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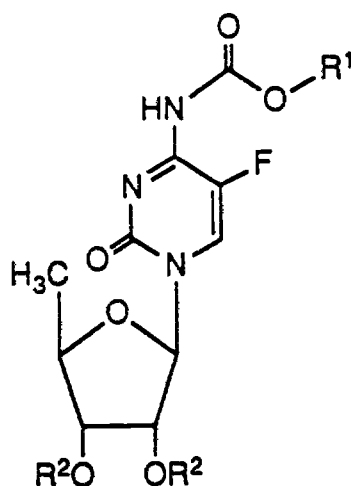
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RAN 4060/166 -001

N-Oxycarbonyl substituted 5'-deoxy-5-fluorocytidines

The present invention relates to N⁴-(substituted-oxycarbonyl)-5'-deoxy-5-fluorocytidine derivatives, and a pharmaceutical composition containing the same for treating tumors.

More particularly, the present invention relates to N⁴-(substituted-oxycarbonyl)-5'-deoxy-5-fluorocytidine derivatives represented by the general formula (I),



(I)

wherein R¹ is a saturated or unsaturated, straight or branched hydrocarbon radical [wherein the number of carbon atoms in the longest straight chain of this hydrocarbon radical ranges from three to seven], or a radical of the formula -(CH₂)_n-Y [in which n is an integer from 0 to 4, when Y is a cyclohexyl radical, or n is an integer from 2 to 4, when Y is a lower alkoxy radical having 1 to 4 carbon atom(s) or a phenyl radical], and R² is a hydrogen atom or a radical easily hydrolyzable under physiological conditions,

as well as hydrates or solvates of the compounds of the general formula (I), and a pharmaceutical composition containing the same with excellent pharmacokinetic profiles for treating tumors with high safety margin.

It is known that many precursors of 5-fluorouracil (5-FU) are useful as antitumor agents, but in general their bioconversion efficiency is still insufficient for the treatment of patients suffering from tumors and they





as well as hydrates or solvates of the compounds of the general formula (I), and a pharmaceutical composition containing the same with excellent pharmacokinetic profiles for treating tumors with high safety margin.

It is known that many precursors of 5-fluorouracil (5-FU) are useful as antitumor agents, but in general their bioconversion efficiency is still insufficient for the treatment of patients suffering from tumors and they cause intestinal toxicities and immunosuppressive toxicities, which are their major and dose limiting toxicities.

USP 4,966,891 discloses precursors of 5-FU which are improved in the above mentioned aspect of bioconversion efficiency and toxicities. They are converted to 5'-deoxy-5-fluorocytidine (5'-DFCR) by acylamidases, to 5'-deoxy-5-fluorouridine (5'-DFUR) by cytidine deaminase, and then to 5-FU by pyrimidine nucleotide phosphorylase in vivo which is preferentially localized in the liver, small intestine and tumor tissues. During intensive studies on the pharmacokinetic profiles of the precursors of 5-FU, particularly of N⁴-(substituted-oxycarbonyl)-5'-deoxy-5-fluorocytidine derivatives, the inventors found that certain specific precursors are selectively converted into 5'-DFCR by an acylamidase isozyme that is preferentially located at the liver but not the other organs of humans, and exhibited more improved pharmacokinetic profiles than the other compounds tested. The further studies based on the above findings enabled the inventors of the present invention to identify that the specific N⁴-(substituted-oxycarbonyl)-5'-deoxy-5-fluorocytidine derivatives (hereinafter referred to as N⁴-(substituted-oxycarbonyl)-5'-DFCR) represented by the above mentioned general formula (I) have selectively improved pharmacokinetic profiles in monkeys, viz. 4 to 7 times higher maximum concentration (C_{max}) of 5'-DFUR and 4 times larger higher area



under the curve (AUC) of 5'-DFUR in blood than the other compounds, and less intestinal toxicity, and thus completed the present invention.

The respective radicals of the general formula (I) which are defined above are explained in more detail as follows;

Explanation of R^1 :

R^1 is a saturated or unsaturated, straight or branched hydrocarbon chain [wherein the length of the hydrocarbon chain represented by the number of carbon atoms counted from the carbon atom bound to the oxycarbonylamino moiety of the compound is three or more and up to seven], or a radical of the formula $-(CH_2)_n-Y$ [in which n is an integer from 0 to 4, when Y is a cyclohexyl radical, or n is an integer from 2 to 4, when Y is a lower alkoxy radical having 1 to 4 carbon atom(s) or a phenyl radical].

In the above, the term "a saturated or unsaturated, straight or branched hydrocarbon radical [wherein the number of carbon atoms in the longest straight chain of this hydrocarbon radical ranges from three to seven]" preferably signifies *n*-propyl, 1-isopropyl-2-methylpropyl, 1,1,2-trimethylpropyl, *n*-butyl, isobutyl, 2-ethylbutyl, 3,3-dimethylbutyl, *n*-pentyl, isopentyl, neopentyl, 2-propylpentyl, *n*-hexyl, 2-ethylhexyl, *n*-heptyl, allyl, 2-buten-1-yl, 3-buten-1-yl, 3-penten-1-yl, 4-penten-1-yl, 3-hexen-1-yl, 4-hexen-1-yl, 5-hexen-1-yl, and the like.

The term "a radical of the formula $-(CH_2)_n-Y$ [in which n is an integer from 0 to 4, when Y is a cyclohexyl radical, or n is an integer from 2 to 4, when Y is a lower alkoxy radical having from 1 to 4 carbon atom(s) or a phenyl radical]" preferably signifies cyclohexyl, cyclohexylmethyl, 2-cyclohexylethyl, 3-cyclohexylpropyl, 4-cyclohexylbutyl, 2-methoxyethyl,



2-ethoxyethyl, 2-propoxyethyl, 3-methoxypropyl, 3-ethoxypropyl, 4-methoxybutyl, 4-ethoxybutyl, phenethyl, 3-phenylpropyl, 4-phenylbutyl, and the like.

In the most preferred embodiment of the compounds in accordance with the present invention, R^1 signifies n-propyl, n-butyl, n-pentyl, isopentyl, n-hexyl, 2-ethylbutyl, phenylethyl, and cyclohexylmethyl.

Explanation of R^2 :

R^2 is a hydrogen atom or a radical easily hydrolyzable under physiological condition.

In the above, the term "a radical easily hydrolyzable under physiological condition" preferably signifies acetyl, propionyl, benzoyl, toluoyl, β -alanyl, valyl, and the like.

Preferred N^4 -(substituted-oxycarbonyl)-5'-DFCRs of the present invention are:

5'-deoxy-5-fluoro- N^4 -(propoxycarbonyl)cytidine,
 N^4 -(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
5'-deoxy-5-fluoro- N^4 -(pentyloxycarbonyl)cytidine,
5'-deoxy-5-fluoro- N^4 -(hexyloxycarbonyl)cytidine,
5'-deoxy-5-fluoro- N^4 -(isopentyloxycarbonyl)cytidine,
5'-deoxy-5-fluoro- N^4 -(neopentyloxycarbonyl)cytidine,
5'-deoxy-5-fluoro- N^4 -[(1,1,2-trimethylpropoxy)carbonyl]cytidine,
5'-deoxy- N^4 -[(3,3-dimethylbutoxy)carbonyl]-5-fluorocytidine,
5'-deoxy-5-fluoro- N^4 -[(1-isopropyl-2-methylpropoxy)carbonyl]cytidine,
5'-deoxy- N^4 -[(2-ethylbutyl)oxycarbonyl]-5-fluorocytidine,
 N^4 -[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
5'-deoxy-5-fluoro- N^4 -[(2-phenylethoxy)carbonyl]cytidine,



2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine,
2',3'-di-O-acetyl-N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
2',3'-di-O-benzoyl-N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(pentyloxycarbonyl)cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(isopentyloxycarbonyl)-
cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(hexyloxycarbonyl)-
cytidine,
2',3'-di-O-acetyl-5'-deoxy-N⁴-[(2-ethylbutyl)oxycarbonyl]-5-
fluorocytidine,
2',3'-di-O-acetyl-N⁴-[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-
fluorocytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-[(2-phenylethoxy)-
carbonyl]cytidine,
5'-deoxy-5-fluoro-N⁴-(isobutoxycarbonyl)cytidine,
5'-deoxy-5-fluoro-N⁴-[(2-propylpentyl)oxycarbonyl]cytidine,
5'-deoxy-N⁴-[(2-ethylhexyl)oxycarbonyl]-5'-fluorocytidine,
5'-deoxy-5-fluoro-N⁴-(heptyloxycarbonyl)cytidine,
N⁴-[(2-cyclohexylethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
N⁴-[(3-cyclohexylpropyl)oxycarbonyl]-5'-deoxy-5-fluorocytidine,
N⁴-(cyclohexyloxycarbonyl)-5'-deoxy-5-fluorocytidine,
5'-deoxy-5-fluoro-N⁴-[(3-phenylpropyl)oxycarbonyl]cytidine, and
5'-deoxy-5-fluoro-N⁴-[(2-methoxyethoxy)carbonyl]cytidine.

and their hydrates or solvates, and the like.

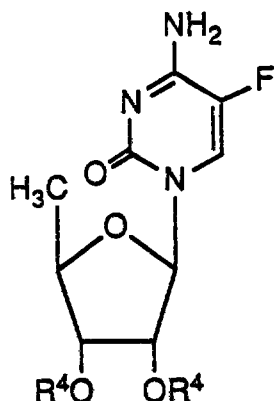
Among the above compounds, particularly preferred N⁴-(substituted-oxycarbonyl)-5'-DFCRs of the present invention are:

5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine,
N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,



5'-deoxy-5-fluoro-N⁴-(pentyloxycarbonyl)cytidine,
 5'-deoxy-5-fluoro-N⁴-(isopentyloxycarbonyl)cytidine,
 5'-deoxy-5-fluoro-N⁴-(hexyloxycarbonyl)cytidine,
 5'-deoxy-N⁴-[(2-ethylbutyl)oxycarbonyl]-5-fluorocytidine,
 5'-deoxy-5-fluoro-N⁴-[(2-phenylethoxy)carbonyl]cytidine,
 N⁴-[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
 and their hydrates or solvates, and the like.

The N⁴-(substituted-oxycarbonyl)-5'-DFCRs represented by the general formula (I) as well as their hydrates or solvates can be prepared by a reaction of a compound represented by the general formula (II),



(II)

wherein R⁴ is a hydroxy-protecting radical such as acetyl, benzoyl, trimethylsilyl, tert-butyldimethylsilyl, and the like, with a compound represented by the general formula (III),



wherein R¹ is the same as defined above,

followed, if necessary, by removal of a protecting radical.



The compounds represented by the above general formula (II) can be prepared by 2',3'-di-O-acylation or silylation of 5'-deoxy-5-fluorocytidine [*J. Med. Chem.*, 22, 1330 (1979)] as described in USP 4,966,891 or by direct coupling of 5-fluorocytosine with 1,2,3-tri-O-acetyl-5-deoxyribofuranose according to the procedure similar to that described in the literature [*Synthesis*, 748 (1981)].

The reaction of the compound of the above general formula (II) with the compound of the above general formula (III) can be carried out in a solvent such as pyridine, dioxane, tetrahydrofuran, acetonitrile, chloroform, dichloromethane and the like in the presence of acid acceptor such as triethylamine, pyridine, picoline, 4-(N,N-dimethylamino)pyridine, lutidine and the like. The reaction can be carried out at a temperature between 0 and 30°C.

The protecting radical may, if necessary, be removed after the reaction by the procedures known to those skilled in the art [*Protective Groups in Organic Synthesis*, John Wiley & Sons, New York, *Can. J. Chem.*, 49, 493 (1971) and USP 4,966,891], e.g. by basic or acidic hydrolysis.

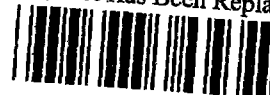
The compounds of the above general formula (I) can exist as unsolvated as well as solvated forms, including hydrated forms. The hydration can be effected in the course of the manufacturing process or can occur gradually as a result of hygroscopic properties of an initially anhydrous product. Solvates with pharmaceutically acceptable solvents such as ethanol can be obtained during, for example, crystallization.

N⁴-(Substituted-oxycarbonyl)-5'-DFCR derivatives represented by the general formula (I) as well as hydrates or solvates of the compounds of the general formula (I) prepared by the present invention exhibit activity against

human colon cancer CXF280 and gastric cancer GXF97 xenografts, mouse colon 26 carcinoma, mouse Lewis lung carcinoma, and the like in mice over a very wide range of dosages both orally and parenterally and are useful as antitumor agents. They are efficiently converted to 5'-DFCR by an acylamidase isozyme, to 5'-DFUR by cytidine deaminase and then to the active metabolite 5-FU by pyrimidine nucleoside phosphorylase.

The present invention further relates to a pharmaceutical composition for the treatment of tumors characterized by containing a compound of the above general formula (I).

The N⁴-(substituted-oxycarbonyl)-5'-DFCRs of the present invention can be administered orally or non-orally to human beings by various conventional administration methods. Moreover, the N⁴-(substituted-oxycarbonyl)-5'-DFCRs according to the present invention are used singly or formulated with a compatible pharmaceutical carrier material. This carrier material can be an organic or inorganic inert carrier material suitable for enteral, percutaneous or parenteral administration such as, water, gelatin, gum arabic, lactose, starch, magnesium stearate, talc, vegetable oils, polyalkylene-glycols or petroleum jelly. The pharmaceutical composition can be made up in a solid form (e.g. as tablets, dragees, enteric coating tablets, granulars, enteric coating granulars, suppositories, capsules or enteric capsules) in a semi-solid form (e.g. as salves) or in a liquid form (e.g. as solutions, suspensions or emulsions). The pharmaceutical composition may be sterilized and/or may contain further adjuvants such as preserving, stabilizing, setting or emulsifying agents, flavor-improving agents, salts for variation of the osmotic pressure or substances acting as buffers. The pharmaceutical composition can be prepared in a conventional manner.



The N⁴-(substituted-oxycarbonyl)-5'-DFCRs according to the present invention can be used alone or as mixtures of two or more different N⁴-(substituted-oxycarbonyl)-5'-DFCRs and the amount of the N⁴-(substituted-oxycarbonyl)-5'-DFCRs is about 0.1 to 99.5%, preferably 0.5 to 95% based on the weight of the pharmaceutical composition.

The pharmaceutical composition according to the present invention may be formulated in a combination with other conventional antitumor agent.

Susceptibility to acylamidase of the N⁴-(substituted-oxycarbonyl)-5'-DFCRs of the present invention and their pharmacokinetic profiles in the monkey are shown as follows:

1. Susceptibility to human and monkey acylamidases

The N⁴-(substituted-oxycarbonyl)-5'-DFCRs of the present invention were incubated with crude extracts of monkey and human liver in the presence of an inhibitor of cytidine deaminase, tetrahydrouridine (0.4 mM) at 37°C for 60 min. Thereafter, the product 5'-DFCR was separated by HPLC and the enzyme susceptibility was calculated from the amount of the product. As Table 1 shows, the compounds provided in the present invention were highly susceptible to the human liver acylamidase, suggesting that they are efficiently biotransformed to 5'-DFCR in human.

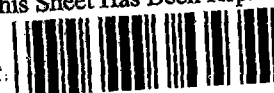


Table 1. Susceptibility to monkey and human acylamidase in the liver and small intestine

Compound (Example No.)	Acylamidase activity (nmol/mg protein/hr)	
	Monkey Liver	Human Liver
11	20	71
12	29	190
13	47	220
14	32	74
15	23	210
16	33	210
17	22	160
20	19	320
21	26	82
22	43	110
24	18	64
25	<13	160
26	20	560
27	59	110



2. Pharmacokinetic profiles in monkeys

The compounds of the present invention were orally administered into groups of 2 to 5 cynomolgous monkeys (3~4 kg). At various times after the administration, plasma was taken for determination of blood concentrations of intact molecules and their active metabolite 5'-DFUR.

Metabolites in the plasma were separated by HPLC and their concentrations were calculated. As Table 2 shows, the compounds of the present invention gave high levels in C_{max} and AUC of the active metabolite 5'-DFUR in the plasma. These results indicate that the compounds provided in the present invention can be effectively utilized for the treatment of various tumors in human beings.



Table 2. Pharmacokinetic Profiles in Monkeys

Compound (Example No.)	Plasma 5'-DFUR	
	C _{max} ($\mu\text{g/ml}$)	AUC ($\mu\text{g}\cdot\text{hr/ml}$)
10	1.44	2.03
11	1.57	2.06
12	2.10	2.90
13	1.50	1.96
14	1.80	2.40
15	2.60	2.89
16	1.40	2.52
17	1.65	2.66

The antitumor activities of the compounds of the present invention are shown as follows:

3. Antitumor testing against human colon cancer xenograft CXF280

CXF280 tumor (about 2 x 2 mm piece) was implanted subcutaneously into BALB/c nu/nu mice (21 - 22 g) on day 0. When tumor volume became 100 mm³ on day around 14, the compounds of the present invention were orally administered daily for 3 weeks. At one day after the last treatment, tumor volume was calculated.

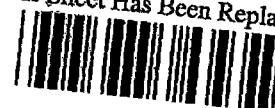


Table 3. Antitumor Effects of Fluorinated Pyrimidines in BALB/c
nu/nu Mice Bearing CXF280 Human Colon Carcinoma

Compound (Example No.)	Dose x 21 (mmol/kg/day)	% Growth inhibition	Fecal observation*
<u>Exp. 1</u>			
Vehicle		-	N
12	0.13	68	
	0.3	69	
	0.67	86	
	1.0	86	
	1.5	96	N
13	0.13	59	
	0.3	66	
	0.67	79	
	1.0	91	
	1.5	94	N
24	0.13	37	
	0.3	64	
	0.67	75	
	1.0	83	
	1.5	89	N
Reference compound			
5-FU	0.089	28	N
	0.13	59	N
	0.2	79	L



Compound (Example No.)	Dose x 21 (mmol/kg/day)	% Growth inhibition	Fecal observation*
<u>Exp. 2</u>			
Vehicle		-	N
10	0.13	39	
	0.3	56	
	0.67	75	
	1.5	86	
	2.25	93	N
11	0.13	46	
	0.3	72	
	0.67	84	
	1.5	95	
	2.25	101	N
14	0.13	68	
	0.3	68	
	0.67	85	
	1.5	94	N
	2.25	100	N
27	0.13	26	
	0.3	72	
	0.67	84	
	1.5	94	N
	2.25	103	N
<u>Reference compound</u>			
5-FU	0.089	NE	N
	0.13	20	N
	0.2	58	L

NE: Not Effective,

* Fecal observation (N: normal feces, L: loose passage)

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The percent inhibition of tumor growth given in Table 3 above was calculated from the formula:

$$\% \text{ Inhibition} = \{1 - (T - V_0)/(C - V_0)\} \times 100$$

V_0 = volume of tumor before treatment was started, T = volume of the tumors from the treated group, C = volume of the tumor from the control group.

As Table 3 shows, the compounds provided in the present invention were safely administered without causing intestinal toxicity and were much more effective than 5-FU.

4. Antitumor and anticachexia activity against mouse colon 26 carcinoma

Antitumor activity of a representative compound (Example 13), of the present invention, was measured as follows:

Mice (CDF1) were subcutaneously inoculated with colon 26 carcinoma (10^6 cells) on day 0. The compound was administered daily for 7 times from day 21 when the animals became cachectic. One day after the last treatment, tumor weight gain, carcass weight gain, adipose tissue weight, concentrations of glucose and the acute phase reactant IAP (immunosuppressive acidic protein) in the serum were measured. As Table 4 shows, mice treated with vehicle were abnormal in cachexia parameters such as adipose tissue weight, serum glucose and IAP levels, whereas treatment with the compound of Example 13 suppressed tumor growth and improved cachexia.

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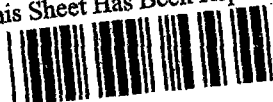




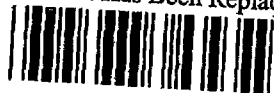
Table 4 Improvement of Tumor Cachexia with Fluorinated Pyrimidines
in Mice Bearing Colon 26 Adenocarcinoma

Compound (Example No.)	Dose x 7 (mmol/kg) (μ g/ml)	Tumor wt. change (g)	Carcass wt. change (g)	Adipose tissue wt. (mg)	Serum glucose (mg/dl)	Serum IAP
Vehicle		1.65	-1.5	11	91	1167
13	0.125	1.24	1.6*	22*	118*	1195
	0.25	0.91*	3.4*	42*	120*	1020
	0.5	0.79*	4.2*	63*	147*	805*
	1	0.06*	5.6*	85*	127*	795*

* $P < 0.05$ versus corresponding value of vehicle group

The toxicity (LD₅₀) of the representative compounds (Example 13, 14, and 17) of the present invention was examined by oral administration daily for 21 days in mice. The representative LD₅₀ values obtained from the experiments were more than 500 mg/kg/day.

A dosage per day to a patient of the N⁴-(substituted-oxycarbonyl)-5'-DFCRs of the present invention may be varied depending upon his weight and state to be remedied, but generally is in the range of 0.5 to 500 mg per 1 kg of weight, preferably about 2 to 200 mg. It should be noted that the compound of the invention can be expected to have 3~5 times higher activity than those of the compounds disclosed in USP 4,966,891 in humans when taking into consideration of the data of C_{max} and AUC of 5'-DFUR after oral administration of the present compounds in monkeys. From the same reason, the compounds of the present invention can be expected to show sufficient activity at the 3~5 times lower dosage than those of the compounds of said U.S. Patent. The present invention can provide a pharmaceutical composition for treating tumors with high safety margin.



The following Examples are intended to illustrate the present invention in more detail, but are not intended to limit its scope in any manner.

Reference example: Preparation of starting material

Preparation of 2',3'-di-O-acetyl-5'-deoxy-5-fluorocytidine

(a) From 5'-deoxy-5-fluorocytidine

5'-Deoxy-5-fluorocytidine (50 mg) was dissolved in dry pyridine (1.3 ml). To the solution was added acetic anhydride (39 ml) with stirring at 0°C. The reaction mixture was stirred for 3 hours at 0°C. After removal of the solvent under reduced pressure, the residue was partitioned between ethyl acetate and ice cooled water. The ethyl acetate layer was dried over magnesium sulfate and concentrated under reduced pressure. The residue was purified by silica gel column chromatography (dichloromethane/methanol=9/1 as an eluent) followed by recrystallization from isopropanol to give 37 mg of 2',3'-di-O-acetyl-5'-deoxy-5-fluorocytidine : 191.5~193°C, FAB-MS m/z 330 (MH⁺).

(b) From 5-fluorocytosine and 1,2,3-tri-O-acetyl-5-deoxy-β-D-ribofuranose

A solution of sodium iodide (3.6 g) and chlorotrimethylsilane (794 ml) in dry acetonitrile (15 ml) was stirred with molecular sieves 4A (200 mg) at 0°C for 5 min (colorless sodium chloride deposited during stirring). 1,2,3-Tri-O-acetyl-5-deoxy-β-D-ribofuranose (2.0 g) was added and the mixture was stirred at 0°C for 30 min. Then, a solution of the trimethylsilylated 5-fluorocytosine, freshly prepared from 5-fluorocytosine (1.12 g), in dry acetonitrile (5 ml) was added at 0°C and stirring was continued for 3 h at room temperature. The mixture was

filtered, the filtrate was concentrated in vacuo, and the residue was partitioned between dichloromethane and saturated aq. sodium bicarbonate solution. The aqueous layer was extracted with $\text{CH}_2\text{Cl}_2/\text{MeOH}$ (10:1). The combined organic layers were dried over anhydrous sodium sulfate and evaporated under reduced pressure. The residue was purified by silica gel chromatography using $\text{CH}_2\text{Cl}_2/\text{MeOH}$ (15:1) as an eluent, followed by recrystallization from isopropanol to give 1.24 g of 2',3'-di-O-acetyl-5'-deoxy-5-fluorocytidine.



Example 1

Preparation of 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-
(propoxycarbonyl)cytidine

To a solution of 2',3'-di-O-acetyl-5'-deoxy-5-fluorocytidine (2 g) in CH₂Cl₂ (15 ml) and dry pyridine (983 ml) was added dropwise n-propyl chloroformate (957 ml) with stirring and cooling on ice bath. After stirring for 30 min at room temperature, the mixture was evaporated to dryness under reduced pressure. The residue was partitioned between ether and saturated aqueous solution of sodium bicarbonate. The organic layer was washed with brine, dried over anhydrous sodium sulfate and filtered.

The filtrate was evaporated to give 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine (2.5 g) : EI-MS m/z 415(M⁺); ¹H-NMR(d₆-DMSO) δ 0.92 (3H, t, J=7.3 Hz), 1.37 (3H, d, J=6.3 Hz), 1.63 (2H, sex, J=7.3 Hz), 4.06~4.14 (3H, m), 5.11 (1H, t, J=6.3 Hz), 5.47 (1H, d.d., J=4.6 & 6.3 Hz), 5.81 (1H, d, J=4.6 Hz), 8.31 (1H, br. s), 10.63 (1H, br. s)

The following compounds were obtained according to a manner analogous to that of Example 1 (R¹ and R² are the same with those in the general formula (I)). The compound of Example 9 was prepared from the known 2',3'-di-O-benzoyl-5'-deoxy-5-fluorocytidine (USP 4,966,891) by the similar manner to that of Example 1.



Example No.	R ¹	R ²	¹ H-NMR (in solvent 1 or 2)	FAB-MS (m/z)
2	n-butyl	acetyl	$\delta(1)$: 0.87 (3H, t, J=7.3Hz), 1.36 (5H, m), 1.59 (2H, m), 2.05 (3H, s), 2.07 (3H, s), 4.12 (3H, m), 5.11 (1H, br.t), 5.47 (1H, br.t), 5.81 (1H, d, J=4.3Hz), 8.34 (1H, br.s), 10.60 (1H, br.s)	430 (MH ⁺)
3	n-pentyl	acetyl	$\delta(1)$: 0.88 (3H, t, J=7.3Hz), 1.31 (5H, m), 1.36 (3H, d, J=6.3Hz), 1.61 (1H, m), 2.06 (3H, s), 2.07 (3H, s), 4.07~4.14 (3H, m), 5.11 (1H, t, J=6.3Hz), 5.47 (1H, d.d, J=6.3 & 4.6Hz), 5.80 (1H, d, J=4.6Hz), 8.28 (1H, br.s), 10.63 (1H, br.s)	444 (MH ⁺)
4	n-hexyl	acetyl	$\delta(1)$: 0.87 (3H, t, J=6.9Hz), 1.30 (6H, m), 1.36 (3H, d, J=6.3Hz), 1.59 (2H, m), 2.06 (3H, s), 2.07 (3H, s), 4.07~4.14 (3H, m), 5.11 (1H, t, J=6.3Hz), 5.45 (1H, d.d, J=6.3 & 4.6Hz), 5.80 (1H, d, J=4.6Hz), 8.28 (1H, br.s), 10.63 (1H, br.s)	458 (MH ⁺)
5	isopentyl	acetyl	$\delta(1)$: 0.90 (6H, d, J=6.9Hz), 1.36 (3H, d, J=6.3Hz), 1.51 (2H, q, J=6.9Hz), 1.68 (1H, m), 2.06 (3H, s), 2.07 (3H, s), 4.09~4.20 (3H, m), 5.11 (1H, t, J=6.3 Hz), 5.46 (1H, d.d, J=6.3 & 4.3Hz), 5.80 (1H, d, J=4.3Hz), 8.28 (1H, br.s), 10.63 (1H, br.s)	444 (MH ⁺)

NMR: solvent 1 = d₆-DMSO, Solvent 2 = CDCl₃



Example No.	R ¹	R ²	¹ H-NMR (in solvent 1 or 2)	FAB-MS (m/z)
6	2-ethylbutyl	acetyl	δ(1): 0.87 (6H, t, J=7.3Hz), 1.23~1.45(7H, m), 1.51 (1H, m), 2.06 (3H, s), 2.07 (3H, s), 4.04 (2H, br. d), 4.12 (1H, t, J=6.3Hz), 5.11 (1H, t, J=6.3Hz), 5.46 (1H, d, J=6.3 & 4.6Hz), 5.81 (d, J=4.6Hz), 8.32 (1H, br.s), 10.61 (1H, br.s)	458 (MH ⁺)
7	cyclohexyl-methyl	acetyl	δ(1): 1.00 (2H, m), 1.11~1.29 (4H, m), 1.36 (3H, d, J=6.3Hz), 1.57~1.77 (5H, m), 2.06 (3H, s), 2.07 (3H, s), 3.92 (2H, br.s), 4.12 (1H, m), 5.11 (1H, t, J=6.3Hz), 5.46 (1H, d, J=6.3 & 4.0Hz), 5.81 (1H, d, J=4.0Hz), 8.33 (1H, br.s), 10.61 (1H, br.s)	470 (MH ⁺)
8	phenethyl	acetyl	δ(1): 1.36 (3H, d, J=6.3Hz), 2.06 (3H, s), 2.07 (3H, s), 2.94 (2H, t, J=6.8Hz), 4.12 (1H, m), 4.32 (2H, br. t), 5.11 (1H, t, J=6.3Hz), 5.46 (1H, d, J=6.3 & 4.3Hz), 5.81 (1H, d, J=4.3Hz), 7.16~7.37 (5H, m), 8.32 (1H, br.s), 10.67 (1H, br.s)	478 (MH ⁺)
9	n-butyl	benzoyl	δ(2): 0.95 (3H, t, J=7.3Hz), 1.42 (2H, m), 1.58 (3H, d, J=6.3Hz), 1.68 (2H, m), 4.16 (2H, br.s), 4.52 (1H, d, q, J=5.8 & 6.3Hz), 5.40 (1H, t, J=5.8Hz), 5.65 (1H, d, J=4.6 & 5.8Hz), 6.16 (1H, d, J=4.6Hz), 7.35~7.98 (11H, m), 11.9 (1H, br.s)	554 (MH ⁺)

NMR: solvent 1 = d₆-DMSO, Solvent 2 = CDCl₃

Example 10

Preparation of 5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine

To a solution of 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine (2.5 g) in CH₂Cl₂ (17 ml) was added dropwise 1N NaOH (17 ml) with stirring and cooling with ice bath. After stirring for 1 hr at 0°C, MeOH (0.9 ml) was added to the mixture. And pH of the reaction mixture was adjusted to 6 by the addition of concentrated HCl and partitioned. The aqueous layer was extracted with a mixed solvent of CH₂Cl₂/MeOH(95/5) successively (40 ml x 10). The combined organic layers were dried over anhydrous sodium sulfate and filtered. The solution was evaporated, and the residue was crystallized from ethyl acetate to give 5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine as colorless crystals (1.6 g, y. 79.8%) : mp. 125-126.5° C; EI-MS m/z 331 (M⁺).

The following compounds were obtained according to a manner analogous to that of Example 10 (R¹ and R² are the same with those in the general formula (I)).





Example No.	R ¹	R ²	Melting point (°C)	Recrystallization solvent	FAB-MS m/z
11	n-butyl	H	119~120	AcOEt	346 (MH ⁺)
12	n-pentyl	H	119~121	AcOEt	EI 359 (M ⁺)
13	n-hexyl	H	114~116	AcOEt	EI 373 (M ⁺)
14	isopentyl	H	119~120	AcOEt	360 (MH ⁺)
15	2-ethylbutyl	H	amorphous*	—	374 (MH ⁺)
16	cyclohexylmethyl	H	126~127	AcOEt	386 (MH ⁺)
17	phenethyl	H	144~145	AcOEt-MeOH	394 (MH ⁺)
18	allyl	H	118.5~120	AcOEt	330 (MH ⁺)

* ¹H-NMR (d₆-DMSO) of Example 15: δ 0.87 (6H, t, J=7 Hz), 1.25~1.45 (7H, m), 1.53 (1H, m), 3.68 (1H, q., J=6 Hz), 3.89 (1H, br. t, J=6 Hz), 4.02 (2H, d, J=6 Hz), 4.10 (1H, m), 5.05 (1H, d, J=6 Hz), 5.4 (1H, d, J=6 Hz), 5.67 (1H, d, J=3 Hz), 8.00 (1H, br. s), 10.55 & 11.60 (total 1H, br. s each).

Example 19

Preparation of N⁴-(cyclohexyloxycarbonyl)-5'-deoxy-5-fluorocytidine

5'-Deoxy-5-fluorocytidine (2.5 g) was dissolved in dry pyridine (20 ml). To the mixture, trimethylsilyl chloride (3.4 ml) was added dropwise at 0°C, and stirred for 30 min at room temperature. To the reaction mixture, cyclohexyl chloroformate (2.0 ml) was added in one portion at 0°C. After stirring of the mixture for 1 hour at room temperature, pyridine was

evaporated under reduced pressure. The residue was then partitioned between saturated aqueous NaHCO_3 and ether. The organic layer was washed with brine, dried over anhydrous MgSO_4 and concentrated under reduced pressure. To the residue were added citric acid (2.0 g) and methanol (50 ml). The mixture was stirred at room temperature overnight. After removal of the solvent under reduced pressure, the residue was dissolved in $\text{CH}_2\text{Cl}_2/\text{MeOH}$ (95:5) and neutralized by aqueous NaOH . The organic layer was dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The residue was purified by silica gel chromatography using $\text{CH}_2\text{Cl}_2/\text{MeOH}$ (20:1) as an eluent, followed by recrystallization from ethyl acetate to give N^4 -(cyclohexyloxycarbonyl)-5'-deoxy-5-fluorocytidine (3.47g : 92% yield) : mp. 134-136°C, FAB-MS m/z 372 (MH^+).

The following compounds were obtained according to a manner analogous to that of Example 19 (R^1 and R^2 are the same with those in the general formula (I)).





Example No.	R ¹	R ²	Melting point (°C)	Recrystallization solvent	FAB-MS m/z
20	2-cyclohexylethyl	H	128~129.5	AcOEt	400 (MH ⁺)
21	3-cyclohexylpropyl	H	amorphous*	—	414 (MH ⁺)
22	3-phenylpropyl	H	120~121	AcOEt	408 (MH ⁺)
23	2-methoxyethyl	H	amorphous**	—	348 (MH ⁺)
24	isobutyl	H	132~134	AcOEt	346 (MH ⁺)
25	2-propylpentyl	H	116~118	AcOEt	402 (MH ⁺)
26	2-ethylhexyl	H	amorphous***	—	402 (MH ⁺)
27	n-heptyl	H	115.5~117.5	AcOEt	388 (MH ⁺)

* ¹H-NMR (d₆-DMSO) of Example 21:

δ 0.78~0.93(2H, m), 1.15~1.27(6H, m), 1.31 (3H, d, J=7 Hz), 1.59~1.75 (7H, m), 3.68 (1H, q, J=6 Hz), 3.89 (1H, br. t, J=6Hz), 4.01~4.14 (3H, m), 5.04 (1H, d, J=6Hz), 5.40 (1H, d, J=6 Hz), 5.67 (1H, d, J=2 Hz), 8.00 (1H, br. s), 10.03 & 10.53 (total 1H, br. s each).

** ¹H-NMR (d₆-DMSO) of Example 23:

δ 1.31 (3H, d, J=5.9 Hz), 3.28 (3H, s), 3.56 (2H, br. t), 3.69 (1H, t, J=6 Hz), 3.89 (1H, m), 4.06 (1H, m), 4.22 (2H, br. t), 5.05 (1H, d, J=6 Hz), 5.40 (1H, br. s), 5.67 (1H, d, J=3 Hz), 8.06 (1H, br. s), 10.65 (1H, br. s).

*** ¹H-NMR (d₆-DMSO) of Example 26:

δ 0.85~0.88 (6H, m), 1.27~1.38 (11H, m), 1.57 (1H, br. d, J=6 Hz), 3.68 (1H, q, J=6 Hz), 3.89~4.02 (4H, m), 5.05 (1H, br. s), 5.41(1H, br. s), 5.67 (1H, d, J=3 Hz), 8.06 (1H, br. s), 10.52 (1H, br. s).



The following examples illustrated pharmaceutical preparations containing a compound provided by the present invention.

Example A:

Interlocking gelatin capsules each containing the following ingredients were manufactured in a manner known *per se*:

N ⁴ -(Butoxycarbonyl)-5'-deoxy-5-fluorocytidine	100 mg
Corn starch	20 mg
Titanium dioxide	385 mg
Magnesium stearate	5 mg
Film	20 mg
PEG 6000	3 mg
Talc	10 mg

543 mg

Example B:

Tablets each containing the following ingredients were manufactured in a manner known *per se*:

N ⁴ -(Butoxycarbonyl)-5'-deoxy-5-fluorocytidine	100 mg
Lactose	25 — mg
Corn starch	20.2 mg
Hydroxypropylmethyl cellulose	4 mg
Magnesium stearate	0.8 mg
Film	10 mg
PEG 6000	1.5 mg
Talc	4.5 mg

166 mg

Example C:

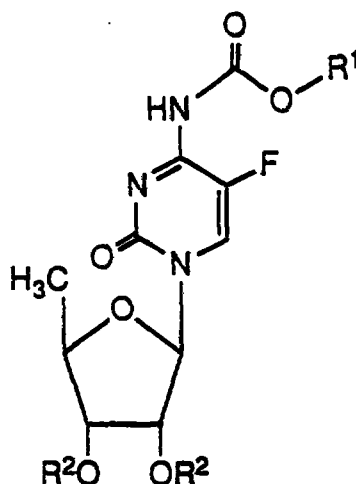
Dry parenteral dosage forms were manufactured in a manner known *per se*:

- (1) A total 5 g of N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine was dissolved in 75 ml of distilled water, the solution was subjected to a bacteriological filtration, and then divided aseptically into 10 sterile vials. The solution was then freeze-dried to yield 500 mg of sterile dry solid per vial.
- (2) Clean N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine in the amount of 500 mg per vial or ampoule was sealed in the receptacle and heat-sterilized.

The above dry dosage forms were reconstituted before use by adding a suitable sterile aqueous solvent such as water for injection or isotonic sodium chloride or 5% dextrose for parenteral administration.

What we claim is:

1. Compounds represented by the general formula (I),

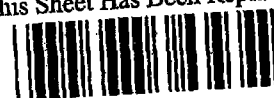


(I)

wherein R^1 is a saturated or unsaturated, straight or branched hydrocarbon radical [wherein the number of the carbon atoms in the longest straight chain of this hydrocarbon radical ranges from three to seven], or a radical of the formula $-(\text{CH}_2)_n-\text{Y}$ [in which n is an integer from 0 to 4, when Y is a cyclohexyl radical, or n is an integer from 2 to 4, when Y is a lower alkoxy radical having 1 to 4 carbon atom(s) or a phenyl radical], and R^2 is a hydrogen atom or a radical easily hydrolyzable under physiological conditions, as well as hydrates or solvates of the compounds of the general formula (I).



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2. The compounds according to claim 1, wherein R^1 is selected from the group consisting of n-propyl, n-butyl, isobutyl, 2-ethylbutyl, n-pentyl, isopentyl, 2-propylpentyl, 1-isopropyl-2-methylpropyl, 1,1,2-trimethylpropyl, 3,3-dimethylbutyl, neopentyl, n-hexyl, 2-ethylhexyl, n-heptyl, allyl, 2-buten-1-yl, 3-buten-1-yl, 3-penten-1-yl, 4-penten-1-yl, 3-hexen-1-yl, 4-hexen-1-yl, 5-hexen-1-yl, cyclohexyl, cyclohexylmethyl, 2-cyclohexylethyl, 3-cyclohexylpropyl, 4-cyclohexylbutyl, 2-methoxyethyl, 2-ethoxyethyl, 3-methoxypropyl, 3-ethoxypropyl, 4-methoxybutyl, 4-ethoxybutyl, phenethyl, 3-phenylpropyl and 4-phenylbutyl.
3. The compounds according to claim 1, selected from a group consisting of:
- 5'-deoxy-5-fluoro- N^4 -(propoxycarbonyl)cytidine,
 - N^4 -(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
 - 5'-deoxy-5-fluoro- N^4 -(pentyloxycarbonyl)cytidine,
 - 5'-deoxy-5-fluoro- N^4 -(hexyloxycarbonyl)cytidine,
 - 5'-deoxy-5-fluoro- N^4 -(isopentyloxycarbonyl)cytidine,
 - 5'-deoxy-5-fluoro- N^4 -(neopentyloxycarbonyl)cytidine,
 - 5'-deoxy-5-fluoro- N^4 -[1,1,2-trimethylpropoxy]carbonyl]cytidine,
 - 5'-deoxy- N^4 [(3,3-dimethylbutoxy)carbonyl]5-fluorocytidine,
 - 5'-deoxy-5-fluoro- N^4 -[(1-isopropyl-2-methylpropoxy)carbonyl]-cytidine,
 - 5'-deoxy- N^4 -[(2-ethylbutyl)oxycarbonyl]-5-fluorocytidine,
 - N^4 -[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
 - 5'-deoxy-5-fluoro- N^4 -[(2-phenylethoxy)carbonyl]cytidine,
 - 2',3'-di-O-acetyl-5'-deoxy-5-fluoro- N^4 -(propoxycarbonyl)cytidine,
 - 2',3'-di-O-acetyl- N^4 -(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,

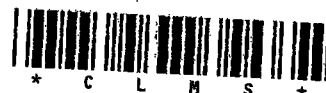


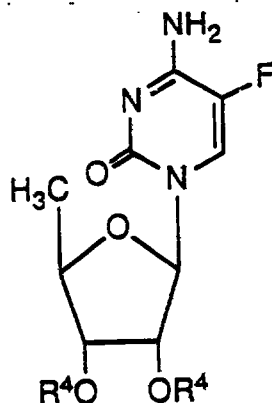


2',3'-di-O-benzoyl-N⁴-(butoxycarbonyl)-5'-deoxy-5-fluoro-
cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(pentyloxycarbonyl)cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(isopentyloxycarbonyl)-
cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(hexyloxycarbonyl)-
cytidine,
2',3'-di-O-acetyl-5'-deoxy-N⁴-[(2-ethylbutyl)oxycarbonyl]-5-
fluorocytidine,
2',3'-di-O-acetyl-N⁴-[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-
fluorocytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-[(2-phenylethoxy)-
carbonyl]cytidine,
5'-deoxy-5-fluoro-N⁴-(isobutoxycarbonyl)cytidine,
5'-deoxy-5-fluoro-N⁴-[(2-propylpentyl)oxycarbonyl]cytidine,
5'-deoxy-N⁴-[(2-ethylhexyl)oxycarbonyl]-5'-fluorocytidine,
5'-deoxy-5-fluoro-N⁴-(heptyloxycarbonyl)cytidine,
N⁴-[(2-cyclohexylethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
N⁴-[(3-cyclohexylpropyl)oxycarbonyl]-5'-deoxy-5-fluorocytidine,
N⁴-(cyclohexyloxycarbonyl)-5'-deoxy-5-fluorocytidine,
5'-deoxy-5-fluoro-N⁴-[(3-phenylpropyl)oxycarbonyl]cytidine, and
5'-deoxy-5-fluoro-N⁴-[(2-methoxyethoxy)carbonyl]cytidine.

4. Compounds according to claim 1, 2 or 3 for use as therapeutically active substances, particularly for use as antitumor active substances.

5. A process for producing the compounds according to claim 1, 2 or 3, which comprises reacting a compound represented by the general formula (II),





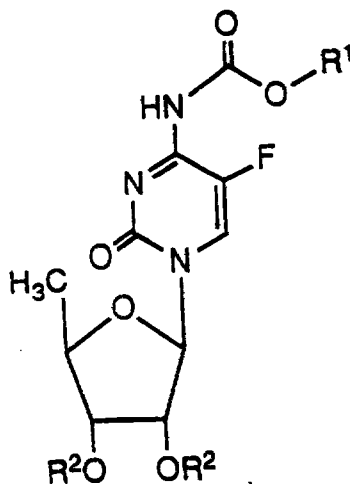
(II)

wherein R^4 is a hydroxy-protecting radical,
with a compound represented by the general formula (III),



wherein R^1 is the same as in claim 1,
and, if necessary, removing the protecting radicals.

6. A pharmaceutical composition for the treatment of tumors characterized by containing a compound of the general formula (I),



(I)





wherein R^1 is a saturated or unsaturated, straight or branched hydrocarbon chain [wherein the number of the carbon atoms in the longest straight chain of this hydrocarbon radical ranges from three to seven], or a radical of the formula $-(CH_2)_n-Y$ [in which n is an integer from 0 to 4, when Y is a cyclohexyl radical, or n is an integer from 2 to 4, when Y is a lower alkoxy radical having 1 to 4 carbon atom(s) or a phenyl radical], and R^2 is a hydrogen atom or a radical easily hydrolyzable under physiological conditions, or a hydrate or solvate of the compound of the general formula (I) as an active ingredient.

7. The pharmaceutical composition according to claim 6, wherein R^1 of the compound is selected from the group consisting of n-propyl, n-butyl, isobutyl, 2-ethylbutyl, n-pentyl, isopentyl, 2-propylpentyl, 1-isopropyl-2-methylpropyl, 1,1,2-trimethylpropyl, 3,3-dimethylbutyl, neopentyl, n-hexyl, 2-ethylhexyl, n-heptyl, allyl, 2-buten-1-yl, 3-buten-1-yl, 3-penten-1-yl, 4-penten-1-yl, 3-hexen-1-yl, 4-hexen-1-yl, 5-hexen-1-yl, cyclohexyl, cyclohexylmethyl, 2-cyclohexylethyl, 3-cyclohexyl-propyl, 4-cyclohexylbutyl, 2-methoxyethyl, 2-ethoxyethyl, 2-propoxyethyl, 3-methoxypropyl, 3-ethoxypropyl, 4-methoxybutyl, 4-ethoxybutyl, phenethyl, 3-phenylpropyl and 4-phenylbutyl.
8. The pharmaceutical composition according to claim 6, wherein the compound is selected from a group consisting of:
- 5'-deoxy-5-fluoro- N^4 -(propoxycarbonyl)cytidine,
 - N^4 -(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
 - 5'-deoxy-5-fluoro- N^4 -(pentyloxycarbonyl)cytidine,
 - 5'-deoxy-5-fluoro- N^4 -(hexyloxycarbonyl)cytidine,





5'-deoxy-5-fluoro-N⁴-(isopentyloxycarbonyl)cytidine,
5'-deoxy-5-fluoro-N⁴-(neopentyloxycarbonyl)cytidine,
5'-deoxy-5-fluoro-N⁴-[(1,1,2-trimethylpropoxy)carbonyl]cytidine,
5'-deoxy-N⁴-[(3,3-dimethylbutoxy)carbonyl]-5-fluorocytidine,
5'-deoxy-5-fluoro-N⁴-[(1-isopropyl-2-methylpropoxy)carbonyl]-
cytidine,
5'-deoxy-N⁴-[(2-ethylbutyl)oxycarbonyl]-5-fluorocytidine,
N⁴-[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
5'-deoxy-5-fluoro-N⁴-[(2-phenylethoxy)carbonyl]cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine,
2',3'-di-O-acetyl-N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
2',3'-di-O-benzoyl-N⁴-(butoxycarbonyl)-5'-deoxy-5-fluoro-
cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(pentyloxycarbonyl)cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(isopentyloxycarbonyl)-
cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(hexyloxycarbonyl)-
cytidine,
2',3'-di-O-acetyl-5'-deoxy-N⁴-[(2-ethylbutyl)oxycarbonyl]-5-
fluorocytidine,
2',3'-di-O-acetyl-N⁴-[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-
fluorocytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-[(2-phenylethoxy)-
carbonyl]cytidine,
5'-deoxy-5-fluoro-N⁴-(isobutoxycarbonyl)cytidine,
5'-deoxy-5-fluoro-N⁴-[(2-propylpentyl)oxycarbonyl]cytidine,
5'-deoxy-N⁴-[(2-ethylhexyl)oxycarbonyl]-5'-fluorocytidine,
5'-deoxy-5-fluoro-N⁴-(heptyloxycarbonyl)cytidine,





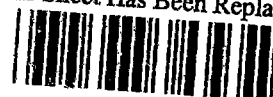
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N^4 -[(2-cyclohexylethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
 N^4 -[(3-cyclohexylpropyl)oxycarbonyl]-5'-deoxy-5-fluorocytidine,
 N^4 -(cyclohexyloxycarbonyl)-5'-deoxy-5-fluorocytidine,
5'-deoxy-5-fluoro- N^4 -[(3-phenylpropyl)oxycarbonyl]cytidine, and
5'-deoxy-5-fluoro- N^4 -[(2-methoxyethoxy)carbonyl]cytidine.

9. The use of the compounds of claim 1, 2 or 3 for the manufacture of an antitumor agent.

10. The invention as hereinbefore described, particularly with reference to the Examples.

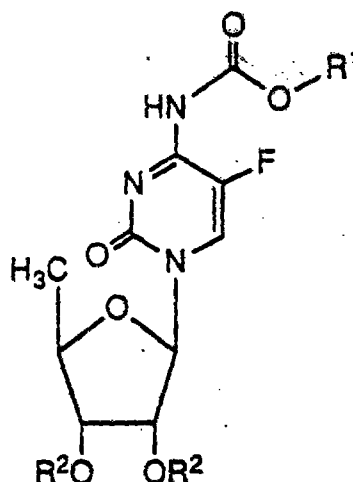
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N-Oxycarbonyl substituted 5'-deoxy-5-fluorocytidines

Abstract

Compounds represented by the general formula (I),



- 5 wherein R^1 is a saturated or unsaturated, straight or branched hydrocarbon radical [wherein the number of carbon atoms in the longest straight chain of this hydrocarbon radical ranges from three to seven], or a radical of the formula $-(CH_2)_n-Y$ [in which n is an integer from 0 to 4, when Y is a cyclohexyl radical, or n is an integer from 2 to 4, when Y is a lower alkoxy radical having 1 to 4 carbon atom(s) or a phenyl radical], and R^2 is a hydrogen atom or a radical easily hydrolyzable under physiological conditions,
- 10 as well as hydrates or solvates of the compounds of the general formula (I), can be utilized in the treatment of tumors. They can be prepared by reacting
- 15 a compound of formula $R^1-OCOCl$ with a N⁴-unsubstituted 5'-deoxy-5-fluorocytidine of the above formula I, wherein R^2 would stand for protecting groups, and if necessary removing the protecting groups.





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cause intestinal toxicities and immunosuppressive toxicities, which are their major and dose limiting toxicities.

USP 4,966,891 discloses precursors of 5-FU which are improved in the above mentioned aspect of bioconversion efficiency and toxicities. They are converted to 5'-deoxy-5-fluorocytidine (5'-DFCR) by acylamidases, to 5'-deoxy-5-fluorouridine (5'-DFUR) by cytidine deaminase, and then to 5-FU by pyrimidine nucleotide phosphorylase in vivo which is preferentially localized in the liver, small intestine and tumor tissues. During intensive studies on the pharmacokinetic profiles of the precursors of 5-FU, particularly of N⁴-(substituted-oxycarbonyl)-5'-deoxy-5-fluorocytidine derivatives, the inventors found that certain specific precursors are selectively converted into 5'-DFCR by an acylamidase isozyme that is preferentially located at the liver but not the other organs of humans, and exhibited more improved pharmacokinetic profiles than the other compounds tested. The further studies based on the above findings enabled the inventors of the present invention to identify that the specific N⁴-(substituted-oxycarbonyl)-5'-deoxy-5-fluorocytidine derivatives (hereinafter referred to as N⁴-(substituted-oxycarbonyl)-5'-DFCR) represented by the above mentioned general formula (I) have selectively improved pharmacokinetic profiles in monkeys, viz. 4 to 7 times higher maximum concentration (C_{max}) of 5'-DFUR and 4 times larger higher area under the curve (AUC) of 5'-DFUR in blood than the other compounds, and less intestinal toxicity, and thus completed the present invention.

The respective radicals of the general formula (I) which are defined above are explained in more detail as follows;

Explanation of R¹:

R¹ is a saturated or unsaturated, straight or branched hydrocarbon radical [wherein the number of carbon atoms in the longest straight chain of this hydrocarbon radical ranges from three to seven], or a radical of the formula -(CH₂)_n-Y [in which n is an integer from 0 to 4, when Y is a cyclohexyl radical, or n is an integer from 2 to 4, when Y is a lower alkoxy radical having 1 to 4 carbon atom(s) or a phenyl radical].

In the above, the term "a saturated or unsaturated, straight or branched hydrocarbon radical [wherein the number of carbon atoms in the longest straight chain of this hydrocarbon radical ranges from three to seven]" preferably signifies n-propyl, 1-isopropyl-2-methylpropyl, 1,1,2-

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trimethylpropyl, n-butyl, isobutyl, 2-ethylbutyl, 3,3-dimethylbutyl, n-pentyl, isopentyl, neopentyl, 2-propylpentyl, n-hexyl, 2-ethylhexyl, n-heptyl, allyl, 2-buten-1-yl, 3-buten-1-yl, 3-penten-1-yl, 4-penten-1-yl, 3-hexen-1-yl, 4-hexen-1-yl, 5-hexen-1-yl, and the like.

The term "a radical of the formula $-(CH_2)_n-Y$ [in which n is an integer from 0 to 4, when Y is a cyclohexyl radical, or n is an integer from 2 to 4, when Y is a lower alkoxy radical having from 1 to 4 carbon atom(s) or a phenyl radical]" preferably signifies cyclohexyl, cyclohexylmethyl, 2-cyclohexylethyl, 3-cyclohexylpropyl, 4-cyclohexylbutyl, 2-methoxyethyl, 2-ethoxyethyl, 2-propoxyethyl, 3-methoxypropyl, 3-ethoxypropyl, 4-methoxybutyl, 4-ethoxybutyl, phenethyl, 3-phenylpropyl, 4-phenylbutyl, and the like.

In the most preferred embodiment of the compounds in accordance with the present invention, R^1 signifies n-propyl, n-butyl, n-pentyl, isopentyl, neopentyl, 3,3-dimethylbutyl, n-hexyl, 2-ethylbutyl, phenylethyl, and cyclohexylmethyl.

Explanation of R^2 :

R^2 is a hydrogen atom or a radical easily hydrolyzable under physiological condition.

In the above, the term "a radical easily hydrolyzable under physiological condition" preferably signifies acetyl, propionyl, benzoyl, toluoyl, β -alanyl, valyl, and the like.

Preferred N^4 -(substituted-oxycarbonyl)-5'-DFCRs of the present invention are:

5'-deoxy-5-fluoro- N^4 -(propoxycarbonyl)cytidine,
 N^4 -(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
 5'-deoxy-5-fluoro- N^4 -(pentyloxycarbonyl)cytidine,
 5'-deoxy-5-fluoro- N^4 -(hexyloxycarbonyl)cytidine,
 5'-deoxy-5-fluoro- N^4 -(isopentyloxycarbonyl)cytidine,
 5'-deoxy-5-fluoro- N^4 -(neopentyloxycarbonyl)cytidine,
 5'-deoxy-5-fluoro- N^4 -[(1,1,2-trimethylpropoxy)carbonyl]cytidine,
 5'-deoxy- N^4 -[(3,3-dimethylbutoxy)carbonyl]-5-fluorocytidine,
 5'-deoxy-5-fluoro- N^4 -[(1-isopropyl-2-methylpropoxy)carbonyl]cytidine,
 5'-deoxy- N^4 -[(2-ethylbutoxy)carbonyl]-5-fluorocytidine,

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N^4 -[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
 5'-deoxy-5-fluoro- N^4 -[(2-phenylethoxy)carbonyl]cytidine,
 2',3'-di-O-acetyl-5'-deoxy-5-fluoro- N^4 -(propoxycarbonyl)cytidine,
 2',3'-di-O-acetyl- N^4 -(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
 2',3'-di-O-benzoyl- N^4 -(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
 2',3'-di-O-acetyl-5'-deoxy-5-fluoro- N^4 -(pentyloxycarbonyl)cytidine,
 2',3'-di-O-acetyl-5'-deoxy-5-fluoro- N^4 -(isopentyloxycarbonyl)cytidine,
 2',3'-di-O-acetyl-5'-deoxy-5-fluoro- N^4 -(hexyloxycarbonyl)cytidine,
 2',3'-di-O-acetyl-5'-deoxy- N^4 -[(2-ethylbutyl)oxycarbonyl]-5-fluorocytidine,
 2',3'-di-O-acetyl- N^4 -[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-
 fluorocytidine,
 2',3'-di-O-acetyl-5'-deoxy-5-fluoro- N^4 -[(2-phenylethoxy)-
 carbonyl]cytidine,
 5'-deoxy-5-fluoro- N^4 -(isobutoxycarbonyl)cytidine,
 5'-deoxy-5-fluoro- N^4 -[(2-propylpentyl)oxycarbonyl]cytidine,
 5'-deoxy- N^4 -[(2-ethylhexyl)oxycarbonyl]-5-fluorocytidine,
 5'-deoxy-5-fluoro- N^4 -(heptyloxycarbonyl)cytidine,
 N^4 -[(2-cyclohexylethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
 N^4 -[(3-cyclohexylpropyl)oxycarbonyl]-5'-deoxy-5-fluorocytidine,
 N^4 -(cyclohexyloxycarbonyl)-5'-deoxy-5-fluorocytidine,
 5'-deoxy-5-fluoro- N^4 -[(3-phenylpropyl)oxycarbonyl]cytidine, and
 5'-deoxy-5-fluoro- N^4 -[(2-methoxyethoxy)carbonyl]cytidine.

and their hydrates or solvates, and the like.

Among the above compounds, particularly preferred N^4 -(substituted-oxycarbonyl)-5'-DFCRs of the present invention are:

5'-deoxy-5-fluoro- N^4 -(propoxycarbonyl)cytidine,
 5'-deoxy-5-fluoro- N^4 -(isopentyloxycarbonyl)cytidine,
 5'-deoxy-5-fluoro- N^4 -(hexyloxycarbonyl)cytidine,
 5'-deoxy- N^4 -[(2-ethylbutyl)oxycarbonyl]-5-fluorocytidine,
 5'-deoxy-5-fluoro- N^4 -(neopentyloxycarbonyl)cytidine,
 5'-deoxy- N^4 -[(3,3-dimethylbutoxy)carbonyl]-5-fluorocytidine,
 5'-deoxy-5-fluoro- N^4 -[(2-phenylethoxy)carbonyl]cytidine,
 N^4 -[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-fluorocytidine, specially



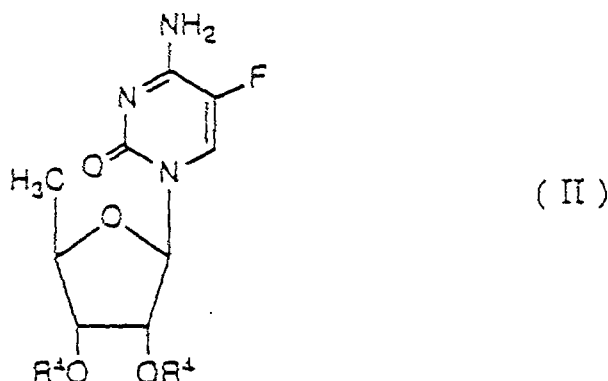
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N^4 -(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
5'-deoxy-5-fluoro- N^4 -(pentyloxycarbonyl)cytidine,
and their hydrates or solvates, and the like.

The N^4 -(substituted-oxycarbonyl)-5'-DFCRs represented by the general formula (I) as well as their hydrates or solvates can be prepared by a reaction of a compound represented by the general formula (II),



wherein R^4 is a hydroxy-protecting radical such as acetyl, benzoyl, trimethylsilyl, tert-butyldimethylsilyl, and the like,
with a compound represented by the general formula (III),



wherein R^1 is the same as defined above,
followed, if necessary, by removal of a protecting radical.

The compounds represented by the above general formula (II) can be prepared by 2',3'-di-O-acylation or silylation of 5'-deoxy-5-fluorocytidine [*J. Med. Chem.*, **22**, 1330 (1979)] as described in USP 4,966,891 or by direct coupling of 5-fluorocytosine with 1,2,3-tri-O-acetyl-5-deoxyribofuranose according to the procedure similar to that described in the literature [*Synthesis*, 748 (1981)].

The reaction of the compound of the above general formula (II) with the compound of the above general formula (III) can be carried out in a solvent such as pyridine, dioxane, tetrahydrofuran, acetonitrile, chloroform, dichloromethane and the like in the presence of acid acceptor such as triethylamine, pyridine, picoline, 4-(N,N-dimethylamino)pyridine, lutidine and the like. The reaction can be carried out at a temperature between 0 and 30°C.

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The protecting radical may, if necessary, be removed after the reaction by the procedures known to those skilled in the art [*Protective Groups in Organic Synthesis*, John Wiley & Sons, New York, *Can. J. Chem.*, 49, 493 (1971) and USP 4,966,891], e.g. by basic or acidic hydrolysis.

The compounds of the above general formula (I) can exist as unsolvated as well as solvated forms, including hydrated forms. The hydration can be effected in the course of the manufacturing process or can occur gradually as a result of hygroscopic properties of an initially anhydrous product. Solvates with pharmaceutically acceptable solvents such as ethanol can be obtained during, for example, crystallization.

N⁴-(Substituted-oxycarbonyl)-5'-DFCR derivatives represented by the general formula (I) as well as hydrates or solvates of the compounds of the general formula (I) prepared by the present invention exhibit activity against human colon cancer CXF280 and gastric cancer GXF97 xenografts, mouse colon 26 carcinoma, mouse Lewis lung carcinoma, and the like in mice over a very wide range of dosages both orally and parenterally and are useful as antitumor agents. They are efficiently converted to 5'-DFCR by an acylamidase isozyme, to 5'-DFUR by cytidine deaminase and then to the active metabolite 5-FU by pyrimidine nucleoside phosphorylase.

The present invention further relates to a pharmaceutical composition, particularly for the treatment of tumors characterized by containing a compound of the above general formula (I).

The N⁴-(substituted-oxycarbonyl)-5'-DFCRs of the present invention can be administered orally or non-orally to human beings by various conventional administration methods. Moreover, the N⁴-(substituted-oxycarbonyl)-5'-DFCRs according to the present invention are used singly or formulated with a compatible pharmaceutical carrier material. This carrier material can be an organic or inorganic inert carrier material suitable for enteral, percutaneous or parenteral administration such as, water, gelatin, gum arabic, lactose, starch, magnesium stearate, talc, vegetable oils, polyalkylene-glycols or petroleum jelly. The pharmaceutical composition can be made up in a solid form (e.g. as tablets, dragees, enteric coating tablets, granulars, enteric coating granulars, suppositories, capsules or enteric capsules) in a semi-solid form (e.g. as salves) or in a liquid form (e.g. as solutions, suspensions or emulsions). The pharmaceutical composition may be sterilized and/or may contain further adjuvants such as preserving,

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stabilizing, setting or emulsifying agents, flavor-improving agents, salts for variation of the osmotic pressure or substances acting as buffers. The pharmaceutical composition can be prepared in a conventional manner.

The N^4 -(substituted-oxycarbonyl)-5'-DFCRs according to the present invention can be used alone or as mixtures of two or more different N^4 -(substituted-oxycarbonyl)-5'-DFCRs and the amount of the N^4 -(substituted-oxycarbonyl)-5'-DFCRs is about 0.1 to 99.5%, preferably 0.5 to 95% based on the weight of the pharmaceutical composition.

The pharmaceutical composition according to the present invention may be formulated in a combination with other conventional antitumor agent.

Susceptibility to acylamidase of the N^4 -(substituted-oxycarbonyl)-5'-DFCRs of the present invention and their pharmacokinetic profiles in the monkey are shown as follows:

1. Susceptibility to human and monkey acylamidases

The N^4 -(substituted-oxycarbonyl)-5'-DFCRs of the present invention were incubated with crude extracts of monkey and human liver in the presence of an inhibitor of cytidine deaminase, tetrahydrouridine (0.4 mM) at 37°C for 60 min. Thereafter, the product 5'-DFCR was separated by HPLC and the enzyme susceptibility was calculated from the amount of the product. As Table 1 shows, the compounds provided in the present invention were highly susceptible to the human liver acylamidase, suggesting that they are efficiently biotransformed to 5'-DFCR in human.

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Table 1. Susceptibility to monkey and human acylamidase in the liver

Compound (Example No.)	Acylamidase activity (nmol/mg protein/hr)	
	Monkey Liver	Human Liver
11	20	71
12	29	190
13	47	220
14	32	74
15	23	210
16	33	210
17	22	160
20	19	320
21	26	82
22	43	110
24	18	64
25	<13	160
26	20	560
27	59	110
28	26	52
29	22	50

2. Pharmacokinetic profiles in monkeys

The compounds of the present invention were orally administered into groups of 2 to 5 cynomolgous monkeys (3-4 kg). At various times after the administration, plasma was taken for determination of blood concentrations of intact molecules and their active metabolite 5'-DFUR.

Metabolites in the plasma were separated by HPLC and their concentrations were calculated. As Table 2 shows, the compounds of the present invention gave high levels in C_{max} and AUC of the active metabolite 5'-DFUR in the plasma. These results indicate that the compounds provided in the present invention can be effectively utilized for the treatment of various tumors in human beings.



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Table 2. Pharmacokinetic Profiles in Monkeys

Compound (Example No.)	Plasma 5'-DFUR	
	C _{max} ($\mu\text{g/ml}$)	AUC ($\mu\text{g}\cdot\text{hr/ml}$)
10	1.44	2.03
11	1.57	2.06
12	2.10	2.90
13	1.50	1.96
14	1.80	2.40
15	2.60	2.89
16	1.40	2.52
17	1.65	2.66
28	1.00	1.40
29	2.00	2.09

The antitumor activities of the compounds of the present invention are shown as follows:

3. Antitumor testing against human colon cancer xenograft CXF280

CXF280 tumor (about 2 x 2 mm piece) was implanted subcutaneously into BALB/c nu/nu mice (21 - 22 g) on day 0. When tumor volume became 100 mm³ on day around 14, the compounds of the present invention were orally administered daily for 3 weeks. At one day after the last treatment, tumor volume was calculated.



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Table 3. Antitumor Effects of Fluorinated Pyrimidines in BALB/c
nu/nu Mice Bearing CXF280 Human Colon Carcinoma

Compound (Example No.)	Dose $\times$ 21 (mmol/kg/day)	% Growth inhibition	Fecal observation *
<u>Exp. 1</u>			
Vehicle			N
12	0.13	68	
	0.3	69	
	0.67	86	
	1.0	86	
	1.5	96	N
13	0.13	59	
	0.3	68	
	0.67	79	
	1.0	91	
	1.5	94	N
24	0.13	37	
	0.3	64	
	0.67	75	
	1.0	83	
	1.5	89	N
<u>Reference compound</u>			
5-FU	0.089	28	N
	0.13	59	N
	0.2	79	L



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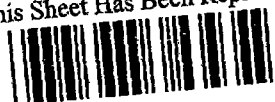
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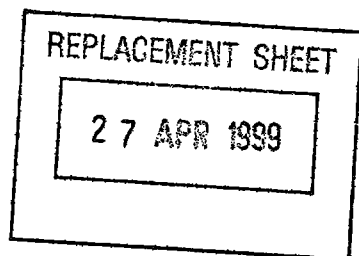
Compound (Example No.)	Dose x 21 (mmol/kg/day)	% Growth inhibition	Fecal observation *
<u>Exp. 2</u>			
Vehicle			N
10	0.13	88	
	0.3	86	
	0.67	75	
	1.5	88	
	2.25	88	N
11	0.13	46	
	0.3	72	
	0.67	84	
	1.5	95	
	2.25	100	N
14	0.13	88	
	0.3	88	
	0.67	88	
	1.5	94	N
	2.25	100	N
27	0.13	26	
	0.3	72	
	0.67	84	
	1.5	94	N
	2.25	103	N
<u>Reference compound</u>			
5-FU	0.089	NE	N
	0.13	20	N
	0.2	58	L

NE: Not Effective,

* Fecal observation (N: normal feces, L: loose passage)

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The percent inhibition of tumor growth given in Table 3 above was calculated from the formula:

$$\% \text{ Inhibition} = (1 - (T - V_0) / (C - V_0)) \times 100$$

V_0 = volume of tumor before treatment was started, T = volume of the tumors from the treated group, C = volume of the tumor from the control group.

As Table 3 shows, the compounds provided in the present invention were safely administered without causing intestinal toxicity and were much more effective than 5-FU.

4. Antitumor and anticachexia activity against mouse colon 26 carcinoma

Antitumor activity of a representative compound (Example 13), of the present invention, was measured as follows. Mice (CDF₁) were subcutaneously inoculated with colon 26 carcinoma (10^6 cells) on day 0. The compound was administered daily for 7 times from day 21 when the animals became cachectic. One day after the last treatment, tumor weight gain, carcass weight gain, adipose tissue weight, concentrations of glucose and the acute phase reactant IAP (immunosuppressive acidic protein) in the serum were measured. As Table 4 shows, mice treated with vehicle were abnormal in cachexia parameters such as adipose tissue weight, serum glucose and IAP levels, whereas treatment with the compound of Example 13 suppressed tumor growth and improved cachexia.

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Table 4 Improvement of Tumor Cachexia with Fluorinated Pyrimidines in Mice Bearing Colon 26 Adenocarcinoma

Compound (Example No.)	Dose $\times 7$ (mmol/kg) (μ g/ml)	Tumor wt. change (g)	Carcass wt. change (g)	Adipose tissue wt. (mg)	Serum glucose (mg/dl)	Serum IAP
Vehicle		1.65	-1.5	11	91	1167
13	0.125	1.24	1.6*	22*	118*	1195
	0.25	0.91*	3.4*	42*	120*	1020
	0.5	0.79*	4.2*	63*	147*	805*
	1	0.006	5.6*	85*	127*	795*

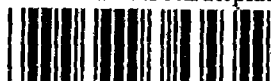
* $P < 0.05$ versus corresponding value of vehicle group

The toxicity (LD₅₀) of the representative compounds (Example 13, 14, and 17) of the present invention was examined by oral administration daily for 21 days in mice. The representative LD₅₀ values obtained from the experiments were more than 500 mg/kg/day.

A dosage per day to a patient of the N⁴-(substituted-oxycarbonyl)-5'-DFCRs of the present invention may be varied depending upon his weight and state to be remedied, but generally is in the range of 0.5 to 500 mg per 1 kg of weight, preferably about 2 to 200 mg. It should be noted that the compound of the invention can be expected to have 3-5 times higher activity than those of the compounds disclosed in USP 4,966,891 in humans, when taking into consideration of the data of C_{max} and AUC of 5'-DFUR after oral administration of the present compounds in monkeys. From the same reason, the compounds of the present invention can be expected to show sufficient activity at the 3-5 times lower dosage than those of the compounds of said U.S. Patent. The present invention can provide a pharmaceutical composition for treating tumors with high safety margin.

The following Examples are intended to illustrate the present invention in more detail, but are not intended to limit its scope in any manner.

Reference example: Preparation of starting material



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Preparation of 2',3'-di-O-acetyl-5'-deoxy-5-fluorocytidine

(a) From 5'-deoxy-5-fluorocytidine

5'-Deoxy-5-fluorocytidine (50 mg) was dissolved in dry pyridine (1.3 ml). To the solution was added acetic anhydride (39 ml) with stirring at 0°C. The reaction mixture was stirred for 3 hours at 0°C. After removal of the solvent under reduced pressure, the residue was partitioned between ethyl acetate and ice cooled water. The ethyl acetate layer was dried over magnesium sulfate and concentrated under reduced pressure. The residue was purified by silica gel column chromatography (dichloromethane/methanol=9/1 as an eluent) followed by recrystallization from isopropanol to give 37 mg of 2',3'-di-O-acetyl-5'-deoxy-5-fluorocytidine : 191.5-193°C, FAB-MS m/z 330 (MH^+).

(b) From 5-fluorocytosine and 1,2,3-tri-O-acetyl-5-deoxy- β -D-ribofuranose

A solution of sodium iodide (3.6 g) and chlorotrimethylsilane (794 ml) in dry acetonitrile (15 ml) was stirred with molecular sieves 4A (200 mg) at 0°C for 5 min (colorless sodium chloride deposited during stirring). 1,2,3-Tri-O-acetyl-5-deoxy- β -D-ribofuranose (2.0 g) was added and the mixture was stirred at 0°C for 30 min. Then, a solution of the trimethylsilylated 5-fluorocytosine, freshly prepared from 5-fluorocytosine (1.12 g), in dry acetonitrile (5 ml) was added at 0°C and stirring was continued for 3 h at room temperature. The mixture was filtered, the filtrate was concentrated in vacuo, and the residue was partitioned between dichloromethane and saturated aq. sodium bicarbonate solution. The aqueous layer was extracted with $CH_2Cl_2/MeOH$ (10:1). The combined organic layers were dried over anhydrous sodium sulfate and evaporated under reduced pressure. The residue was purified by silica gel chromatography using $CH_2Cl_2/MeOH$ (15:1) as an eluent, followed by recrystallization from isopropanol to give 1.24 g of 2',3'-di-O-acetyl-5'-deoxy-5-fluorocytidine.

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Example 1Preparation of 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)-cytidine

To a solution of 2',3'-di-O-acetyl-5'-deoxy-5-fluorocytidine (2 g) in CH₂Cl₂ (15 ml) and dry pyridine (983 ml) was added dropwise n-propyl chloroformate (957 ml) with stirring and cooling on ice bath. After stirring for 30 min at room temperature, the mixture was evaporated to dryness under reduced pressure. The residue was partitioned between ether and saturated aqueous solution of sodium bicarbonate. The organic layer was washed with brine, dried over anhydrous sodium sulfate and filtered.

The filtrate was evaporated to give 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine (2.5 g): EI-MS m/z 415(M⁺); ¹H-NMR(d₆-DMSO) δ 0.92 (3H, t, J=7.3 Hz), 1.37 (3H, d, J=6.3 Hz), 1.63 (2H, sex, J=7.3 Hz), 4.06-4.14 (3H, m), 5.11 (1H, t, J=6.3 Hz), 5.47 (1H, d.d., J=4.6 & 6.3 Hz), 5.81 (1H, d, J=4.6 Hz), 8.31 (1H, br. s), 10.63 (1H, br. s)

The following compounds were obtained according to a manner analogous to that of Example 1 (R¹ and R² are the same with those in the general formula (I)). The compound of Example 9 was prepared from the known 2',3'-di-O-benzoyl-5'-deoxy-5-fluorocytidine (USP 4,966,891) by the similar manner to that of Example 1.



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Example No.	R ¹	R ²	¹ H-NMR (in solvent 1 or 2)	FAB-MS (m/z)
2	n-butyl	acetyl	$\delta(1)$: 0.87 (3H, t, J=7.3Hz), 1.36 (5H, m), 1.59 (2H, m), 2.05 (3H, s), 2.07 (3H, s), 4.12 (3H, m), 5.11 (1H, br.t), 5.47 (1H, br.t), 5.81 (1H, d, J=4.3Hz), 8.34 (1H, br.s), 10.60 (1H, br.s)	430 (M11 ⁺)
3	n-pentyl	acetyl	$\delta(1)$: 0.88 (3H, t, J=7.3Hz), 1.31 (5H, m), 1.36 (3H, d, J=6.3Hz), 1.61 (1H, m), 2.06 (3H, s), 2.07 (3H, s), 4.07-4.14 (3H, m), 5.11 (1H, t, J=6.3Hz), 5.47 (1H, d.d, J=6.3 & 4.6Hz), 5.80 (1H, d, J=4.6Hz), 8.28 (1H, br.s), 10.63 (1H, br.s)	444 (M11 ⁺)
4	n-hexyl	acetyl	$\delta(1)$: 0.87 (3H, t, J=6.9Hz), 1.30 (6H, m), 1.36 (3H, d, J=6.3Hz), 1.59 (2H, m), 2.06 (3H, s), 2.07 (3H, s), 4.07-4.14 (3H, m), 5.11 (1H, t, J=6.3Hz), 5.45 (1H, d.d, J=6.3 & 4.6Hz), 5.80 (1H, d, J=4.6Hz), 8.28 (1H, br.s), 10.63 (1H, br.s)	458 (M11 ⁺)
5	isopentyl	acetyl	$\delta(1)$: 0.90 (6H, d, J=6.9Hz), 1.36 (3H, d, J=6.3Hz), 1.51 (2H, q, J=6.9Hz), 1.68 (1H, m), 2.06 (3H, s), 2.07 (3H, s), 4.09-4.20 (3H, m), 5.11 (1H, t, J=6.3Hz), 5.46 (1H, d.d, J=6.3 & 4.3Hz), 5.80 (1H, d, J=4.3Hz), 8.28 (1H, br.s), 10.63 (1H, br.s)	444 (M11 ⁺)

NMR: solvent 1 = d₆-DMSO, Solvent 2 = CDCl₃

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Example No.	R ¹	R ²	¹ H-NMR (in solvent 1 or 2)	FAB-MS (m/z)
6	2-ethylbutyl	acetyl	δ(1): 0.87 (6H, t, J=7.3Hz), 1.23~1.45(7H, m), 1.51 (1H, m), 2.06 (3H, s), 2.07 (3H, s), 4.04 (2H, br. d), 4.12 (1H, t, J=6.3Hz), 5.11 (1H, t, J=6.3Hz), 5.46 (1H, d, J=6.3 & 4.6Hz), 5.81 (d, J=4.6Hz), 8.32 (1H, br. s), 10.61 (1H, br. s)	458 (M11')
7	cyclohexyl- methyl	acetyl	δ(1): 1.00 (2H, m), 1.11~1.29 (4H, m), 1.36 (3H, d, J=6.3Hz), 1.57~1.77 (5H, m), 2.06 (3H, s), 2.07 (3H, s), 3.92 (2H, br. s), 4.12 (1H, m), 5.11 (1H, t, J=6.3Hz), 5.46 (1H, d, J=6.3 & 4.0Hz), 5.81 (1H, d, J=4.0Hz), 8.33 (1H, br. s), 10.61 (1H, br. s)	470 (M11')
8	phenethyl	acetyl	δ(1): 1.36 (3H, d, J=6.3Hz), 2.06 (3H, s), 2.07 (3H, s), 2.94 (2H, t, J=6.8Hz), 4.12 (1H, m), 4.32 (2H, br. t), 5.11 (1H, t, J=6.3Hz), 5.46 (1H, d, J=6.3 & 4.3Hz), 5.81 (1H, d, J=4.3Hz), 7.16~7.37 (5H, m), 8.32 (1H, br. s), 10.67 (1H, br. s)	478 (M11')
9	n-butyl	benzoyl	δ(2): 0.95 (3H, t, J=7.3Hz), 1.42 (2H, m), 1.58 (3H, d, J=6.3Hz), 1.68 (2H, m), 4.16 (2H, br. s), 4.52 (1H, d, J=5.8 & 6.3Hz), 5.40 (1H, t, J=5.8Hz), 5.65 (1H, d, J=4.6 & 5.8Hz), 6.16 (1H, d, J=4.6Hz), 7.35~7.98 (11H, m), 11.9 (1H, br. s)	554 (M11')

NMR: solvent 1 = d₆-DMSO, Solvent 2 = CDCl₃

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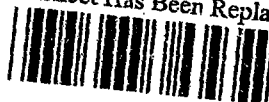
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Example 10Preparation of 5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine

To a solution of 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine (2.5 g) in CH₂Cl₂ (17 ml) was added dropwise 1N NaOH (17 ml) with stirring and cooling with ice bath. After stirring for 1 hr at 0°C, MeOH (0.9 ml) was added to the mixture. And pH of the reaction mixture was adjusted to 6 by the addition of concentrated HCl and partitioned. The aqueous layer was extracted with a mixed solvent of CH₂Cl₂/MeOH(95/5) successively (40-ml x 10). The combined organic layers were dried over anhydrous sodium sulfate and filtered. The solution was evaporated, and the residue was crystallized from ethyl acetate to give 5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine as colorless crystals (1.6 g, y. 79.8%) : mp. 125-126.5° C; EI-MS m/z 331 (M⁺).

The following compounds were obtained according to a manner analogous to that of Example 10 (R¹ and R² are the same with those in the general formula (I)).

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Example No.	R ¹	R ²	Melting point (°C)	Recrystallization solvent	FAB-MS m/z
11	n-butyl	H	119-120	AcOEt	346 (MH ⁺)
12	n-pentyl	H	110-121	AcOEt	EI 359 (M ⁺)
13	n-hexyl	H	114-116	AcOEt	EI 373 (M ⁺)
14	isopentyl	H	119-120	AcOEt	360 (MH ⁺)
15	2-ethylbutyl	H	amorphous*		374 (MH ⁺)
16	cyclohexyl-methyl	H	126-127	AcOEt	386 (MH ⁺)
17	phenethyl	H	144-145	AcOEt-MeOH	394 (MH ⁺)
18	allyl	H	118.5-120	AcOEt	330 (MH ⁺)

* ¹H-NMR (d₆-DMSO) of Example 15: δ 0.87 (6H, t, J=7 Hz), 1.25-1.45 (7H, m), 1.53 (1H, m), 3.68 (1H, q, J=6 Hz), 3.89 (1H, br. t, J=6 Hz), 4.02 (2H, d, J=6 Hz), 4.10 (1H, m), 5.05 (1H, d, J=6 Hz), 5.4 (1H, d, J=6 Hz), 5.67 (1H, d, J=3 Hz), 8.00 (1H, br. s), 10.55 & 11.60 (total 1H, br. s each).

Example 19

Preparation of N⁴-(cyclohexyloxycarbonyl)-5'-deoxy-5-fluorocytidine

5'-Deoxy-5-fluorocytidine (2.5 g) was dissolved in dry pyridine (20 ml). To the mixture, trimethylsilyl chloride (3.4 ml) was added dropwise at 0°C, and stirred for 30 min at room temperature. To the reaction mixture, cyclohexyl chloroformate (2.0 ml) was added in one portion at 0°C. After stirring of the mixture for 1 hour at room temperature, pyridine was evaporated under reduced pressure. The residue was then partitioned between saturated aqueous NaHCO₃ and ether. The organic layer was washed with brine, dried over anhydrous MgSO₄ and concentrated under reduced pressure. To the residue were added citric acid (2.0 g) and methanol (50 ml). The mixture was stirred at room temperature overnight. After removal of the solvent

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under reduced pressure, the residue was dissolved in $\text{CH}_2\text{Cl}_2/\text{MeOH}$ (95:5) and neutralized by aqueous NaOH . The organic layer was dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The residue was purified by silica gel chromatography using $\text{CH}_2\text{Cl}_2/\text{MeOH}$ (20:1) as an eluent, followed by recrystallization from ethyl acetate to give N^4 -(cyclohexyloxycarbonyl)-5'-deoxy-5-fluorocytidine (3.47g : 92% yield) : mp. 134-136°C, FAB-MS m/z 372 (MH^+).

The following compounds were obtained according to a manner analogous to that of Example 19 (R^1 and R^2 are the same with those in the general formula (I)).

Example No.	R^1	R^2	Melting point ($^{\circ}\text{C}$)	Recrystallization solvent	FAB-MS m/z
20	2-cyclohexyl-ethyl	H	128-129.5	AcOEt	400 (MH^+)
21	3-cyclohexyl-propyl	H	amorphous*		414 (MH^+)
22	3-phenyl-propyl	H	120-121	AcOEt	408 (MH^+)
23	2-methoxy-ethyl	H	amorphous**		348 (MH^+)
24	isobutyl	H	132-134	AcOEt	346 (MH^+)
25	2-propylethyl	H	116-118	AcOEt	402 (MH^+)
26	2-ethylhexyl	H	amorphous***		402 (MH^+)
27	n-heptyl	H	115.5-117.5	AcOEt	388 (MH^+)

* ^1H -NMR (d_6 -DMSO) of Example 21:

δ 0.78-0.93(2H, m), 1.15-1.27(6H, m), 1.31 (3H, d, $J=7$ Hz), 1.59-1.75 (7H, m), 3.68 (1H, q, $J=6$ Hz), 3.89 (1H, br. t, $J=6$ Hz), 4.01-4.14 (3H, m), 5.04 (1H, d, $J=6$ Hz), 5.40 (1H, d, $J=6$ Hz), 5.67 (1H, d, $J=2$ Hz), 8.00 (1H, br. s), 10.03 & 10.53 (total 1H, br. s each).



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** ¹H-NMR (d₆-DMSO) of Example 23:

δ 1.31 (3H, d, J=5.9 Hz), 3.23 (3H, s), 3.56 (2H, br. t), 3.69 (1H, t, J=6 Hz), 3.89 (1H, m), 4.06 (1H, m), 4.22 (2H, br. t), 5.05 (1H, d, J=6 Hz), 5.40 (1H, br. s), 5.67 (1H, d, J=3 Hz), 8.06 (1H, br. s), 10.65 (1H, br. s).

*** ¹H-NMR (d₆-DMSO) of Example 26:

δ 0.95-0.88 (6H, m), 1.27-1.38 (11H, m), 1.57 (1H, br. d, J=6 Hz), 3.68 (1H, q, J=6 Hz), 3.89-4.02 (4H, m), 5.05 (1H, br. s), 5.41 (1H, br. s), 5.67 (1H, d, J=3 Hz), 8.06 (1H, br. s), 10.52 (1H, br. s).

Example 28Preparation of 5'-deoxy-5-fluoro-N⁴-(neopentylloxycarbonyl)cytidine

5'-Deoxy-2',3'-di-O-acetyl-5-fluorocytidine (1.5 g) and dry pyridine (0.74 ml) were dissolved in dry dichloromethane (15 ml). To the mixture, toluene solution of neopentyl chloroformate (3 eq.) was added dropwise at 0°C, and stirred at room temperature for 1 hr. After the solvent was removed under reduced pressure, the residue was partitioned between ether and saturated aqueous solution of sodium carbonate. The organic layer was successively washed with water and brine, dried over anhydrous sodium sulfate and concentrated under reduced pressure to give crude 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(neopentylloxycarbonyl)cytidine as pale yellow oil. This crude product was dissolved in ethanol (15 ml) and cooled on ice-bath. Then 1N aqueous sodium hydroxide solution was added dropwise while maintaining the temperature below 15°C. After the addition was completed, the reaction mixture was neutralized with conc. hydrochloric acid at 0°C. The solution was concentrated under reduced pressure, and the concentrate was partitioned between water and a mixed solution of CH₂Cl₂/MeOH (95:5). The aqueous layer was back-extracted with CH₂Cl₂/MeOH (95:5) ten times (20 ml each). All organic layers were combined, dried over anhydrous sodium sulfate and concentrated under reduced pressure. The residue was purified by silica gel column chromatography using CH₂Cl₂/MeOH (20:1) as an eluent to give 5'-deoxy-5-fluoro-N⁴-(neopentylloxycarbonyl)cytidine (1.37 g; 84% yield) as amorphous powder: FAB-MS m/z 360 (MH⁺); ¹H-NMR (d₆-DMSO) δ 0.93 (9H, s), 1.31 (3H, d, J=6.3 Hz), 3.68 (1H, q, J=5.9 Hz), 3.81 (2H, br. s), 3.87-3.92 (1H, m), 4.04-4.09 (1H, m), 5.05 (1H, d, J=5.9 Hz), 5.41 (1H, br. d, J=5.3 Hz), 5.67 (1H, dd, J=1.3, 3.6 Hz), 8.04 (1H, br. s), 10.53 (-1H, br. s).



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Example 295'-Deoxy-N⁴-[(3,3-dimethylbutoxycarbonyl)-5-fluorocytidine

was obtained according to a manner analogous to that of Example 28 except that 3,3-dimethylbutyl chloroformate was used as the acylating agent: amorphous powder (71% yield); FAB-MS m/z 374 (MH⁺); ¹H-NMR (d₆-DMSO) δ 0.93 (9H, s), 1.31 (3H, d, J=6.3Hz), 1.55 (2H, t, J=7.3Hz), 3.68 (1H, q, J=5.9Hz), 3.84-3.93 (1H, m), 4.03-4.09 (1H, m), 4.15 (2H, t, J=7.3Hz), 5.05 (1H, d, J=5.9Hz), 5.40 (1H, br, d, J=5.3Hz), 5.67 (1H, dd, J=1.3, 4.0Hz), 8.00 (1H, br, s), 10.53 (~1H, br, s).

The following examples illustrate pharmaceutical preparations containing a compound provided by the present invention.

Example A:

Interlocking gelatin capsules each containing the following ingredients were manufactured in a manner known *per se*:

N ⁴ -(Butoxycarbonyl)-5'-deoxy-5-fluorocytidine	100 mg
Corn starch	20 mg
Titanium dioxide	385 mg
Magnesium stearate	5 mg
Film	20 mg
PEG 6000	3 mg
Talc	10 mg

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Example B:

Tablets each containing the following ingredients were manufactured in a manner known *per se*:

N ⁴ -(Butoxycarbonyl)-5'-deoxy-5-fluorocytidine	100 mg
Lactose	25 mg
Corn starch	20.2 mg
Hydroxypropylmethyl cellulose	4 mg
Magnesium stearate	0.8 mg
Film	10 mg
PEG 6000	1.5 mg
Talc	4.5 mg

166 mgExample C:

Dry parenteral dosage forms were manufactured in a manner known *per se*:

- (1) A total 5 g of N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine was dissolved in 75 ml of distilled water, the solution was subjected to a bacteriological filtration, and then divided aseptically into 10 sterile vials. The solution was then freeze-dried to yield 500 mg of sterile dry solid per vial.
- (2) Clean N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine in the amount of 500 mg per vial or ampoule was sealed in the receptacle and heat-sterilized.

The above dry dosage forms were reconstituted before use by adding a suitable sterile aqueous solvent such as water for injection or isotonic sodium chloride or 5% dextrose for parenteral administration.

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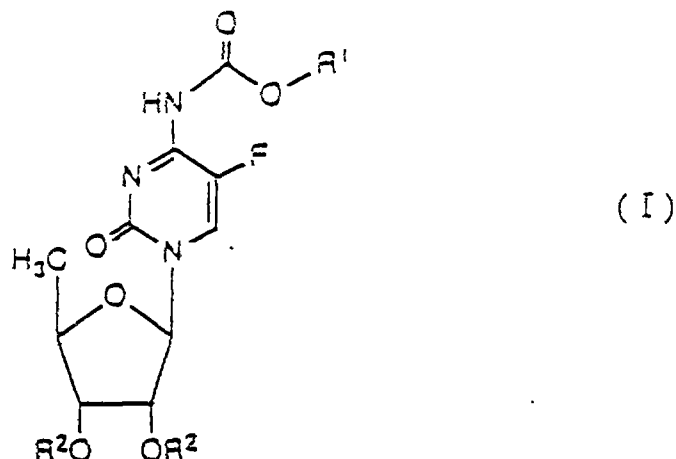
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Claims

1. Compounds represented by the general formula (I),



wherein R^1 is a saturated or unsaturated, straight or branched hydrocarbon radical [wherein the number of carbon atoms in the longest straight chain of this hydrocarbon radical ranges from three to seven], or a radical of the formula $-(CH_2)_n-Y$ [in which n is an integer from 0 to 4, when Y is a cyclohexyl radical, or n is an integer from 2 to 4, when Y is a lower alkoxy radical having 1 to 4 carbon atom(s) or a phenyl radical], and R^2 is a hydrogen atom or a radical easily hydrolyzable under physiological conditions, as well as hydrates or solvates of the compounds of the general formula (I).

2. The compounds according to claim 1, wherein R^1 is selected from the group consisting of n-propyl, 1-isopropyl-2-methylpropyl, 1,1,2-trimethylpropyl, n-butyl, isobutyl, 2-ethylbutyl, 3,3-dimethylbutyl, n-pentyl, isopentyl, neopentyl, 2-propylpentyl, n-hexyl, 2-ethylhexyl, n-heptyl, allyl, 2-buten-1-yl, 3-buten-1-yl, 3-penten-1-yl, 4-penten-1-yl, 3-hexen-1-yl, 4-hexen-1-yl, 5-hexen-1-yl, cyclohexyl, cyclohexylmethyl, 2-cyclohexylethyl, 3-cyclohexylpropyl, 4-cyclohexylbutyl, 2-methoxyethyl, 2-ethoxyethyl, 3-methoxypropyl, 3-ethoxypropyl, 4-methoxybutyl, 4-ethoxybutyl, phenethyl, 3-phenyl-propyl and 4-phenylbutyl.

3. The compounds according to claim 1, selected from a group consisting of:

5'-deoxy-5-fluoro- N^4 -(propoxycarbonyl)cytidine,
5'-deoxy-5-fluoro- N^4 -(hexyloxycarbonyl)cytidine,

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5'-deoxy-5-fluoro-N⁴-(isopentyloxycarbonyl)cytidine,
 5'-deoxy-5-fluoro-N⁴-(neopentyloxycarbonyl)cytidine,
 5'-deoxy-5-fluoro-N⁴-[(1,1,2-trimethylpropoxy)carbonyl]cytidine,
 5'-deoxy-N⁴-[(3,3-dimethylbutoxy)carbonyl]-5-fluorocytidine,
 5'-deoxy-5-fluoro-N⁴-[(1-isopropyl-2-methylpropoxy)carbonyl]cytidine,
 5'-deoxy-N⁴-[(2-ethylbutyl)oxycarbonyl]-5-fluorocytidine,
 N⁴-[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
 5'-deoxy-5-fluoro-N⁴-[(2-phenylethoxy)carbonyl]cytidine,
 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine,
 2',3'-di-O-acetyl-N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
 2',3'-di-O-benzoyl-N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(pentyloxycarbonyl)cytidine,
 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(isopentyloxycarbonyl)cytidine,
 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(hexyloxycarbonyl)cytidine,
 2',3'-di-O-acetyl-5'-deoxy-N⁴-[(2-ethylbutyl)oxycarbonyl]-5-fluorocytidine,
 2',3'-di-O-acetyl-N⁴-[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-
 fluorocytidine,
 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-[(2-phenylethoxy)-
 carbonyl]cytidine,
 5'-deoxy-5-fluoro-N⁴-(isobutoxycarbonyl)cytidine,
 5'-deoxy-5-fluoro-N⁴-[(2-propylpentyl)oxycarbonyl]cytidine,
 5'-deoxy-N⁴-[(2-ethylhexyl)oxycarbonyl]-5'-fluorocytidine,
 5'-deoxy-5-fluoro-N⁴-(heptyloxycarbonyl)cytidine,
 N⁴-[(2-cyclohexylethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
 N⁴-[(3-cyclohexylpropyl)oxycarbonyl]-5'-deoxy-5-fluorocytidine,
 N⁴-(cyclohexyloxycarbonyl)-5'-deoxy-5-fluorocytidine,
 5'-deoxy-5-fluoro-N⁴-[(3-phenylpropyl)oxycarbonyl]cytidine, and
 5'-deoxy-5-fluoro-N⁴-[(2-methoxyethoxy)carbonyl]cytidine, particularly
 N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine and
 5'-deoxy-5-fluoro-N⁴-(pentyloxycarbonyl)cytidine.

4. Compounds according to claim 1, 2 or 3 for use as therapeutically active substances, particularly for use as antitumor active substances.



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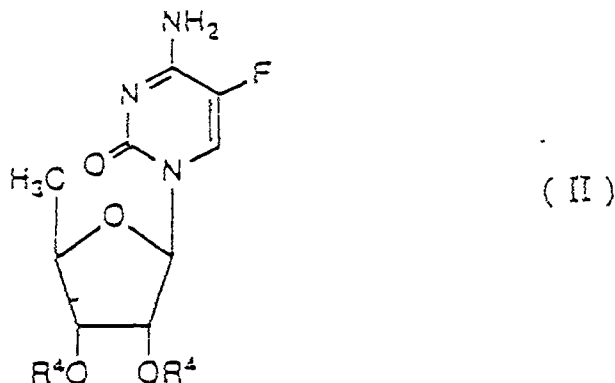
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5. A process for producing the compounds according to claim 1, 2 or 3, which comprises reacting a compound represented by the general formula (II),



wherein R^4 is a hydroxy-protecting radical,
with a compound represented by the general formula (III),



wherein R^1 is the same as defined above,
and, if necessary, removing the protecting radicals.

6. A pharmaceutical composition, particularly for the treatment of tumors characterized by containing a compound of the general formula (I), as in claim 1, or a hydrate or solvate of the compound of the general formula (I), as an active ingredient.

7. The use of the compounds of claim 1, 2 or 3 for the manufacture of an antitumor agent.



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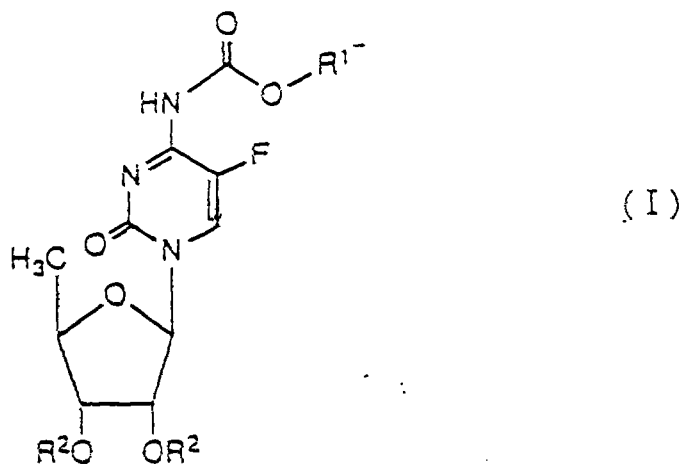
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N-OXYCARBONYL SUBSTITUTED 5'-DOEXY-5-FLUOROCYTIDINES

Abstract

Compounds represented by the general formula (I),



wherein R^1 is a saturated or unsaturated, straight or branched hydrocarbon radical [wherein the number of carbon atoms in the longest straight chain of this hydrocarbon radical ranges from three to seven], or a radical of the formula $-(CH_2)_n-Y$ [in which n is an integer from 0 to 4, when Y is a cyclohexyl radical, or n is an integer from 2 to 4, when Y is a lower alkoxy radical having 1 to 4 carbon atom(s) or a phenyl radical], and R^2 is a hydrogen atom or a radical easily hydrolyzable under physiological conditions, as well as hydrates or solvates of the compounds of the general formula (I), can be utilized in the treatment of tumors. They can be prepared by reacting a compound of formula $R^1-OCOC\text{Cl}$ with a N^4 -unsubstituted 5'-deoxy-5-fluorocytidine of the above formula I, wherein R^2 would stand for protecting groups, and if necessary removing the protecting groups.





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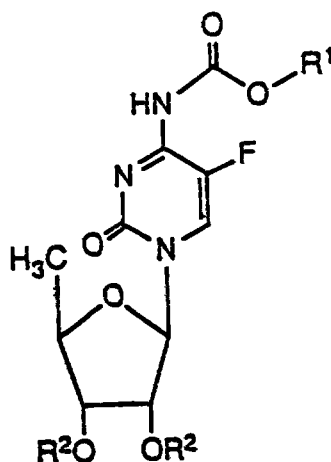
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Claims

1. Compounds represented by the general formula (I),



(I)

wherein R¹ is n-propyl, n-butyl, n-pentyl, isopentyl, neopentyl, 3,3-dimethylbutyl, n-hexyl, 2-ethylbutyl, phenylethyl, and cyclohexylmethyl; and R² is a hydrogen atom or a radical easily hydrolyzable under physiological conditions,

as well as hydrates or solvates of the compounds of the general formula (I).

2. N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine.

3. 5'-deoxy-5-fluoro-N⁴-(pentyloxycarbonyl)cytidine.

4. The compounds

5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine,
5'-deoxy-5-fluoro-N⁴-(hexyloxycarbonyl)cytidine,
5'-deoxy-5-fluoro-N⁴-(isopentyloxycarbonyl)cytidine,
5'-deoxy-5-fluoro-N⁴-(neopentyloxycarbonyl)cytidine,
5'-deoxy-N⁴-{(3,3-dimethylbutoxy)carbonyl}-5-fluorocytidine,
5'-deoxy-N⁴-{(2-ethylbutyl)oxycarbonyl}-5-fluorocytidine,
N⁴-{(cyclohexylmethoxy)carbonyl}-5'-deoxy-5-fluorocytidine,
5'-deoxy-5-fluoro-N⁴-{(2-phenylethoxy)carbonyl}cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine,
2',3'-di-O-acetyl-N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
2',3'-di-O-benzoyl-N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(pentyloxycarbonyl)cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(isopentyloxycarbonyl)cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(hexyloxycarbonyl)cytidine,
2',3'-di-O-acetyl-5'-deoxy-N⁴-{(2-ethylbutyl)oxycarbonyl}-5-fluorocytidine,
2',3'-di-O-acetyl-N⁴-{(cyclohexylmethoxy)carbonyl}-5'-deoxy-5-fluorocytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-{(2-phenylethoxy)-carbonyl}cytidine.

5. A process for producing the compounds according to claims 1-4 which comprises reacting a compound represented by the general formula (II),

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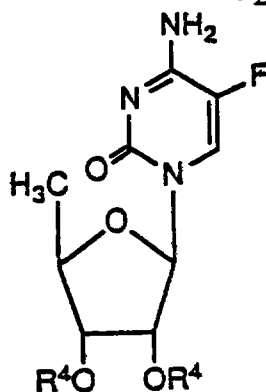


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(II)

wherein R^4 is a hydroxy-protecting radical,
with a compound represented by the general formula (III),



(III)

wherein R^1 is the same as defined above,
and, if necessary, removing the protecting radicals.

6. A pharmaceutical composition, particularly for the treatment of tumors characterized by containing a compound of the general formula (I), as in claim 1, or a hydrate or solvate of the compound of the general formula (I), as an active ingredient.
7. The use of the compounds of claims 1-4 for the manufacture of an antitumor agent.

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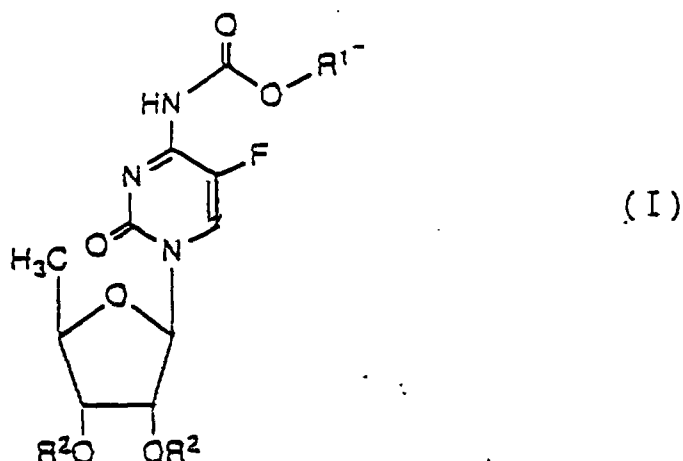


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N-OXYCARBONYL SUBSTITUTED 5'-DOEXY-5-FLUOROCYTIDINES

Abstract

Compounds represented by the general formula (I),



wherein R^1 is a saturated or unsaturated, straight or branched hydrocarbon radical [wherein the number of carbon atoms in the longest straight chain of this hydrocarbon radical ranges from three to seven], or a radical of the formula $-(CH_2)_n-Y$ [in which n is an integer from 0 to 4, when Y is a cyclohexyl radical, or n is an integer from 2 to 4, when Y is a lower alkoxy radical having 1 to 4 carbon atom(s) or a phenyl radical], and R^2 is a hydrogen atom or a radical easily hydrolyzable under physiological conditions,

as well as hydrates or solvates of the compounds of the general formula (I), can be utilized in the treatment of tumors. They can be prepared by reacting a compound of formula $R^1-OCOC(=O)Cl$ with a N^4 -unsubstituted 5'-deoxy-5-fluorocytidine of the above formula I, wherein R^2 would stand for protecting groups, and if necessary removing the protecting groups.

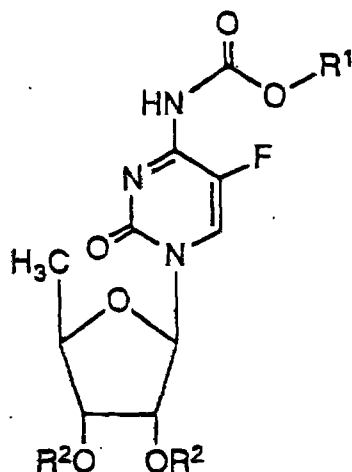
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N-OXYCARBONYL SUBSTITUTED 5'-DOEXY-5-FLUOROCYTHIDINES

The present invention relates to N⁴-(substituted-oxycarbonyl)-5'-deoxy-5-fluorocytidine derivatives, and a pharmaceutical composition containing the same for treating tumors.

More particularly, the present invention relates to N⁴-(substituted-oxycarbonyl)-5'-deoxy-5-fluorocytidine derivatives represented by the general formula (I),



(I)

wherein R¹ is n-propyl, n-butyl, n-pentyl, isopentyl, neopentyl, 3,3-dimethylbutyl, n-hexyl, 2-ethylbutyl, phenylethyl, and cyclohexylmethyl; and R² is a hydrogen atom or a radical easily hydrolyzable under physiological conditions,

as well as hydrates or solvates of the compounds of the general formula (I), and a pharmaceutical composition containing the same with excellent pharmacokinetic profiles for treating tumors with high safety margin.

It is known that many precursors of 5-fluorouracil (5-FU) are useful as antitumor agents, but in general their bioconversion efficiency is still insufficient for the treatment of patients suffering from tumors and they cause intestinal toxicities and immunosuppressive toxicities, which are their major and dose limiting toxicities.

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USP 4,966,891 discloses precursors of 5-FU which are improved in the above mentioned aspect of bioconversion efficiency and toxicities. They are converted to 5'-deoxy-5-fluorocytidine (5'-DFCR) by acylamidases, to 5'-deoxy-5-fluorouridine (5'-DFUR) by cytidine deaminase, and then to 5-FU by pyrimidine nucleotide phosphorylase in vivo which is preferentially localized in the liver, small intestine and tumor tissues. During intensive studies on the pharmacokinetic profiles of the precursors of 5-FU, particularly of N⁴-(substituted-oxycarbonyl)-5'-deoxy-5-fluorocytidine derivatives, the inventors found that certain specific precursors are selectively converted into 5'-DFCR by an acylamidase isozyme that is preferentially located at the liver but not the other organs of humans, and exhibited more improved pharmacokinetic profiles than the other compounds tested. The further studies based on the above findings enabled the inventors of the present invention to identify that the specific N⁴-(substituted-oxycarbonyl)-5'-deoxy-5-fluorocytidine derivatives (hereinafter referred to as N⁴-(substituted-oxycarbonyl)-5'-DFCR) represented by the above mentioned general formula (I) have selectively improved pharmacokinetic profiles in monkeys, viz. 4 to 7 times higher maximum concentration (C_{max}) of 5'-DFUR and 4 times larger higher area under the curve (AUC) of 5'-DFUR in blood than the other compounds, and less intestinal toxicity.

The term "a radical easily hydrolyzable under physiological condition" preferably signifies acetyl, propionyl, benzoyl, toluoyl, β -alanyl, valyl, and the like.

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Preferred N⁴-(substituted-oxycarbonyl)-5'-DFCRs of the present invention are:

5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine,
N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
5'-deoxy-5-fluoro-N⁴-(pentyloxycarbonyl)cytidine,
5'-deoxy-5-fluoro-N⁴-(hexyloxycarbonyl)cytidine,
5'-deoxy-5-fluoro-N⁴-(isopentyloxycarbonyl)cytidine,
5'-deoxy-5-fluoro-N⁴-(neopentyloxycarbonyl)cytidine,
5'-deoxy-N⁴-[(3,3-dimethylbutoxy)carbonyl]-5-fluorocytidine,
5'-deoxy-N⁴-[(2-ethylbutoxy)carbonyl]-5-fluorocytidine,
N⁴-[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
5'-deoxy-5-fluoro-N⁴-[(2-phenylethoxy)carbonyl]cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine,
2',3'-di-O-acetyl-N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
2',3'-di-O-benzoyl-N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(pentyloxycarbonyl)cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(isopentyloxycarbonyl)-cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(hexyloxycarbonyl)-cytidine,
2',3'-di-O-acetyl-5'-deoxy-N⁴-[(2-ethylbutyl)oxycarbonyl]-5-fluorocytidine,
2',3'-di-O-acetyl-N⁴-[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-[(2-phenylethoxy)-carbonyl]cytidine,
and their hydrates or solvates, and the like.

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Among the above compounds, particularly preferred N⁴-(substituted-oxycarbonyl)-5'-DFCRs of the present invention are:

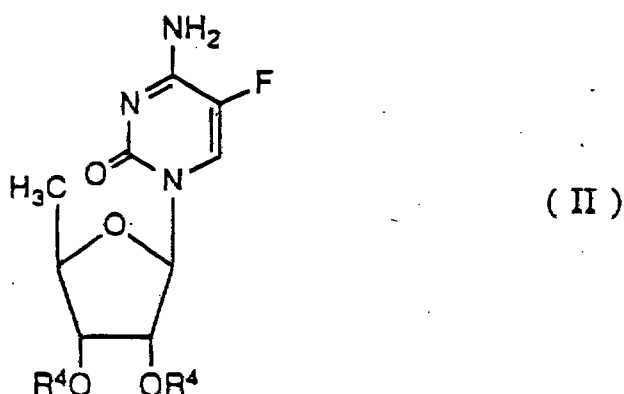
5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine,
5'-deoxy-5-fluoro-N⁴-(isopentyloxycarbonyl)cytidine,
5'-deoxy-5-fluoro-N⁴-(hexyloxycarbonyl)cytidine,
5'-deoxy-N⁴-[(2-ethylbutyl)oxycarbonyl]-5-fluorocytidine,
5'-deoxy-5-fluoro-N⁴-(neopentyloxycarbonyl)cytidine,
5'-deoxy-N⁴-[(3,3-dimethylbutoxy)carbonyl]-5-fluorocytidine,
5'-deoxy-5-fluoro-N⁴-[(2-phenylethoxy)carbonyl]cytidine,
N⁴-[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-fluorocytidine, especially

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N^4 -(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
5'-deoxy-5-fluoro- N^4 -(pentyloxycarbonyl)cytidine,
and their hydrates or solvates, and the like.

The N^4 -(substituted-oxycarbonyl)-5'-DFCRs represented by the general formula (I) as well as their hydrates or solvates can be prepared by a reaction of a compound represented by the general formula (II),



wherein R^4 is a hydroxy-protecting radical such as acetyl, benzoyl, trimethylsilyl, tert-butyldimethylsilyl, and the like,
with a compound represented by the general formula (III),



wherein R^1 is the same as defined above,
followed, if necessary, by removal of a protecting radical.

The compounds represented by the above general formula (II) can be prepared by 2',3'-di-O-acylation or silylation of 5'-deoxy-5-fluorocytidine [*J. Med. Chem.*, **22**, 1330 (1979)] as described in USP 4,966,891 or by direct coupling of 5-fluorocytosine with 1,2,3-tri-O-acetyl-5-deoxyribofuranose according to the procedure similar to that described in the literature [*Synthesis*, 748 (1981)].

The reaction of the compound of the above general formula (II) with the compound of the above general formula (III) can be carried out in a solvent such as pyridine, dioxane, tetrahydrofuran, acetonitrile, chloroform, dichloromethane and the like in the presence of acid acceptor such as triethylamine, pyridine, picoline, 4-(*N,N*-dimethylamino)pyridine, lutidine and the like. The reaction can be carried out at a temperature between 0 and

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The protecting radical may, if necessary, be removed after the reaction by the procedures known to those skilled in the art [*Protective Groups in Organic Synthesis*, John Wiley & Sons, New York, *Can. J. Chem.*, 49, 493 (1971) and USP 4,966,891], e.g. by basic or acidic hydrolysis.

The compounds of the above general formula (I) can exist as unsolvated as well as solvated forms, including hydrated forms. The hydration can be effected in the course of the manufacturing process or can occur gradually as a result of hygroscopic properties of an initially anhydrous product. Solvates with pharmaceutically acceptable solvents such as ethanol can be obtained during, for example, crystallization.

N⁴-(Substituted-oxycarbonyl)-5'-DFCR derivatives represented by the general formula (I) as well as hydrates or solvates of the compounds of the general formula (I) prepared by the present invention exhibit activity against human colon cancer CXF280 and gastric cancer GXF97 xenografts, mouse colon 26 carcinoma, mouse Lewis lung carcinoma, and the like in mice over a very wide range of dosages both orally and parenterally and are useful as antitumor agents. They are efficiently converted to 5'-DFCR by an acylamidase isozyme, to 5'-DFUR by cytidine deaminase and then to the active metabolite 5-FU by pyrimidine nucleoside phosphorylase.

The present invention further relates to a pharmaceutical composition, particularly for the treatment of tumors characterized by containing a compound of the above general formula (I).

The N⁴-(substituted-oxycarbonyl)-5'-DFCRs of the present invention can be administered orally or non-orally to human beings by various conventional administration methods. Moreover, the N⁴-(substituted-oxycarbonyl)-5'-DFCRs according to the present invention are used singly or formulated with a compatible pharmaceutical carrier material. This carrier material can be an organic or inorganic inert carrier material suitable for enteral, percutaneous or parenteral administration such as, water, gelatin, gum arabic, lactose, starch, magnesium stearate, talc, vegetable oils, polyalkylene-glycols or petroleum jelly. The pharmaceutical composition can be made up in a solid form (e.g. as tablets, dragees, enteric coating tablets, granulars, enteric coating granulars, suppositories, capsules or enteric capsules) in a semi-solid form (e.g. as salves) or in a liquid form (e.g. as solutions, suspensions or emulsions). The pharmaceutical composition may be sterilized and/or may contain further adjuvants such as preserving,

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stabilizing, setting or emulsifying agents, flavor-improving agents, salts for variation of the osmotic pressure or substances acting as buffers. The pharmaceutical composition can be prepared in a conventional manner.

The N⁴-(substituted-oxycarbonyl)-5'-DFCRs according to the present invention can be used alone or as mixtures of two or more different N⁴-(substituted-oxycarbonyl)-5'-DFCRs and the amount of the N⁴-(substituted-oxycarbonyl)-5'-DFCRs is about 0.1 to 99.5%, preferably 0.5 to 95% based on the weight of the pharmaceutical composition.

The pharmaceutical composition according to the present invention may be formulated in a combination with other conventional antitumor agent.

Susceptibility to acylamidase of the N⁴-(substituted-oxycarbonyl)-5'-DFCRs of the present invention and their pharmacokinetic profiles in the monkey are shown as follows:

1. Susceptibility to human and monkey acylamidases

The N⁴-(substituted-oxycarbonyl)-5'-DFCRs of the present invention were incubated with crude extracts of monkey and human liver in the presence of an inhibitor of cytidine deaminase, tetrahydrouridine (0.4 mM) at 37°C for 60 min. Thereafter, the product 5'-DFCR was separated by HPLC and the enzyme susceptibility was calculated from the amount of the product. As Table 1 shows, the compounds provided in the present invention were highly susceptible to the human liver acylamidase, suggesting that they are efficiently biotransformed to 5'-DFCR in human.

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Table 1. Susceptibility to monkey and human acylamidase in the liver

Compound (Example No.)	Acylamidase activity (nmol/mg protein/hr)	
	Monkey Liver	Human Liver
11	20	71
12	29	190
13	47	220
14	32	74
15	23	210
16	33	210
17	22	160
20	19	320
21	26	82
22	43	110
24	18	64
25	<13	160
26	20	560
27	59	110
28	25	52
29	22	50

2. Pharmacokinetic profiles in monkeys

The compounds of the present invention were orally administered into groups of 2 to 5 cynomolgous monkeys (3-4 kg). At various times after the administration, plasma was taken for determination of blood concentrations of intact molecules and their active metabolite 5'-DFUR.

Metabolites in the plasma were separated by HPLC and their concentrations were calculated. As Table 2 shows, the compounds of the present invention gave high levels in C_{max} and AUC of the active metabolite 5'-DFUR in the plasma. These results indicate that the compounds provided in the present invention can be effectively utilized for the treatment of various tumors in human beings.

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Table 2. Pharmacokinetic Profiles in Monkeys

Compound (Example No.)	Plasma 5'-DFUR	
	C _{max} ($\mu\text{g/ml}$)	AUC ($\mu\text{g}\cdot\text{hr}/\text{ml}$)
10	1.44	2.03
11	1.57	2.06
12	2.10	2.90
13	1.50	1.96
14	1.80	2.40
15	2.60	2.89
16	1.40	2.52
17	1.65	2.66
28	1.00	1.40
29	2.00	2.09

The antitumor activities of the compounds of the present invention are shown as follows:

3. Antitumor testing against human colon cancer xenograft CXF280

CXF280 tumor (about 2 x 2 mm piece) was implanted subcutaneously into BALB/c nu/nu mice (21 - 22 g) on day 0. When tumor volume became 100 mm³ on day around 14, the compounds of the present invention were orally administered daily for 3 weeks. At one day after the last treatment, tumor volume was calculated.

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Table 3. Antitumor Effects of Fluorinated Pyrimidines in BALB/c
nu/nu Mice Bearing CFX280 Human Colon Carcinoma

Compound (Example No.)	Dose x 21 (mmol/kg/day)	% Growth inhibition	Fecal observation *
<u>Exp. 1</u>			
Vehicle			N
12	0.13	68	
	0.3	69	
	0.67	86	
	1.0	86	
	1.5	96	N
13	0.13	59	
	0.3	66	
	0.67	79	
	1.0	91	
	1.5	94	N
24	0.13	37	
	0.3	64	
	0.67	75	
	1.0	83	
	1.5	89	N
<u>Reference compound</u>			
5-FU	0.089	28	N
	0.13	59	N
	0.2	79	L

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Compound (Example No.)	Dose x 21 (mmol/kg/day)	% Growth inhibition	Fecal observation *
<u>Exp. 2</u>			
Vehicle			N
10	0.13	39	
	0.3	56	
	0.67	75	
	1.5	86	
	2.25	93	N
11	0.13	46	
	0.3	72	
	0.67	84	
	1.5	95	
	2.25	100	N
14	0.13	68	
	0.3	68	
	0.67	85	
	1.5	94	N
	2.25	100	N
27	0.13	26	
	0.3	72	
	0.67	84	
	1.5	94	N
	2.25	103	N
<u>Reference compound</u>			
5-FU	0.089	NE	N
	0.13	20	N
	0.2	58	L

NE: Not Effective,

* Fecal observation (N; normal feces, L: loose passage)

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The percent inhibition of tumor growth given in Table 3 above was calculated from the formula:

$$\% \text{ Inhibition} = (1 - (T - V_0)/(C - V_0)) \times 100$$

V_0 = volume of tumor before treatment was started, T = volume of the tumors from the treated group, C = volume of the tumor from the control group.

As Table 3 shows, the compounds provided in the present invention were safely administered without causing intestinal toxicity and were much more effective than 5-FU.

4. Antitumor and anticachexia activity against mouse colon 26 carcinoma

Antitumor activity of a representative compound (Example 13), of the present invention, was measured as follows. Mice (CDF₁) were subcutaneously inoculated with colon 26 carcinoma (10^6 cells) on day 0. The compound was administered daily for 7 times from day 21 when the animals became cachectic. One day after the last treatment, tumor weight gain, carcass weight gain, adipose tissue weight, concentrations of glucose and the acute phase reactant IAP (immunosuppressive acidic protein) in the serum were measured. As Table 4 shows, mice treated with vehicle were abnormal in cachexia parameters such as adipose tissue weight, serum glucose and IAP levels, whereas treatment with the compound of Example 13 suppressed tumor growth and improved cachexia.

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Table 4 Improvement of Tumor Cachexia with Fluorinated Pyrimidines in Mice Bearing Colon 26 Adenocarcinoma

Compound (Example No.)	Dose x 7 (mmol/kg) (μ g/ml)	Tumor wt. change (g)	Carcass wt. change (g)	Adipose tissue wt. (mg)	Serum glucose (mg/dl)	Serum IAP
Vehicle		1.65	-1.5	11	91	1167
13	0.125	1.24	1.6*	22*	118*	1195
	0.25	0.91*	3.4*	42*	120*	1020
	0.5	0.79*	4.2*	63*	147*	805*
	1	0.006	5.6*	85*	127*	795*

* $P < 0.05$ versus corresponding value of vehicle group

The toxicity (LD₅₀) of the representative compounds (Example 13, 14, and 17) of the present invention was examined by oral administration daily for 21 days in mice. The representative LD₅₀ values obtained from the experiments were more than 500 mg/kg/day.

A dosage per day to a patient of the N⁴-(substituted-oxycarbonyl)-5'-DFCRs of the present invention may be varied depending upon his weight and state to be remedied, but generally is in the range of 0.5 to 500 mg per 1 kg of weight, preferably about 2 to 200 mg. It should be noted that the compound of the invention can be expected to have 3-5 times higher activity than those of the compounds disclosed in USP 4,966,891 in humans, when taking into consideration of the data of C_{max} and AUC of 5'-DFUR after oral administration of the present compounds in monkeys. From the same reason, the compounds of the present invention can be expected to show sufficient activity at the 3-5 times lower dosage than those of the compounds of said U.S. Patent. The present invention can provide a pharmaceutical composition for treating tumors with high safety margin.

The following Examples are intended to illustrate the present invention in more detail, but are not intended to limit its scope in any manner.

Reference example: Preparation of starting material

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Preparation of 2',3'-di-O-acetyl-5'-deoxy-5-fluorocytidine

(a) From 5'-deoxy-5-fluorocytidine

5'-Deoxy-5-fluorocytidine (50 mg) was dissolved in dry pyridine (1.3 ml). To the solution was added acetic anhydride (39 ml) with stirring at 0°C. The reaction mixture was stirred for 3 hours at 0°C. After removal of the solvent under reduced pressure, the residue was partitioned between ethyl acetate and ice cooled water. The ethyl acetate layer was dried over magnesium sulfate and concentrated under reduced pressure. The residue was purified by silica gel column chromatography (dichloromethane/methanol=9/1 as an eluent) followed by recrystallization from isopropanol to give 37 mg of 2',3'-di-O-acetyl-5'-deoxy-5-fluorocytidine : 191.5-193°C, FAB-MS m/z 330 (MH⁺).

(b) From 5-fluorocytosine and 1,2,3-tri-O-acetyl-5-deoxy-β-D-ribofuranose

A solution of sodium iodide (3.6 g) and chlorotrimethylsilane (794 ml) in dry acetonitrile (15 ml) was stirred with molecular sieves 0.4 nm (4Å) (200 mg) at 0°C for 5 min (colorless sodium chloride deposited during stirring). 1,2,3-Tri-O-acetyl-5-deoxy-β-D-ribofuranose (2.0 g) was added and the mixture was stirred at 0°C for 30 min. Then, a solution of the trimethylsilylated 5-fluorocytosine, freshly prepared from 5-fluorocytosine (1.12 g), in dry acetonitrile (5 ml) was added at 0°C and stirring was continued for 3 h at room temperature. The mixture was filtered, the filtrate was concentrated in vacuo, and the residue was partitioned between dichloromethane and saturated aq. sodium bicarbonate solution. The aqueous layer was extracted with CH₂Cl₂/MeOH (10:1). The combined organic layers were dried over anhydrous sodium sulfate and evaporated under reduced pressure. The residue was purified by silica gel chromatography using CH₂Cl₂/MeOH (15:1) as an eluent, followed by recrystallization from isopropanol to give 1.24 g of 2',3'-di-O-acetyl-5'-deoxy-5-fluorocytidine.

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Example 1Preparation of 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)-cytidine

To a solution of 2',3'-di-O-acetyl-5'-deoxy-5-fluorocytidine (2 g) in CH₂Cl₂ (15 ml) and dry pyridine (983 ml) was added dropwise n-propyl chloroformate (957 ml) with stirring and cooling on ice bath. After stirring for 30 min at room temperature, the mixture was evaporated to dryness under reduced pressure. The residue was partitioned between ether and saturated aqueous solution of sodium bicarbonate. The organic layer was washed with brine, dried over anhydrous sodium sulfate and filtered.

The filtrate was evaporated to give 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine (2.5 g) : EI-MS m/z 415(M⁺); ¹H-NMR(d₆-DMSO) δ 0.92 (3H, t, J=7.3 Hz), 1.37 (3H, d, J=6.3 Hz), 1.63 (2H, sex, J=7.3 Hz), 4.06-4.14 (3H, m), 5.11 (1H, t, J=6.3 Hz), 5.47 (1H, d.d., J=4.6 & 6.3 Hz), 5.81 (1H, d, J=4.6 Hz), 8.31 (1H, br. s), 10.63 (1H, br. s)

The following compounds were obtained according to a manner analogous to that of Example 1 (R¹ and R² are the same with those in the general formula (I)). The compound of Example 9 was prepared from the known 2',3'-di-O-benzoyl-5'-deoxy-5-fluorocytidine (USP 4,966,891) by the similar manner to that of Example 1.

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Example No.	R ¹	R ²	¹ H-NMR (in solvent 1 or 2)	FAB-MS (m/z)
2	n-butyl	acetyl	$\delta(1)$: 0.87 (3H, t, J=7.3Hz), 1.36 (5H, m), 1.59 (2H, m), 2.05 (3H, s), 2.07 (3H, s), 4.12 (3H, m), 5.11 (1H, br.t), 5.47 (1H, br.t), 5.81 (1H, d, J=4.3Hz), 8.34 (1H, br.s), 10.60 (1H, br.s)	430 (MH ⁺)
3	n-pentyl	acetyl	$\delta(1)$: 0.88 (3H, t, J=7.3Hz), 1.31 (5H, m), 1.36 (3H, d, J=6.3Hz), 1.61 (1H, m), 2.06 (3H, s), 2.07 (3H, s), 4.07-4.14 (3H, m), 5.11 (1H, t, J=6.3Hz), 5.47 (1H, d.d, J=6.3 & 4.6Hz), 5.80 (1H, d, J=4.6Hz), 8.28 (1H, br.s), 10.63 (1H, br.s)	444 (MH ⁺)
4	n-hexyl	acetyl	$\delta(1)$: 0.87 (3H, t, J=6.9Hz), 1.30 (6H, m), 1.36 (3H, d, J=6.3Hz), 1.59 (2H, m), 2.06 (3H, s), 2.07 (3H, s), 4.07-4.14 (3H, m), 5.11 (1H, t, J=6.3Hz), 5.45 (1H, d.d, J=6.3 & 4.6Hz), 5.80 (1H, d, J=4.6Hz), 8.28 (1H, br.s), 10.63 (1H, br.s)	458 (MH ⁺)
5	isopentyl	acetyl	$\delta(1)$: 0.90 (6H, d, J=6.9Hz), 1.36 (3H, d, J=6.3Hz), 1.51 (2H, q, J=6.9Hz), 1.68 (1H, m), 2.06 (3H, s), 2.07 (3H, s), 4.09-4.20 (3H, m), 5.11 (1H, t, J=6.3 Hz), 5.46 (1H, d.d, J=6.3 & 4.3Hz), 5.80 (1H, d, J=4.3Hz), 8.28 (1H, br.s), 10.63 (1H, br.s)	444 (MH ⁺)

NMR: solvent 1 = d₆-DMSO, Solvent 2 = CDCl₃

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Example No.	R ¹	R ²	¹ H-NMR (in solvent 1 or 2)	FAB-MS (m/z)
6	2-ethylbutyl	acetyl	δ(1): 0.87 (6H, t, J=7.3Hz), 1.23-1.45(7H, m), 1.51 (1H, m), 2.06 (3H, s), 2.07 (3H, s), 4.04 (2H, br. d), 4.12 (1H, t, J=6.3Hz), 5.11 (1H, t, J=6.3Hz), 5.46 (1H, d, J=6.3 & 4.6Hz), 5.81 (d, J=4.6Hz), 8.32 (1H, br.s), 10.61 (1H, br.s)	458 (MH ⁺)
7	cyclohexyl-methyl	acetyl	δ(1): 1.00 (2H, m), 1.11-1.29 (4H, m), 1.36 (3H, d, J=6.3Hz), 1.57-1.77 (5H, m), 2.06 (3H, s), 2.07 (3H, s), 3.92 (2H, br.s), 4.12 (1H, m), 5.11 (1H, t, J=6.3Hz), 5.46 (1H, d, J=6.3 & 4.0Hz), 5.81 (1H, d, J=4.0Hz), 8.33 (1H, br.s), 10.61 (1H, br.s)	470 (MH ⁺)
8	phenethyl	acetyl	δ(1): 1.36 (3H, d, J=6.3Hz), 2.06 (3H, s), 2.07 (3H, s), 2.94 (2H, t, J=6.8Hz), 4.12 (1H, m), 4.32 (2H, br. t), 5.11 (1H, t, J=6.3Hz), 5.46 (1H, d, J=6.3 & 4.3Hz), 5.81 (1H, d, J=4.3Hz), 7.16-7.37 (5H, m), 8.32 (1H, br.s), 10.67 (1H, br.s)	478 (MH ⁺)
9	n-butyl	benzoyl	δ(2): 0.95 (3H, t, J=7.3Hz), 1.42 (2H, m), 1.58 (3H, d, J=6.3Hz), 1.68 (2H, m), 4.16 (2H, br.s), 4.52 (1H, d, q, J=5.8 & 6.3Hz), 5.40 (1H, t, J=5.8Hz), 5.65 (1H, d, J=4.6 & 5.8Hz), 6.16 (1H, d, J=4.6Hz), 7.35-7.98 (11H, m), 11.9(1H, br.s)	554 (MH ⁺)

NMR: solvent 1 = d₆-DMSO, Solvent 2 = CDCl₃

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Example 10Preparation of 5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine

To a solution of 2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine (2.5 g) in CH₂Cl₂ (17 ml) was added dropwise 1N NaOH (17 ml) with stirring and cooling with ice bath. After stirring for 1 hr at 0°C, MeOH (0.9 ml) was added to the mixture. And pH of the reaction mixture was adjusted to 6 by the addition of concentrated HCl and partitioned. The aqueous layer was extracted with a mixed solvent of CH₂Cl₂/MeOH(95/5) successively (40 ml x 10). The combined organic layers were dried over anhydrous sodium sulfate and filtered. The solution was evaporated, and the residue was crystallized from ethyl acetate to give 5'-deoxy-5-fluoro-N⁴-(propoxycarbonyl)cytidine as colorless crystals (1.6 g, y. 79.8%) : mp. 125-126.5° C; EI-MS m/z 331 (M⁺).

The following compounds were obtained according to a manner analogous to that of Example 10 (R¹ and R² are the same with those in the general formula (I)).

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Example No.	R ¹	R ²	Melting point (°C)	Recrystallization solvent	FAB-MS m/z
11	n-butyl	H	119-120	AcOEt	346 (MH ⁺)
12	n-pentyl	H	110-121	AcOEt	EI 359 (M ⁺)
13	n-hexyl	H	114-116	AcOEt	EI 373 (M ⁺)
14	isopentyl	H	119-120	AcOEt	360 (MH ⁺)
15	2-ethylbutyl	H	amorphous*		374 (MH ⁺)
16	cyclohexyl-methyl	H	126-127	AcOEt	386 (MH ⁺)
17	phenethyl	H	144-145	AcOEt-MeOH	394 (MH ⁺)
18	allyl	H	118.5-120	AcOEt	330 (MH ⁺)
<i>(not according to the present invention)</i>					

* ¹H-NMR (d₆-DMSO) of Example 15: δ 0.87 (6H, t, J=7 Hz), 1.25-1.45 (7H, m), 1.53 (1H, m), 3.68 (1H, q., J=6 Hz), 3.89 (1H, br. t, J=6 Hz), 4.02 (2H, d, J=6 Hz), 4.10 (1H, m), 5.05 (1H, d, J=6 Hz), 5.4 (1H, d, J=6 Hz), 5.67 (1H, d, J=3 Hz), 8.00 (1H, br. s), 10.55 & 11.60 (total 1H, br. s each).

Example 19
(not according to the present invention)

Preparation of N⁴-(cyclohexyloxycarbonyl)-5'-deoxy-5-fluorocytidine

5'-Deoxy-5-fluorocytidine (2.5 g) was dissolved in dry pyridine (20 ml). To the mixture, trimethylsilyl chloride (3.4 ml) was added dropwise at 0°C, and stirred for 30 min at room temperature. To the reaction mixture, cyclohexyl chloroformate (2.0 ml) was added in one portion at 0°C. After stirring of the mixture for 1 hour at room temperature, pyridine was evaporated under reduced pressure. The residue was then partitioned between saturated aqueous NaHCO₃ and ether. The organic layer was washed with brine, dried over anhydrous MgSO₄ and concentrated under reduced pressure. To the residue were added citric acid (2.0 g) and methanol (50 ml). The mixture was stirred at room temperature overnight. After removal of the solvent

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under reduced pressure, the residue was dissolved in $\text{CH}_2\text{Cl}_2/\text{MeOH}$ (95:5) and neutralized by aqueous NaOH . The organic layer was dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The residue was purified by silica gel chromatography using $\text{CH}_2\text{Cl}_2/\text{MeOH}$ (20:1) as an eluent, followed by recrystallization from ethyl acetate to give N^4 -(cyclohexyloxycarbonyl)-5'-deoxy-5-fluorocytidine (3.47g : 92% yield) : mp. 134-136°C, FAB-MS m/z 372 (MH^+).

The following compounds (not according to the present invention) were obtained according to a manner analogous to that of Example 19 (R^1 and R^2 are the same with those in the general formula(I)).

Example No.	R^1	R^2	Melting point (°C)	Recrystallization solvent	FAB-MS m/z
20	2-cyclohexyl-ethyl	H	128-129.5	AcOEt	400 (MH^+)
21	3-cyclohexyl-propyl	H	amorphous*	-	414 (MH^+)
22	3-phenyl-propyl	H	120-121	AcOEt	408 (MH^+)
23	2-methoxy-ethyl	H	amorphous**	-	348 (MH^+)
24	isobutyl	H	132-134	AcOEt	346 (MH^+)
25	(2-propylethyl)	H	116-118	AcOEt	402 (MH^+)
26	2-ethylhexyl	H	amorphous***	-	402 (MH^+)
27	n-heptyl	H	115.5-117.5	AcOEt	388 (MH^+)

* ^1H -NMR (d_6 -DMSO) of Example 21:

δ 0.78-0.93(2H, m), 1.15-1.27(6H, m), 1.31 (3H, d, $J=7$ Hz), 1.59-1.75 (7H, m), 3.68 (1H, q, $J=6$ Hz), 3.89 (1H, br. t, $J=6\text{Hz}$), 4.01-4.14 (3H, m), 5.04 (1H, d, $J=6\text{Hz}$), 5.40 (1H, d, $J=6$ Hz), 5.67 (1H, d, $J=2$ Hz), 8.00 (1H, br. s), 10.03 & 10.53 (total 1H, br. s each).

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**** $^1\text{H-NMR}$ ($\text{d}_6\text{-DMSO}$) of Example 23:**

δ 1.31 (3H, d, $J=5.9$ Hz), 3.28 (3H, s), 3.56 (2H, br. t), 3.69 (1H, t, $J=6$ Hz), 3.89 (1H, m), 4.06 (1H, m), 4.22 (2H, br. t), 5.05 (1H, d, $J=6$ Hz), 5.40 (1H, br. s), 5.67 (1H, d, $J=3$ Hz), 8.06 (1H, br. s), 10.65 (1H, br. s).

***** $^1\text{H-NMR}$ ($\text{d}_6\text{-DMSO}$) of Example 26:**

δ 0.85-0.88 (6H, m), 1.27-1.38 (11H, m), 1.57 (1H, br. d, $J=6$ Hz), 3.68 (1H, q, $J=6$ Hz), 3.89-4.02 (4H, m), 5.05 (1H, br. s), 5.41 (1H, br. s), 5.67 (1H, d, $J=3$ Hz), 8.06 (1H, br. s), 10.52 (1H, br. s).

Example 28**Preparation of 5'-deoxy-5-fluoro- N^4 -(neopentyloxycarbonyl)cytidine**

5'-Deoxy-2',3'-di-O-acetyl-5-fluorocytidine (1.5 g) and dry pyridine (0.74 ml) were dissolved in dry dichloromethane (15 ml). To the mixture, toluene solution of neopentyl chloroformate (3 eq.) was added dropwise at 0°C , and stirred at room temperature for 1 hr. After the solvent was removed under reduced pressure, the residue was partitioned between ether and saturated aqueous solution of sodium carbonate. The organic layer was successively washed with water and brine, dried over anhydrous sodium sulfate and concentrated under reduced pressure to give crude 2',3'-di-O-acetyl-5'-deoxy-5-fluoro- N^4 -(neopentyloxycarbonyl)cytidine as pale yellow oil. This crude product was dissolved in ethanol (15 ml) and cooled on ice-bath. Then 1N aqueous sodium hydroxide solution was added dropwise while maintaining the temperature below 15°C . After the addition was completed, the reaction mixture was neutralized with conc. hydrochloric acid at 0°C . The solution was concentrated under reduced pressure, and the concentrate was partitioned between water and a mixed solution of $\text{CH}_2\text{Cl}_2/\text{MeOH}$ (95:5). The aqueous layer was back-extracted with $\text{CH}_2\text{Cl}_2/\text{MeOH}$ (95:5) ten times (20 ml each). All organic layers were combined, dried over anhydrous sodium sulfate and concentrated under reduced pressure. The residue was purified by silica gel column chromatography using $\text{CH}_2\text{Cl}_2/\text{MeOH}$ (20:1) as an eluent to give 5'-deoxy-5-fluoro- N^4 -(neopentyloxycarbonyl)cytidine (1.37 g; 84% yield) as amorphous powder: FAB-MS m/z 360 (MH^+); $^1\text{H-NMR}$ ($\text{d}_6\text{-DMSO}$) δ 0.93 (9H, s), 1.31 (3H, d, $J=6.3$ Hz), 3.68 (1H, q, $J=5.9$ Hz), 3.81 (2H, br. s), 3.87-3.92 (1H, m), 4.04-4.09 (1H, m), 5.05 (1H, d, $J=5.9$ Hz), 5.41 (1H, br. d, $J=5.3$ Hz), 5.67 (1H, dd, $J=1.3, 3.6$ Hz), 8.04 (1H, br. s), 10.53 (~1H, br. s).

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Example 295'-Deoxy-N⁴-[(3,3-dimethylbutoxy)carbonyl]-5-fluorocytidine

was obtained according to a manner analogous to that of Example 28 except that 3,3-dimethylbutyl chloroformate was used as the acylating agent: amorphous powder (71% yield); FAB-MS m/z 374 (MH⁺); ¹H-NMR (d₆-DMSO) δ 0.93 (9H, s), 1.31 (3H, d, J=6.3Hz), 1.55 (2H, t, J=7.3Hz), 3.68 (1H, q, J=5.9Hz), 3.84-3.93 (1H, m), 4.03-4.09 (1H, m), 4.15 (2H, t, J=7.3Hz), 5.05 (1H, d, J=5.9Hz), 5.40 (1H, br, d, J=5.3Hz), 5.67 (1H, dd, J=1.3, 4.0Hz), 8.00 (1H, br, s), 10.53 (-1H, br. s).

The following examples illustrate pharmaceutical preparations containing a compound provided by the present invention.

Example A:

Interlocking gelatin capsules each containing the following ingredients were manufactured in a manner known *per se*:

N ⁴ -(Butoxycarbonyl)-5'-deoxy-5-fluorocytidine	100 mg
Corn starch	20 mg
Titanium dioxide	385 mg
Magnesium stearate	5 mg
Film	20 mg
PEG 6000	3 mg
Talc	10 mg

543 mg

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Example B:

Tablets each containing the following ingredients were manufactured in a manner known *per se*:

N ⁴ -(Butoxycarbonyl)-5'-deoxy-5-fluorocytidine	100 mg
Lactose	25 mg
Corn starch	20.2 mg
Hydroxypropylmethyl cellulose	4 mg
Magnesium stearate	0.8 mg
Film	10 mg
PEG 6000	1.5 mg
Talc	4.5 mg

166 mgExample C:

Dry parenteral dosage forms were manufactured in a manner known *per se*:

- (1) A total 5 g of N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine was dissolved in 75 ml of distilled water, the solution was subjected to a bacteriological filtration, and then divided aseptically into 10 sterile vials. The solution was then freeze-dried to yield 500 mg of sterile dry solid per vial.
- (2) Clean N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine in the amount of 500 mg per vial or ampoule was sealed in the receptacle and heat-sterilized.

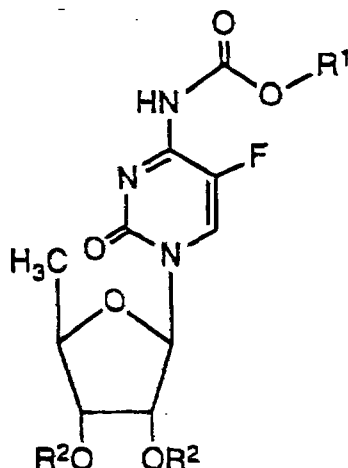
The above dry dosage forms were reconstituted before use by adding a suitable sterile aqueous solvent such as water for injection or isotonic sodium chloride or 5% dextrose for parenteral administration.



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Claims

1. Compounds represented by the general formula (I),



(I)

wherein R^1 is n-propyl, n-butyl, n-pentyl, isopentyl, neopentyl, 3,3-dimethylbutyl, n-hexyl, 2-ethylbutyl, phenylethyl, and cyclohexylmethyl; and R^2 is a hydrogen atom or a radical easily hydrolyzable under physiological conditions, as well as hydrates or solvates of the compounds of the general formula (I).

2. N^4 -(butoxycarbonyl)-5'-deoxy-5-fluorocytidine.

3. 5'-deoxy-5-fluoro- N^4 -(pentyloxycarbonyl)cytidine.

4. The compounds

5'-deoxy-5-fluoro- N^4 -(propoxycarbonyl)cytidine,

5'-deoxy-5-fluoro- N^4 -(hexyloxycarbonyl)cytidine,

5'-deoxy-5-fluoro- N^4 -(isopentyloxycarbonyl)cytidine,

5'-deoxy-5-fluoro- N^4 -(neopentyloxycarbonyl)cytidine,

5'-deoxy- N^4 -[(3,3-dimethylbutoxy)carbonyl]-5-fluorocytidine,

5'-deoxy- N^4 -[(2-ethylbutyl)oxycarbonyl]-5-fluorocytidine,

N^4 -[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,

5'-deoxy-5-fluoro- N^4 -(2-phenylethoxy)carbonyl]cytidine,

2',3'-di-O-acetyl-5'-deoxy-5-fluoro- N^4 -(propoxycarbonyl)cytidine,

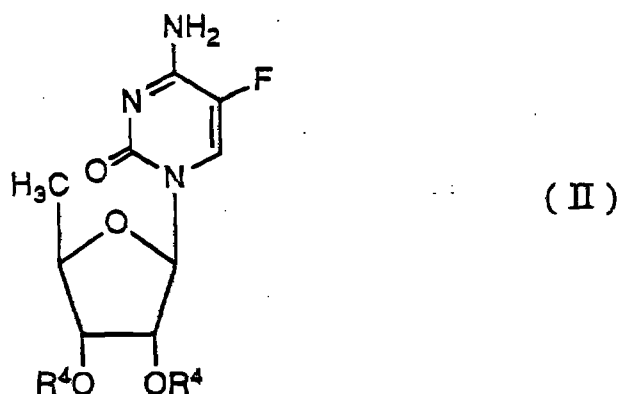
2',3'-di-O-acetyl- N^4 -(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,



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2',3'-di-O-benzoyl-N⁴-(butoxycarbonyl)-5'-deoxy-5-fluorocytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(pentyloxycarbonyl)cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(isopentyloxycarbonyl)cytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-(hexyloxycarbonyl)cytidine,
2',3'-di-O-acetyl-5'-deoxy-N⁴-[(2-ethylbutyl)oxycarbonyl]-5-fluorocytidine,
2',3'-di-O-acetyl-N⁴-[(cyclohexylmethoxy)carbonyl]-5'-deoxy-5-fluorocytidine,
2',3'-di-O-acetyl-5'-deoxy-5-fluoro-N⁴-[(2-phenylethoxy)-carbonyl]cytidine.

5. A process for producing the compounds according to claims 1-4 which comprises reacting a compound represented by the general formula (II),



wherein R⁴ is a hydroxy-protecting radical,
with a compound represented by the general formula (III),
$$R^1OCOCI \quad (III)$$

wherein R¹ is the same as defined above,
and, if necessary, removing the protecting radicals.

6. A pharmaceutical composition, particularly for the treatment of tumors characterized by containing a compound of the general formula (I), as in claim 1, or a hydrate or solvate of the compound of the general formula (I), as an active ingredient.

7. The use of the compounds of claims 1-4 for the manufacture of an antitumor agent.