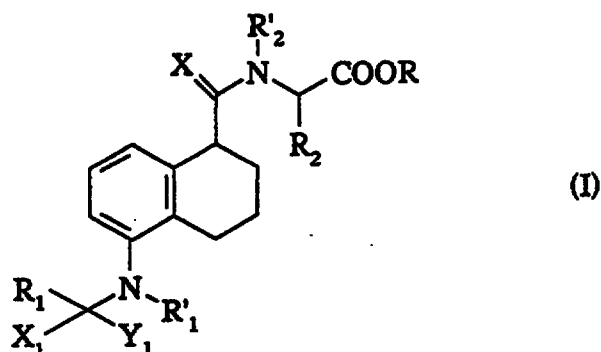


NEW FARNESYL TRANSFERASE INHIBITORS, THEIR
PREPARATION AND THE PHARMACEUTICAL COMPOSITIONS
WHICH CONTAIN THEM

The present invention relates to new farnesyl
 5 transferase inhibitors of general formula:



optionally to their salts, to their preparation and to
 the pharmaceutical compositions which contain them.

The inhibition of farnesyl transferase, and
 consequently of the farnesylation of the Ras protein,
 10 blocks the capacity of the mutated Ras protein to
 transform normal cells into cancerous cells.

The C-terminal sequence of the Ras gene
 contains the unit "CAAX" or "Cys-Aaa₁-Aaa₂-Xaa", in
 which Aaa represents an aliphatic amino acid and Xaa
 15 represents any amino acid.

It is known that tetrapeptides with a CAAX
 sequence can inhibit the farnesylation of the Ras
 protein. For example, peptide inhibitors of farnesyl
 transferase, Cys-Aaa₁-Aaa₂-Xaa, which are especially

represented by the peptides Cys-Val-Leu-Ser, Cys-Val-Ile-Met and Cys-Val-Val-Met which manifest their inhibitory activity at concentrations in the region of 10^{-6} M or of 10^{-7} M, have been described in PCT

5 Application WO 91/16340 and in Application EP 0,461,869.

It has now been found, and this forms the subject of the present invention, that the peptides of general formula (I) manifest their inhibitory activity
10 (IC_{50}) at concentrations of the order of 10^{-8} or of 10^{-9} M.

In the general formula (I),
 R_1 represents a radical of general formula $Y-S-A_1$ in which Y represents a hydrogen atom or an amino acid residue or a fatty acid residue or an alkyl or
 15 alkoxy carbonyl radical, and A_1 represents a straight or branched alkylene radical containing 1 to 4 carbon atoms, optionally substituted at the position α to the $>C(X_1)(Y_1)$ group by an amino, alkylamino, alkanoylamino or alkoxy carbonylamino radical, the straight or
 20 branched alkyl or alkanoyl part of which contains 1 to 6 carbon atoms,
 X_1 and Y_1 each represent a hydrogen atom or form, together with the carbon atom to which they are bonded, a $>C=O$ group,
 25 R'_1 represents a hydrogen atom or a straight or branched alkyl radical containing 1 to 6 carbon atoms,
 X represents an oxygen or sulphur atom,

R_2 represents a straight or branched alkyl, alkenyl or alkynyl radical containing 1 to 6 carbon atoms, optionally substituted by a hydroxyl radical, an alkoxy radical containing 1 to 4 carbon atoms, a mercapto radical, an alkylthio radical containing 1 to 4 carbon atoms, an alkylsulphinyl radical containing 1 to 4 carbon atoms or an alkylsulphonyl radical containing 1 to 4 carbon atoms, it being understood that, when R_2 represents an alkyl radical substituted by a hydroxyl radical, R_2 can form a lactone with the carboxyl radical at the α position,

R'_2 represents a hydrogen atom or a straight or branched alkyl radical containing 1 to 6 carbon atoms, and

R represents a hydrogen atom or an alkyl radical containing 1 to 6 carbon atoms, optionally substituted by an alkoxy radical containing 1 to 4 carbon atoms, an alkylthio radical containing 1 to 4 carbon atoms, an alkylsulphinyl radical containing 1 to 4 carbon atoms, an alkylsulphonyl radical containing 1 to 4 carbon atoms, a phenyl radical, a phenoxy radical, a phenylthio radical, a phenylsulphinyl radical, a phenylsulphonyl radical, an alkylamino radical containing 1 to 4 carbon atoms or a dialkylamino radical in which each alkyl part contains 1 to 4 carbon atoms, or a phenyl radical, optionally substituted by one or a number of atoms or radicals chosen from

halogen atoms and alkyl, alkyloxy, alkylthio or alkanoyl radicals.

More particularly,

R_1 represents a radical of formula $Y-S-A_1-$ in which Y
 5 represents a hydrogen atom or a lysine residue or a fatty acid residue containing up to 20 carbon atoms and A_1 represents an ethylene or propylene radical optionally substituted by an amino radical,
 X_1 and Y_1 each represent a hydrogen atom or form,
 10 together with the carbon atom to which they are bonded, a $>C=O$ group,
 R'_1 represents a hydrogen atom or a methyl radical,
 X represents an oxygen atom,
 R_2 represents an alkyl radical containing 1 to 4 carbon
 15 atoms, optionally substituted by a hydroxyl, methoxy, mercapto, methylthio, methylsulphanyl or methylsulphonyl radical,
 R'_2 represents a hydrogen atom or a methyl radical, and
 R represents a hydrogen atom or an alkyl radical
 20 containing 1 to 4 carbon atoms, optionally substituted by an alkoxy radical, or a phenyl radical.

More particularly still,

R_1 represents a radical of formula $Y-S-A_1-$ in which Y
 represents a hydrogen atom and A_1 represents an ethylene
 25 or propylene radical optionally substituted by an amino radical,
 X_1 and Y_1 each represent a hydrogen atom or form,

together with the carbon atom to which they are bonded,
a $>C=O$ group,

R'_1 represents a hydrogen atom,

X represents an oxygen atom,

5 R_2 represents a methyl, ethyl, propyl or butyl radical
optionally substituted by a hydroxyl, methoxy, mercapto
or methylthio radical,

R'_2 represents a hydrogen atom, and

R represents a hydrogen atom or an alkyl radical
10 containing 1 to 4 carbon atoms.

The products of general formula (I) in which
 R_1 represents a 2-mercaptoethyl or 1-amino-2-
mercaptoethyl radical, X_1 and Y_1 each represent a
hydrogen atom or form, together with the carbon atom to
15 which they are bonded, a $>C=O$ group, R'_1 represents a
hydrogen atom, X represents an oxygen atom, R_2
represents an n-butyl or 2-(methylthio)ethyl radical
and R'_2 represents a hydrogen atom, and R represents a
hydrogen atom or a methyl radical are very particularly
20 advantageous.

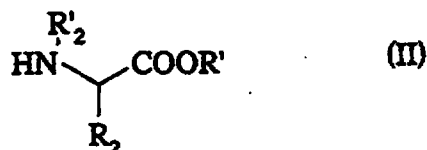
The present invention also relates to the
stereoisomeric forms of the products of general formula
(I). The amino acid residues represented by
 $R_1C(X_1)(Y_1)(NR'_1)$ and $R'_2CH(NR'_2)CO-OH$ preferably have the
25 configuration of the natural amino acids.

The present invention also relates to the
inorganic or organic salts of the products of general

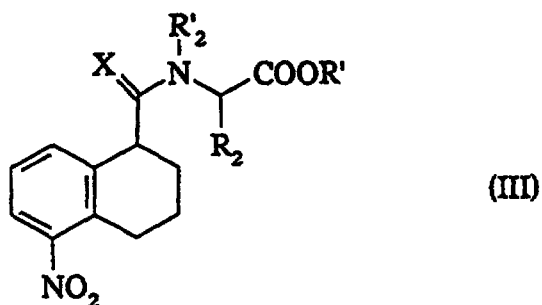
formula (I).

The new products according to the invention can be prepared by the application of known methods derived from the methods used more particularly in peptide chemistry for chain assembly.

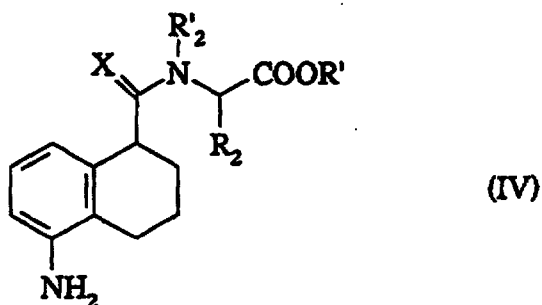
Generally, the products of general formula (I), [lacuna] which X_1 and Y_1 form, together with the carbon atom to which they are bonded, a $>C=O$ group and X represents an oxygen atom, are obtained from 5-nitro-1,2,3,4-tetrahydronaphthyl-1-carboxylic acid, with which is condensed an amino acid of general formula:



in which R_2 and R'_2 are defined as above and R' represents an alkyl radical containing 1 to 4 carbon atoms which is optionally substituted by a phenyl radical, preferably a tert-butyl radical, the reaction being carried out in the presence of a coupling agent, such as hydroxybenzotriazole and dicyclohexylcarbodiimide, and of a base, such as triethylamine, in an organic solvent, such as dimethylformamide, in order to give a product of general formula:



in which X represents an oxygen atom and R_2 , R'_2 and R' are defined as above, which is reduced, preferably by means of stannous chloride, to a product of general formula:

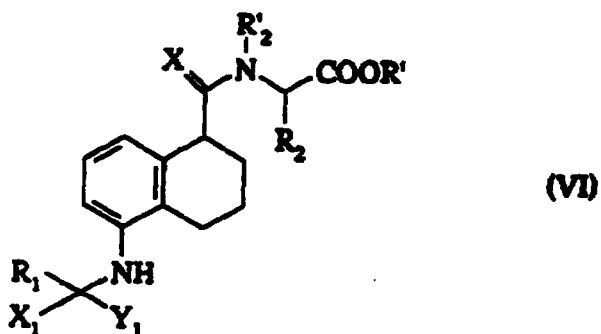


- 5 in which X represents an oxygen atom and R_2 , R'_2 and R' are defined as above, with which is condensed a product of formula:



- in which R_1 is defined as above and X_1 and Y_1 form, together with the carbon atom to which they are bonded,
 10 a $>C=O$ group, it being understood that the amino and mercapto functional groups carried by R_1 are optionally protected by appropriate protecting groups, such as a

trityl radical for the mercapto functional group or a
 tert-butoxycarbonyl radical for the amino functional
 group, the reaction preferably being carried out in the
 presence of an alkyl haloformate (isobutyl
 5 chloroformate) and of an organic base
 (N-methylmorpholine) in an inert organic solvent
 (tetrahydrofuran), in order to obtain a product of
 general formula:



in which the symbols X, X₁, Y₁, R₁, R₂, R'₂ and R' are
 10 defined as above, the protective groups of which are
 replaced by hydrogen atoms, by means of trifluoroacetic
 acid in the presence of ethanedithiol, when the
 protective groups represent trityl, tert-butoxycarbonyl
 or tert-butyl radicals, in order to obtain a product of
 15 general formula (I) in which X₁ and Y₁ form, together
 with the carbon atom to which they are bonded, a >C=O
 group.

Generally, the products of general formula
 (I) in which the symbols X₁ and Y₁ each represent a
 20 hydrogen atom can be obtained by reaction of an

aldehyde of general formula:



in which R_1 is defined as above, it being understood that the amino and mercapto functional groups carried by R_1 are optionally protected by appropriate protective groups, such as a trityl radical for the mercapto functional group or a tert-butoxycarbonyl radical for the amino functional group, with a product of general formula (V) in the presence of a reducing agent, such as sodium cyanoborohydride, sodium borohydride, sodium triacetoxymethylborohydride or hydrogen in the presence of a catalyst. Generally, the reaction is carried out in an organic solvent such as an alcohol, for instance methanol, optionally in combination with another organic solvent such as an ether, for instance tetrahydrofuran. It is particularly advantageous to carry out the reaction in anhydrous medium.

Condensation of the aldehyde with the amine having been carried out, the protecting groups are replaced by hydrogen atoms by application of the usual techniques. Thus, the Boc or trityl or tert-butyl protecting groups can be replaced by hydrogen atoms by means of trifluoroacetic acid in the presence of ethanedithiol.

The products of general formula (I) in which X represents a sulphur atom can generally be obtained from a product of general formula (III) in which X

represents an oxygen atom by thionation and then by carrying out the reduction, condensation or reductive amination, according to the situation, and deprotection stages described above for the preparation of a product of general formula (I) in which X represents an oxygen atom.

When, in the general formula (I), the R_2 symbol forms a lactone with the carboxyl functional group in the α position, treatment in basic medium of the corresponding product leads to the product of general formula (I) in which R_2 represents an alkyl radical substituted by a hydroxyl radical. Generally, opening of the lactone takes place as soon as the pH becomes greater than 7. It is particularly advantageous to carry out the reaction in the presence of an inorganic base (sodium hydroxide or potassium hydroxide) in aqueous/alcoholic medium, such as a water/methanol mixture.

The products of general formula (I) in which R represents an optionally substituted alkyl radical or an optionally substituted phenyl radical as indicated above can be obtained by esterification of a product of general formula (I) in which R represents a hydrogen atom under the usual esterification conditions which do not affect the remainder of the molecule.

The products of general formula (I) in which R represents a hydrogen atom can also be obtained by

saponification of a product of general formula (VI), followed by replacement of the protective groups carried by R₁ under the conditions described above.

5-Nitro-1,2,3,4-tetrahydronaphthyl-

5 1-carboxylic acid, which can be obtained as a mixture with 7-nitro-1,2,3,4-tetrahydronaphthyl-1-carboxylic acid, can be prepared according to the process described by T. Nakayama et al., Chem. Pharm. Bull., 32, 3968 (1984).

10 The products of general formula (I) can be purified according to the usual methods, such as chromatography.

The following examples illustrate the preparation of the products according to the invention.

15 EXAMPLE 1

5-Nitro-1,2,3,4-tetrahydronaphthyl-1(R,S)-carboxylic acid is prepared according to the method of Nakayama, T. et al., Chem. Pharm. Bull., 32, 3968 (1984).

20 1.24 g of (L)-methionine methyl ester hydrochloride, 0.84 g of 1-hydroxybenzotriazole, 0.9 cm³ of triethylamine and 1.28 g of dicyclohexylcarbodiimide are added to a solution of 1.23 g of 5-nitro-1,2,3,4-tetrahydronaphthalene-1(R,S)-carboxylic acid in 25 cm³
25 of chloroform and 7.5 cm³ of dimethylformamide. The reaction mixture is stirred for 2 days at a temperature in the region of 20°C, filtered on sintered glass and

then washed with 50 cm³ of chloroform. The organic solution is washed twice with 50 cm³ of a 10% (w/v) aqueous sodium hydrogencarbonate solution, then once with 50 cm³ of a 10 % aqueous citric acid solution, once
5 with distilled water and finally with a saturated aqueous sodium chloride solution. The organic phase is dried over magnesium sulphate, filtered and then concentrated to dryness under reduced pressure. 3.68 g of the methyl ester of N-(5-nitro-1,2,3,4-tetrahydro-
10 naphthyl-1(R,S)-carbonyl)-(L)-methionine are obtained in the form of an oil, the characteristics of which are the following:

- proton nuclear magnetic resonance spectrum (300 MHz; d₆-(CD₃)₂SO; δ in ppm; coupling constants J in Hz):
15 1.55-2.10 (mt, 6H, CH₂CH₂ at 2 and CH₂ at 3), 2.07 (s, 3H, SCH₃), 2.56 (mt, 1H, CH at 1), 4.45 (mt, 1H, CHCOO), 7.35-7.55 and 7.77 (2 mts, respectively 2H and 1H, H at 6 and H at 7 and H at 8), 8.63 and 8.69 (2d, J = 8.5, 1H, CONH).

20 6.32 g of tin(II) chloride dihydrate are added to a solution of 3.68 g of the methyl ester of N-(5-nitro-1,2,3,4-tetrahydronaphthyl-1(R,S)-carbonyl)-(L)-methionine in 100 cm³ of ethanol. The reaction mixture is stirred for 30 minutes at a temperature in
25 the region of 70°C and then cooled to a temperature in the region of 20°C. After dilution with 100 cm³ of ethyl acetate, the reaction mixture is poured onto ice and

then brought to pH = 7-8 by addition of a 5 % aqueous sodium hydrogencarbonate solution. The mixture obtained is filtered on sintered glass covered with Celite. The organic phase is separated by settling and the aqueous
 5 phase is extracted twice with 150 cm³ of ethyl acetate. The organic phases are combined, dried over magnesium sulphate, filtered and concentrated to dryness under reduced pressure. 2.49 g of the methyl ester of N-(5-amino-1,2,3,4-tetrahydronaphthyl-1(R,S)-carbonyl)-(L)-
 10 methionine are thus obtained in the form of an oil, the characteristics of which are the following:

- proton nuclear magnetic resonance spectrum (300 MHz, d6-(CD₃)₂SO; δ in ppm; coupling constants J in Hz):

1.50-2.10 (mt, 6H, CH₂CH₂ at 2 and CH₃ at 2), 2.10 (s, 3H, SCH₃), 2.39 and 2.53 (2 mts, each 2H, CH₂S and CH₂,
 15 at 4), 3.66 (mt, 1H, CH at 1), 3.69 (s, 3H, CHCOO), 4.75 (broad s, 2H, NH₂), 6.30-6.60 and 6.82 (2 mts, respectively 2H and 1H, H at 6 and H at 7 and H at 8), 8.48 (d, J = 9, 1H, CONH).

20 3.73 g of S-triphenylmethyl-N-(tert-butoxycarbonyl)cysteinol, 0.48 cm³ of concentrated acetic acid, molecular sieve (3Å) and then 0.52 g of sodium cyanoborohydride are added to a solution of 1.24 g of the methyl ester of N-(5-amino-
 25 1,2,3,4-tetrahydronaphthyl-1(R,S)-carbonyl)-(L)-methionine in 60 cm³ of methanol. The reaction mixture is stirred for 2 days at a temperature in the region of

20°C and then filtered on sintered glass, covered with Celite. The sintered glass is washed with methanol. The filtrate is concentrated to dryness under reduced pressure. The residue is dissolved in 150 cm³ of ethyl acetate and washed with 100 cm³ of a 10 % (w/v) aqueous sodium hydrogencarbonate solution, 100 cm³ of a 10 % (w/v) aqueous citric acid solution, 100 cm³ of distilled water, a further 100 cm³ of a 10 % (w/v) aqueous sodium hydrogencarbonate solution and finally with 100 cm³ of a saturated aqueous sodium chloride solution. The organic phase is dried over magnesium sulphate, filtered and concentrated to dryness under reduced pressure. 5.62 g of the methyl ester of N-[5-(2(R)-tert-butoxycarbonylamino-3-(triphenylmethylmercapto)-propylamino)-1,2,3,4-tetrahydronaphthyl-1(R,S)-carbonyl]-(L)-methionine are obtained in the form of a beige foam, the characteristics of which are the following:

- proton nuclear magnetic resonance spectrum (300 MHz, d6-(CD₃)₂SO with a few drops of d4-CD₃COOD; δ in ppm; T = 393K; coupling constants J in Hz): 1.38 (s, 9H, C(CH₃)₃), 1.50-2.05 (mt, 6H, CH₂CH₂ at 2 and CH₂ at 3), 2.06 (s, 3H, SCH₃), 2.05-2.45 and 2.53 (2 mts, respectively 4H and 2H, 2 CH₂S and CH₂ at 4), 2.85-3.05 (mt, 2H, NH₂), 3.63 (mt, 1H, CH at 1), 3.63 and 3.67 (2 s, 3H, COOCH₃), 3.71 (mt, 1H, CHN), 4.43 (mt, 1H, CHCOO), 6.30-6.56 and 6.90 (2 mts, respectively 2H and

1H, H at 6 and H at 7 and H at 8), 7.15-7.35 (mt, 15H, aromatic protons), 8.36 and 8.39 (2 poorly resolved d, J = 10, 1H, CONH).

110 cm³ of trifluoroacetic acid are added, at a temperature in the region of 20°C, to a mixture of 5.45 g of the methyl ester of N-[5-(2(R)-tert-butoxycarbonylamino-3-(triphenylmethyl-mercapto)propylamino)-1,2,3,4-tetrahydronaphthyl-1(R,S)-carbonyl]-(L)-methionine in 10 cm³ of ethanedithiol. The reaction mixture is stirred for 2 hours at a temperature in the region of 20°C and is then concentrated under reduced pressure. The residue is triturated 3 times with 25 cm³ of ethyl ether and then dried under reduced pressure. The residue is purified by high performance liquid chromatography (C₁₈ phase), elution being carried out with an acetonitrile/water mixture containing 0.1 % of trifluoroacetic acid. 0.4 g of the trifluoroacetate of the methyl ester of N-[5-(2(R)-amino-3-mercapto-propylamino)-1,2,3,4-tetrahydronaphthyl-1(R,S)-carbonyl]-(L)-methionine is obtained in the form of a powder, the characteristics of which are the following:

- proton nuclear magnetic resonance spectrum (300 MHz; d6-(CD₃)₂SO with a few drops of d4-CD₃COOD; T = 393°K; δ in ppm; coupling constants J in Hz): 1.55-2.10 (mt, 6H, CH₂CH₂ at 2 and CH₂ at 3), 2.04 (s, 3H, SCH₃), 2.30-2.65 and 2.80 (2 mts, respectively 4H and 2H, 2 CH₂S and

CH₂ at 4), 3.30 and 3.35-3.50 (respectively dd, J = 14 and 8 and mt, each 1H, NCH₂), 3.43 (mt, 1H, CHN), 3.63 (mt, 1H, CH at 1), 3.63 (s, 3H, COOCH₃), 4.42 (mt, 1H, CHCOO), 6.40-6.60 and 6.95 (2 mts, respectively 2H and 1H, H at 6 and H at 7 and H at 8), 8.35 and 8.38 (2 poorly resolved d, J = 8, 1H, CONH).

- elemental analysis: C₂₀H₃₁N₃O₃S₂·1.25CF₃CO₂H

Calculated %: C=47.7, H=5.70, N=7.4, S=11.9

Found: 47.8, 5.37, 7.1, 10.6

10 EXAMPLE 2

0.17 g of lithium hydroxide monohydrate (LiOH·H₂O) is added to a solution of 1.98 g of the methyl ester of N-[5-(2(R)-tert-butoxycarbonylamino-3-(triphenylmethylmercapto)propylamino)-1,2,3,4-tetrahydronaphthyl-1(R,S)-carbonyl]- (L)-methionine in 8.4 cm³ of distilled water and 30 cm³ of tetrahydrofuran. The solution is stirred for 20 hours at a temperature in the region of 20°C and is then concentrated under reduced pressure. The residue is dissolved in distilled water. The pH is brought to 3 by addition of a 10 % (w/v) aqueous citric acid solution. The aqueous phase is extracted 3 times with 100 cm³ of ethyl acetate. The organic phases are combined, washed with a saturated aqueous sodium chloride solution, dried over magnesium sulphate, filtered and concentrated to dryness under reduced pressure. 1.92 g of N-[5-(2(R)-tert-

butoxycarbonylamino-3-(triphenylmethyl-mercapto)propylamino)-1,2,3,4-tetrahydronaphthyl-1(R,S)-carbonyl]-(L)-methionine are obtained in the form of a foam.

- 5 8 cm³ of trifluoroacetic acid are added, at a temperature in the region of 20°C, to a mixture of 0.5 g of N-[5-(2(R)-tert-butoxycarbonylamino-3-(triphenylmethylmercapto)propylamino)-1,2,3,4-tetrahydronaphthyl-1(R,S)-carbonyl]-(L)-methionine in 2.5 cm³ of
- 10 triethylsilane. The reaction mixture is stirred for 2 hours at a temperature in the region of 20°C and is then concentrated under reduced pressure. The residue is triturated 3 times with 25 cm³ of ethyl ether and then dried under reduced pressure. The residue is
- 15 purified by high performance liquid chromatography (C₁₈ phase), elution being carried out with an acetonitrile/water mixture containing 0.1 % of trifluoroacetic acid. 0.094 g of the trifluoroacetate of N-[5-(2(R)-amino-3-mercaptopropylamino)-
- 20 1,2,3,4-tetrahydronaphthyl-1(R,S)-carbonyl]-(L)-methionine is obtained in the form of a powder, the characteristics of which are the following:
- proton nuclear magnetic resonance spectrum (300 MHz, d6-(CD₃)₂SO; δ in ppm; coupling constants J in Hz);
- 25 1.55-2.10 (mt, 6H, CH₂CH₂ at 2 and CH₂ at 3), 2.06 (s, 3H, SCH₃), 2.30-2.65 and 2.75-2.30 (2 mts, respectively 4H and 2H, 2 CH₂S and CH₂ at 4), 3.30 and 3.35-3.50

(respectively dd, $J = 14$ and 8 and mt, each 1H, NCH_2),
 3.43 (mt, 1H, CHN), 3.66 (mt, 1H, CH at 1), 4.37 (mt,
 1H, CHCOO), 6.40-6.60 and 6.95 (2 mts, respectively 2H
 and 1H, H at 6 and H at 7 and H at 8), 7.95 (broad s,
 5 3H, NH_3^+), 8.33 and 8.35 (2 d, $J = 9$, 1H, CONH).

- elemental analysis: $\text{C}_{19}\text{H}_{29}\text{N}_3\text{O}_3\text{S}_2 \cdot 1.33\text{CF}_3\text{CO}_2\text{H}$

Calculated %:	C=46.2,	H=5.42,	N=7.46,	S=11.38	F=13.46
Found:	45.8,	5.5,	7.47,	11.25	13.2

The inhibitory activity with respect to
 10 farnesyl transferase and to farnesylation of the Ras
 protein may be demonstrated in the following test:

Farnesyl transferase activity is determined
 by the quantity of [^3H]farnesyl transferred from
 [^3H]farnesyl pyrophosphate ([^3H]FPP) to the p21 H-Ras
 15 protein. The standard reaction mixture is composed, for
 a final volume of 60 μl , of 50 mM Tris-HCl, 5 mM MgCl_2 ,
 5 mM dithiotreitol, 0.2 % octyl β -D-glucopyranoside,
 200 picomol p21 H-ras, 4.5 picomol [^3H]FPP (activity
 61000 dpm/picomol).

20 Reaction is initiated by adding approximately
 5 ng of human farnesyl transferase purified from THP1
 cell cultures. After incubation for 20 minutes at 37°C
 in a microtitration plate containing 96 1- cm^3 wells per
 plate (Titer Plate®, Beckman), the reaction is stopped
 25 by adding 0.4 cm^3 of 0.1 % SDS in methanol at 0°C . The
 mixture is then treated with 0.4 cm^3 of 30 %

trichloroacetic acid (TCA) in methanol. The plates are left in ice for 1 hour. The precipitated contents are then retained on Filtermat®, (Pharmacia) glass fibre membranes with the filtration unit (Combi Cell Harvester®, Skatron), and rinsed with 6 % trichloroacetic acid in distilled water. The membranes are dried in a microwave oven, then impregnated with scintillation medium by melting of Meltilex® (Pharmacia) under hot air, and lastly counted in cpm in a β -Plate counter® (LKB). Each test is repeated 3 times.

The unit of activity is defined as 1 picomole of [³H]FPP transferred to p21 H-Ras in 20 minutes.

The percentage inhibition values are obtained by comparison of the tests with and without inhibitor after deduction of blanks, the IC₅₀ values being measured on the basis of the inhibitions obtained with 9 different concentrations using Enzfitter® or Grafit® software.

The activity against cells can be determined in the following way:

The cell line is the THAC line (CCL 39 cells transfected with activated Ha-Ras) according to K. Seuwen et al., EMBO J., 7(1) 161-168 (1988). The cells are cultured in Petri dishes with a diameter of 6 cm containing a DMEM medium, 5 % foetal calf serum

and 1 % G418.

After culturing for 24 hours, the culture medium is changed (with or without the serum) and the product to be studied is added in solution in

5 dimethylformamide (DMF), in the presence or in the absence of DTT (final concentrations of 0.5 % in DMF and 0.1 mM in DTT). After culturing for 24 hours at 37°C, the cells are lysed in 1 cm³ of lysis buffer (20 mM Tris, HCl, 1 % Triton X114, 5 mM MgCl₂, 7 mM DTT,

10 150 mM NaCl, pH = 7.4). The lysates are clarified by centrifuging at 4000 revolutions/minute for 10 minutes. Extraction with Triton X114 makes it possible to separate the farnesylated Ras protein from the non-farnesylated Ras protein (C. Bordier, J. Biol. Chem.,

15 256 (4), 1604-1607 (1981)]. The farnesylated Ras protein, which is more hydrophobic, is found in the detergent phase whereas the non-farnesylated Ras protein is in the aqueous phase. The samples are denatured by heating at 95°C in the denaturation buffer

20 for electrophoresis and deposited on a 14 % polyacrylamide gel. When the dye reaches the bottom of the gel, the proteins of the gel are transferred onto a PVDF membrane. The Ras protein is visualized by the Western blot technique: the membrane is incubated with

25 an anti-Ras specific monoclonal antibody (pan-Ras Ab3, Oncogène Science) and then with protein A labelled with ¹²⁵I. After autoradiography, the bands are identified,

cut out and counted in a γ counter. The radioactivity of the bands corresponding to farnesylated Ras and to non-farnesylated Ras makes it possible to determine the percentage of inhibition of farnesylation of the Ras protein.

The results obtained are collated in Table I.

TABLE I

PRODUCT	Inhibitory activity IC_{50} nM	% of inhibition against cells (THAC)
Example 1	15	>10 (10 μ M)
Example 2	405	50 (50 μ M)

The new products of general formula (I) can be in the form of non-toxic and pharmaceutically acceptable salts. These non-toxic salts comprise the salts with inorganic acids (hydrochloric, sulphuric, hydrobromic, phosphoric and nitric acids) or with organic acids (acetic, propionic, succinic, maleic, hydroxymaleic, benzoic, fumaric, methanesulphonic, trifluoroacetic or oxalic acid), or with inorganic bases (sodium hydroxide, potassium hydroxide, lithium hydroxide, calcium hydroxide) or organic bases (tertiary amines such as triethylamine, piperidine, benzylamine), depending on the nature of the R_1 and R symbols of the product of general formula (I).

The present invention also relates to pharmaceutical compositions containing at least one product of general formula (I), in combination with one or more pharmaceutically acceptable diluents or
5 adjuvants, which may be either inert or physiologically active.

These compositions may be administered orally, parenterally or rectally.

The compositions for oral administration
10 comprise tablets, pills, powders or granules. In these compositions, the active product according to the invention is mixed with one or more inert diluents such as sucrose, lactose or starch. These compositions can comprise substances other than diluents, for example
15 lubricants such as magnesium stearate.

As liquid compositions for oral administration, solutions, suspensions, syrups, elixirs and pharmaceutically acceptable emulsions, containing inert diluents such as water or liquid paraffin, may be
20 used. These compositions can also comprise substances other than diluents, for example wetting, sweetening or flavouring products.

The compositions according to the invention for parenteral administration can be sterile solutions,
25 aqueous or non-aqueous, suspensions or emulsions. As solvent or vehicle, propylene glycol, a polyethylene glycol, vegetable oils, especially olive oil, or

injectable organic esters, for example ethyl oleate, may be employed. These compositions can also contain adjuvants, especially wetting, emulsifying and dispersing agents. The sterilization may be carried out
5 in several ways, for example using a bacteriological filter, by incorporating sterilizing agents in the composition or by heating. They may also be prepared in the form of sterile solid compositions which can be dissolved at the time of use in sterile water or any
10 other sterile injectable medium.

The compositions for rectal administration are suppositories which can contain, besides the active product, excipients such as cocoa butter.

The compositions according to the invention
15 are especially useful in human therapy in the treatment of cancers of various origins.

In human therapy, the doses depend on the effect sought, the period of treatment and factors specific to the subject to be treated.

20 Generally, in man, the doses are between 0.1 and 20 mg/kg per day via the intraperitoneal route.

A composition according to the invention is illustrated in the following example.

EXAMPLE

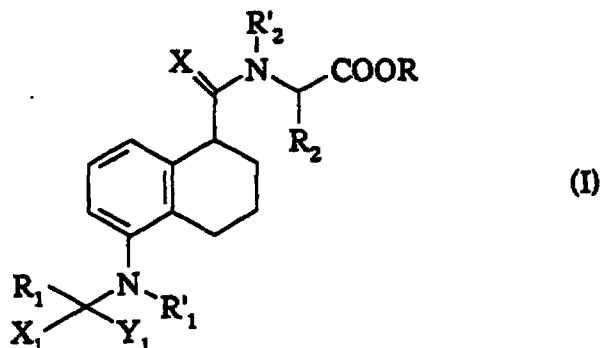
25 200 mg of the product obtained in Example 1 are dissolved in 100 cm³ of physiological serum. The solution obtained is divided up aseptically into 10 cm³

phials.

The phials are administered as a single injection or by perfusion.

CLAIMS

1. New products of general formula:



in which:

- R_1 represents a radical of general formula $Y-S-A_1-$ in which Y represents a hydrogen atom or an amino acid residue or a fatty acid residue or an alkyl or alkoxy carbonyl radical, and A_1 represents a straight or branched alkylene radical containing 1 to 4 carbon atoms, optionally substituted at the position α to the $>C(X_1)(Y_1)$ group by an amino, alkylamino, alkanoylamino or alkoxy carbonylamino radical, the straight or branched alkyl or alkanoyl part of which contains 1 to 6 carbon atoms,
- X_1 and Y_1 each represent a hydrogen atom or form, together with the carbon atom to which they are bonded, a $>C=O$ group,
- R'_1 represents a hydrogen atom or a straight or branched alkyl radical containing 1 to 6 carbon atoms,
- X represents an oxygen or sulphur atom,
- R_2 represents a straight or branched alkyl, alkenyl or



alkynyl radical containing 1 to 6 carbon atoms, optionally substituted by a hydroxyl radical, an alkoxy radical containing 1 to 4 carbon atoms, a mercapto radical, an alkylthio radical containing 1 to 4 carbon atoms, an alkylsulphinyl radical containing 1 to 4 carbon atoms or an alkylsulphonyl radical containing 1 to 4 carbon atoms, it being understood that, when R_2 represents an alkyl radical substituted by a hydroxyl radical, R_2 can form a lactone with the carboxyl radical at the α position,

R'_2 represents a hydrogen atom or a straight or branched alkyl radical containing 1 to 6 carbon atoms, and R represents a hydrogen atom or an alkyl radical containing 1 to 6 carbon atoms, optionally substituted by an alkoxy radical containing 1 to 4 carbon atoms, an alkylthio radical containing 1 to 4 carbon atoms, an alkylsulphinyl radical containing 1 to 4 carbon atoms, an alkylsulphonyl radical containing 1 to 4 carbon atoms, a phenyl radical, a phenoxy radical, a phenylthio radical, a phenylsulphinyl radical, a phenylsulphonyl radical, an alkylamino radical containing 1 to 4 carbon atoms or a dialkylamino radical in which each alkyl part contains 1 to 4 carbon atoms, or a phenyl radical, optionally substituted by one or a number of atoms or radicals chosen from halogen atoms and alkyl, alkyloxy, alkylthio or alkanoyl radicals.



2. New products according to claim 1 in which:

R_1 represents a radical of formula $Y-S-A_1-$ in which Y represents a hydrogen atom or a lysine residue or a fatty acid residue containing up to 20 carbon atoms and A_1 represents an ethylene or propylene radical optionally substituted by an amino radical, X_1 and Y_1 each represent a hydrogen atom or form, together with the carbon atom to which they are bonded, a $>C=O$ group, R'_1 represents a hydrogen atom or a methyl radical, X represents an oxygen atom, R_2 represents an alkyl radical containing 1 to 4 carbon atoms, optionally substituted by a hydroxyl, methoxy, mercapto, methylthio, methylsulphanyl or methylsulphonyl radical, R'_2 represents a hydrogen atom or a methyl radical, and R represents a hydrogen atom or an alkyl radical containing 1 to 4 carbon atoms, optionally substituted by an alkoxy radical, or a phenyl radical.

3. New products according to claim 1 in which:

R_1 represents a radical of formula $Y-S-A_1-$ in which Y represents a hydrogen atom and A_1 represents an ethylene or propylene radical optionally substituted by an amino radical, X_1 and Y_1 each represent a hydrogen atom or form,



together with the carbon atom to which they are bonded,

a $>C=O$ group,

R'_1 represents a hydrogen atom,

X represents an oxygen atom,

5 R_2 represents a methyl, ethyl, propyl or butyl radical
optionally substituted by a hydroxyl, methoxy, mercapto
or methylthio radical,

R'_2 represents a hydrogen atom, and

R represents a hydrogen atom or an alkyl radical
10 containing 1 to 4 carbon atoms.

4. New products according to claim 1 in
which R_1 represents a 2-mercaptoethyl or 1-amino-2-
mercaptoethyl radical, X_1 and Y_1 each represent a
hydrogen atom or form, together with the carbon atom to
15 which they are bonded, a $>C=O$ group, R'_1 represents a
hydrogen atom, X represents an oxygen atom, R_2
represents an n-butyl or 2-(methylthio)ethyl radical
and R'_2 represents a hydrogen atom, and R represents a
hydrogen atom or a methyl radical.

20 5. Pharmaceutical composition,
characterized in that it contains a sufficient amount
of a product according to one of claims 1 to 4 in
combination with one or a number of inert or
physiologically active pharmaceutically acceptable
25 diluents or adjuvants.