A peptide derivative represented by the following formula or a salt thereof (see above formula) wherein A and B each represent either of the following (a) and (b), (a) A represents a hydrogen atom, and B represents a phenyl group substituted with a halogen atom, hydroxyl group, lower alkyl group or lower alkoxy group, or a heteroaryl group, (b) A represents -CONH-R¹, -CSNH-R¹, a hydroxymethyl group, a lower alkoxy carbonyl group or a carboxyl group, wherein, R¹ represents a lower alkyl group or a heteroaryl group, and B represents a phenyl group optionally substituted with a halogen atom, hydroxyl group, lower alkyl group or lower alkoxy group, has an antitumor activity stronger than that of dolastatin 10, and is useful as an anticancer or antitumor agent.
A peptide derivative represented by the following formula or a salt thereof

![Chemical Structure](image)

wherein A and B each represent either of the following (a) and (b),  
(a) A represents a hydrogen atom, and B represents a phenyl group substituted with a halogen atom, hydroxyl group, lower alkyl group or lower alkoxy group, or a heteroaryl group,  
(b) A represents \( -\text{CONH-R}^1 \), \( -\text{CSNH-R}^1 \), a hydroxymethyl group, a lower alkoxy carbonyl group or a carboxyl group, wherein, \( R^1 \) represents a lower alkyl group or a heteroaryl group, and B represents a phenyl group optionally substituted with a halogen atom, hydroxyl group, lower alkyl group or lower alkoxy group,

has an antitumor activity stronger than that of dolastatin 10, and is useful as an anticancer or antitumor agent.
5 Technical Field

This invention relates to a novel peptide derivative having an antitumor activity, and, more
detailedly, relates to a peptide derivative represented
by the following formula or a salt thereof

\[ \text{CH}_3\text{N} - \text{NH} - \text{I} \text{CH}_3\text{OCH}_3\]

\[ \text{OCH}_3\]

\[ \text{NH} - \text{CH} - \text{CH}_2 - \text{B} \]

(1)

wherein A and B each represent either of the
following (a) and (b),
(a) A represents a hydrogen atom, and B
represents a phenyl group substituted with a
halogen atom, hydroxyl group, lower alkyl
group or lower alkoxy group, or a heteroaryl
group,
(b) A represents -CONH-R\(^1\), -CSNH-R\(^1\), a
hydroxymethyl group, a lower alkoxy carbonyl
group or a carboxyl group, wherein, R\(^1\) rep-
resents a lower alkyl group or a heteroaryl
group, and B represents a phenyl group option-
ally substituted with a halogen atom, hydroxyl
group, lower alkyl group or lower alkoxy
group.

Background Art

Peptides having a cytostatic activity and/or
an antineoplasms activity have been isolated from marine
molluscs, sea hare Dolabella auricularia and these
peptides are called dolastatins 1 to 15. Among them,
dolastatin 10 is a pentapeptide extracted from Dolabella auricularia from the Indian Ocean in 1987 by G. R. Pettit, et al. and having the following structural formula, and is said to be the strongest cytostatic substance presently known (see, G. R. Pettit, et al., J. Am. Chem. Soc., 109, 6883 (1987) and U.S. Patent No. 4,816,444).

Further, recently, publication was made on the total synthesis of dolastatin 10 itself (see, U.S. Patent No. 4,978,744).

In this connection, the present inventors previously disclosed certain dolastatin 10 derivatives (see, WO93/03054 Pamphlet).

The present inventors found that certain dolastatin 10 derivatives wherein the dolaphenine (which means an α-(thiazolyl)phenethylamino group) at the C-terminus of dolastatin 10 is substituted with another substituent have a much stronger antitumor activity than that of dolastatin 10.

Disclosure of Invention

In the present description, the term "lower" means that the number of the carbon atoms of a group or compound to which this term is attached is 6 or less, preferably 4 or less.

In the above formula (I), as the "lower alkyl group", there can, for example, be mentioned methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-
butyl, tert-butyl, n-hexyl groups, etc. and as the
"lower alkoxy group", there can, for example, be men-
tioned methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy
groups, etc. Further, the "halogen atom" includes
fluorine, chlorine, bromine and iodine atoms.

The "heteroaryl group" means an aromatic
heterocyclic group containing hetero atom(s) selected
from O, S and N, preferably, 5 or 6-membered heterocyc-
clic group containing 1 to 4 hetero atoms, such as
thiényl, furyl, pyrrolyl, imidazolyl, thiazolyl,
oxazolyl, thiazadiazolyl, tetrazolyl, pyridyl,
pyrimidinyl, triazinyl groups, etc.

The "phenyl group substituted with a halogen
atom, hydroxyl group, lower alkyl group or lower alkoxy
group" represented by the symbol B includes a phenyl
group substituted with one halogen atom, hydroxyl group,
lower alkyl group or lower alkoxy group, and there can,
for example, be mentioned 2-fluorophenyl, 2-chloro-
phenyl, 2-bromophenyl, 3-fluorophenyl, 3-iodophenyl,
4-chlorophenyl, 4-bromophenyl, 2-hydroxyphenyl,
2-methylphenyl, 4-ethylphenyl, 2-methoxyphenyl,
4-ethoxyphenyl groups, etc. Further, the "phenyl group
optionally substituted with a halogen atom, hydroxyl
group, lower alkyl group or lower alkoxy group" includes
an unsubstituted phenyl group besides the above substi-
tuted phenyl groups.

A group of preferred compounds in the inven-
tion are compounds of the above formula (I) wherein A
represents a hydrogen atom and B represents a phenyl
group substituted with a halogen atom, hydroxyl group,
lower alkyl group or lower alkoxy group, or a heteroaryl
group, particularly compounds of the above formula (I)
wherein B represents a phenyl group substituted with a
halogen atom, hydroxyl group, lower alkyl group or lower
alkoxy group; a thiényl group; or a pyridyl group.

Another group of preferred compounds are
compounds of the above formula (I) wherein A represents
-CONH-R¹, -CSNH-R¹, a hydroxymethyl group, a lower
alkoxycarbonyl group or a carboxyl group, wherein R¹
represents a lower alkyl group or a heteroaryl group,
and B represents a phenyl group optionally substituted
with a halogen atom, hydroxyl group, lower alkyl group
or lower alkoxy group, particularly compounds of the
above formula (I) wherein A represents -CONH-R¹,
-CSNH-R¹, a hydroxymethyl group, a lower alkoxy carbonyl
group or a carboxyl group, wherein R¹ represents a lower
alkyl group, a thiazolyl group or thiadiazolyl group,
and B represents an unsubstituted phenyl group.

In the compounds of the above formula (I) of the invention, the carbon atoms to which an isopropyl
group, a sec-butyl group, a methoxy group and a methyl
group bind respectively are asymmetric carbon atoms, and therefore, they can arbitrary have an R- or S-configu-
ration. All those compounds are included in the scope of the invention, but in view of pharmacological activi-
ty, compounds having the same configuration as dolastatin 10 are preferred.

The peptide compounds of the above formula (I) can, further, exist as salts, preferably pharmaceutically acceptable salts, and as examples of such salts, there can be mentioned hydrochlorides, hydro-
bromides, trifluoroacetates, p-toluenesulfonates, acete-
tates, etc.

According to the invention, a peptide compound of the above formula (I) can be prepared by condensing the respective amino acids or peptide fragments, for example, according to a liquid phase synthesis method (see, E. Schröder and K. Lübke, "The Peptides", volume

For example, for avoiding racemization at the condensation reaction, it is preferred to conduct syn-
thesis by condensing a tripeptide fragment of the fol-
lowing formula (II)

\[
\begin{align*}
&\text{CH}_3\text{N} \quad \text{NH} \quad \text{N} \quad \text{COOH} \\
&\text{CH}_3
\end{align*}
\]

(II)

with a fragment of the following formula (III)

\[
\begin{align*}
&\text{NH} \quad \text{NH} \quad \text{CH} \quad \text{CH}_2 \quad \text{B} \\
&\text{O} \quad \text{CH}_3
\end{align*}
\]

(III)

wherein A and B are as defined above.

Further, for synthesizing many compounds of the invention efficiently, it is preferred to conduct the synthesis by condensing a tetrapeptide fragment of the following formula (IV)

\[
\begin{align*}
&\text{CH}_3\text{N} \quad \text{NH} \quad \text{N} \quad \text{COOH} \\
&\text{CH}_3
\end{align*}
\]

(IV)

with a fragment of the following formula (V)

\[
\begin{align*}
&\text{H}_2\text{N} \quad \text{CH} \quad \text{CH}_2 \quad \text{B} \\
&\text{A}
\end{align*}
\]

(V)

wherein A and B are as defined above.

The condensation reaction can be conducted, generally, by treating the fragments with a condensing agent, e.g. dicyclohexylcarbodiimide (DCC), diphenyl phosphoryl azide (DPPA) or diethyl phosphorocyanidate (DEPC), a so-called BOP reagent, or the like in an inert
solvent such as, for example, chloroform, ethyl acetate, tetrahydrofuran (THF), dimethylformamide (DMF) or acetonitrile, if necessary in the presence of an organic base such as, for example, triethylamine, N-methylmorpholine or diisopropylethylamine (DIEA).

The reaction temperature is usually −10°C to room temperature, preferably around 0°C. The ratios of the compound of the formula (III), the organic base and the condensing agent to the compound of the formula (II) are not strictly limited, but, usually, it is advantageous to use the compound of the formula (III) of at least one mole, preferably of the order of 1.0 to 1.1 moles, the organic base of the order of 2 moles, and the condensing agent of the equimolar order, respectively per mole of the compound of the formula (II).

A compound of the formula (I) wherein A represents a carboxyl group can also be prepared by alkali hydrolysis of the compound of the formula (I) wherein A represents a lower alkoxy carbonyl group.

The isolation and purification of thus obtained peptide compound of the formula (I) from the reaction mixture can be conducted by methods known per se, for example by recrystallization, ion exchange chromatography, gel filtration, high performance liquid chromatography, etc.

The compounds of the above formula (III) and (IV) used as starting materials in the above reaction are novel compounds not disclosed in prior literatures, and can easily be prepared by condensing amino acids, which are constituents thereof, according to a liquid phase synthesis method.

The peptide compounds of the formula (I) of the invention have a higher antitumor activity than dolastatin 10, and have a large therapeutic index, and are useful for treatment of acute myelocytic leukemia, acute lymphocytic leukemia, chronic melanoma, pulmonary
adenocarcinoma, neuroblastoma, pulmonary small cell
carcinoma, breast cancer, colon cancer, ovary cancer,
bladder cancer, etc.

The antitumor activity of the compounds can be
assayed as follows.

(1) Assay of antitumor activity

0.1 ml (10^6 cells/mouse) portions of mouse
leukemia P388 cells were implanted intraperitoneally
into 7-week-old CDF1 mice. A compound was intraperito-
neally administered thereinto on the first day (the day
after implantation) and the fifth day after implanta-
tion, and the life or death of the mice was observed for
60 days. From the results were calculated increases in
life span (ILS, %) according to the following equation.

In the following equation, T means median survival days
of the chemical administration group, and C means median
survival days of the control group.

\[ ILS = \frac{T - C}{C} \times 100 \]

The results are shown in the following Table. Antitumor
activity is shown as the relative ratio in the
case where the ILS of dolastatin 10 is supposed to be
100.

<table>
<thead>
<tr>
<th>Example No. of compound</th>
<th>Antitumor activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>190</td>
</tr>
<tr>
<td>12</td>
<td>190</td>
</tr>
<tr>
<td>14</td>
<td>190</td>
</tr>
<tr>
<td>dolastatin 10</td>
<td>100</td>
</tr>
</tbody>
</table>

The compounds of the invention, when used as a drug, can be used
by formulating them, usually together with pharmaceutically acceptable carriers, into
any dosage form of solid forms (e.g., tablets, hard capsules, soft
capsules, granules, powders, fine granules, pills,
troches, etc.), semi-solid forms (e.g., suppositories,
ointments, etc.) and liquid forms (e.g., injections, emulsions, suspensions, lotions, sprays, etc.). As nontoxic additives usable in the above formulations, there can, for example, be mentioned starches, gelatin, glucose, lactose, fructose, maltose, magnesium carbonate, talc, magnesium stearate, methylcellulose, carboxymethylcellulose or salts thereof, gum arabic, polyethylene glycol, p-hydroxybenzoic acid alkyl esters, syrups, ethanol, propylene glycol, vaseline, carbowax, glycerol, sodium chloride, sodium sulfite, sodium phosphate, citric acid, etc. The drug can also contain another therapeutically effective drug.

The content of the compound of the invention in the drug varies depending on the dosage form, but it is generally preferred that the drug contains the compound at a concentration of 0.1 to 50 wt% in the case of solid and semi-solid forms, and at a concentration of 0.05 to 10 wt% in the case of liquid form.

The dose of the compound of the invention can widely be varied depending on the kind of warm-blooded animals including human beings as a subject, administration routes, the seriousness of symptoms, the diagnoses of doctors, etc., but can generally be on the order of 0.01 to 50 mg/kg per day. However, it is of course possible to administer the compound in an amount smaller than the lower limit of the above range or in an amount larger than the upper limit thereof in accordance with the seriousness of symptom of the patient and the diagnosis of the doctor as mentioned above. The above dose can be administered once a day or in divided several portions per day.

Examples

The invention is further described below according to Referential Examples and Examples.

As for the structure of compounds correspond-
ing to compound numbers used in Referential Examples and Examples, please refer to the following Flow Sheets 1 and 2. Therein, Bu represents a tert-butyl group, Boc a tert-butoxycarbonyl group, Bz a benzyl group, Me a methyl group, B a phenyl group substituted with a halogen atom, hydroxyl group, lower alkyl group or lower alkoxy group, or a heteroaryl group, and A –CONH–R', –CSNH–R', a hydroxymethyl group, a lower alkoxy carbonyl group or a carboxyl group, wherein R' represents a lower alkyl group or a heteroaryl group.
Referential Example 1
Preparation of compound 2

30 ml of a tetrahydrofuran – n-hexane (1 : 1) solution of 23.8 % lithium diisopropylamide (LDA, 66.4 mmoles) is gradually poured into 40 ml of anhydrous tetrahydrofuran under stirring at -20° in an atmosphere of nitrogen, the mixture is cooled to -78°, and 9.84 g (60 mmoles) of benzyl propionate is added dropwise over a period of 30 minutes. 5 minutes later, a solution of 7.96 g (40 mmoles) of Boc-prolinal in 40 ml of tetrahydrofuran is added dropwise at the same temperature over a period of 1 hour. The mixture is stirred at the same temperature for 15 minutes, 150 ml of ice-cooled 1N-hydrochloric acid is added, and the mixture is warmed to room temperature. The mixture is extracted with ethyl acetate, the ethyl acetate layer is washed with water and dried, the solvent is distilled off under reduced pressure, and the remaining oily matter is purified by silica gel flash chromatography using ethyl acetate – n-hexane (1 : 5) as an eluent to obtain the desired compound 2 as colorless oily matter. 3.86 g (26.6 %).

\[ \alpha \]_D^{27} = -28.4° (c = 0.82, MeOH)

\(^1\)H-NMR (CDCl\textsubscript{3}, δ) 1.30 (3H, d, J=7.0Hz), 1.45 (9H, s), 1.6–2.1 (m), 2.61 (1H, quintet, J=7.0Hz), 3.0–3.6 (m), 3.7–4.1 (m), 5.13 (2H, s), 7.34 (5H, s)

Referential Example 2
Preparation of compound 3

730 mg (2.01 mmoles) of compound 2 obtained in

Referential Example 1 is dissolved in 10 ml of dimethylformamide, 0.7 ml (11.22 mmoles) of methyl iodide is poured therein under stirring, and 0.16 g (4.00 mmoles) of sodium hydride (60 % in mineral oil) is added therein. Stirring is continued at 0° for 1 hour, ice water is added, and the mixture is extracted with ethyl acetate – benzene (4 : 1). The organic layer is washed
with 5% potassium hydrogen sulfate, saturated aqueous sodium bicarbonate, 5% sodium thiosulfate and saturated saline in this order, and dried. The resultant crude product is purified by silica gel flash chromatography using ethyl acetate - n-hexane (1:10) as an eluent to obtain the desired compound 3 as colorless oily matter. 530 mg (72.5%).

\[ \alpha \]_D^{27} -25.7° (c = 0.389, MeOH)

^1H-NMR (CDCl3, δ) 1.26 (3H, d, J=6.8Hz), 1.45 (9H, s), 1.65-2.1 (m), 2.56 (1H, quintet, J=7.0Hz), 3.0-4.0 (m), 3.38 (3H, s), 5.14 (2H, s), 7.34 (5H, s)

**Referential Example 3**

**Preparation of compound 4**

(a) 1 ml of concentrated hydrochloric acid is added to 97.1 mg (0.2 mmole) of compound 1 (known compound) under ice cooling, and the mixture is stirred at 0° for 1 hour and evaporated to dryness under reduced pressure. The residue is dissolved in 2 ml of dimethylformamide, 0.15 ml of triethylamine is added dropwise at 0°, and the mixture is again evaporated to dryness under reduced pressure.

(b) On the other hand, 76 mg (0.2 mmole) of compound 3 obtained in Referential Example 2 is dissolved in 0.5 ml of ethyl acetate, 2.0 ml of 2N-hydrogen chloride/ethyl acetate is added under ice cooling, and the mixture is brought to room temperature, stirred for 1.5 hours, evaporated to dryness under reduced pressure and then dried.

The products obtained in (a) and (b) are combined and dissolved in 0.8 ml of dimethylformamide, 34.3 mg (1.1 equivalents) of DEPC is added, the mixture is ice-cooled, 56 μl (2 equivalents) of triethylamine is added, and stirring is continued under ice cooling for 1 hour and then at room temperature overnight. The solvent is evaporated under reduced pressure, the residue is dissolved in dichloromethane, and the solution is
washed with saturated aqueous sodium bicarbonate and saturated saline and dried. The resultant crude product is purified by silica gel flash chromatography using dichloromethane - methanol (20 : 1) as an eluent, and then by Sephadex®LH-20 chromatography using n-hexane - dichloromethane - methanol (2 : 7.5 : 2.5) as an eluent to obtain the desired compound 4 as an amorphous solid. 117 mg (85.0 %).

$$\left[\alpha\right]_D^{26} = -44.0^\circ \text{ (c = 0.80, MeOH)}$$

$^1$H-NMR (CDCl$_3$, δ) 0.7-1.5 (m), 1.27 (3H, d, J=7.0Hz), 1.5-2.25 (m), 2.25-2.9 (m), 3.01 (3H, s), 3.29 (3H, s), 3.35 (3H, s), 3.8-4.3 (m), 4.5-5.0 (m), 5.13 (2H, s), 7.34 (5H, s)

Referential Example 4-A

Preparation of compound 6-A

(in compound 6, A = CONH-Et, * = S)

1.33 g (5 mmoles) of Boc-phenylalanine is dissolved in 20 ml of tetrahydrofuran, and while the solution is stirred at -15°, 0.56 ml (5 mmoles) of N-methylmorpholine and then 0.67 ml (5 mmoles) of isobutyl chloroformate are added. After stirring the mixture at -15° for 5 minutes, 0.64 g (2 equivalents) of aqueous 70 % ethylamine solution is added, and stirring is continued at -15° for 15 minutes and then at room temperature for 1.5 hours. The reaction solution is concentrated under reduced pressure, the residue is dissolved in ethyl acetate, the solution is washed with ice-cooled 2N-hydrochloric acid and saturated aqueous sodium bicarbonate and dried, the solvent is distilled off, and the residue is crystallized from ethyl acetate-ether-n-hexane to obtain the desired compound 6-A as needle crystals. 1.12 g (76.7 %).

Melting point 123-4°.

$^1$H-NMR (CDCl$_3$, δ) 0.99 (3H, t, J=7.3Hz), 1.41 (9H, s), 2.9-3.2 (m), 3.22 (2H, q, J=7.3Hz), 4.25 (1H, dd, J=14.3Hz, J=7.5Hz), 5.04 (1H, br. d) 5.61 (1H, br.

*Trade-mark
s), 7.25 (5H, s)

**Referential Example 4-B**

Preparation of compound 6-B

(in compound 6, A = CONH-Et, * = R)

The desired compound 6-B is obtained from BOC-D-phenylalanine in all the same manner as in Referential Example 4-A.

**Referential Example 4-C**

Preparation of compound 6-C

(in compound 6, A = CONH- \( \text{S} \), * = S)

133 mg (0.5 mmole) of Boc-phenylalanine and 50 mg (0.5 mmole) of 2-aminothiazole are dissolved in 1 ml of dimethylformamide, and while the solution is stirred at 0°, 86 mg (1 equivalent) of DEPC and 70 μl (1 equivalent) of triethylamine are added. After stirring is continued at 0° for 3 hours and then at room temperature overnight, the mixture is evaporated to dryness under reduced pressure, the residue is dissolved in dichloromethane, and the solution is washed with 10% citric acid and saturated aqueous sodium bicarbonate and dried. The crude product is purified by preparative TLC using ethyl acetate – n-hexane (3 : 4) as a developing solvent to obtain the desired compound 6-C as sand-like crystals. 128 mg (73.6%). Melting point 158-160°.

\[ [\alpha]_D^{25} = -11.0^\circ \text{ (c = 0.2, CHCl}_3) \]

\(^1\text{H-NMR (CDCl}_3, \delta \) 1.41 (9H, s), 3.0-3.3 (2H, m), 4.5-4.8 (1H, m), 5.0-5.2 (1H, br. d), 7.23 (5H, m), 7.26 (2H, dd, J=41.3Hz, J=3.7Hz)

**Referential Example 4-D**

Preparation of compound 6-D

(in compound 6, A = CONH- \( \text{S} \), * = S)

The desired compound 6-D is obtained from BOC-phenylalanine and 2-amino-1,3,4-thiadiazole in all
the same manner as in Referential Example 4-C.

\[ [\alpha]_{D}^{27} +34.1^\circ, (c = 0.960, \text{MeOH}) \]

\[ ^{1}H\text{-NMR (CDCl}_{3}, \delta ) \quad 1.28 (9\text{H, s}), 3.0-3.3 \]

\[ (2\text{H, m}), 4.6-4.9 (1\text{H, m}), 6.27 (1\text{H, d, } J=7.3\text{Hz}), 7.26 \]

\[ 5 \text{(5H, s)}, 8.84 (1\text{H, s}), 13.5 (1\text{H, br. s}) \]

Referential Example 4-E

Preparation of compound 6-E

(in compound 6, A = CSNH-Et, * = S)

0.217 g (0.745 mmole) of compound 6-A obtained in Referential Example 4-A and 151 mg (0.5 equivalent) of Lawesson reagent are dissolved in 5 ml of benzene, and the solution is refluxed with heating for 45 minutes. The reaction solution is evaporated to dryness under reduced pressure, and the residue is purified by preparative TLC using dichloromethane - methanol (40 : 1) as a developing solvent to obtain the desired thioamide (compound 6-E) as a yellow waxy solid. 0.230 g (quantitative).

\[ ^{1}H\text{-NMR (CDCl}_{3}, \delta \) 1.01 (3H, t, \(J=7.3\text{Hz}\)), 1.41 \]

\[ 3.0-3.2 (2\text{H, m}), 3.3-3.7 (2\text{H, m}), 4.48 (1\text{H, dd, } J=14.5\text{Hz}, J=7.9\text{Hz}), 5.25-5.55 (1\text{H, br. d}), 7.24 (5\text{H, s}) \]

Example 1

Preparation of compound 5-A

(in compound 5, B = \(\begin{array}{c}
\text{Cl} \\
\end{array}\))

(a) 400 mg (0.58 mmole) of compound 4 obtained in Referential Example 3 is dissolved in 6 ml of t-butanol - water (9 : 1), 80 mg of 5 % palladium-carbon is added, and the solution is stirred under a stream of hydrogen for 5 hours. The catalyst is filtered and washed, and the filtrate and the washings are evaporated to dryness under reduced pressure and dried to obtain compound 4', a carboxylic acid, as a colorless glassy solid. 337 mg (quantitative).

(b) 35 mg (60 μmoles) of the carboxylic acid obtained in (a) and 14 mg (1.5 equivalents) of
p-chlorophenethylamine are dissolved in 0.5 ml of dimethylformamide, and under ice cooling and stirring, 12.4 mg (1.2 equivalents) of DEPC and 16 µl (1.88 equivalents) of triethylamine are added, and stirring is continued at 0° for at least 3 hours and then overnight allowing the ice to melt. The reaction solution is concentrated under reduced pressure, the residue is dissolved in dichloromethane, and the solution is washed with saturated aqueous sodium bicarbonate and saturated saline and dried. The resultant crude product is purified by preparative TLC using dichloromethane - methanol (10 : 1) as a developing solvent and then Sephadex LH-20 chromatography using n-hexane - dichloromethane - methanol (2 : 7.5 : 2.5) as an eluent to obtain the desired compound 5-A as amorphous powder. 35.2 mg (79.6%).

\[ \alpha \]_D^{28} = -32.9° (c = 0.292, MeOH)

\[ ^1\text{H-NMR (CDCl}_3, \delta \) 0.7-1.1 (m), 1.22 (3H, d, J=7.0Hz), 2.26 (6H, s), 3.03 (3H, s), 3.31 (3H, s), 3.36 (3H, s), 3.7-4.2 (m), 4.79 (1H, dd, J=9.2Hz, 6.6Hz), 6.86 (1H, br. d), 7.1-7.3 (4H, m) \]

Examples 2 to 15

The following compounds are obtained by reacting compound 4' with the corresponding phenethylamine derivative in the same manner as in Example 1.
<table>
<thead>
<tr>
<th>Example</th>
<th>Compound</th>
<th>$[^1]H$-NMR (CDCl$_3$, $\delta$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>5 - B</td>
<td>0.7 - 1.1 (m), 1.21 (3H, d, $J=7.0$ Hz), 2.2 - 2.65 (m), 3.34 (3H, s), 4.76 (H, dd, $J=6.8$, 7.3 Hz).</td>
</tr>
<tr>
<td>3</td>
<td>5 - C</td>
<td>0.7 - 1.15 (m), 1.21 (3H, d, $J=7.3$ Hz), 2.5 (3H, s), 3.34 (3H, s), 4.2 (4H, dd, $J=4.4$, 8.8 Hz).</td>
</tr>
<tr>
<td>4</td>
<td>5 - D</td>
<td>0.7 - 1.15 (m), 1.21 (3H, d, $J=7.0$ Hz), 2.5 (3H, s), 3.34 (3H, s), 4.85 (3H, s), 9.8 (1H, dd, $J=7.9$, 8.8 Hz).</td>
</tr>
<tr>
<td>5</td>
<td>5 - E</td>
<td>0.75 - 1.22 (m), 2.5 (3H, s), 3.51 (3H, s), 4.5 (4.2, 4H, dd, $J=4.2$, 8.8 Hz).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$[\alpha]_D$ (MeOH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(C = 0.293)</td>
</tr>
<tr>
<td>(C = 0.364)</td>
</tr>
<tr>
<td>(C = 0.381)</td>
</tr>
<tr>
<td>(C = 0.381)</td>
</tr>
<tr>
<td>(C = 0.297)</td>
</tr>
<tr>
<td>Compound</td>
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<tr>
<td>----------</td>
</tr>
<tr>
<td>Example</td>
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### Table

<table>
<thead>
<tr>
<th></th>
<th>1H-NMR (CDCl₃; δ)</th>
<th></th>
<th>1H-NMR (CDCl₃; δ)</th>
<th></th>
<th>1H-NMR (CDCl₃; δ)</th>
<th></th>
<th>1H-NMR (CDCl₃; δ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7 ~ 1.2 (m)</td>
<td>1.22 (3H, d: J = 7.1Hz)</td>
<td></td>
<td>0.7 ~ 1.1 (m)</td>
<td>1.19 (3H, d: J = 7.3Hz)</td>
<td></td>
<td>0.5 ~ 1.1 (m)</td>
<td>0.66 ~ 1.2 (m)</td>
</tr>
<tr>
<td>1.5 ~ 2.3 (m)</td>
<td>2.39 (3H, s)</td>
<td></td>
<td>2.5 ~ 2.9 (m)</td>
<td>3.01 (3H, s)</td>
<td></td>
<td>2.3 ~ 2.7 (m)</td>
<td>2.37 (3H, s)</td>
</tr>
<tr>
<td>3.56 (3H, s)</td>
<td>3.37 (3H, s)</td>
<td></td>
<td>3.65 ~ 4.25 (m)</td>
<td>4.6 ~ 5.05 (m)</td>
<td></td>
<td>3.87 (3H, s)</td>
<td>4.18 (3H, s)</td>
</tr>
<tr>
<td>4.5 ~ 4.95 (m)</td>
<td>5.9 ~ 6.22 (m)</td>
<td></td>
<td>6.55 ~ 7.2 (5H, m)</td>
<td>7.0 ~ 7.4 (4H, m)</td>
<td></td>
<td>6.9 ~ 7.3 (4H, m)</td>
<td>7.37 (3H, s)</td>
</tr>
</tbody>
</table>

### αD (MeOH)

<table>
<thead>
<tr>
<th></th>
<th>αD (MeOH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-31.2° (C = 0.284)</td>
<td>(28°)</td>
</tr>
<tr>
<td>-30.3° (C = 0.307)</td>
<td>(23°)</td>
</tr>
<tr>
<td>-44.6° (C = 0.435)</td>
<td>(25°)</td>
</tr>
<tr>
<td>-44.5° (C = 0.339)</td>
<td>(22°)</td>
</tr>
<tr>
<td>Example</td>
<td>Compound</td>
</tr>
<tr>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>10</td>
<td><img src="image1" alt="Chemical Structure" /></td>
</tr>
<tr>
<td>11</td>
<td><img src="image2" alt="Chemical Structure" /></td>
</tr>
<tr>
<td>12</td>
<td><img src="image3" alt="Chemical Structure" /></td>
</tr>
<tr>
<td>13</td>
<td><img src="image4" alt="Chemical Structure" /></td>
</tr>
</tbody>
</table>

- **5-J**: ![Chemical Structure](image1)
- **5-K**: ![Chemical Structure](image2)
- **5-L**: ![Chemical Structure](image3)
- **5-M**: ![Chemical Structure](image4)
<table>
<thead>
<tr>
<th>Example</th>
<th>Compound</th>
<th>[\alpha] D</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>![Chemical Structure 1]</td>
<td>(\text{MeOH})) (\text{n.-d.})</td>
</tr>
<tr>
<td>15</td>
<td>![Chemical Structure 2]</td>
<td>(-41.2^\circ) ((25^\circ))</td>
</tr>
</tbody>
</table>

1H-NMR (CDCl\(_3\), \(\delta\)):

- 0.6 \approx 1.15 (m), 1.24 (9H, d, J=6.8Hz),
- 1.5 \approx 2.2 (m), 2.30 (6H, s),
- 3.02 (3H, s), 3.32 (3H, s),
- 4.79 (1H, dd, J=9.0Hz, J=6.7Hz),
- 6.7 \approx 7.2 (3H, m),
- 7.0 \approx 7.75 (4H, m).

\(\text{B} = \text{C} = 1.68\)
Example 16
Preparation of compound 7-A

(in compound 7, A = \( \text{CONH} \), * = S)

70 mg (0.2 mmole) of compound 6-C obtained in Referential Example 4-C is dissolved in 1 ml of 50% trifluoroacetic acid-dichloromethane at 0°, and the solution is brought to room temperature, stirred for 3 hours and evaporated under reduced pressure. The residue is washed thoroughly with ether and dried under reduced pressure.

The above compound and 88 mg (0.15 mmole) of compound 4' obtained in (a) of Example 1 are dissolved in 1.5 ml of dimethylformamide, and under ice cooling and stirring, 30 mg (0.184 mmole) of DEPC and 41 mg (0.406 mmole) of triethylamine are added. Stirring is continued at 0° for 3 hours and then at room temperature overnight, the reaction solution is evaporated under reduced pressure, the residue is dissolved in dichloromethane, and the solution is washed with saturated aqueous sodium bicarbonate and saturated saline and dried. The resultant product is purified by preparative TLC using dichloromethane - methanol (10 : 1) as a developing solvent to obtain the desired compound 7-A as white powder. 86.5 mg (69.6%).

\([\alpha]_D^{28} -26.1°\) (c = 0.3185, MeOH)

\[^1\text{H}-\text{NMR}\ (\text{CDCl}_3, \delta)\ 0.7-1.3\ (m), 1.11\ (3H, d, J=6.6\text{Hz}), 2.98\ (3H, s), 2.99\ (3H, s), 3.34\ (6H, s), 3.5-4.2\ (m), 4.5-5.1\ (m), 7.23\ (5H, s), 7.41\ (2H, dd, J=56.5\text{Hz}, J=4.0\text{Hz})\]

Examples 17 to 24

Compounds 6-A, 6-B, 6-D and 6-E obtained in Referential Examples 4-A, 4-B, 4-D and 4-E are deprotected respectively according to Example 16, and then reacted with compound 4' to obtain the desired
compounds 7-B, 7-C, 7-D and 7-E. Likewise, by reaction of L- or D-phenylalanine methyl ester hydrochloride or phenylalanine ethyl ester or phenylalaninol with compound 4', the corresponding compounds 7-F, 7-G, 7-H and 5 7-I are obtained. The results are shown in the following Table.
<table>
<thead>
<tr>
<th>Example Compound</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td></td>
<td>7-B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>7-C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>7-D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>7-B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>7-P</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**$^1$H-NMR (CDCl$_3$, $\delta$)**

- 0.6~1.2 (m)
- 1.5~2.0 (m)
- 2.42 (6H, s)
- 3.31 (3H, s)
- 3.6~4.2 (m)
- 4.5~4.9 (m)
- 7.25 (5H, s)

**$[\alpha]_D$**

- $\alpha$ = 51.2° (C = 0.3475, (27°))
- $\alpha$ = 50.8° (C = 0.323)
- $\alpha$ = 30.6° (C = 0.310)
- $\alpha$ = 47.8° (C = 0.347)

**Diastereomeric Composition**

- *S*
- *R*
- *S*
- *S*
- *S*

**Diagram**

- 7-B
- 7-C
- 7-D
- 7-B
- 7-P

**Notes**

- n.d.
<table>
<thead>
<tr>
<th>Example</th>
<th>Compound</th>
<th>A</th>
<th>*</th>
<th>[α] D (MeOH)</th>
<th>¹H-NMR (CDCl₃, δ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>7 - G</td>
<td>-COOMe</td>
<td>R</td>
<td>-48.7° (C=0.3285) (28°)</td>
<td>0.7<del>1.2 (m), 1.21 (3H, d, J=7.3Hz), 1.5</del>2.3 (m), 2.50 (6H, br. s), 3.02 (3H, s), 3.32 (3H, s), 3.34 (3H, s), 3.70 (3H, s), 3.8<del>4.3 (m), 4.4</del>5.0 (m), 7.0~7.4 (5H, m)</td>
</tr>
<tr>
<td>23</td>
<td>7 - H</td>
<td>-COOEt</td>
<td>S</td>
<td>-56.4° (C=0.3265) (27°)</td>
<td>0.7<del>1.1 (m), 1.21 (3H, t, J=7.3Hz), 2.70 (6H, br. s), 3.02 (3H, s), 3.32 (3H, s), 3.34 (3H, s), 4.15 (2H, q, J=7.3Hz), 4.5</del>4.9 (m), 7.24 (5H, s)</td>
</tr>
<tr>
<td>24</td>
<td>7 - I</td>
<td>-CH₂OH</td>
<td>S</td>
<td>-51.6° (C=0.2735) (27°)</td>
<td>0.6<del>1.2 (m), 1.13 (3H, d, J=7.0Hz), 1.5</del>2.3 (m), 2.44 (6H, br. s), 3.02 (3H, s), 3.32 (3H, s), 3.40 (3H, s), 3.9~4.4 (m), 4.76 (1H, dd, J=8.8Hz, J=6.8Hz), 7.25 (5H, s)</td>
</tr>
</tbody>
</table>
Example 25
Preparation of compound 7-J
(in compound 7, A = COOH, * = S)

38.1 mg (50 μmoles) of compound 7-F obtained in Example 21 is dissolved in 0.5 ml of methanol, 55 μl (55 μmoles) of 1N-sodium hydroxide is added, and the mixture is stirred at room temperature for 3 hours. The mixture is ice-cooled, 55 μl of 1N-hydrochloric acid is added, the mixture is evaporated to dryness under reduced pressure, and the tetrahydrofuran-soluble part of the residue is purified by Sephadex LH-20 chromatography using n-hexane - dichloromethane - methanol (2 : 7.5 : 2.5) as an eluent to obtain powder of the desired compound 7-J. 37.4 mg (100 %).

\[ \alpha \]_3^0 \text{D} = -33.4° (c = 0.3265, MeOH)

$^1$H-NMR (CDCl$_3$, δ) 0.6-1.3 (m), 1.5-2.2 (m), 2.6-2.8 (6H, m), 3.07 (3H, s), 3.33 (3H, s), 3.38 (3H, s), 3.6-4.2 (m), 4.5-4.9 (m), 7.21 (5H, s)

Example 26
Preparation of compound 7-K
(in compound 7, A = COOH, * = R)

Compound 7-K is obtained from compound 7-G in all the same manner as in Example 25.

\[ \alpha \]_2^0 \text{D} = -63.4° (c = 0.330, MeOH)

$^1$H-NMR (CDCl$_3$, δ) 0.7-1.4 (m), 1.5-2.3 (m), 2.71 (6H, br. s), 3.04 (3H, s), 3.32 (3H, s), 3.37 (3H, s), 4.6-5.0 (m), 7.22 (5H, s)
CLAIMS:

1. A peptide derivative represented by the following formula:

or a salt thereof, wherein A represents a hydrogen atom, and B represents a phenyl group substituted with an o-fluoro group or hydroxyl group, or, a heteroaryl group.

2. The peptide derivative or salt according to claim 1, wherein B represents a heteroaryl group selected from the group consisting of thienyl, furyl, pyrrolyl, imidazolyl, thiazolyl, oxazolyl, thiadiazolyl, tetrazolyl, pyridyl, pyrimidinyl and triazinyl groups.

3. The peptide derivative or salt according to claim 1, wherein B represents a thienyl or pyridyl group.

4. The peptide derivative or salt according to claim 1, wherein B represents a phenyl group substituted with an o-fluoro group or hydroxyl group.

5. The peptide or salt according to any one of claims 1 to 4, wherein the peptide has the formula:
6. An antitumor drug, which comprises:

   the peptide derivative as defined in any one of claims 1 to 5 or a pharmaceutically acceptable salt thereof, and

5  a pharmaceutically acceptable carrier.

SMART & BIGGAR
OTTAWA, CANADA

PATENT AGENTS