

METHODS OF TREATING ACNE

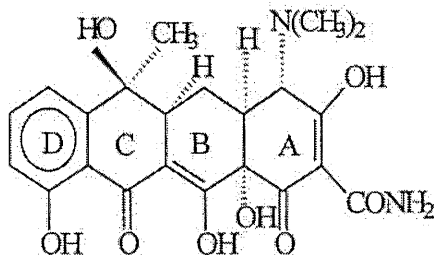
BACKGROUND OF THE INVENTION

Acne is a common inflammatory disease in skin areas where sebaceous glands are largest, most numerous, and most active. In its mildest form, acne is a more or less superficial disorder characterized by slight, spotty skin irritations. In such cases, ordinary skin hygiene is typically a satisfactory treatment. In the more inflammatory types of acne, however, pustules; infected cysts; and in extreme cases, canalizing, inflamed and infected sacs appear. Without effective treatment, these lesions may become extensive and leave permanent, disfiguring scars.

Micro-organisms, especially *Propionibacterium acnes*, are strongly implicated in the pathogenesis of acne. The micro-organisms are thought to release microbial mediators of inflammation into the dermis or trigger the release of cytokines from ductal keratinocytes.

Accordingly, the efficacy of antibiotics in treating acne is thought to be due, in significant part, to the direct inhibitory effect of the antibiotics on the growth and metabolism of these micro-organisms. Systemically-administered tetracycline antibiotics, especially minocycline hydrochloride, are particularly effective in treating acne.

The tetracyclines are a class of compounds of which tetracycline is the parent compound. Tetracycline has the following general structure:



Structure A

of IL-1 in comedones destined to become inflamed may enhance resolution and promote repair of the damaged follicular epithelium.

Another possible activity of tetracyclines in acne therapy was investigated by
5 Bodokh, I., et al., *Acta. Derm. Venerol.*, 77:255-259 (1997). Their study was designed to
evaluate the action of minocycline on sebaceous excretion in acne patients. A 100mg daily
dose of minocycline was administered. A subclinical increase in seborrhoea was reported.
The authors propose that minocycline induces an increase in seborrhoea via a reduction in
ductal obstruction. The mechanism by which the ductal obstruction is reduced is proposed
10 to be the reduction in ductal irritation. The authors suggest that the reduction of ductal
irritation is due to minocycline's direct effect on *P. acnes*, or minocycline's effect on the
lipase produced by *P. acnes*.

Bodokh et al. also found that during treatment no correlation exists between
15 seborrhoea intensity and clinical severity of acne. The authors state that the lack of
correlation shows that seborrhoea is pathogenic because it is the "culture medium" of *P.*
acnes. Thus, it can be concluded that the authors consider the antimicrobial activity of
minocycline as a significant therapeutic activity with respect to acne.

20 Similarly, in a recent clinical study it was found that tetracycline doses lower than
antimicrobial doses had no clinical effect on acne. (Cunliffe et al., *J. Am. Acad.*
Dermatol., 16:591-9 (1987).) In particular, a 100mg total daily dose of minocycline; and a
1.0g total daily dose of tetracycline were found to be necessary to successfully treat acne.

25 The antimicrobial effects of antibiotics are generally directly proportional to the
dose administered of the antibiotics. Accordingly, in moderate to severe (i.e.
inflammatory) forms of acne, oral antibiotics are typically administered at high doses. For
example, in conventional acne therapy, tetracycline is administered at an initial dose of
500 to 2,000 mg/day, followed by a maintenance dose of 250-500 mg/day.

30

Clearly, the state-of-the-art teaching is that the clinical efficacy of systemically-administered tetracyclines in the treatment of acne is due in significant part to the antimicrobial effects of the tetracyclines.

5 The use of tetracycline antibiotics, however, can lead to undesirable side effects. For example, the long term administration of antibiotic tetracyclines can reduce or eliminate healthy microbial flora, such as intestinal flora, and can lead to the production of antibiotic resistant organisms or the overgrowth of yeast and fungi. Other side effects include gastrointestinal symptoms such as nausea, vomiting, abdominal pain, diarrhea,
10 rashes, and other allergic reactions. Tetracyclines also can cause fetal harm if used during pregnancy.

 Accordingly, there is a need for an effective treatment of acne which does not cause the undesirable side effects produced by the systemically-administered antibiotics
15 used in conventional acne therapy.

SUMMARY OF INVENTION

 The present invention provides a method of treating acne in a human in need
20 thereof. The method comprises administering systemically to the human a tetracycline compound in an amount that is effective to treat acne but has substantially no antimicrobial activity, without administering a bisphosphonate compound.

BRIEF DESCRIPTION OF THE DRAWINGS

25 Figure 1 shows the photoirritancy factor (PIF) for some tetracycline compounds. For structure K, the compounds indicated are as follows:

30	COL	R7	R8	R9
	308	hydrogen	hydrogen	amino
	311	hydrogen	hydrogen	palmitamide
	306	hydrogen	hydrogen	dimethylamino

For structures L, M, N or O the compounds indicated are as follows:

COL	R7	R8	R9
801	hydrogen	hydrogen	acetamido
802	hydrogen	hydrogen	dimethylaminoacetamido
804	hydrogen	hydrogen	nitro
805	hydrogen	hydrogen	amino

For structure P, R7 is hydrogen, R8 is hydrogen and R9 is nitro.

DETAILED DESCRIPTION

The present invention provides methods of treating acne. As used herein, the term "acne" is a disorder of the skin characterized by papules, pustules, cysts, nodules, comedones, and other blemishes or skin lesions. These blemishes and lesions are often accompanied by inflammation of the skin glands and pilosebaceous follicles, as well as, microbial, especially bacterial, infection.

For the purposes of this specification, acne includes all known types of acne. Some types of acne include, for example, acne vulgaris, cystic acne, acne atrophica, bromide acne, chlorine acne, acne conglobata, acne cosmetica, acne detergentica, epidemic acne, acne estivalis, acne fulminans, halogen acne, acne indurata, iodide acne, acne keloid, acne mechanica, acne papulosa, pomade acne, premenstrual acne, acne pustulosa, acne rosacea, acne scorbutica, acne scrofulosorum, acne urticata, acne varioliformis, acne venenata, propionic acne, acne excoriee, gram negative acne, steroid acne, and nodulocystic acne.

The present invention can also be used to treat certain other types of acneiform dermal disorders, e.g. perioral dermatitis, seborrheic dermatitis in the presence of acne, gram negative folliculitis, sebaceous gland dysfunction, hidradenitis suppurativa, pseudo-folliculitis barbae, or folliculitis.

The method comprises the administration of a tetracycline compound to a human in an amount which is effective to treat acne, but which has substantially no antimicrobial activity.

- 5 The tetracycline compound can be an antimicrobial or non-antimicrobial compound. The tetracycline compound has the general structure indicated above.

- Some examples of antimicrobial tetracycline compounds include doxycycline, minocycline, tetracycline, oxytetracycline, chlortetracycline, demeclocycline, lymecycline
10 and their pharmaceutically acceptable salts. Doxycycline is preferably administered as its hydrate salt or as a hydrate, preferably monohydrate.

- Non-antimicrobial tetracycline compounds are structurally related to the antibiotic tetracyclines, but have had their antibiotic activity substantially or completely eliminated
15 by chemical modification. For example, non-antimicrobial tetracycline compounds are capable of achieving antibiotic activity comparable to that of tetracycline at concentrations at least about ten times, preferably at least about twenty five times, greater than that of tetracycline.

- 20 Examples of chemically modified non-antimicrobial tetracyclines (CMT's) include, 4-de(dimethylamino)tetracycline (CMT-1), tetracyclinonitrile (CMT-2), 6-demethyl-6-deoxy-4-de(dimethylamino)tetracycline (CMT-3), 7-chloro-4-de(dimethylamino)tetracycline (CMT-4), tetracycline pyrazole (CMT-5), 4-hydroxy-4-de(dimethylamino)tetracycline (CMT-6), 4-de(dimethylamino)-12 α -deoxytetracycline
25 (CMT-7), 6-deoxy-5 α -hydroxy-4-de(dimethylamino)tetracycline (CMT-8), 4-de(dimethylamino)-12 α -deoxyanhydrotetracycline (CMT-9), 4-de(dimethylamino)minocycline (CMT-10).

- Further examples of chemically modified non-antimicrobial tetracyclines include
30 Structures C-Z. (See Index of Structures.)

The minimal amount of the tetracycline compound administered to a human is the lowest amount capable of providing effective treatment of acne. Effective treatment is a reduction or inhibition of the blemishes and lesions associated with acne.

5 The amount of a tetracycline compound that has substantially no antimicrobial activity is an amount that does not significantly prevent the growth of microbes, e.g. bacteria.

For example, tetracycline compounds that have significant antimicrobial activity
10 may be administered in an amount which is 10-80% of the antimicrobial amount. More preferably, the antimicrobial tetracycline compound is administered in an amount which is 40-70% of the antimicrobial amount.

Some examples of antimicrobial amounts of members of the tetracycline family
15 include 100mg/day of doxycycline, 200mg/day of minocycline, 250mg of tetracycline four times a day, 1000mg/day of oxytetracycline, 600mg/day of demeclocycline and 600mg/day of lymecycline.

An example of an antimicrobial tetracycline administered in a non-antimicrobial
20 amount is doxycycline hyclate administered at a 20 milligram dose twice daily. Such a formulation is sold for the treatment of periodontal disease by CollaGenex Pharmaceuticals, Inc. of Newtown, Pennsylvania under the trademark Periostat ®.

The tetracycline compound may be administered by sustained release. Sustained
25 release administration is a method of drug delivery to achieve a certain level of the drug over a particular period of time. The level typically is measured by serum concentration. Further description of methods of delivering tetracycline compounds by sustained release can be found in the patent application, "Controlled Delivery of Tetracycline and Tetracycline Derivatives," filed on April 5, 2001 and assigned to CollaGenex
30 Pharmaceuticals, Inc. of Newtown, Pennsylvania. The aforementioned application is incorporated herein by reference in its entirety.

For example, 40 milligrams of doxycycline may be administered by sustained release over a 24 hour period.

5 The antimicrobial tetracycline compound can be administered in an amount which results in a serum tetracycline concentration which is 10-80% of the minimum antimicrobial serum concentration. The minimum antimicrobial serum concentration is the lowest concentration known to exert a significant antimicrobial effect.

10 Some examples of the approximate minimum antimicrobial serum concentrations of members of the tetracycline family follow.

15 A single dose of two 100mg minocycline HCl tablets administered to adult humans results in minocycline serum levels ranging from 0.74 to 4.45 $\mu\text{g/ml}$ over a period of an hour. The average level is 2.24 $\mu\text{g/ml}$.

20 Two hundred and fifty milligrams of tetracycline HCl administered every six hours over a twenty-four hour period produces a peak plasma concentration of approximately 3 $\mu\text{g/ml}$. Five hundred milligrams of tetracycline HCl administered every six hours over a twenty-four hour period produces a serum concentration level of 4 to 5 $\mu\text{g/ml}$.

25 The minimum antimicrobial serum concentration of doxycycline is 1 $\mu\text{g/ml}$. Accordingly, a serum concentration of doxycycline in the range of about 0.1 to about 0.8 $\mu\text{g/ml}$ is 10-80% of the minimum antimicrobial serum concentration of doxycycline. The more preferred range is about 0.4 to about 0.7 $\mu\text{g/ml}$.

To achieve this serum concentration, doxycycline can be administered by sustained release, or by intermittent administration.

30 In another embodiment, the tetracycline compound can be administered in an amount which results in a serum concentration between about 0.1 and 10.0 $\mu\text{g/ml}$, more

preferably between 0.3 and 5.0 µg/ml. For example, doxycycline is administered in an amount which results in a serum concentration between about 0.1 and 0.8 µg/ml, more preferably between 0.4 and 0.7 µg/ml.

- 5 Non-antimicrobial tetracycline compounds can be used in higher amounts than antimicrobial tetracyclines, while avoiding the indiscriminate killing of microbes, and the emergence of resistant microbes. For example, 6-demethyl-6-deoxy-4-de(dimethylamino)tetracycline (CMT-3) may be administered in doses of about 40 to about 200 mg/day, or in amounts that result in serum levels of about 1.55ug/ml to about 10
10 ul/ml.

The actual preferred amounts of tetracycline compound in a specified case will vary according to the particular compositions formulated, the mode of application, and the particular sites and subject being treated.

- 15 The tetracycline compounds can be in the form of pharmaceutically acceptable salts of the compounds. The term "pharmaceutically acceptable salt" refers to a salt prepared from tetracycline compounds and pharmaceutically acceptable non-toxic acids or bases. The acids may be inorganic or organic acids of tetracycline compounds. Examples
20 of inorganic acids include hydrochloric, hydrobromic, hydroiodic, sulfuric, and phosphoric acids. Examples of organic acids include carboxylic and sulfonic acids. The radical of the organic acids may be aliphatic or aromatic. Some examples of organic acids include formic, acetic, phenylacetic, propionic, succinic, glycolic, glucuronic, maleic, furoic, glutamic, benzoic, anthranilic, salicylic, phenylacetic, mandelic, embonic (pamoic),
25 methanesulfonic, ethanesulfonic, panthenoic, benzenesulfonic, stearic, sulfanilic, alginic, as tartaric, citric, gluconic, gulonic, arylsulfonic, and galacturonic acids. Appropriate organic bases may be selected, for example, from N,N-dibenzylethylenediamine, chloroprocaine, choline, diethanolamine, ethylenediamine, meglumine (N-methylglucamine), and procaine.

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Preferably, the tetracycline compounds have low phototoxicity, or is administered in an amount that results in a serum level at which the phototoxicity is acceptable. Phototoxicity is a chemically-induced photosensitivity. Such photosensitivity renders skin susceptible to damage, e.g. sunburn, blisters, accelerated aging, erythemas and eczematoid lesions, upon exposure to light, in particular ultraviolet light. The preferred amount of the tetracycline compound produces no more phototoxicity than is produced by the administration of a 40mg total daily dose of doxycycline.

Phototoxicity can be evaluated in terms of a photoirritancy factor (PIF), as described in the examples. A PIF value of about 1.0 indicates that a compound is considered to have no measurable phototoxicity.

The low phototoxic derivatives preferably have PIF values no greater than about 5, preferably no greater than about 2, more preferably no greater than about 1.5, most preferably no greater than about 1.2, and optimally about 1.

Some antimicrobial tetracyclines having low phototoxicity include, for example, minocycline and tetracycline.

Some non-antimicrobial tetracyclines having low phototoxicity include, but are not limited to, tetracycline compounds having the general formulae:

STRUCTURE K

wherein: R7, R8, and R9 taken together in each case, have the following meanings:

	R7	R8	R9
30	hydrogen	hydrogen	amino
	hydrogen	hydrogen	palmitamide
	hydrogen	hydrogen	dimethylamino
and			

STRUCTURE L
STRUCTURE N

STRUCTURE M
STRUCTURE O

5

wherein: R7, R8, and R9 taken together in each case, have the following meanings:

	R7	R8	R9
10	hydrogen	hydrogen	acetamido
	hydrogen	hydrogen	dimethylaminoacetamido
	hydrogen	hydrogen	nitro
	hydrogen	hydrogen	amino
	and		

15

STRUCTURE P

wherein: R7, R8, and R9 taken together are, respectively, hydrogen, hydrogen and nitro.

20

The tetracycline compounds are administered without administering a bisphosphonate compound. Bisphosphonates compounds are related to inorganic pyrophosphonic acid. The bisphosphonates include, as non-limiting examples, alendronate ((4-amino-1- hydroxybutylidene) bisphosphonic acid), clodronate (dichloromethane diphosphonic acid), etidronate ((1-hydroxyethylidene) diphosphonic acid) and pamidronate ((3-amino-1- hydroxypropylidene) bisphosphonic acid); also risedronate ([-hydroxy-2-(3-pyridinyl)ethylidene] bisphosphonic acid), tiludronate, i.e., tiludronic acid ([[(4-chlorophenyl) thio] methylene] bisphosphonic acid) and zolendronate.

25

The tetracycline compounds are administered systemically. For the purposes of this specification, "systemic administration" means administration to a human by a method that causes the compounds to be absorbed into the bloodstream.

30

For example, the tetracyclines compounds can be administered orally by any method known in the art. For example, oral administration can be by tablets, capsules, pills, troches, elixirs, suspensions, syrups, wafers, chewing gum and the like.

5 Additionally, the tetracycline compounds can be administered enterally or parenterally, e.g., intravenously, intramuscularly, or subcutaneously, as injectable solutions or suspensions. Administration can also be intranasally, in the form of, for example, an intranasal spray; or transdermally, in the form of, for example, a patch.

10 For the pharmaceutical purposes described above, the tetracycline compounds of the invention can be formulated per se in pharmaceutical preparations optionally with a suitable pharmaceutical carrier (vehicle) or excipient as understood by practitioners in the art. These preparations can be made according to conventional chemical methods.

15 Examples of carriers and excipients include starch, milk, sugar, certain types of clay, gelatin, stearic acid or salts thereof, magnesium or calcium stearate, talc, vegetable fats or oils, gums and glycols.

20 In the embodiment in which the tetracycline compound is a non-antimicrobial tetracycline compound, administration can include topical application. Particular non-antimicrobial tetracycline compounds have only limited biodistribution, e.g. CMT-5. In such cases, topical application is the preferred method of administration of the compound.

25 Carrier compositions deemed to be suited for topical use include gels, salves, lotions, creams, ointments and the like. The non-antimicrobial tetracycline compound can also be incorporated with a support base or matrix or the like which can be directly applied to skin.

30 Topical application of non-antimicrobial tetracycline compounds in amounts of up to about 25% (w/w) in a vehicle are effective in treating acne while not inducing

significant toxicity in the human. Amounts of from about 0.1% to about 10% are preferred.

5 Combined or coordinated topical and systemic administration of the tetracycline compounds is also contemplated under the invention. For example, a non-absorbable non-antimicrobial tetracycline compound can be administered topically, while a tetracycline compound capable of substantial absorption and effective systemic distribution in a human can be administered systemically.

10 The tetracycline compounds are prepared by methods known in the art. For example, natural tetracyclines may be modified without losing their antibiotic properties, although certain elements of the structure must be retained. The modifications that may and may not be made to the basic tetracycline structure have been reviewed by Mitscher in *The Chemistry of Tetracyclines*, Chapter 6, Marcel Dekker, Publishers, New York (1978).
15 According to Mitscher, the substituents at positions 5-9 of the tetracycline ring system may be modified without the complete loss of antibiotic properties. Changes to the basic ring system or replacement of the substituents at positions 1-4 and 10-12, however, generally lead to synthetic tetracyclines with substantially less or effectively no antimicrobial activity.

20 Further methods of preparing the tetracycline compounds are described in the examples.

EXAMPLES

25 The following examples serve to provide further appreciation of the invention but are not meant in any way to restrict the effective scope of the invention.

Preparation of Compounds

30 EXAMPLE 1

4-Dedimethylamino-7-dimethylamino-6-demethyl-6-deoxy-9-nitrotetracycline sulfate

To a solution of one millimole of 4-dedimethylamino-7-dimethylamino-6-demethyl-6-deoxytetracycline in 25 ml of concentrated sulfuric acid at 0°C was added 1.05 mmole of potassium nitrate. The resulting solution was stirred at ice bath temperature for 15 minutes and poured in one liter of cold ether with stirring. The precipitated solid was allowed to settle and the majority of solvent decanted. The remaining material was filtered through a sintered glass funnel and the collected solid was washed well with cold ether. The product was dried in a vacuum desiccator overnight.

EXAMPLE 2

9-amino-4-dedimethylamino-7-dimethylamino-6-demethyl-6-deoxytetracycline sulfate

To a solution of 300 mg of the 9-nitro compound from example 1, in 30 ml of ethanol was added 50 mg of PtO₂. The mixture was hydrogenated at atmospheric pressure until the theoretical amount of hydrogen was absorbed. The system is flushed with nitrogen, the catalyst PtO₂ is filtered and the filtrate added dropwise to 300 ml of ether. The product that separates is filtered and dried in a vacuum desiccator.

EXAMPLE 3

9-Acetamido-4-dedimethylamino-7-dimethylamino-6-demethyl-6-deoxytetracycline sulfate

To a well stirred cold solution of 500 mg of 9-amino-4-dedimethylamino-7-dimethylamino-6-demethyl-6-deoxytetracycline sulfate from example 2, in 2.0 ml of 1.3-dimethyl-2-imidazolidinone, 500 mg of sodium bicarbonate was added followed by 0.21 ml of acetyl chloride. The mixture is stirred at room temperature for 30 minutes, filtered and the filtrate was added dropwise to 500 ml of ether. The product that separated was filtered and dried in a vacuum desiccator.

EXAMPLE 4

4-Dedimethylamino-7-dimethylamino-6-demethyl-6-deoxy-9-diazoniumtetracycline sulfate

5 To a solution of 0.5 g of 9-amino-4-dedimethylamino-7-dimethylamino-6-demethyl-6-deoxytetracycline sulfate, from example 2, in 10 ml of 0.1N hydrochloric acid in methanol cooled in an ice bath, 0.5 ml of n-butyl nitrite was added. The solution was stirred at ice bath temperature for 30 minutes and then poured into 250 ml of ether. The product that separated was filtered, washed with ether and dried in a vacuum desiccator.

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EXAMPLE 5

9-Azido-4-dedimethylamino-7-dimethylamino-6-demethyl-6-deoxytetracycline sulfate

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To a solution of 0.3 mmole of 4-dedimethylamino-7-dimethylamino-6-demethyl-6-deoxy-9-diazoniumtetracycline sulfate, from example 4, 10 ml of 0.1 N methanolic hydrogen chloride was added 0.33 mmole of sodium azide. The mixture was stirred at room temperature for 1.5 hours. The reaction mixture was then poured into 200 ml of ether. The product that separated was filtered and dried in a vacuum desiccator.

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EXAMPLE 6

9-Amino-8-chloro-4-dedimethylamino-7-dimethylamino-6-demethyl-6-deoxy-tetracycline sulfate

25

One gram of 9-azido-4-dedimethylamino-7-dimethylamino-6-demethyl-6-deoxytetracycline hydrochloride, from example 4, was dissolved in 10 ml of concentrated sulfuric acid saturated with HCL at 0°C. The mixture was stirred at ice bath temperature for 1.5 hours and then slowly added dropwise to 500 ml of cold ether. The product that separated was filtered, washed with ether and dried in a vacuum desiccator.

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EXAMPLE 7

4-Dedimethylamino-7-dimethylamino-6-demethyl-6-deoxy-9-ethoxythiocarbonylthio-tetracycline sulfate

5 A solution of 1.0 mmole of 4-dedimethylamino-7-dimethylamino-6-demethyl-6-deoxy-9-diazoniumtetracycline sulfate, from example 4, in 15 ml of water was added to a solution of 1.15 mmole of potassium ethyl xanthate in 15 ml of water. The mixture was stirred at room temperature for one hour. The product separated and was filtered and dried in a vacuum desiccator.

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EXAMPLE 8A

General Procedure for Nitration

15 To 1 mmole of a 4-dedimethylamino-6-deoxytetracycline in 25 ml of concentrated sulfuric acid at 0°C was added 1 mmole of potassium nitrate with stirring. The reaction solution was stirred for 15 minutes and then poured into 100 g of chopped ice. The aqueous solution was extracted 5 times with 20 ml of butanol each time. The butanol extracts were washed three times with 10 ml of water each time, and concentrated *in vacuo* to a volume of 25 ml. The light yellow crystalline solid which precipitated was
20 filtered, washed with 2 ml of butanol and dried *in vacuo* at 60°C for 2 hours. This solid was a mixture of the two mononitro isomers.

EXAMPLE 8B

4-Dedimethylamino-6-deoxy-9-nitrotetracycline

25

 To 980 mg of the nitration product from 4-dedimethylamino-6-deoxytetracycline (a mixture of the 2 isomers) in 25 ml of methanol was added enough triethylamine to dissolve the solid. The filtered solution (pH 9.0) was adjusted to pH 5.2 with concentrated sulfuric acid. A crystalline yellow solid (236 mg.) was obtained (29% yield). The
30 material at this point was quite pure and contained only small amounts of the 7-isomer. Final purification was accomplished by liquid partition chromatography using a

diatomaceous earth packed column and the solvent system: chloroform: butanol: 0.5 M phosphate buffer (pH 2) (16:1:10).

EXAMPLE 9

5 4-Dedimethylamino-6-deoxy-7-nitrotetracycline

The methanol filtrate from example 8 was immediately adjusted to pH 1.0 with concentrated sulfuric acid. The light yellow crystalline solid, which was obtained as the sulfate salt. A purified free base was obtained by adjusting an aqueous solution of the sulfate salt (25 mg/ml) to pH 5.2 with 2 N sodium carbonate.

10

EXAMPLE 10

9-Amino-4-dedimethylamino-6-deoxytetracycline

To a solution of 300 mg of the 9-nitro compound, prepared in example 8, in 30 ml of ethanol was added 50 mg of PtO₂. The mixture was hydrogenated at atmospheric pressure until the theoretical amount of hydrogen was absorbed. The system is flushed with nitrogen, the PtO₂ catalyst is filtered and the filtrate added dropwise to 300 ml of ether. The solid that separates is filtered and dried in a vacuum desiccator.

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EXAMPLE 11

9-Acetamido-4-dedimethylamino-6-deoxytetracycline sulfate

To well stirred cold solution of 500 mg of 9-amino-4-dedimethylamino-6-deoxytetracycline sulfate, from example 10, in 2.0 ml of 1,3-dimethyl-2-imidazolidinone was added 500 mg of sodium bicarbonate followed by 0.21 ml of acetyl chloride. The mixture was stirred at room temperature for 30 minutes, filtered and the filtrate was added dropwise to 500 ml of ether. The solid that separated was filtered and dried in a vacuum desiccator.

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EXAMPLE 12

4-Dedimethylamino-6-deoxy-9-diazoniumtetracycline sulfate

To a solution of 0.5 g of 9-amino-4-dedimethylamino-6-deoxytetracycline sulfate,
5 from example 10, in 10 ml of 0.1N hydrochloric acid in methanol cooled in an ice bath
was added 0.5 ml of n-butyl nitrite. The solution was stirred at ice bath temperature for 30
minutes and the poured into 250 ml of ether. The solid that separated was filtered, washed
with ether and dried in a vacuum desiccator.

EXAMPLE 13

9-Azido-4-dedimethylamino-6-deoxytetracycline sulfate

To a solution of 0.3 mmole of 4-dedimethylamino-6-deoxy-9-
diazoniumtetracycline sulfate, of example 12, 10 ml of 0.1 N methanolic hydrogen
15 chloride was added 0.33 mmole of sodium azide. The mixture was stirred at room
temperature for 1.5 hours. The reaction mixture was then poured into 200 ml of ether.
The solid that separated was filtered and dried in a vacuum desiccator.

EXAMPLE 14

20 9-Amino-8-chloro-4-dedimethylamino-6-deoxytetracycline sulfate

One gram of 9-azido-4-dedimethylamino-7-dimethylamino-6-deoxytetracycline
hydrochloride, from example 13, was dissolved in 10 ml of concentrated sulfuric acid
saturated with HCL at 0°C. The mixture was stirred at ice bath temperature for 1.5 hours
25 and then slowly added dropwise to 500 ml of cold ether. The solid that separated was
filtered, washed and ether and dried in a vacuum desiccator.

EXAMPLE 15

4-Dedimethylamino-6-deoxy-9-ethoxythiocarbonylthiotetracycline sulfate

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A solution of 1.0 mmole of 4-dedimethylamino-6-deoxy-9-diazoniumtetracycline sulfate, from example 12, in 15 ml of water was added to a solution of 1.15 mmole of potassium ethyl xanthate in 15 ml of water. The mixture was stirred at room temperature for one hour. The solid that separated was filtered and dried in a vacuum desiccator.

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EXAMPLE 16

9-Dimethylamino-4-dedimethylamino-6-deoxytetracycline sulfate

To a solution of 100 mg. of the 9-amino compound from example 10, in 10 ml of ethylene glycol monomethyl ether is added 0.05 ml of concentrated sulfuric acid, 0.4 ml. of a 40% aqueous formaldehyde solution and 100 mg of a 10% palladium on carbon catalyst. The mixture is hydrogenated under atmospheric pressure and room temperature for 20 minutes. The catalyst was filtered and the filtrate was evaporated to dryness under reduced pressure. The residue is dissolved in 5 ml of methanol and this solution was added to 100 ml of ether. The product that separated was filtered and dried, yield, 98 mg.

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EXAMPLE 17

7-Amino-4-dedimethylamino-6-deoxytetracycline

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This compound can be made using Procedure A or B. Procedure A. To a solution of 300 mg of the 7-nitro compound, from example 1, in 30 ml of ethanol was added 50 mg of PtO₂. The mixture was hydrogenated at atmospheric pressure until the theoretical amount of hydrogen was absorbed. The system is flushed with nitrogen, the catalyst PtO₂ is filtered and the filtrate added dropwise to 300 ml of ether. The solid that separates is filtered and dried in a vacuum desiccator.

25

Procedure B. 1 g of 6-deoxy-4-dedimethylamino-tetracycline was dissolved in 7.6 ml THF and 10.4 ml methanesulfonic acid at -10°C. After warming the mixture to 0°C a solution of 0.86 g of dibenzyl azodicarboxylate was added and the mixture stirred for 2

30

hours at 0°C to yield 7-[1,2-bis(carbobenzyloxy)hydrazino]-4-dedimethylamino-6-deoxytetracycline. A solution of 1 millimole of this material in 70 ml 2-methoxyethanol, and 300 mg 10% Pd-C was hydrogenated at room temperature to give 7-amino-6-deoxy-4-dedimethylaminotetracycline.

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EXAMPLE 18

7-Amino-6-deoxy-5-hydroxy-4-dedimethylaminotetracycline

1g of 6-deoxy-5-hydroxy-4-dedimethylaminotetracycline **3** was dissolved in 7.6 ml THF and 10.4 ml methanesulfonic acid at -10°C. After warming the mixture to 0°C a solution of 0.86g dibenzyl azodicarboxylate in 0.5 ml THF was added and the mixture stirred for 2 hours at 0°C to yield 7-[1,2-bis(carbobenzyloxy)hydrazino]-4-dedimethylamino-6-deoxy-5-hydroxytetracycline. A solution of 1 millimole of this material in 70 ml 2-methoxyethanol, and 300 mg 10% Pd-C was hydrogenated at room temperature to give 7-amino-6-deoxy-5-hydroxytetracycline.

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EXAMPLE 19

7-Acetamido-4-dedimethylamino-6-deoxy-5-hydroxytetracycline sulfate.

To well stirred cold solution of 500 mg of 7-amino-4-dedimethylamino-6-deoxy-5-hydroxytetracycline sulfate, from example 18, in 2.0 ml of 1,3-dimethyl-2-imidazolidinone was added 500 mg of sodium bicarbonate followed by 0.21 ml of acetyl chloride. The mixture was stirred at room temperature for 30 minutes, filtered and the filtrate was added dropwise to 500 ml of ether. The solid that separated was filtered and dried in a vacuum desiccator.

20
25

EXAMPLE 20

4-Dedimethylamino-6-deoxy-5-hydroxy-7-diazoniumtetracycline hydrochloride

To a solution of 0.5 g of 7-amino-4-dedimethylamino-6-deoxy-5-hydroxytetracycline sulfate, from example 20, in 10 ml of 0.1N hydrochloric acid in

30

methanol cooled in an ice bath was added 0.5 ml of n-butyl nitrite. The solution was stirred at ice bath temperature for 30 minutes and then poured into 250 ml of ether. The solid that separated was filtered, washed with ether and dried in a vacuum desiccator.

5

EXAMPLE 21

7-Azido-4-dedimethylamino-6-deoxy-5-hydroxytetracycline

To a solution of 0.3 mmole of 4-dedimethylamino-6-deoxy-5-hydroxy-7-diazoniumtetracycline hydrochloride, from example 20, 10 ml of 0.1 N methanolic
10 hydrogen chloride was added 0.33 mmole of sodium azide. The mixture was stirred at room temperature for 1.5 hours. The reaction mixture was then poured into 200 ml of ether. The solid that separated was filtered and dried in a vacuum desiccator.

EXAMPLE 22

15 7-Amino-8-chloro-4-dedimethylamino-6-deoxy-5-hydroxytetracycline sulfate

One gram of 7-azido-4-dedimethylamino-7-dimethylamino-6-deoxy-5-hydroxytetracycline sulfate, from example 21, was dissolved in 10 ml of concentrated
20 sulfuric acid (previously saturated with hydrogen chloride) at 0°C. The mixture was stirred at ice bath temperature for 1.5 hours and then slowly added dropwise to 500 ml of cold ether. The solid that separated was filtered, washed with ether and dried in a vacuum desiccator.

EXAMPLE 23

25 4-Dedimethylamino-6-deoxy-5-hydroxy-7-ethoxythiocarbonylthiotetracycline

A solution of 1.0 mmole of 4-dedimethylamino-6-deoxy-5-hydroxy-7-diazoniumtetracycline hydrochloride, from example 20, in 15 ml of water was added to a
30 solution of 1.15 mmole of potassium ethyl xanthate in 15 ml of water. The mixture was stirred at room temperature for one hour. The solid that separated was filtered and dried in a vacuum desiccator.

EXAMPLE 24

7-Dimethylamino-4-dedimethylamino-6-deoxy-5-hydroxytetracycline sulfate

- 5 To a solution of 100 mg of the 7-amino compound in 10 ml of ethylene glycol monomethyl ether is added 0.05 ml of concentrated sulfuric acid, 0.4 ml of a 40% aqueous formaldehyde solution and 100 mg of a 10% palladium on carbon catalyst. The mixture is reduced with hydrogen at atmospheric pressure and room temperature for 20 minutes. The catalyst was filtered and the filtrate was evaporated to dryness under reduced pressure.
- 10 The residue is dissolved in 5 ml of methanol and this solution was added to 100 ml of ether. The product that separated was filtered and dried, yield, 78 mg.

EXAMPLE 25

7-Diethylamino-4-dedimethylamino-5-hydroxytetracycline sulfate

- 15 To a solution of 100 mg of the 7-amino compound in 10 ml of ethylene glycol monomethyl ether is added 0.05 ml of concentrated sulfuric acid, 0.4 ml of acetaldehyde and 100 mg of a 10% palladium on carbon catalyst. The mixture is reduced with hydrogen at atmospheric pressure at room temperature for 20 minutes. The catalyst was filtered and
- 20 filtrate was evaporated to dryness under reduced pressure. The residue is dissolved in 5 ml of methanol and this solution was added to 100 ml of ether. The product that separated was filtered and dried.

EXAMPLE 26

- 25 **4-Dedimethylamino-6-deoxy-7-diazoniumtetracycline hydrochloride**

- To a solution of 0.5 g. of 7-amino-4-dedimethylamino-6-deoxytetracycline sulfate, from example 17, in 10 ml of 0.1N hydrochloric acid in methanol cooled in an ice bath was added 0.5 ml of n-butyl nitrite. The solution was stirred at ice bath temperature for 30
- 30 minutes and then poured into 250 ml of ether. The solid that separated was filtered, washed with ether and dried in a vacuum desiccator.

EXAMPLE 27

7-Azido-4-dedimethylamino-6-deoxytetracycline

To a solution of 0.3 mmole of 4-dedimethylamino-6-deoxy-7-diazoniumtetracycline hydrochloride, from example 26, 10 ml of 0.1 N methanolic hydrogen chloride was added 0.33 mmole of sodium azide. The mixture was stirred at room temperature for 1.5 hours. The reaction mixture was then poured into 200 ml of ether. The solid that separated was filtered and dried in a vacuum desiccator.

EXAMPLE 28

7-Amino-8-chloro-4-dedimethylamino-6-deoxytetracycline sulfate

One gram of 7-azido-4-dedimethylamino-7-dimethylamino-6-deoxytetracycline sulfate was dissolved in 10 ml of concentrated sulfuric acid (previously saturated with hydrogen chloride) at 0°C. The mixture was stirred at ice bath temperature for 1.5 hours and then slowly added dropwise to 500 ml of cold ether. The solid that separated was filtered, washed with ether and dried in a vacuum desiccator.

EXAMPLE 29

4-Dedimethylamino-6-deoxy-7-ethoxythiocarbonylthiotetracycline

A solution of 1.0 mmole of 4-dedimethylamino-6-deoxy-7-diazoniumtetracycline hydrochloride, from example 26, in 15 ml of water was added to a solution of 1.15 mmole of potassium ethyl xanthate in 15 ml of water. The mixture was stirred at room temperature for one hour. The solid that separated was filtered and dried in a vacuum desiccator.

EXAMPLE 30

7-Dimethylamino-4-dedimethylamino-6-deoxytetracycline sulfate

To a solution of 100 mg of the 7-amino compound, from example 26, in 10 ml of ethylene glycol monomethyl ether is added 0.05 ml of concentrated sulfuric acid, 0.4 ml of a 40% aqueous formaldehyde solution and 100 mg of a 10% palladium on carbon catalyst. The mixture is reduced with hydrogen at atmospheric pressure and room temperature for 20 minutes. The catalyst was filtered and the filtrate was evaporated to dryness under reduced pressure. The residue is dissolved in 5 ml of methanol and this solution was added to 100 ml of ether. The product that separated was filtered and dried.

10

EXAMPLE 31

9-Acetamido-8-chloro-4-dedimethylamino-7-dimethylamino-6-deoxy-6-demethyltetracycline

To well stirred cold solution of 500 mg of 9-amino-8-chloro-4-dedimethylamino-6-deoxy-6-demethyl-7-dimethyl amino tetracycline sulfate, from example 6, in 2.0 ml of 1,3-dimethyl -2-imidazolidinone was added 500 mg of sodium bicarbonate followed by 0.21 ml. of acetyl chloride. The mixture was stirred at room temperature for 30 minutes, filtered and the filtrate was added dropwise to 500 ml of ether. The solid that separated was filtered and dried in a vacuum desiccator.

EXAMPLE 32

8-Chloro-4-dedimethylamino-7-dimethylamino-6-deoxy-6-demethyl-9-ethoxythiocarbonylthiotetracycline

A solution of 1.0 mmole of -8-chloro-4-dedimethylamino-6-deoxy-6-demethyl-7-dimethyl amino-9-diazoniumtetracycline hydrochloride in 15 ml of water was added to a solution of 1.15 mmole of potassium ethyl xanthate in 15 ml of water. The mixture was stirred at room temperature for one hour. The solid that separated was filtered and dried in a vacuum desiccator.

EXAMPLE 33

8-Chloro-9-dimethylamino-4-dedimethylamino-7-dimethylamino-6-deoxy-6-demethytetracycline sulfate

To a solution of 100 mg. of the 9- amino compound, from example 6, in 10 ml of ethylene glycol monomethyl ether is added 0.05 ml of concentrated sulfuric acid, 0.4 ml of acetaldehyde and 100 mg of a 10% palladium on carbon catalyst. The mixture is reduced with hydrogen at atmospheric pressure and room temperature for 20 minutes. The catalyst was filtered and the filtrate was evaporated to dryness under reduced pressure. The residue is dissolved in 5 ml of methanol and this solution was added to 100 ml of ether. The product that separated was filtered and dried.

EXAMPLE 34

N-(4-methylpiperazin-1-yl) methyl-4-dedimethylamino-6-demethyl-6-deoxytetracycline

An aqueous solution of 58 mg (37%) formaldehyde (0.72 mmol) was added to a solution of 203 mg (0.49 mmol) of 4-dedimethylamino-6-demethyl-6-deoxytetracycline in 5.0 ml ethylene glycol dimethyl ether. The mixture was stirred at room temperature for 0.5 hours. 56 mg (0.56 mmol) of 1-methylpiperazine was then added and the resulting mixture was stirred overnight and refluxed for 20 minutes. The mixture was then cooled and a solid product was collected by filtration. The solid product was then washed with the solvent and dried by vacuum filtration.

EXAMPLE 35

N-(4-methylpiperazin-1-yl)methyl-4-dedimethylamino-6-demethyl-6-deoxy-9-hexanoylaminotetracycline

An aqueous solution of 49 mg 37 % formaldehyde (0.60 mmol) was added to a solution of 146 mg (0.30 mmol) of 4-dedimethylamino-6-demethyl-6-deoxy-9-hexanoylaminotetracycline in 5.0 ml ethylene glycol dimethyl ether. The mixture was stirred at room temperature for 0.5 hours. 60 mg (0.60 mmol) of 1-methylpiperazine

was then added and the resulting mixture was stirred overnight and refluxed for 20 minutes. The mixture was then cooled and a solid product was collected by filtration. The solid product was then washed with the solvent and dried by vacuum filtration.

EXAMPLE 36

4-Dedimethylamino-6-demethyl-6-deoxy-9-hexanoylaminotetracycline.

1.54 g (7.2 mmol) of hexanoic anhydride and 150 mg of 10% Pd/C catalyst were added to 300 mg (0.72 mmol) of 4-dedimethylamino-6-demethyl-6-deoxytetracycline in 6.0 ml of 1,4-dioxane and 6.0 ml of methanol. The mixture was hydrogenated overnight at room temperature. The catalyst was removed by filtration and the filtrate was concentrated under reduced pressure. The residue was dissolved in 7 ml of ethyl acetate and triturated with 50 ml of hexane to produce a solid product. The solid product was filtered and dried by vacuum filtration.

EXAMPLE 37

Phototoxicity Determination

BALB/c 3T3 (CCL-163) cells were obtained from ATCC and cultured in antibiotic-free Dulbecco's Minimum Essential Medium (4.5g/l glucose)(DMEM) supplemented with L-glutamine (4mM) and 10% newborn calf serum. The working cell bank was prepared and found to be free of mycoplasma. Streptomycin sulfate (100 µg/ml) and penicillin (100 IU/ml) were added to the medium after the cells were treated with test article in 96-well plates.

Serial dilutions of the tetracycline derivatives were prepared in DMSO at concentrations 100x to final testing concentration. The CMT dilutions in DMSO were then diluted in Hanks' Balanced Salt Solution (HBSS) for application to the cells. The final DMSO concentration was 1% in treated and control cultures. For the dose range finding assay, 8 serial dilutions covered a range of 100 to 0.03 mg/ml in half log steps while the definitive assays used 6 to 8 doses prepared in quarter log steps, centered on the expected 50% toxicity point. In many cases, the dose range for

treatment without UV light was different from the dose range selected with UV light. One hundred µg/ml is the highest dose recommended to prevent false negative results from UV absorption by the dosing solutions.

Controls: Each assay included both negative (solvent) and positive controls. Twelve wells of negative control cultures were used on each 96-well plate. Chlorpromazine (Sigma) was used as the positive control and was prepared and dosed like the test tetracycline derivatives.

Solar Simulator: A Dermalight SOL 3 solar simulator, equipped with a UVA H1 filter (320-400 nm), was adjusted to the appropriate height. Measurement of energy through the lid of a 96-well microtiter plate was carried out using a calibrated UV radiometer UVA sensor. Simulator height was adjusted to deliver 1.7 ± 0.1 m/Wcm² of UVA energy (resulting dose was 1J/cm² per 10 min.)

Phototoxicity Assay: Duplicate plates were prepared for each test material by seeding 10^4 3T3 cells per well in µl of complete medium 24 hours before treatment. Prior to treatment, the medium was removed, and the cells washed once with 125 µl prewarmed HBSS. Fifty µl of prewarmed HBSS were added to each well. Fifty µl of test article dilutions were added to the appropriate wells and the plates returned to the incubator for approximately one hour. Following the 1 hr incubation, the plates designated for the photoirritation assay were exposed (with the lid on) to 1.7 ± 0.1 mW/cm² UVA light for 50 ± 2 minutes at room temperature resulting in an irradiation dose of 5J/cm². Duplicate plates designated for the cytotoxicity assay were kept in the dark room temperature for 50 ± 2 minutes. After the 50 minute exposure period the test article dilutions were decanted from the plates and the cells washed once with 125 µl HBSS. One hundred µl of medium were added to all wells and the cells incubated as above for 24 ± 1 hours.

After 24 hours of incubation, the medium was decanted and 100 µl of the Neutral Red containing media added to each well. The plates were returned to the incubator and incubated for approximately 3 hours. After 3 hours, the medium was

decanted and each well rinsed once with 250 µl of HBSS. The plates were blotted to remove the HBSS and 100 µl of Neutral Red Solvent were added to each well. After a minimum of 20 minutes of incubation at room temperature (with shaking), the absorbance at 550 nm was measured with a plate reader, using the mean of the blank outer wells as the reference. Relative survival was obtained by comparing the amount of neutral red taken by test article and positive control treated groups to the neutral red taken up by the negative group on the same plate. IC₅₀ values for both the UVA exposed and non-exposed groups were determined whenever possible. One dose range finding and at least two definitive trails were performed on each tetracycline derivative and control compound.

Determination of Phototoxicity: Phototoxicity of the tetracycline derivatives can be measured by its photoirritancy factor (PIF). The PIF was determined by comparing the IC₅₀ without UVA [IC₅₀(-UVA)] with the IC₅₀ with UVA [IC₅₀(+UVA)]:

$$\text{PIF} = \frac{\text{IC}_{50}(-\text{UVA})}{\text{IC}_{50}(+\text{UVA})}$$

If both IC₅₀ values can be determined, the cut off value of the factor to discriminate between phototoxicants and non-phototoxicants is a factor of 5. A factor greater than 5 is indicative of phototoxic potential of the test material.

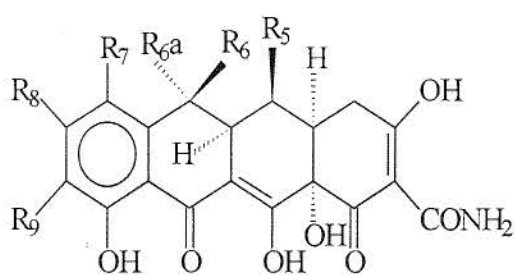
If IC₅₀ (+UVA) can be determined but IC₅₀(-UVA) cannot, the PIF cannot be calculated, although the compound tested may have some level of phototoxic potential. In this case, a ">PIF" can be calculated and the highest testable dose (-UVA) will be used for calculation of the ">PIF."

$$>\text{PIF} = \frac{\text{maximum dose } (-\text{UVA})}{\text{IC}_{50}(+\text{UVA})}$$

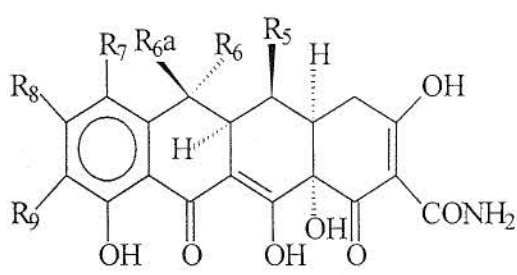
If both, IC₅₀(-UVA) and IC₅₀(+UVA) cannot be calculated because the chemical does not show cytotoxicity (50% reduction in viability) up to the highest dose tested, this would indicate a lack of phototoxic potential.

Thus, while there have been described what are presently believed to be the preferred embodiments of the present invention, those skilled in the art will realize that other and further embodiments can be made without departing from the spirit of the invention, and it is intended to include all such further modifications and changes as come within the true scope of the claims set forth herein.

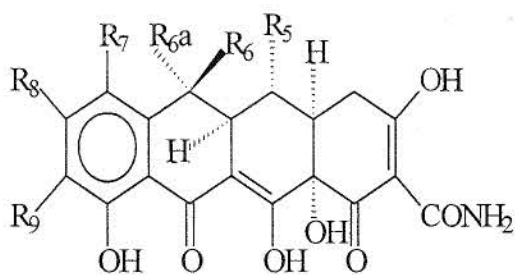
INDEX OF STRUCTURES



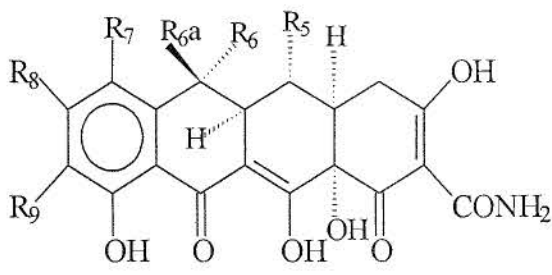
Structure C



Structure D



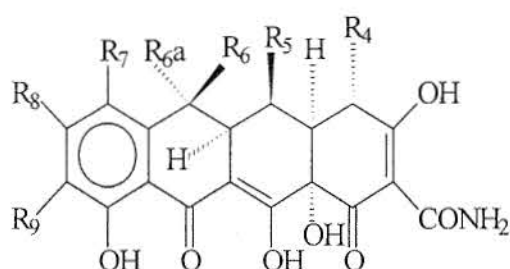
Structure E



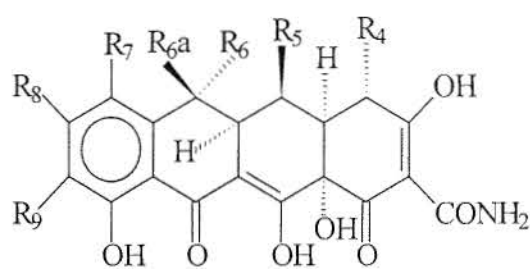
Structure F

wherein R7 is selected from the group consisting of hydrogen, amino, nitro, mono(lower alkyl) amino, halogen, di(lower alkyl)amino, ethoxythiocarbonylthio, azido, acylamino, diazonium, cyano, and hydroxyl; R6-a is selected from the group consisting of hydrogen and methyl; R6 and R5 are selected from the group consisting of hydrogen and hydroxyl; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of hydrogen, amino, azido, nitro, acylamino, hydroxy, ethoxythiocarbonylthio, mono(lower alkyl)amino, halogen, diazonium, di(lower alkyl)amino and $RCH(NH_2)CO$; R is hydrogen or lower alkyl; and pharmaceutically acceptable and unacceptable salts thereof; with the following provisos: when either R7 and R9 are hydrogen then R8 must be halogen; and when R6-a, R6, R5 and R9 are all hydrogen and R7 is hydrogen, amino, nitro, halogen, dimethylamino or diethylamino, then R8 must be halogen; and when R6-a is methyl, R6 and R9 are both hydrogen, R5 is hydroxyl and R7 is hydrogen, amino, nitro, halogen or diethylamino, then R8 is halogen; and when R6-a is methyl, R6 is hydroxyl, R5, R7 and R9 are all hydrogen, then R8 must be halogen; and when R6-a,

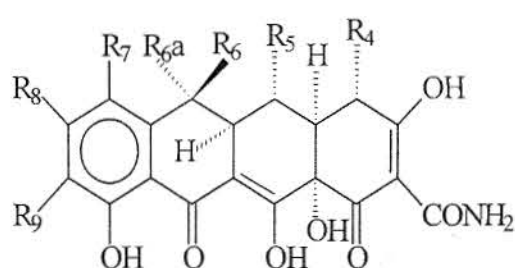
R6 and R5 are all hydrogen, R9 is methylamino and R7 is dimethylamino, then R8 must be halogen; and when R6-a is methyl, R6 is hydrogen, R5 is hydroxyl, R9 is methylamino and R7 is dimethylamino, then R8 must be halogen; and when R6-a is methyl, R6, R5 and R9 are all hydrogen and R7 is cyano, then R8 must be halogen.



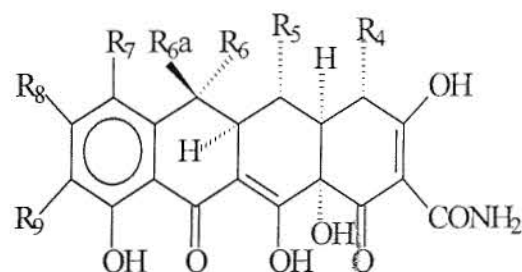
Structure G



Structure H



Structure I

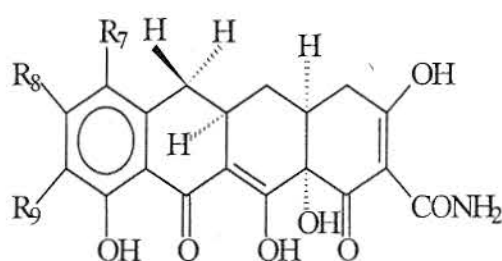


Structure J

wherein R7 is selected from the group consisting of hydrogen, amino, nitro, mono(lower alkyl) amino, halogen, di(lower alkyl)amino, ethoxythiocarbonylthio, azido, acylamino, diazonium, cyano, and hydroxyl; R6-a is selected from the group consisting of hydrogen and methyl; R6 and R5 are selected from the group consisting of hydrogen and hydroxyl; R4 is selected from the group consisting of NOH, N-NH-A, and NH-A, where A is a lower alkyl group; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of hydrogen, amino, azido, nitro, acylamino, hydroxy, ethoxythiocarbonylthio,

mono(lower alkyl) amino, halogen, di(lower alkyl)amino and $\text{RCH}(\text{NH}_2)\text{CO}$; R is hydrogen or lower alkyl; and pharmaceutically acceptable and unacceptable salts thereof; with the following provisos: when R4 is NOH, N-NH-alkyl or NH-alkyl and R7, R6-a, R6, R5, and R9 are all hydrogen, then R8 must be halogen; and when R4 is NOH, R6-a is methyl, R6 is hydrogen or hydroxyl, R7 is halogen, R5 and R9 are both hydrogen, then R8 must be halogen; and when R4 is N-NH-alkyl, R6-a is methyl, R6 is hydroxyl and R7, R5, R9 are all hydrogen, then R8 must be halogen; and when R4 is NH-alkyl, R6-a, R6, R5 and R9 are all hydrogen, R7 is hydrogen, amino, mono(lower alkyl)amino, halogen, di(lower alkyl)amino or hydroxyl, then R8 must be halogen; and when R4 is NH-alkyl, R6-a is methyl, R6 and R9 are both hydrogen, R5 is hydroxyl, and R7 is mono(lower alkyl)amino or di(lower alkyl)amino, then R8 must be halogen; and when R4 is NH-alkyl, R6-a is methyl, R6 is hydroxy or hydrogen and R7, R5, and R9 are all be hydrogen, then R8 must be halogen.

General Formula (I)



Structure K

wherein R7, R8, and R9 taken together in each case, have the following meanings:

R7
azido
dimethylamino
hydrogen
hydrogen

R8
hydrogen
hydrogen
hydrogen
hydrogen

R9
hydrogen
azido
amino
azido

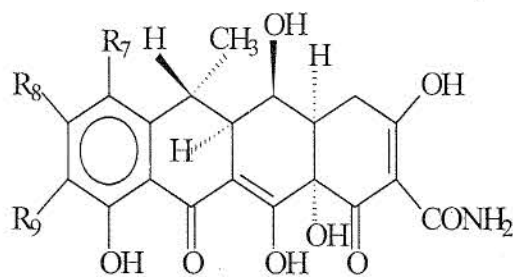
hydrogen
dimethylamino
acylamino
hydrogen
amino
hydrogen
amino
hydrogen
dimethylamino
dimethylamino
dimethylamino
hydrogen
amino
acylamino
amino
acylamino
monoalkylamino
nitro
dimethylamino
dimethylamino
dimethylamino
hydrogen

hydrogen
hydrogen
hydrogen
hydrogen
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chloro
chloro
chloro
chloro
chloro
chloro
chloro
chloro
hydrogen
hydrogen

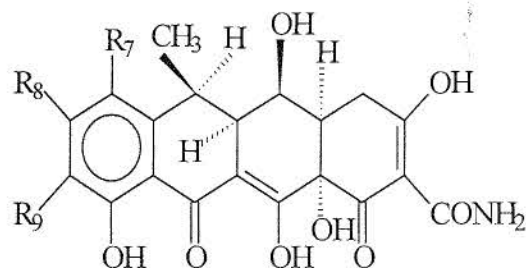
nitro
amino
hydrogen
acylamino
nitro
(N,N-dimethyl)glycylamino
amino
ethoxythiocarbonylthio
acylamino
diazonium
amino
amino
amino
acylamino
hydrogen
hydrogen
amino
amino
acylamino
dimethylamino
hydrogen
dimethylamino

and

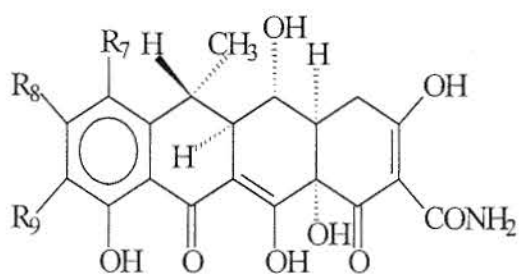
General Formula (II)



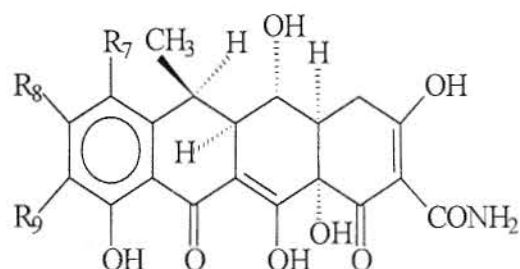
Structure L



Structure M



Structure N



Structure O

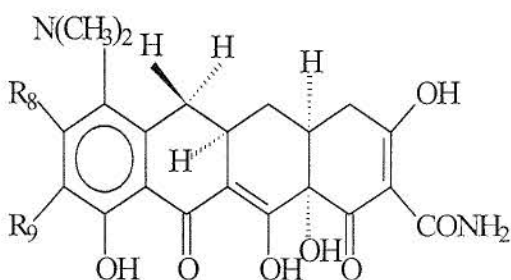
wherein R7, R8, and R9 taken together in each case, have the following meanings:

R7	R8	R9
azido	hydrogen	hydrogen
dimethylamino	hydrogen	azido
hydrogen	hydrogen	amino
hydrogen	hydrogen	azido
hydrogen	hydrogen	nitro
dimethylamino	hydrogen	amino
acylamino	hydrogen	hydrogen
hydrogen	hydrogen	acylamino
amino	hydrogen	nitro
hydrogen	hydrogen	(N,N-dimethyl)glycylamino
amino	hydrogen	amino
hydrogen	hydrogen	ethoxythiocarbonylthio
dimethylamino	hydrogen	acylamino
hydrogen	hydrogen	diazonium
hydrogen	hydrogen	dimethylamino
diazonium	hydrogen	hydrogen
ethoxythiocarbonylthio	hydrogen	hydrogen
dimethylamino	chloro	amino
amino	chloro	amino
acylamino	chloro	acylamino
hydrogen	chloro	amino

amino	chloro	hydrogen
acylamino	chloro	hydrogen
monoalkyl amino	chloro	amino
nitro	chloro	amino

and

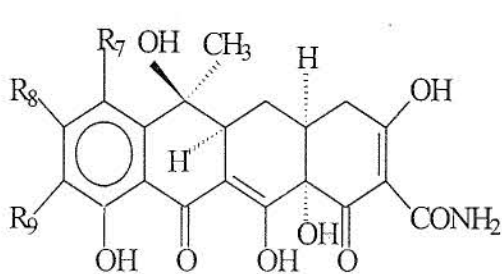
General Formula (III)



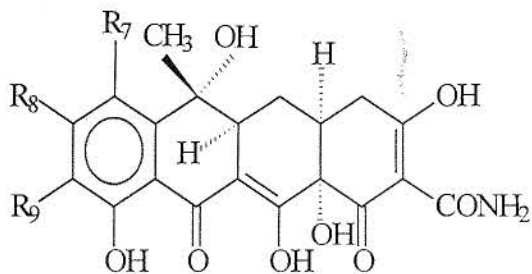
Structure P

wherein R₈ is hydrogen or halogen and R₉ is selected from the group consisting of nitro, (N,N-dimethyl)glycylamino, and ethoxythiocarbonylthio; and

General Formula (IV)



Structure Q



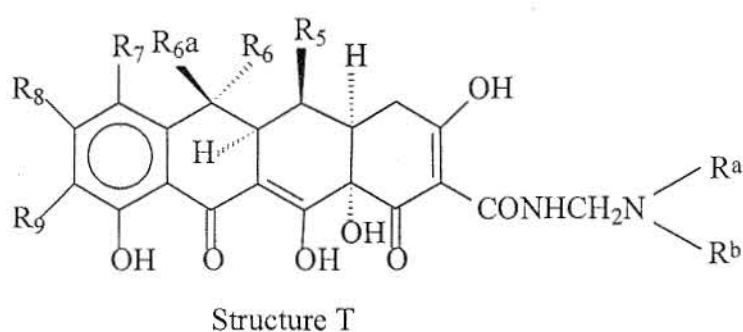
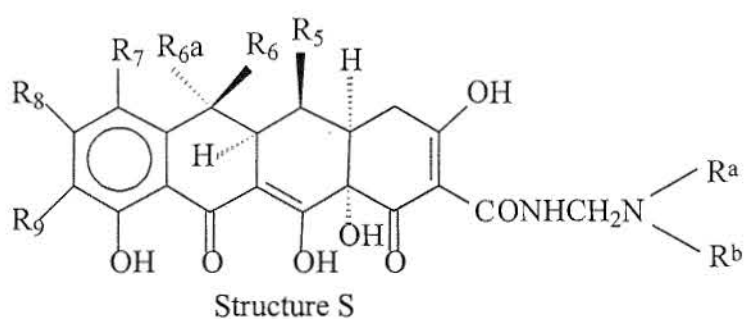
Structure R

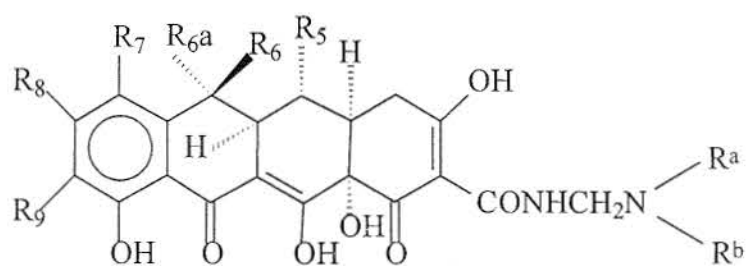
wherein R₇, R₈, and R₉ taken together in each case, have the following meanings:

R ₇	R ₈	R ₉
amino	hydrogen	hydrogen

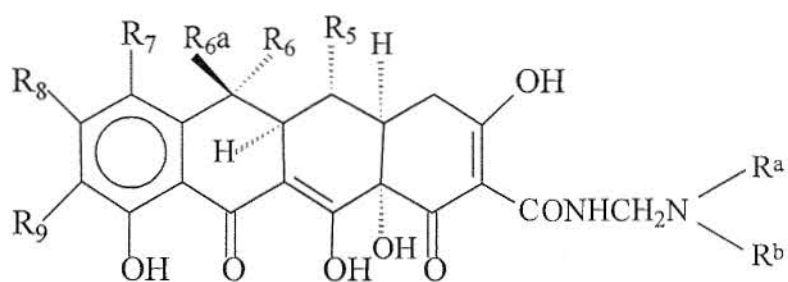
nitro	hydrogen	hydrogen
azido	hydrogen	hydrogen
dimethylamino	hydrogen	azido
hydrogen	hydrogen	amino
hydrogen	hydrogen	azido
hydrogen	hydrogen	nitro
bromo	hydrogen	hydrogen
dimethylamino	hydrogen	amino
acylamino	hydrogen	hydrogen
hydrogen	hydrogen	acylamino
amino	hydrogen	nitro
hydrogen	hydrogen	(N,N-dimethyl)glycylamino
amino	hydrogen	amino
diethylamino	hydrogen	hydrogen
hydrogen	hydrogen	ethoxythiocarbonylthio
dimethylamino	hydrogen	methylamino
dimethylamino	hydrogen	acylamino
dimethylamino	chloro	amino
amino	chloro	amino
acylamino	chloro	acylamino
hydrogen	chloro	amino
amino	chloro	hydrogen
acylamino	chloro	hydrogen
monoalkylamino	chloro	amino
nitro	chloro	amino

and pharmaceutically acceptable and unacceptable salts thereof.

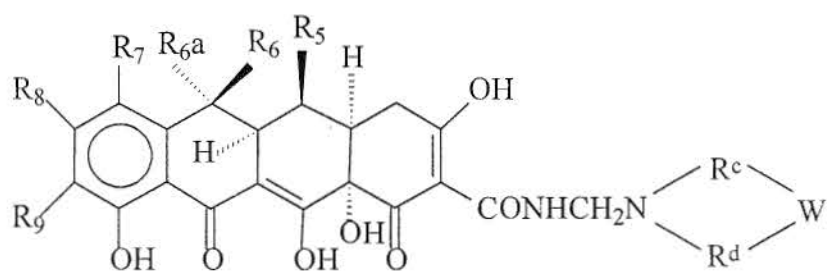




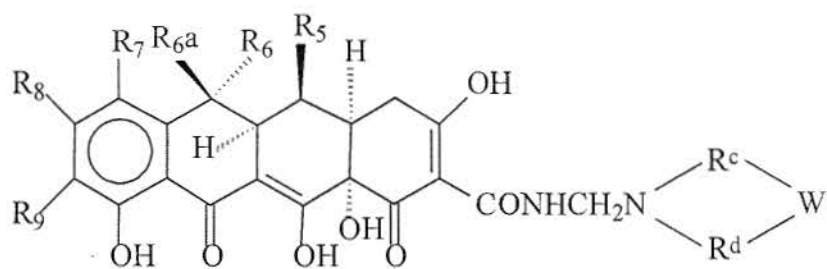
Structure U



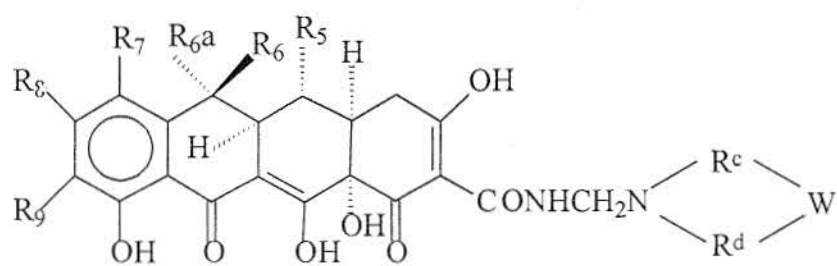
Structure V



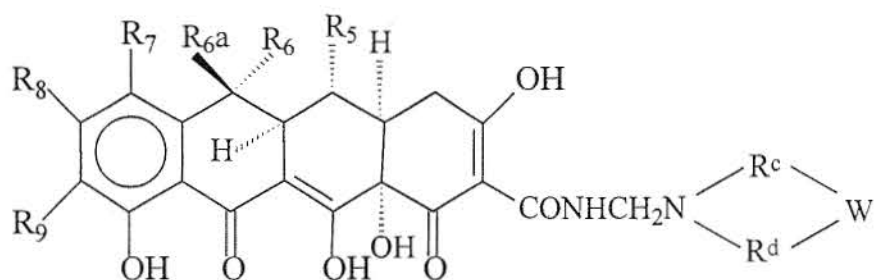
Structure W



Structure X



Structure Y



Structure Z

wherein R7 is selected from the group consisting of hydrogen, amino, nitro, mono(lower alkyl) amino, halogen, di(lower alkyl)amino, ethoxythiocarbonylthio, azido, acylamino, diazonium, cyano, and hydroxyl; R6-a is selected from the group consisting of hydrogen and methyl; R6 and R5 are selected from the group consisting of hydrogen and hydroxyl; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of hydrogen, amino, azido, nitro, acylamino, hydroxy,

ethoxythiocarbonylthio, mono(lower alkyl) amino, halogen, diazonium, di(lower alkyl)amino and $RCH(NH_2)CO$; R is hydrogen or lower alkyl; R^a and R^b are selected from the group consisting of hydrogen, methyl, ethyl, n-propyl and 1-methylethyl with the proviso that R^a and R^b cannot both be hydrogen; R^c and R^d are, independently $(CH_2)_nCHR^e$ wherein n is 0 or 1 and R^e is selected from the group consisting of hydrogen, alkyl, hydroxy, lower(C_1 - C_3) alkoxy, amino, or nitro; and, W is selected from the group consisting of $(CHR^e)_m$ wherein m is 0-3 and R^e is as above, NH, $N(C_1-C_3)$ straight chained or branched alkyl, O, S and $N(C_1-C_4)$ straight chain or branched alkoxy; and pharmaceutically acceptable and unacceptable salts thereof. In a further embodiment, the following provisos apply: when either R7 and R9 are hydrogen then R8 must be halogen; and when R6-a, R6, R5 and R9 are all hydrogen and R7 is hydrogen, amino, nitro, halogen, dimethylamino or diethylamino, then R8 must be halogen; and when R6-a is methyl, R6 and R9 are both hydrogen, R5 is hydroxyl, and R7 is hydrogen, amino, nitro, halogen or diethylamino, then R8 is halogen; and when R6-a is methyl, R6 is hydroxyl, R5, R7 and R9 are all hydrogen, then R8 must be halogen; and when R6-a, R6 and R5 are all hydrogen, R9 is methylamino and R7 is dimethylamino, then R8 must be halogen; and when R6-a is methyl, R6 is hydrogen, R5 is hydroxyl, R9 is methylamino and R7 is dimethylamino, then R8 must be halogen; and when R6-a is methyl, R6, R5 and R9 are all hydrogen and R7 is cyano, then R8 must be halogen.

STRUCTURE K

wherein: R7, R8, and R9 taken together in each case, have the following meanings:

R7	R8	R9
hydrogen	hydrogen	amino
hydrogen	hydrogen	palmitamide

and

STRUCTURE L STRUCTURE M STRUCTURE N STRUCTURE O

wherein: R7, R8, and R9 taken together in each case, have the following meanings:

R7	R8	R9
hydrogen	hydrogen	acetamido
hydrogen	hydrogen	dimethylaminoacetamido
hydrogen	hydrogen	nitro
hydrogen	hydrogen	amino

and

STRUCTURE P

wherein: R7, R8, and R9 taken together are, respectively, hydrogen, hydrogen and nitro.

STRUCTURE K:

wherein: R7, R8, and R9 taken together are, respectively, hydrogen, hydrogen and dimethylamino.

STRUCTURE C STRUCTURE D STRUCTURE E STRUCTURE F

wherein R7 is selected from the group consisting of an aryl, alkenyl and alkynyl; R6-a is selected from the group consisting of hydrogen and methyl; R6 and R5 are selected from the group consisting of hydrogen and hydroxyl; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of hydrogen, amino, azido, nitro, acylamino, hydroxy, ethoxythiocarbonylthio, mono(lower alkyl) amino, halogen, diazonium, di(lower alkyl)amino and RCH(NH₂)CO; and pharmaceutically acceptable and unacceptable salts thereof;

or

STRUCTURE C STRUCTURE D STRUCTURE E STRUCTURE F

wherein: R7 is selected from the group consisting of hydrogen, amino, nitro, mono(lower alkyl) amino, halogen, di(lower alkyl)amino, ethoxythiocarbonylthio, azido, acylamino, diazonium, cyano, and hydroxyl; R6-a is selected from the group consisting of hydrogen and methyl; R6 and R5 are selected from the group consisting of hydrogen and hydroxyl; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of an aryl, alkenyl and alkynyl; and pharmaceutically acceptable and unacceptable salts thereof;

or

STRUCTURE C STRUCTURE D STRUCTURE E STRUCTURE F

wherein: R7 and R9 are selected from the group consisting of an aryl, alkene, alkyne, or mixtures thereof; R6-a is selected from the group consisting of hydrogen and methyl; R6 and R5 are selected from the group consisting of hydrogen and hydroxyl; R8 is selected from the group consisting of hydrogen and halogen; and pharmaceutically acceptable and unacceptable salts thereof.

STRUCTURE G STRUCTURE H STRUCTURE I STRUCTURE J

wherein R7 is selected from the group consisting of an aryl, alkenyl and alkynyl; R6-a is selected from the group consisting of hydrogen and methyl; R6 and R5 are selected from the group consisting of hydrogen and hydroxyl; R4 is selected from the group consisting of NOH, N-NH-A, and NH-A, where A is a lower alkyl group; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of hydrogen, amino, azido, nitro, acylamino, hydroxy, ethoxythiocarbonylthio, mono(lower alkyl) amino, halogen, di(lower alkyl)amino and RCH(NH₂)CO; and pharmaceutically acceptable and unacceptable salts thereof;

or

STRUCTURE G STRUCTURE H STRUCTURE I STRUCTURE J

wherein R7 is selected from the group consisting of hydrogen, amino, nitro, mono(lower alkyl) amino, halogen, di(lower alkyl)amino, ethoxythiocarbonylthio, azido, acylamino, diazonium, cyano, and hydroxyl; R6-a is selected from the group consisting of hydrogen and methyl; R6 and R5 are selected from the group consisting of hydrogen and hydroxyl; R4 is selected from the group consisting of NOH, N-NH-A, and NH-A, where A is a lower alkyl group; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of an aryl, alkenyl and alkynyl; and pharmaceutically acceptable and unacceptable salts thereof;

OR

STRUCTURE G STRUCTURE H STRUCTURE I STRUCTURE J

wherein: R7 and R9 are selected from the group consisting of an aryl, alkenyl, alkynyl; or mixtures thereof; R6-a is selected from the group consisting of hydrogen and methyl; R6 and R5 are selected from the group consisting of hydrogen and hydroxyl; R4 is selected from the group consisting of NOH, N-NH-A, and NH-A, where A is a lower alkyl group; and R8 is selected from the group consisting of hydrogen and halogen; and pharmaceutically acceptable and unacceptable salts thereof.

STRUCTURE K

wherein R7 is selected from the group consisting of an aryl, alkenyl and alkynyl; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of hydrogen, amino, azido, nitro, acylamino, hydroxy, ethoxythiocarbonylthio, mono(lower alkyl) amino, halogen, di(lower alkyl)amino and RCH(NH₂)CO; and pharmaceutically acceptable and unacceptable salts thereof;

OR

STRUCTURE K

wherein: R7 is selected from the group consisting of hydrogen, amino, nitro, mono(lower alkyl) amino, halogen, di(lower alkyl)amino, ethoxythiocarbonylthio, azido, acylamino, diazonium, cyano, and hydroxyl; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of an aryl, alkenyl and alkynyl; and pharmaceutically acceptable and unacceptable salts thereof;

or

STRUCTURE K

wherein: R7 and R9 are selected from the group consisting of an aryl, alkenyl, alkynyl and mixtures thereof; and R8 is selected from the group consisting of hydrogen and halogen; and pharmaceutically acceptable and unacceptable salts thereof;

and

STRUCTURE L STRUCTURE M STRUCTURE N STRUCTURE O

wherein: R7 is selected from the group consisting of an aryl, alkenyl and alkynyl; R8 is selected from the group consisting of hydrogen and halogen; and pharmaceutically acceptable and unacceptable salts thereof;

or

STRUCTURE L STRUCTURE M STRUCTURE N STRUCTURE O

wherein R7 is selected from the group consisting of hydrogen, amino, nitro, mono(lower alkyl) amino, halogen, di(lower alkyl)amino, ethoxythiocarbonylthio, azido, acylamino, diazonium, cyano, and hydroxyl; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of an aryl, alkenyl and alkynyl; and pharmaceutically acceptable and unacceptable salts thereof;

or

STRUCTURE L STRUCTURE M STRUCTURE N STRUCTURE O

wherein R7 is and R9 are selected from the group consisting of an aryl, alkenyl, alkynyl and mixtures thereof; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of hydrogen, amino, azido, nitro, acylamino, hydroxy, ethoxythiocarbonylthio, mono(lower alkyl) amino, halogen, di(lower alkyl)amino and $\text{RCH}(\text{NH}_2)\text{CO}$; and pharmaceutically acceptable and unacceptable salts thereof;

and

STRUCTURE P

wherein R9 is selected from the group consisting of an aryl, alkenyl and alkynyl; and R8 is selected from the group consisting of hydrogen and halogen; and pharmaceutically acceptable and unacceptable salts thereof;

and

STRUCTURE Q STRUCTURE R

wherein R7 is selected from the group consisting of an aryl, alkenyl and alkynyl; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of hydrogen, amino, azido, nitro, acylamino, hydroxy, ethoxythiocarbonylthio, mono(lower alkyl) amino, halogen, di(lower alkyl)amino and $\text{RCH}(\text{NH}_2)\text{CO}$; and pharmaceutically acceptable and unacceptable salts thereof;

or

STRUCTURE Q STRUCTURE R

wherein R7 is selected from the group consisting of hydrogen, amino, nitro, mono(lower alkyl) amino, halogen, di(lower alkyl)amino, ethoxythiocarbonylthio, azido, acylamino, diazonium, cyano, and hydroxyl; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of an aryl, alkenyl and alkynyl; and pharmaceutically acceptable and unacceptable salts thereof;

or

STRUCTURE Q STRUCTURE R

wherein R7 and R9 are selected from the group consisting of an aryl, alkenyl, alkynyl; and mixtures thereof; R8 is selected from the group consisting of hydrogen and halogen; and pharmaceutically acceptable and unacceptable salts thereof.

STRUCTURES S-Z

wherein R7 is selected from the group consisting of an aryl, alkenyl and alkynyl; R6-a is selected from the group consisting of hydrogen and methyl; R6 and R5 are selected from the group consisting of hydrogen and hydroxyl; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of hydrogen, amino, azido, nitro, acylamino, hydroxy, ethoxythiocarbonylthio, mono(lower alkyl) amino, halogen, diazonium, di(lower alkyl)amino and $\text{RCH}(\text{NH}_2)\text{CO}$; R^a and R^b are selected from the group consisting of hydrogen, methyl, ethyl, n-propyl and 1-methylethyl with the proviso that R^a and R^b cannot both be hydrogen; R^c and R^d are, independently, $(\text{CH}_2)_n\text{CHR}^e$ wherein n is 0 or 1 and R^e is selected from the group consisting of hydrogen, alkyl, hydroxy, lower($\text{C}_1\text{-C}_3$) alkoxy, amino, or nitro; and, W is selected from the group consisting of $(\text{CHR}^e)_m$ wherein m is 0-3 and said R^e is as above, NH, $\text{N}(\text{C}_1\text{-C}_3)$ straight chained or branched alkyl, O, S and $\text{N}(\text{C}_1\text{-C}_4)$ straight chain or branched alkoxy; and pharmaceutically acceptable and unacceptable salts thereof;

or

STRUCTURES S-Z

wherein R7 is selected from the group consisting of hydrogen, amino, nitro, mono(lower alkyl) amino, halogen, di(lower alkyl)amino, ethoxythiocarbonylthio, azido, acylamino, diazonium, cyano, and hydroxyl; R6-a is selected from the group consisting of hydrogen and methyl; R6 and R5 are selected from the group consisting of hydrogen and hydroxyl; R8 is selected from the group consisting of hydrogen and halogen; R9 is selected from the group consisting of an aryl, alkenyl and alkynyl; R^a and R^b are selected from the group consisting of hydrogen, methyl, ethyl, n-propyl and 1-methylethyl with the proviso that R^a and R^b cannot both be hydrogen; R^c and R^d are, independently, (CH₂)_nCHR^e wherein n is 0 or 1 and R^e is selected from the group consisting of hydrogen, alkyl, hydroxy, lower(C₁-C₃) alkoxy, amino, or nitro; and, W is selected from the group consisting of (CHR^e)_m wherein m is 0-3 and said R^e is as above, NH, N(C₁-C₃) straight chained or branched alkyl, O, S and N(C₁-C₄) straight chain or branched alkoxy; and pharmaceutically acceptable and unacceptable salts thereof;

or

STRUCTURES S-Z

wherein: R7 and R9 are selected from the group consisting of an aryl, alkenyl, alkynyl and mixtures thereof; R6-a is selected from the group consisting of hydrogen and methyl; R6 and R5 are selected from the group consisting of hydrogen and hydroxyl; R8 is selected from the group consisting of hydrogen and halogen; R^a and R^b are selected from the group consisting of hydrogen, methyl, ethyl, n-propyl and 1-methylethyl with the proviso that R^a and R^b cannot both be hydrogen; R^c and R^d are, independently, (CH₂)_nCHR^e wherein n is 0 or 1 and R^e is selected from the group consisting of hydrogen, alkyl, hydroxy, lower(C₁-C₃) alkoxy, amino, or nitro; and W is selected from the group consisting of (CHR^e)_m wherein m is 0-3 and said R^e is as above, NH, N(C₁-C₃) straight chained or branched

alkyl, O, S and N(C₁-C₄) straight chain or branched alkoxy; and pharmaceutically acceptable and unacceptable salts thereof.