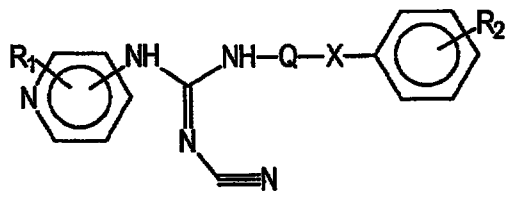
CYANOGUANIDINES AS CELL PROLIFERATION INHIBITORS

This invention relates to a hitherto unknown class of compounds which shows strong activity in inhibiting undesirable cell proliferation in e.g. skin cells and cancer cells, to pharmaceutical preparations containing these compounds, to dosage units of such preparations, and to their use in the treatment and prophylaxis of diseases characterized by abnormal cell differentiation and/or cell proliferation such as e.g. psoriasis and cancer.

The compounds of the present invention are represented by the general formula I



I

or their tautomeric forms, the attachment to the pyridine ring being in the 3- or 4-position, in which formula R_1 stands for one or more substituents which can be the same or different and are selected from the group consisting of: hydrogen, halogen, trifluoromethyl, carboxy, C_1-C_4 alkyl, alkoxy or alkoxycarbonyl, nitro, amino or cyano and Q stands for C_9-C_{20} divalent hydrocarbon radical which can be saturated, straight or branched or Q stands for C_4-C_{20} divalent hydrocarbon radical which can be cyclic or unsaturated and X stands for oxygen, sulfur or nitrogen the latter optionally being substituted by hydrogen or C_1-C_4 alkyl and R_2 stands for one or more substituents which can be the same or different and are selected

from the group consisting of: hydrogen, C_1-C_4 alkyl or alkoxy, hydroxy, halogen, triflouromethyl, cyano, carboxamido, sulfamoyl or nitro.

If the present compounds contain one or more asymmetric carbon atoms, these compounds may form optical isomers or diastereoisomers. The present invention also comprises such isomers, and mixtures of same.

The present salts of the compounds of formula I may be formed with pharmaceutically acceptable inorganic or organic acids, such as hydrochloric, hydrobromic and hydroiodic acid, phosphoric acid, sulphuric acid, nitric acid, 4-toluenesulphonic acid, methanesulphonic acid, formic acid, acetic acid, propionic acid, citric acid, tartaric acid, succinic acid, benzoic acid and maleic acid.

Even if the present compounds are well absorbed after enteral administration, in some cases it can be advantageous to prepare suitable bioreversible derivatives of compounds of the invention, i.e. to prepare so-called prodrugs, preferably derivatives, the physicochemical properties of which leads to improved solubility at physiological pH and/or absorption and/or bioavailability of the compound in question.

Such derivatives are for instance pyridyl N-oxide derivatives of compounds of the invention, such compounds being prepared by oxidation of the pyridyl N by a suitable oxidising agent, e.g. with 3-chloroperbenzoic acid in an inert solvent, e.g. dichloromethane.

Other suitable methods to improve the physicochemical properties and/or solubility of the compounds concerned can be used as well.

N-Alkyl-*N'*-cyano-*N"*-pyridylguanidines, described in United Kingdom Patent No. 1,489,879, are potent potassium channel activators with a pronounced effect as pre-capillary vasodilators, reducing the total peripheral resistance in animals and in man, and are thus useful as antihypertensives. As stated in International Patent No. PCT/DK93/00291, filing date September 13, 1993 , Publication No. WO 94/06770 the introduction of aryloxy-containing radicals into the aliphatic groups from the above-cited U.K. Patent has led to structures showing more specific pharmacological

effects on isolated tissues and cells and with no or a negligible effect on ^{86}Rb-efflux from potassium channels, as compared with the established effect of compounds covered by the above-mentioned U.K. Patent.

The compounds of the present invention inhibit the proliferation of various tumour cell lines in cultures at lower concentrations than the known compounds , confer table 1 below, thus making them potentially useful in antineoplastic chemotherapy.

The inhibition of tumour cell proliferation was studied using different types of human cancer cell lines. The cell lines under investigation were small cell lung carcinoma (NYH), non small cell lung carcinoma (NCI-H460), and breast cancer (MCF-7) using the following general procedure:

The cells were cultured *in vitro* for 24 hours in the presence of the compound under investigation. DNA synthesis was measured by incorporation of [3H]thymidine, and the median inhibitory concentrations (IC_{50}) of the compounds were calculated.

Table 1. Inhibition of tumour cell proliferation *in vitro* in human breast cancer (MCF-7), human small cell lung carcinoma (NYH) and human non small cell lung cancer (NCI-H460) cell lines by compounds of the following examples of the present invention.

Compound from	MCF-7 IC_{50} (nM)	NYH IC_{50} (nM)	NCI-H460 IC_{50} (nM)
Example No. 1	21	4.5	-
Example No. 3	13	5.9	49
Example No. 4	18	5.3	43
Prior art A	920	380	>1000
Prior art B	250	45	67

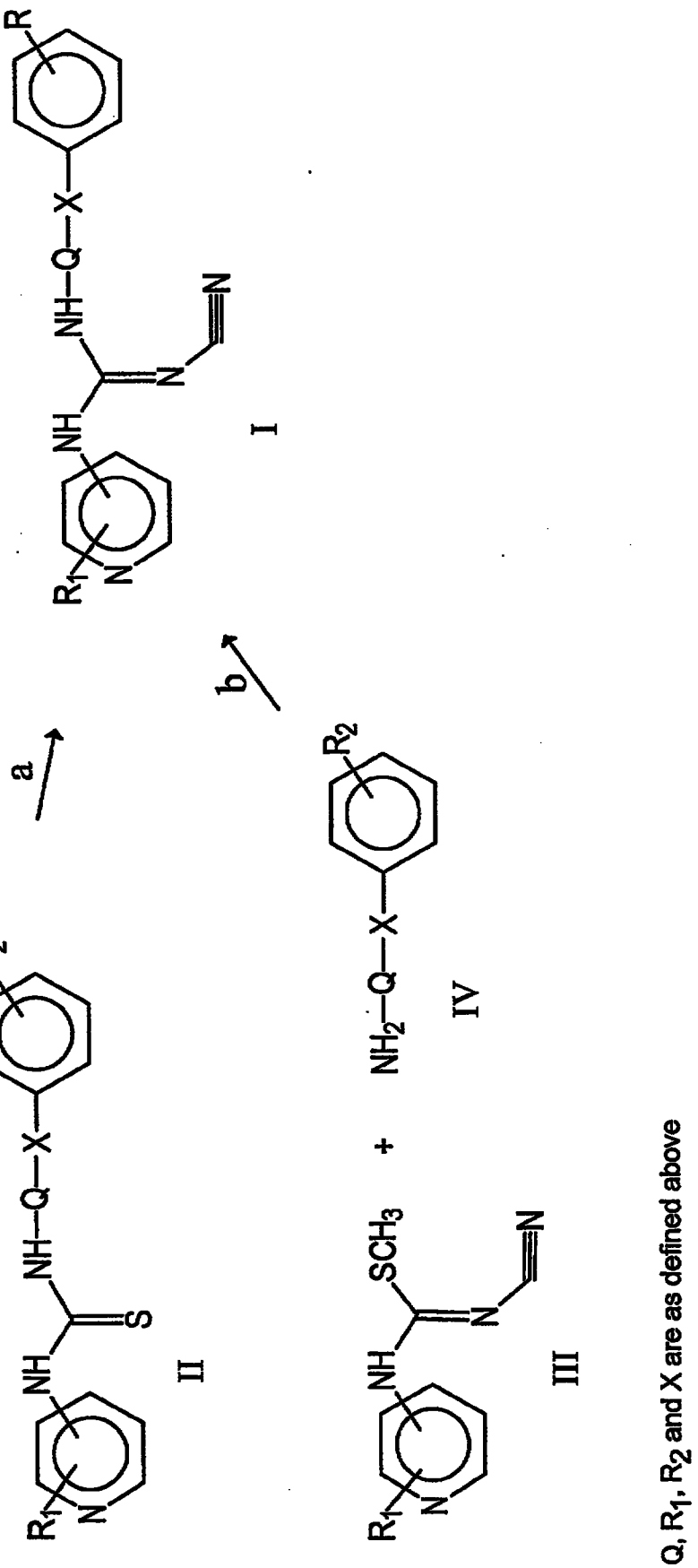
A: *N*-Cyano-*N'*-(4-phenoxybutyl)-*N''*-4-pyridylguanidine in PCT/DK93/00291, example 14.

B: *N*-Cyano-*N'*-(5-phenoxypentyl)-*N''*-4-pyridylguanidine in PCT/DK93/00291, example 18.

The results show that the compounds of the present invention are able to inhibit the proliferation of tumour cells *in vitro* at the same or lower concentrations than the compounds A and B from PCT/DK93/00291.

The compounds of the invention are well tolerated and non-toxic and are exerting the described beneficial activities with no or minimal effect on the systemic blood pressure. In general, they may be administered by oral, intravenous, intraperitoneal, intranasal or transdermal routes.

The present invention also relates to methods for preparing the desired compounds of the general formula I. The compounds of the formula I may conveniently be prepared by standard procedures detailed in the art. The routes are outlined in the following reaction scheme.



Q, R_1, R_2 and X are as defined above

a) DCCD, NH_2CN, Et_3N, CH_3CN, 2 weeks. (General procedure 1).

b) DMAP, Et_3N, Pyridine, 10 days. (General procedure 2).

The present compounds are intended for use in pharmaceutical compositions which are useful in the treatment of the above mentioned diseases.

The amount required of a compound of formula (I) (hereinafter referred to as the active ingredient) for therapeutic effect will, of course, vary both with the particular compound, the route of administration and the mammal under treatment. A suitable dose of a compound of formula (I) for systemic treatment is 0.1 to 400 mg per kilogram bodyweight, the most preferred dosage being 1.0 to 100 mg per kg of mammal bodyweight, for example 5 to 20 mg/kg; administered once or more times daily.

A daily dose (for adults) may amount to 1 mg to 10000 mg, preferably from 70 - 5000 mg, and in the veterinary practice correspondingly, in daily doses from 0.1 to 400 mg/kg bodyweight.

While it is possible for an active ingredient to be administered alone as the raw chemical, it is preferable to present it as a pharmaceutical formulation. Conveniently, the active ingredient comprises from 0.1% to 99% by weight of the formulation. Conveniently, dosage units of a formulation contain between 0.5 mg and 1 g of the active ingredient. For topical administration, the active ingredient preferably comprises from 1% to 20% by weight of the formulation but the active ingredient may comprise as much as 50% w/w. Formulations suitable for nasal or buccal administration may comprise 0.1% to 20% w/w. for example about 2% w/w of active ingredient.

By the term "dosage unit" is meant a unitary, i.e. a single dose which is capable of being administered to a patient, and which may be readily handled and packed, remaining as a physically and chemically stable unit dose comprising either the active material as such or a mixture

of it with solid or liquid pharmaceutical diluents or carriers.

The formulations, both for veterinary and for human medical use, of the present invention comprise an active ingredient in association with a pharmaceutically acceptable carrier therefor and optionally other therapeutic ingredient(s). The carrier(s) must be "acceptable" in the sense of being compatible with the other ingredients of the formulations and not deleterious to the recipient thereof.

The formulations include those in a form suitable for oral, rectal, parenteral (including subcutaneous, intramuscular, intravenous and intraperitoneal) administration.

The formulations may conveniently be presented in dosage unit form and may be prepared by any of the methods well known in the art of pharmacy. All methods include the step of bringing the active ingredient into association with the carrier which constitutes one or more accessory ingredients. In general, the formulations are prepared by uniformly and intimately bringing the active ingredient into association with a liquid carrier or a finely divided solid carrier or both, and then, if necessary, shaping the product into the desired formulation.

Formulations of the present invention suitable for oral administration may be in the form of discrete units as capsules, sachets, tablets or lozenges, each containing a predetermined amount of the active ingredient; in the form of a powder or granules; in the form of a solution or a suspension in an aqueous liquid or non-aqueous liquid; or in the form of an oil-in-water emulsion or a water-in-oil emulsion. The active ingredient may also be administered in the form of a bolus, electuary or paste.

Formulations for rectal administration may be in the form of a suppository incorporating the active ingredient and a carrier such as cocoa butter, or in the form of an enema.

Formulations suitable for parenteral administration conveniently comprise a sterile oily or aqueous preparation of the active ingredient which is preferably isotonic with the blood of the recipient.

In addition to the aforementioned ingredients, the formulations of

this invention may include one or more additional ingredients, such as diluents, buffers, flavouring agents, binders, surface active agents, thickeners, lubricants, preservatives, e.g. methylhydroxybenzoate (including anti-oxidants), emulsifying agents and the like.

The compositions may further contain other therapeutically active compounds usually applied in the treatment of the above mentioned pathological conditions, e.g. antineoplastic agents which may result in synergistic effects on tumour cells.

The invention will now be further described in the following general procedures, preparations and examples:

The exemplified compounds I are listed in table 2.

Table 2.

Compound No.	Example No.	R_1	3- or 4-Pyridyl	Q	X	R_2
101	1	H	4	$(CH_2)_{11}$	O	H
102	2	H	4	$(CH_2)_{17}$	O	H
103	3	H	4	$(CH_2)_{10}$	O	H
104	4	H	4	$(CH_2)_9$	O	H
105	5	6-OMe	3	$(CH_2)_{11}$	O	H
106	6	2-Cl	3	$(CH_2)_{11}$	O	H
107	7	H	4	#	O	4-Cl

#: $(CH_2)_2CH=CH(CH_2)_2$, E-isomer.

All melting points are uncorrected. For ^1H and ^{13}C nuclear magnetic resonance (NMR) spectra (300 MHz) chemical shift values (δ) are quoted, unless otherwise specified, for deuterochloroform and hexadeute-

rodimethylsulfoxide solutions relative to internal chloroform (^{1}H NMR δ 7.25, ^{13}C NMR δ 76.81) or tetramethylsilane (δ 0.00). The value for a multiplet (m), either defined (doublet (d), triplet (t), quartet (q)) or not at the approximate mid point is given unless a range is quoted (s singlet, b broad). Chromatography was performed on silica gel. The following abbreviations and formulas are used: CH_3CN (acetonitrile), DMAP (dimethylaminopyridine), CH_2Cl_2 (dichloromethane), $CDCl_3$ (deuterochloroform), MeOH (methanol), NH_3(aq) (ammonia), MeOD (tetradeuteromethanol) and DMSO-d_6 (hexadeuterodimethylsulfoxide).

General procedure 1: Conversion of compounds of the general formula II into compounds of the general formula I.

A compound of the general formula II (5 mmol) was suspended in acetonitrile (12 ml) and dicyclohexylcarbodiimide (10 mmol), cyanamide (10 mmol) and triethylamine (0.07 ml) was added. The reaction mixture was stirred at room temperature for 2 weeks.

The reaction mixture was filtered and washed with acetonitrile. The white solid containing product and dicyclohexylthiourea was triturated with chloroform (20 ml) overnight and filtered to give the product of general formula I as white crystals.

General procedure 2: Coupling of compounds of the general formula III with compounds of the general formula IV resulting in compounds of the general formula I.

A compound of the general formula III (4 mmol), a compound of the general formula IV (5 mmol), triethylamine (0.12 ml) and 4-dimethylaminopyridine (15 mg) were dissolved in pyridine (4 ml). The reaction mixture was stirred for 10 days at room temperature.

The product was either precipitated with ether to give the pure compound as white crystals or evaporated *in vacuo* to the crude product .

Example 1:

N-Cyano-*N'*-(11-phenoxyundecyl)-*N''*-4-pyridylguanidine (Compound 101)

General method 1.

Starting compound II: *N*-(11-Phenoxyundecyl)-*N'*-4-pyridylthiourea.

Purification: General procedure.

M.p. 135-136 °C.

^{13}C NMR (DMSO-d_6) δ: 158.6, 157.2, 149.9, 145.9, 129.3, 120.2, 116.4, 114.5, 114.3, 67.1, 41.7, 28.9, 28.8, 28.7, 28.6, 28.0, 26.1, 25.4.

Example 2:

N-Cyano-*N'*-(17-phenoxyheptadecyl)-*N''*-4-pyridylguanidine (Compound 102)

General procedure 2. Reaction conditions: 5 h at 80°C.

Starting compound III: *S*-Methyl *N*-cyano-*N'*-4-pyridylisothiourea.

Starting compound IV: 17-Phenoxyheptadecylamine.

Purification: General procedure.

M.p. 134-135 °C.

^{13}C NMR ($CDCl_3$/MeOD) δ: 159.4, 149.9, 146.7, 129.7, 120.9, 117.3, 115.6, 114.9, 68.3, 42.9, 30.0, 29.9, 29.7, 29.6, 27.0, 26.3.

Example 3:

N-Cyano-*N'*-(10-phenoxydecyl)-*N''*-4-pyridylguanidine (Compound 103)

General procedure 2.

Starting compound III: *S*-Methyl *N*-cyano-*N'*-4-pyridylisothiourea.

Starting compound IV: 10-Phenoxydecylamine.

Purification: General procedure.

M.p. 128-129 °C.

^{13}C NMR (DMSO-d_6) δ: 158.7, 157.3, 150.1, 145.9, 129.4, 120.3, 116.5, 114.6, 114.4, 67.3, 41.8, 28.9, 28.8, 28.7, 28.7, 26.2, 25.6.

Example 4:

N-Cyano-*N'*-(9-phenoxynonyl)-*N''*-4-pyridylguanidine (Compound 104)

General procedure 2.

Starting compound III: *S*-Methyl *N*-cyano-*N'*-4-pyridylisothiourea.

Starting compound IV: 9-Phenoxynonylamine.

Purification: General procedure.

M.p. 142-144 °C.

^{1}H NMR (DMSO-d_6) δ: 9.37 (bs, 1H), 8.39 (bd, 2H), 7.85 (bt, 1H), 7.25 (m, 4H), 6.90 (m, 3H), 3.93 (t, 2H), 3.27 (q, 2H), 1.70 (m, 2H), 1.53 (m, 2H), 145-1.20 (m, 10H).

Example 5:

N-Cyano-*N'*-(11-phenoxyundecyl)-*N''*-5-(2-methoxypyridyl)guanidine (Compound 105)

General procedure 2. Reaction conditions: 96 h at 60°C.

Starting compound III: *S*-Methyl *N*-cyano-*N'*-5-(2-methoxypyridyl)isothiourea.

Starting compound IV: 11-Phenoxyundecylamine.

Purification: Flash chromatography (Eluent CH_2Cl_2/MeOH/NH_3(aq) 90:10:1) followed by trituration in CH_2Cl_2.

M.p. 97-98 °C.

^{13}C NMR (DMSO-d_6) δ:161.2, 158.6, 158.6, 143.3, 137.0, 129.3, 128.0, 120.2, 117.3, 114.3, 110.3, 67.2, 53.2, 41.3, 28.9, 28.9, 28.9, 28.8, 28.7, 28.6, 26.1, 25.5

Example 6:

N-Cyano-*N'*-(11-phenoxyundecyl)-*N''*-3-(2-chloropyridyl)guanidine (Compound 106)

General procedure 2. Reaction conditions: 96 h at 60°C.

Starting compound III: *S*-Methyl *N*-cyano-*N'*-3-(2-chloropyridyl)isothiourea.

Starting compound IV: 11-Phenoxyundecylamine.

Purification: Flash chromatography (Eluent CH_2Cl_2/MeOH/NH_3(aq) 98:2:0.2).

M.p. 149-150 °C.

^{13}C NMR (DMSO-d_6) δ: 158.6, 157.8, 147.7, 147.2, 138.0, 131.7, 129.3, 123.6, 120.2, 116.9, 114.3, 67.1, 41.4, 28.9, 28.9, 28.8, 28.8, 28.7, 28.6, 26.0, 25.4

Example 7:

(E)-N-(6-(4-Chlorophenoxy)-hex-3-enyl)-*N'*-Cyano-*N''*-4-pyridylguanidine (Compound 107)

General procedure 2. Reaction conditions: 96 h at 60°C.

Starting compound III: *S*-Methyl *N*-cyano-*N'*-4-pyridylisothiourea.

Starting compound IV: (E)-6-(4-Chlorophenoxy)-hex-3-enylamine.

Purification: General procedure.

Example 8:

Capsules

1 Capsule contains:

N-Cyano-*N'*-(11-phenoxyundecyl)-*N''*-4-pyridylguanidine (active compound)	100 mg
Polyethylene Glycol	962 mg
Gelatine Capsule no. 00	
Gelatine	122 mg

Example 9:

Tablet

Manufacture of 10.000 tablets

I	*N*-Cyano-*N'*-(11-phenoxyundecyl)-*N''*-4-pyridylguanidine (active compound)	10,000 kg
	Cross carmellose sodium	0,300 kg

II	Hydroxypropylmethyl cellulose,	
	low viscosity type	0,200 kg
	Sorbimacrogol oleate	0,010 kg
	Purified water	q.s.
III	Crosscarmellose sodium	0,200 kg
	Coloidal anhydrous silica	0,050 kg
	Magnesium stearate	0,050 kg

I is mixed intimately in a highshear mixer, is wetted with II and granulated into a moist mass. The moist granulate is dried in a fluid-bed dryer at an inlet air temperature of 60°C until the dried granulate has a water activity of 0.3-0.4 (= in equilibrium with air of 30-40% R.H.).

The dried granulate is passed through a sieve with mesh openings of 850 mm.

The sieved granulate is finally mixed with III in a cone mixer.

The finished granulate is compressed into tablets of mass 1071 mg and sufficient hardness.

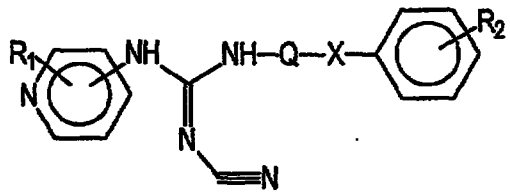
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WHAT WE CLAIM IS:

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1. A compound of the formula I



I

or their tautomeric forms, the attachment to the pyridine ring being in the 3- or 4-position, in which formula R_1 stands for one or more substituents which can be the same or different and are selected from the group consisting of: hydrogen, halogen, trifluoromethyl, carboxy, C_1-C_4 alkyl, alkoxy or alkoxycarbonyl, nitro, amino or cyano and Q stands for C_9-C_{20} divalent hydrocarbon radical which can be saturated, straight or branched or Q stands for C_4-C_{20} divalent hydrocarbon radical which can be cyclic or unsaturated and X stands for oxygen, sulfur or nitrogen the latter optionally being substituted by hydrogen or C_1-C_4 alkyl and R_2 stands for one or more substituents which can be the same or different and are selected from the group consisting of: hydrogen, C_1-C_4 alkyl or alkoxy, hydroxy, halogen, triflouromethyl, cyano, carboxamido, sulfamoyl or nitro; and pharmaceutically acceptable, non-toxic salts and N-oxides thereof.

2. A compound according to formula I of claim 1, in which the attachment to the pyridine ring is in the 4-position, in which formula R_1 stands for hydrogen and Q stands for C_9-C_{20} divalent hydrocarbon radical which can be saturated, straight or branched or Q stands for C_4-C_{20} divalent hydrocarbon radical which can be unsaturated and X stands for oxygen, and R_2 stands for one or more substituents which can be the same or different and are selected from the group consisting of: hydrogen,

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C_1-C_4 alkyl or alkoxy, or halogen; and pharmaceutically acceptable, non-toxic salts and N-oxides thereof.

3. A salt according to claim 1 in which the salt is selected from the group consisting of salts formed with hydrochloric, hydrobromic and hydroiodic acid, phosphoric acid, sulphuric acid, nitric acid, p-toluenesulphonic acid, methanesulphonic acid, formic acid, acetic acid, propionic acid, citric acid, tartaric acid, and maleic acid, and lithium, sodium, potassium, magnesium, calcium salts, as well as salts with ammonia, C_1-C_6-alkylamines, C_1-C_6 alkanolamines, procaine, cycloalkylamines, benzylamines, and heterocyclic amines.

4. A compound of claim 1 which is selected from the group consisting of:

N-Cyano-*N'*-(11-phenoxyundecyl)-*N"*-4-pyridylguanidine;
N-Cyano-*N'*-(10-phenoxydecyl)-*N"*-4-pyridylguanidine;
N-Cyano-*N'*-(9-phenoxynonyl)-*N"*-4-pyridylguanidine;

and their salts and pure enantiomeric forms.

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5. A pharmaceutical preparation, containing a compound according to any one of claims 1 - 4 alone or together with the necessary auxiliary agents.

6. A method of treating patients in need of treatment characterized in administering to said patients an effective amount of one or more compounds according to any of claims 1 - 5, if necessary together or concomitantly with one or more other therapeutically active components.

7. A method according to claim 6 for the treatment and prophy-



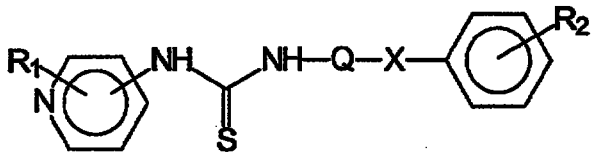
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laxis of disease states characterised in undesirable cell proliferation in e.g. skin cells and cancer cells.

8. A method for producing a compound of formula I according to claim 1, in which

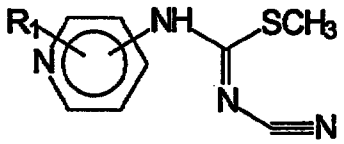
a) a compound of the general formula II



II

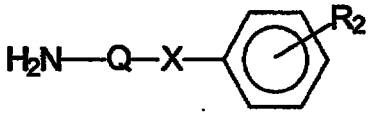
is reacted with dicyclohexylcarbodiimide, and cyanamide in the presence of triethylamine or another tertiary amine in acetonitrile or another inert solvent at room temperature or above;

b) a compound of the general formula III



III

is reacted with a compound of the general formula IV



IV

in the presence of triethylamine or another tertiary amine and 4-dimethylaminopyridine in pyridine or another inert solvent at room temperature or above.

9. The use of a compound of claim 1 in the manufacture of a medicament for the treatment and prophylaxis of a number of disease states, characterised by undesirable cell proliferation in e.g. skin cells and cancer cells.