived from a saturated aliphatic radical of ten or fewer carbon atoms, or from a cyclic or saturated aliphatic cyclic radical of 5 to 10 carbon atoms, or from phenyl or lower alkylphenyl radical, or B is —CHO or a lower alkyl acetal deriva-

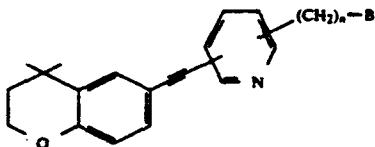
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tive thereof, or an acetal derivative thereof formed with a lower alkyl diol, or B is $-\text{COR}_1$ or a lower alkyl ketal derivative thereof, or a ketal derivative thereof formed with a lower alkyl diol, where R_1 is $-(\text{CH}_2)_m\text{CH}_3$ where m is 0-4, or a pharmaceutically acceptable salt of the compound defined in said formula.

11. A compound of claim 10 which is 6-(2-(4,4,7-trimethylthiochroman-6-yl)ethynyl)nicotinic acid or a pharmaceutically acceptable salt thereof.

12. A compound of the formula



where n is 0 or 1, and B is H, $-\text{COOH}$ or a pharmaceutically acceptable salt thereof, or an ester thereof with a saturated aliphatic alcohol of ten or fewer carbon atoms, or with a cyclic or saturated aliphatic cyclic alcohol of 5 to 10 carbon atoms, or with phenol or with a lower alkylphenol, or an amide or a mono or di-substituted amide thereof, the substituents on the amide being selected from a group consisting of saturated aliphatic radicals of ten or fewer carbon atoms, cyclic or saturated aliphatic cyclic radicals of 5 to 10 carbon atoms, and phenyl or lower alkylphenyl radicals, or B is CH_2OH or an ester derivative thereof derived from a saturated aliphatic acid of ten or fewer carbon atoms, or from a cyclic or saturated aliphatic cyclic acid of 5 to 10 carbon atoms, or from benzoic acid, or an ether derivative thereof derived from a saturated aliphatic radical of ten or fewer carbon atoms, or from a cyclic or saturated aliphatic cyclic radical of 5 to 10 carbon atoms, or from phenyl or lower alkylphenyl radical, or B is $-\text{CHO}$ or a lower alkyl acetal derivative thereof, or an acetal derivative thereof formed with a lower alkyl diol, or B is $-\text{COR}_1$ or a lower alkyl ketal derivative thereof, or a ketal derivative thereof formed with a lower alkyl diol, where R_1 is $-(\text{CH}_2)_m\text{CH}_3$ where m is 0-4, or a pharmaceutically acceptable salt of the compound defined in said formula.

13. A compound of claim 12 where B is $-\text{COOH}$ or a pharmaceutically acceptable salt, lower alkyl ester or mono- or di-lower alkyl amide thereof.

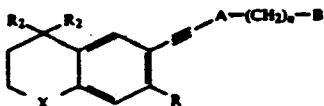
14. 6-(2-(4,4-dimethylchroman-6-yl)ethynyl)nicotinic acid or a pharmaceutically acceptable salt thereof.

15. Ethyl 6-(2-(4,4-dimethylchroman-6-yl)ethynyl)nicotinate.

16. A compound of claim 12 where B is $-\text{CH}_2\text{OH}$ or a lower alkyl ether or lower alkyl acid ester thereof.

17. A compound of claim 12 where B is $-\text{CHO}$ or an acetal derivative thereof.

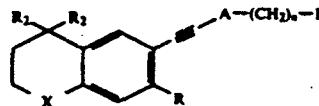
18. A pharmaceutical composition comprising a pharmaceutically acceptable excipient and a compound of the formula



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where X is S or O; R is hydrogen or lower alkyl; R_2 is methyl; A is pyridyl; n is 0-2; and B is H, $-\text{COOH}$ or a pharmaceutically acceptable salt thereof, or an ester thereof with a saturated aliphatic alcohol of ten or fewer carbon atoms, or with a cyclic or saturated aliphatic cyclic alcohol of 5 to 10 carbon atoms, or with phenol or with a lower alkylphenol, or an amide or a mono or di-substituted amide thereof, the substituents on the amide being selected from a group consisting of saturated aliphatic radicals of ten or fewer carbon atoms, cyclic or saturated aliphatic cyclic radicals of 5 to 10 carbon atoms, and phenyl or lower alkylphenyl radicals, or B is CH_2OH or an ester derivative thereof derived from a saturated aliphatic acid of ten or fewer carbon atoms, or from a cyclic or saturated aliphatic cyclic acid of 5 to 10 carbon atoms, or from benzoic acid, or an ether derivative thereof derived from a saturated aliphatic radical of ten or fewer carbon atoms, or from a cyclic or saturated aliphatic cyclic radical of 5 to 10 carbon atoms, or from phenyl or lower alkylphenyl radical, or B is $-\text{CHO}$ or a lower alkyl acetal derivative thereof, or an acetal derivative thereof formed with a lower alkyl diol, or B is $-\text{COR}_1$ or a lower alkyl ketal derivative thereof, or a ketal derivative thereof formed with a lower alkyl diol, where R_1 is $-(\text{CH}_2)_m\text{CH}_3$ where m is 0-4, or a pharmaceutically acceptable salt of the compound defined in said formula.

19. A method of treating psoriasis in a mammal which method comprises administering alone or in conjunction with a pharmaceutically acceptable excipient, a therapeutically effective amount of a compound of the formula



where X is S or O; R is hydrogen or lower alkyl; R_2 is methyl; A is pyridyl; n is 0-2; and B is H, $-\text{COOH}$ or a pharmaceutically acceptable salt thereof, or an ester thereof with a saturated aliphatic alcohol of ten or fewer carbon atoms, or with a cyclic or saturated aliphatic cyclic alcohol of 5 to 10 carbon atoms, or with phenol or with a lower alkylphenol, or an amide or a mono or di-substituted amide thereof, the substituents on the amide being selected from a group consisting of saturated aliphatic radicals of ten or fewer carbon atoms, cyclic or saturated aliphatic cyclic radicals of 5 to 10 carbon atoms, and phenyl or lower alkylphenyl radicals, or B is CH_2OH or an ester derivative thereof derived from a saturated aliphatic acid of ten or fewer carbon atoms, or from a cyclic or saturated aliphatic cyclic acid of 5 to 10 carbon atoms, or from benzoic acid, or an ether derivative thereof derived from a saturated aliphatic radical of ten or fewer carbon atoms, or from a cyclic or saturated aliphatic cyclic radical of 5 to 10 carbon atoms, or from phenyl or lower alkylphenyl radical, or B is $-\text{CHO}$ or a lower alkyl acetal derivative thereof, or an acetal derivative thereof formed with a lower alkyl diol, or B is $-\text{COR}_1$ or a lower alkyl ketal derivative thereof, or a ketal derivative thereof formed with a lower alkyl diol, where R_1 is $-(\text{CH}_2)_m\text{CH}_3$ where m is 0-4, or a pharmaceutically acceptable salt of the compound defined in said formula.