(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 253 640 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
30.07.2014 Bulletin 2014/31

(21) Application number: **09710413.7**

(22) Date of filing: **13.02.2009**

(51) Int Cl.:
C07H 19/073 *(2006.01)* ***C07H 21/04*** *(2006.01)*

(86) International application number:
PCT/JP2009/000562

(87) International publication number:
WO 2009/101810 (20.08.2009 Gazette 2009/34)

(54) **PHOTORESPONSIVE NUCLEIC ACID MANUFACTURING METHOD**

VERFAHREN ZUR HERSTELLUNG EINER FOTOREAKTIVEN NUKLEINSÄURE

PROCÉDÉ DE FABRICATION D'UN ACIDE NUCLÉIQUE PHOTORÉACTIF

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK TR

(30) Priority: **14.02.2008 JP 2008033713**

(43) Date of publication of application:
24.11.2010 Bulletin 2010/47

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Printed by Jouve, 75001 PARIS (FR)

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Description

Technical Field

[0001] The present invention relates to a method of manufacturing a photoresponsive nucleic acid.

Background Art

[0002] Coupling of nucleic acids is one of the basic techniques in the field of molecular biology. The coupling of nucleic acids is used, for example, for introduction of a gene or detection of a base sequence, in combination with hybridization. For such a reason, coupling of nucleic acids is a very important technique used not only for basic studies in molecular biology but also for diagnosis or therapeutics in medical field, development or production of an agent for therapeutics or an agent for diagnosis, and development or production of an enzyme or a microorganism in the field of engineering and agriculture, for example.

[0003] In the related art, coupling of nucleic acids has been carried out by using, for example, a DNA ligase, etc. However, it is disadvantageous in that, for such reaction based on an enzymatic reaction occurring in a living body, a specific condition is required and the enzymes used are relatively expensive and not stable enough, etc. To overcome these disadvantages, a technology of coupling nucleic acids without using enzymes has been studied.

[0004] As a technology of coupling nucleic acids without using enzymes, there is a method using an organic compound reactive to a nucleic acid. In recent years, a technique of coupling nucleic acids based on photoreaction has been drawing attention due to the advantages that temporal and spatial control of the reaction is freely achievable and the reaction can be carried out under a mild condition compared to general organic chemistry, etc.

[0005] As for such a technique for photocoupling, a photocoupling technique using 5-cyanovinyldeoxyuridine and its derivatives (photocoupling nucleic acids or photoresponsive nucleic acids) is known (Patent Document 1: Japanese Patent No. 3753938 and Patent Document 2: Japanese Patent No. 3753942).

[0006] Although these photoresponsive nucleic acids have excellent characteristics, their synthesis is not easy, a long reaction time like several hours to several days is required to obtain a target compound in sufficient amount. In addition, as it is accompanied by a side reaction, yield is not high, i.e., it is only 50% to 60%.

Patent Document 1: Japanese Patent No. 3753938
Patent Document 2: Japanese Patent No. 3753942

Disclosure of the Invention

Problems to be Solved by the Invention

[0007] As described above, the compounds known as photoresponsive (photocoupling) nucleic acids including 5-cyanovinyldeoxyuridine and its derivatives cannot be easily synthesized, have required a long reaction time, and are produced with low yield.

[0008] For such reasons, there has been longed for a method of manufacturing a compound known as photoresponsive (photocoupling) nucleic acids by which the compound can be obtained with high yield within a short period of time compared to the conventional technology.

[0009] Under the circumstances, an object of the present invention is to provide a method of manufacturing a compound known as photoresponsive (photocoupling) nucleic acids in a simple way within a short period of time with high yield compared to the conventional technology.

[0010] In addition, to obtain conventionally a photoresponsive (photocoupling) nucleic acid compound as a derivative in which part of the base in oligodeoxyribonucleotide (ODN) is modified, for example, it has to be prepared by using a DNA synthesizer, etc., starting from a modified nucleoside including base moieties that are modified in advance and undergoing the form of a phosphoroamidite. Specifically, according to the conventional technology, when it is desired to produce photoresponsive nucleic acids having a differently modified base from an oligodeoxyribonucleotide having an identical base sequence, a method of preparing photoresponsive nucleic acids by which an oligodeoxyribonucleotide having a desired base sequence is prepared first and then a desired modification is carried out for the target base to obtain desired photoresponsive nucleic acids (i.e., post-synthetic method) cannot be employed. If it is desired to obtain photoresponsive nucleic acids having a differently modified base, it is necessary to start from a modified nucleoside having base moieties that are modified in advance and, after undergoing the form of a phosphoroamidite, the entire oligodeoxyribonucleotide should be synthesized therefrom each time.

[0011] For such reasons, a method of preparing photoresponsive nucleic acids by which an oligodeoxyribonucleotide having a desired base sequence is prepared and a desired modification is carried out for the target base whenever it is

desired (i.e., post-synthetic method) has been needed.

[0012] Thus, the another object of the present invention is to provide a method of producing a compound known as photoresponsive (photocoupling) nucleic acids by which an oligodeoxyribonucleotide having a desired base sequence is prepared and then a desired modification is carried out for the target base whenever it is desired to obtain the desired photoresponsive nucleic acids.

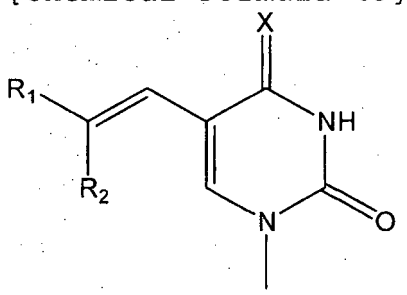
Means for Solving the Problems

[0013] As a result of extensive studies regarding a method of manufacturing a photoresponsive nucleic acid, inventors of the present invention found that the objects described above can be accomplished by the manufacturing method described below, and therefore completed the invention.

[0014] Accordingly, the present invention is directed to the following [1] to [13].

[1] A method of manufacturing a nucleic acid having a group represented by the following Formula XI:

[Chemical Formula 49]

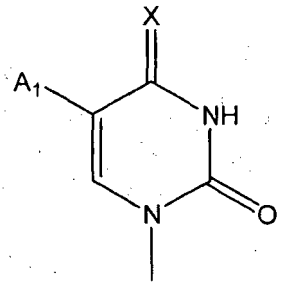


(XI)

(in the Formula XI, X represents O, S or NH,
R1 represents a hydrogen atom, a cyano group, a carboxamide group, an alkoxycarbonyl group, or a monovalent group of a substituted or unsubstituted aromatic compound, and
R2 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group.),
wherein the method comprises the following step (a):

(a) a nucleic acid having the Formula I as a base moiety:

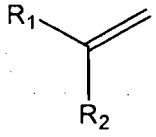
[Chemical Formula 40]



(I)

(in the Formula I, X represents O, S or NH, and
A1 represents a halogen atom.)
is reacted with the compound that is represented by the following Formula II

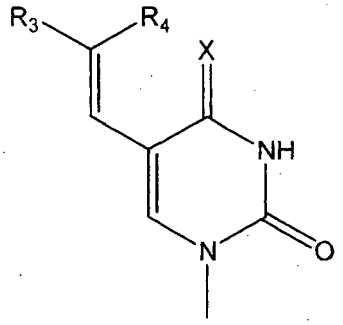
[Chemical Formula 44]



(II)

(in the Formula II, R1 represents a hydrogen atom, a cyano group, a carboxamide group, an alkoxycarbonyl group, or a monovalent group of a substituted or unsubstituted aromatic compound, and
R2 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group.)
in the presence of a palladium complex catalyst, a basic substance and a solvent by microwave heating; or
a method of manufacturing a nucleic acid having a group represented by the following Formula XV:

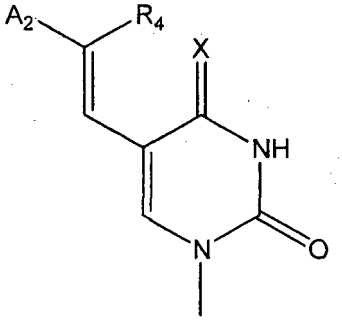
[Chemical Formula 53]



(XV)

(in the Formula XV, X represents O, S or NH,
R4 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group, and
R3 represents a monovalent group of a substituted or unsubstituted aromatic compound, a hydrogen atom, a cyano group, a carboxamide group or an alkoxycarbonyl group.), wherein the method comprises the following step (b):
(b) a nucleic acid having the Formula VI as a base moiety:

[Chemical Formula 45]



(VI)

(in the Formula VI, X represents O, S or NH,
R4 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group, and
A2 represents a halogen atom.)
is reacted with the compound that is represented by the following Formula VII:

$$R^3\text{-}B(OH)_2 \qquad \text{(VII)}$$

(in the Formula VII, R3 represents a monovalent group of a substituted or unsubstituted aromatic compound, a hydrogen atom, a cyano group, a carboxamide group or an alkoxycarbonyl group.)
in the presence of a palladium complex catalyst, a basic substance and a solvent by microwave heating.
[2] The method according to [1], comprising the step (a).
[3] The method according to [1], comprising the step (b).
[4] The method according to [1] or [2], wherein the step (a) is carried out by heating by microwaves in the presence of a palladium complex catalyst, a basic substance, a solvent, and an aqueous solution of carboxylate.
[5] The method according to [1], or [3], wherein the step (b) is carried out by heating by microwaves in the presence of a palladium complex catalyst, a basic substance, a solvent, and an aqueous solution of carboxylate.
[6] The method according to any one of [1] to [5], wherein the basic substance is trialkylamine having a C1 to C6

alkyl group.

[7] The method according to [1] or [2], wherein the step (a) is carried out by heating by microwaves in the presence of a palladium complex catalyst, a solvent, and an aqueous solution of carboxylate.

[8] The method according to [1] or [3], wherein the step (b) is carried out by heating by microwaves in the presence of a palladium complex catalyst, a solvent, and an aqueous solution of carboxylate.

[9]. The method according to any one of [4] to [8], wherein the aqueous solution of carboxylate is an aqueous solution of an alkali metal salt of C1 to C3 carboxylic acid.

[10]. The method according to any one of [4] to [9], wherein the aqueous solution of carboxylate is a buffer solution having a pH range of 4.5 to 6.0.

[11]. The method according to any one of [1] to [10], wherein the heating by microwaves is carried out in the temperature range of 70 to 140°C.

[12]. The method according to any one of [1] to [11], wherein the heating by microwaves is carried out in the time range of 1 to 30 minutes.

[13] The method according to any one of [1] to [12], wherein the solvent is an aprotic polar solvent.

Effects of the Invention

[0015] According to the present invention, a compound known as photoresponsive (photocoupling) nucleic acids can be obtained with higher yield within a shorter time than that of the conventional technology. For example, regarding the synthesis of a monomer of photoresponsive nucleic acids, the reaction can be completed within several minutes compared to several hours required by the method of conventional technology. Furthermore, the yield is also increased by several tens of percent than before, and therefore manufacturing with favorable efficiency in every aspect can be carried out.

[0016] Furthermore, when obtaining conventionally a photoresponsive (photocoupling) nucleic acid compound, for example, as a derivative in which part of the base in oligodeoxyribonucleotide (ODN) is modified, it has to start from a modified nucleoside including base moieties that are modified in advance, then the modified nucleoside is rendered into the form of a phosphoroamidite. In addition, it has to be prepared by using a DNA synthesizer, etc. Specifically, when it is desired to produce photoresponsive nucleic acids having a differently modified base from an oligodeoxyribonucleotide having an identical base sequence, a method of preparing photoresponsive nucleic acids by which an oligodeoxyribonucleotide having a desired base sequence is prepared first and then a desired modification is carried out for the target base to obtain desired photoresponsive nucleic acids (i.e., post-synthetic method) cannot be employed. If it is desired to obtain photoresponsive nucleic acids having a differently modified base, it is necessary to start from a modified nucleotide having base moieties that are modified in advance and, the modified nucleotide is rendered into the form of a phosphoroamidite, and the entire oligodeoxyribonucleotide should be synthesized therefrom each time.

[0017] On the other hand, the present invention is to provide for the first time a method of providing a desired photoresponsive nucleic acids by which an oligodeoxyribonucleotide having a desired base sequence is prepared and then a desired modification is carried out for the target base whenever it is desired (i.e., post-synthetic method).

[0018] According to the post-synthetic method of the present invention, an oligomer of photoresponsive nucleic acids may be manufactured in a day, which requires a week to prepare according to the conventional synthetic method based on a phosphoroamidite method. Further, since it has very high yield, an innovative manufacturing method with favorable efficiency in every aspect is provided for the first time by the invention.

Brief Description of the Drawings

[0019]

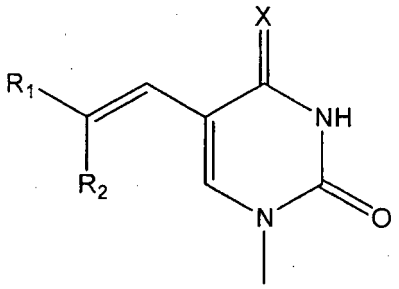
Fig. 1 is a drawing showing the structural formula of ^{CV}U.
Fig. 2 is a drawing showing the structural formula of ^{CMV}U.
Fig. 3 is a drawing showing the structural formula of ^{CNV}U.
Fig. 4 is a drawing showing the structural formula of ^{V}U.
Fig. 5 is a drawing showing the HPLC chart.
Fig. 6 is a drawing showing the HPLC chart.
Fig. 7 is a drawing showing the HPLC chart.
Fig. 8 is a drawing showing the HPLC chart.

Best Mode for carrying out the Invention

[0020] Herein below, the present invention is explained in detail in view of specific embodiments. However, the present invention is not limited to the specific embodiments that are given below as an example.

[0021] The present invention relates to a method of manufacturing a nucleic acid having a group represented by the following Formula XI:

[Chemical Formula 49]

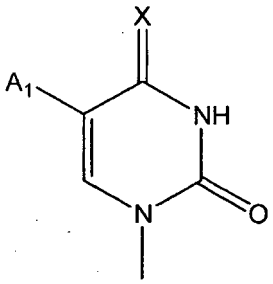


(XI)

(in the Formula XI, X represents O, S or NH,
R1 represents a hydrogen atom, a cyano group, a carboxamide group, an alkoxycarbonyl group, or a monovalent group of a substituted or unsubstituted aromatic compound, and
R2 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group.), wherein the method comprises the following step (a):

(a) a nucleic acid having the Formula I as a base moiety:

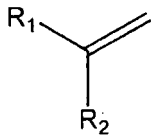
[Chemical Formula 40]



(I)

(in the Formula I, X represents O, S or NH, and
A1 represents a halogen atom.)
is reacted with the compound that is represented by the following Formula II

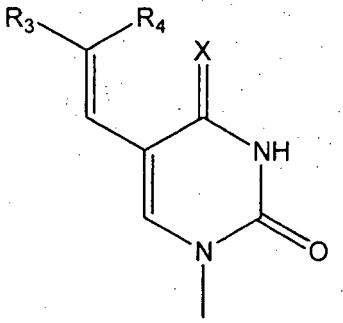
[Chemical Formula 44]



(II)

(in the Formula II, R1 represents a hydrogen atom, a cyano group, a carboxamide group, an alkoxycarbonyl group, or a monovalent group of a substituted or unsubstituted aromatic compound, and
R2 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group.)
in the presence of a palladium complex catalyst, a basic substance and a solvent by microwave heating; or
a method of manufacturing a nucleic acid having a group represented by the following Formula XV:

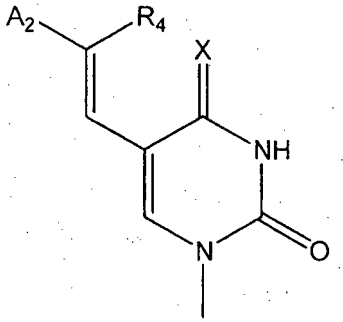
[Chemical Formula 53]



(XV)

(in the Formula XV, X represents O, S or NH,
R4 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group, and
R3 represents a monovalent group of a substituted or unsubstituted aromatic compound, a hydrogen atom, a cyano group, a carboxamide group or an alkoxycarbonyl group.),
wherein the method comprises the following step (b):
(b) a nucleic acid having the Formula VI as a base moiety:

[Chemical Formula 45]



(VI)

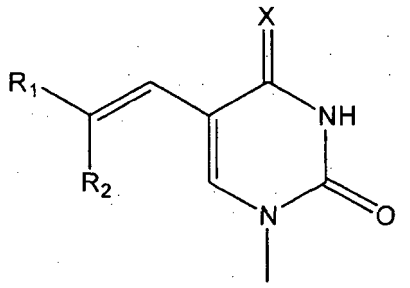
(in the Formula VI, X represents O, S or NH,
R4 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group, and
A2 represents a halogen atom.)
is reacted with the compound that is represented by the following Formula VII:

$$R_3\text{-}B(OH)_2 \qquad \text{(VII)}$$

(in the Formula VII, R3 represents a monovalent group of a substituted or unsubstituted aromatic compound, a hydrogen atom, a cyano group, a carboxamide group or an alkoxycarbonyl group.)
in the presence of a palladium complex catalyst, a basic substance and a solvent by microwave heating.

[0022] By using the method described above, the present invention provides a method of manufacturing photoresponsive nucleic acids including the following groups that are represented by Formula XI, as photoresponsive nucleic acids that are produced according to step (a):

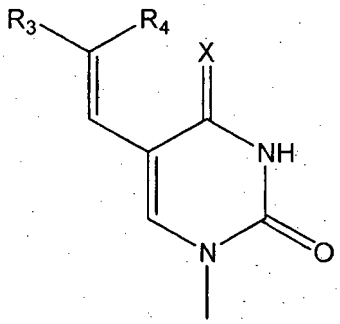
[Chemical Formula 27]



(XI)

(in Formula XI, X represents O, S or NH, R1 represents a hydrogen atom, a cyano group, a carboxamide group, an alkoxycarbonyl group, or a monovalent group of a substituted or unsubstituted aromatic compound, and R2 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group.)
(the group represented by Formula XI is produced from a reaction between the groups that are represented by Formula I and Formula II), and
a method of manufacturing photoresponsive nucleic acids including the following groups that are represented by Formula XV as photoresponsive nucleic acids that are produced according to step (b):

[Chemical Formula 31]



(XV)

(in Formula XV, X represents O, S or NH, R4 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group, and R3 represents a monovalent group of a substituted or unsubstituted aromatic compound, a hydrogen atom, a cyano group, a carboxamide group or an alkoxycarbonyl group.)
(the group represented by Formula XV is produced from a reaction between the groups that are represented by Formula VI and Formula VII).

[0023] The reaction in step (a) of the present invention is based on so-called Heck reaction (Mizoroki-Heck reaction), which enables accomplishment of dramatic time shortening and yield improvement compared to the conventional Heck reaction and also enables the post-synthesis of an oligomer of modified nucleic acids which has been impossible before.

[0024] The reaction in step (b) of the present invention is based on so-called Suzuki coupling (Suzuki-Miyaura coupling), which enables accomplishment of dramatic time shortening and yield improvement compared to conventional Suzuki coupling and also enables the post-synthesis of an oligomer of modified nucleic acids which has been impossible before.

[0025] Therefore, for the reaction of step (a) and step (b) of the present invention, conditions and the compounds (functional groups) which are conventionally used for Heck reaction and Suzuki coupling can be also used, unless specifically described otherwise in the present invention.

[0026] As for R1, any group which can be used for Heck reaction as above may be used. In the present invention, it may be generally a hydrogen atom, a cyano group, a carboxamide group, an alkoxycarbonyl group, or a monovalent group of a substituted or unsubstituted aromatic compound, and preferably a hydrogen atom, a cyano group, a carboxamide group, or a C2 to C6 alkoxycarbonyl group. As for the alkoxycarbonyl group, a C2 to C6, preferably C2 to C4 alkoxycarbonyl group may be generally used. Specific examples include a methoxycarbonyl group, an ethoxycarbonyl group, a propoxycarbonyl group and a butoxycarbonyl group. In particular, a methoxycarbonyl group and an ethoxycarbonyl group are preferred. The monovalent group of a substituted or unsubstituted aromatic compound may be a mono-

valent group of a substituted or unsubstituted heterocyclic compound.

[0027] As for R2, any group which can be used for Heck reaction as above may be used. In the present invention, it may be generally a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group, and preferably a hydrogen atom, a C1 to C3 alkyl group, a C1 to C3 alkoxy group, a cyano group or a C1 to C3 acyl group.

[0028] As for R3, any group which can be used for Suzuki coupling as above may be used. In the present invention, it may be generally a monovalent group of a substituted or unsubstituted aromatic compound, a hydrogen atom, a cyano group, a carboxamide group or an alkoxycarbonyl group, and preferably a monovalent group of a substituted or unsubstituted aromatic compound, a hydrogen atom, a cyano group, a carboxamide group, a C2 to C6 alkoxycarbonyl group. As for the alkoxycarbonyl group, a C2 to C6, preferably C2 to C4 alkoxycarbonyl group may be used. Specific examples include a methoxycarbonyl group, an ethoxycarbonyl group, a propoxycarbonyl group and a butoxycarbonyl group. In particular, a methoxycarbonyl group and ethoxycarbonyl are preferred. The monovalent group of a substituted or unsubstituted aromatic compound may be a monovalent group of a substituted or unsubstituted heterocyclic compound. With respect to R3 group for Suzuki coupling, a bulky group having a wide planar structure may be also used with high efficiency. Specifically, by introducing a group as R3 group for Suzuki coupling, a group which is larger than R1 group for Heck reaction, i.e., a group having a wide planar structure, may be appropriately introduced.

[0029] As for R4, any group which can be used for Suzuki coupling as above may be used. In the present invention, it may be generally a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group, and preferably a hydrogen atom, C1 to C3 alkyl group, a C1 to C3 alkoxy group, a cyano group or a C1 to C3 acyl group.

[0030] According to a preferred embodiment, the monovalent group of a substituted or unsubstituted aromatic compound includes generally 1 to 10, preferably 1 to 8, more preferably 1 to 6, still more preferably 1 to 4, and particularly more preferably 1 to 3 rings, and it may be the monovalent group of a substituted or unsubstituted heterocyclic compound.

[0031] According to a preferred embodiment, the monovalent group of a substituted or unsubstituted aromatic compound generally consists of a 4- to 8-membered ring, preferably a 4- to 7-membered ring, more preferably a 4- to 6-membered ring, and still more preferably 5- to 6-membered ring, and it may be the monovalent group of a substituted or unsubstituted heterocyclic compound.

[0032] According to a preferred embodiment, the monovalent group of a substituted or unsubstituted aromatic compound includes one to three 5- to 6-membered rings, and a monovalent group in which at least one ring is a heterocyclic ring is used.

[0033] According to a preferred embodiment, examples of the monovalent group of a substituted or unsubstituted aromatic compound include a monovalent group of benzene, phentalene, indene, naphthalene, azulene, heptalene, biphenylene, as-indacene, s-indacene, acenaphthylene, fluorene, phenalene, phenanthrene and anthracene.

[0034] According to a preferred embodiment, examples of the monovalent group of a substituted or unsubstituted aromatic compound include a monovalent group of furan, benzofuran, isobenzofuran, thiophene, benzothiophene, isobenzothiophene, pyrrole, benzopyrrole and isobenzopyrrole.

[0035] According to a preferred embodiment, examples of the monovalent group of a substituted or unsubstituted aromatic compound include furan-2-yl, furan-3-yl, benzofuran-2-yl, benzofuran-3-yl, isobenzofuran-1-yl, isobenzofuran-3-yl, thiophen-2-yl, thiophen-3-yl, benzothiophen-2-yl, benzothiophen-3-yl, isobenzothiophen-1-yl, isobenzothiophen-3-yl, pyrrol-2-yl, pyrrol-3-yl, benzopyrrol-2-yl, benzopyrrol-3-yl, isobenzopyrrol-1-yl, and isobenzopyrrol-3-yl. According to a preferred embodiment, examples of the monovalent group of a substituted or unsubstituted aromatic compound include furan-2-yl, benzofuran-2-yl, thiophen-2-yl, benzothiophen-2-yl, pyrrol-2-yl and benzopyrrol-2-yl.

[0036] A1 represents a halogen atom and specific examples include a fluorine atom, a chlorine atom, a bromine atom and an iodine atom. According to a preferred embodiment, examples of the halogen atom for A1 include a bromine atom and an iodine atom. Particularly preferred examples include an iodine atom.

[0037] A2 represents a halogen atom and specific examples include a fluorine atom, a chlorine atom, a bromine atom and an iodine atom. According to a preferred embodiment, examples of the halogen atom for A2 include a bromine atom and an iodine atom. Particularly preferred examples include a bromine atom.

[0038] Step (a) and step (b) are carried out by microwave heating in the presence of a palladium complex catalyst, a basic substance, and a solvent.

[0039] In the present invention, shortening of reaction time and improvement of yield are achieved simultaneously by heating by microwaves.

[0040] Heating by microwaves is generally carried out to obtain the temperature range of 70 to 140°C, preferably 75 to 125°C, more preferably 80 to 120°C, and still more preferably 80 to 110°C. The heating by microwaves is carried out at said temperature generally for the time period of 1 to 30 minutes, preferably 2 to 20 minutes, more preferably 3 to 20 minutes, and still more preferably 3 to 10 minutes. The heating by microwaves may be carried out in two or at least three divided steps. The frequency of magnetron that is used for a microwave may be any one which can provide the temperature and time described above. In general, frequency of 2.45 GHz may be used. The power of microwave may be any one

which can provide the temperature and time described above.

[0041] Examples of a palladium complex catalyst which may be suitably used include a $PdCl_4$ catalyst and $Pd(OAc)_2$ catalyst, etc.

[0042] As for the solvent, a solvent which can be used for Heck reaction and Suzuki coupling may be used. In particular, an aprotic polar solvent is preferred. Examples of an aprotic polar solvent which may be suitably used include acetone, acetonitrile, N,N-dimethylformamide (DMF) and dimethyl sulfoxide (DMSO). Preferably, DMF and DMSO may be used. These aprotic polar solvents may be used with addition of water.

[0043] As for the basic substance, a basic substance which can be used for Heck reaction and Suzuki coupling may be used. Examples of a basic substance which may be suitably used include trialkylamine. Examples of trialkylamine include trialkylamine having a C1 to C6 alkyl group, preferably trialkylamine having a C1 to C4 alkyl group, and more preferably trialkylamine having a C2 to C4 alkyl group. According to the preferred embodiment, trimethylamine, triethylamine, tripropylamine and tributylamine may be used. Preferably, triethylamine and tributylamine may be used.

[0044] According to the preferred embodiment, step (a) and step (b) are carried out by heating by microwaves in the presence of a palladium complex catalyst, a basic substance, a solvent, and a substance for activating the reaction. With heating by microwaves in the presence of a substance for activating the reaction, reaction of step (a) and step (b) may be carried out in a particularly preferable way.

[0045] As for the substance for activating the reaction which may be used for the present invention, an aqueous solution of carboxylate may be mentioned. Examples of carboxylate include C1 to C3 carboxylate, and preferably acetate may be used. Examples of the carboxylate include an alkali metal salt, preferably a sodium salt or a potassium salt, and more preferably a sodium salt may be used.

[0046] The aqueous solution of carboxylate is preferably a buffer solution having pH range of 4.5 to 6.0, and more preferably pH 5.0 to 5.5. The buffer solution may be prepared by further adding carboxylic acid to the carboxylate dissolved in water.

[0047] According to the preferred embodiment of the present invention, the aqueous solution of carboxylate may be used both as a basic substance and a substance for activating the reaction.

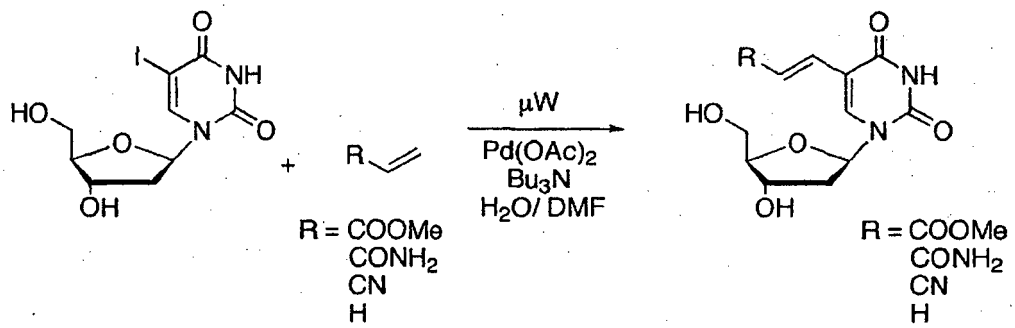
Examples

[0048] Herein below, the present invention is explained in detail in view of the Examples. However, the present invention is not limited to the Examples.

[Synthesis of a photoresponsive compound from 5-iodo-2'-deoxyuridine (^{I}U)]

[0049] Synthesis of a photoresponsive compound with high yield within a short period of time was carried out by efficient heating using microwaves. For this, multiple kinds of a substrate having a vinyl group as shown in the Scheme 1 were tested.

[Chemical Formula 35]



Scheme (1)

[Example 1] (Reference)

(1) Synthesis of 5-carbomethoxyvinyl-2'-deoxyuridine (^{CV}U)

[0050] The compound (^{CV}U) shown in Fig. 1 was synthesized according to the Scheme (1). Under nitrogen atmosphere, palladium (II) acetate (13.4 mg, 0.06 mmol) was dissolved in DMF (500 μL) and added with 5-iodo-2' -deoxyuridine (200

mg, 0.56 mmol) as powder itself to give a suspension. Furthermore, tributylamine (130 μL, 0.56 mmol) and methylacrylate (120 μL, 1.12 mmol) were also added thereto. After the addition of the reagents, the mixture was heated to 100°C by irradiation of microwaves and reacted for 4 minutes. The sample obtained after the completion of the reaction was filtered to remove palladium powder and the solvent was removed by using an evaporator. Purification was carried out by using a silica gel column. The solvent for elution was varied from $CHCl_3$:MeOH = 95:5 to 9:1 to obtain a product as a white solid (162 mg, 0.52 mmol, 92%). From the results of ^1H NMR analysis, it was identified as 5-carbomethoxyvinyl-2' -deoxyuridine (^{CV}U), i.e., the compound shown in Fig. 1.

^1H NMR (DMSO 300 MHz) δ11.6 (br. s, 1H, 3NH); 8.42 (s, 1H, H-C(6)); 7.38 (d, 1H, J=16.2 Hz, CH=CH); 6.86 (d, 1H, J=16.2 Hz, CH=CH); 6.14 (t, 1H, J=6.3, H-C(1')); 5.26 (d, 1H J= 4.2 Hz, 3'-OH); 5.17 (t, 1H, J= 5.4 Hz, 5'-OH); 4.26 (m, 1H, H-C(3')); 3.81 (dd, 1H, J= 6.6, 3.3 Hz, H-C(4')); 3.69 (s, 3H, OMe); 3.63-3.59 (m, 2H, H-C(5')); 2.21-2.16 (m, 2H, H-C(2')).

HRMS (MALDI) cald. for $C_{13}H_{17}N_2O_7$ [$(M+H)^+$]: 313.104, found: 313.333.

[Example 2] (Reference)

(2) Synthesis of 5-carbamoylvinyl-2'-deoxyuridine (^{CMV}U)

[0051] The compound (^{CMV}U) shown in Fig. 2 was synthesized according to the Scheme (1). Under nitrogen atmosphere, palladium (II) acetate (13.4 mg, 0.06 mmol) was dissolved in DMF (500 μL) and added with 5-iodo-2' -deoxyuridine (200 mg, 0.56 mmol) as powder itself to give a suspension. Furthermore, tributylamine (130 μL, 0.56 mmol) and acrylamide (100 mg, 1.40 mmol) were also added thereto. After the addition of the reagents, the mixture was heated to 100°C by irradiation of microwaves and reacted for 4 minutes. The sample obtained after the completion of the reaction was filtered to remove palladium powder and the solvent was removed by using an evaporator. The resultant was washed with the solvent of $CHCl_3$:MeOH = 1:1 to obtain a product as a white solid (141 mg, 0.48 mmol, 85%). From the results of ^1H NMR analysis, it was identified as 5-carbamoylvinyl-2'-deoxyuridine (^{CMV}U), i.e., the compound shown in Fig. 2.

^1H NMR (DMSO 300 MHz) δ11.5 (br. s, 1H, 3NH); 8.28 (s, 1H, H-C(6); 7.50 (br. s, 1H, NH_2) ; 6.91 (br. s , 1H, NH_2); 7.12 (d, 1H, J=15.6 Hz, CH=CH); 6.97 (d, 1H, J=15.6 Hz, CH=CH); 6.14 (t, 1H, J=6.3, H-C(1')); 5.25 (d, 1H, J=4.2 Hz, 3'-OH); 5.16 (t, 1H, J=5.1 Hz, 5'-0H); 4.26 (m, 1H, H-C(3')); 3.81 (m, 1H, H-C(4')); 3.66-3.59 (m, 2H, H-C(5'); 2.21-2.09 (m, 2H, H-C(2')).

HRMS (MALDI) cald. for $C_{12}H_{15}N_3O_6N_a$ [$(M+Na)^+$]: 320.086, found: 320.502.

[Example 3] (Reference)

(3) Synthesis of 5-cyanovinyl-2'-deoxyuridine (^{CNV}U)

[0052] The compound (^{CNV}U) shown in Fig. 3 was synthesized according to the Scheme (1). Under nitrogen atmosphere, palladium (II) acetate (13.4 mg, 0.06 mmol) was dissolved in DMF (500 μL) and added with 5-iodo-2' -deoxyuridine (200 mg, 0.56 mmol) as powder itself to give a suspension. Furthermore, tributylamine (130 μL, 0.56 mmol) and acrylonitrile (91 μL, 1.40 mmol) were also added thereto. After the addition of the reagents, the mixture was heated to 100°C by irradiation of microwaves and reacted for 4 minutes. The sample obtained after the completion of the reaction was filtered to remove palladium powder and the solvent was removed by using an evaporator. Purification was carried out by using a silica gel column. The solvent for elution was varied from $CHCl_3$: MeOH = 95:5 to 9:1 to obtain a product as a white solid (82 mg, 0.31 mmol, 54%). From the results of ^1H NMR analysis, it was identified as 5-carbomethoxyvinyl-2' -deoxyuridine (^{CNV}U), i.e., the compound shown in Fig. 3.

^1H NMR (DMSO 300 MHz) δ11.7 (br. s, 1H, 3NH) ; 8.35 (s, 1H, H-C(6)); 7.23 (d, 1H, J=16.2 Hz, CH=CH); 6.52 (d, 1H, J=16.2 Hz, CH=CH); 6.10 (t, 1H, J=6.0, H-C(1')); 5.27 (d, 1H, J=4.2 Hz, 3'-OH); 5.11 (t, 1H, J=5.4 Hz, 5'-OH); 4.25 (m, 1H, H-C(3')); 3.82 (dd, 1H, J=7.2, 3.6 Hz, H-C(4')); 3.68-3.57 (m,2H, H-C(5')); 2.20-2.15 (m, 2H, H-C(2')).

HRMS (MALDI) cald. for $C_{12}H_{13}N_3O_6Na$ [$(M+Na)^+$]: 302.075, found: 302.067.

[Example 4] (Reference)

(4) Synthesis of 5-vinyl-2'-deoxyuridine (^{V}U)

[0053] The compound (^{V}U) shown in Fig. 4 was synthesized according to the Scheme (1). Under nitrogen atmosphere, palladium (II) acetate (13.4 mg, 0.06 mmol) was dissolved in DMF (500 μL) and added with 5-iodo-2' -deoxyuridine (200 mg, 0.56 mmol) as powder itself to give a suspension. Furthermore, tributylamine (130 μL, 0.56 mmol) and methylacrylate (1.04 mL, 11.3 mmol) were also added thereto. After the addition of the reagents, the mixture was heated to 100°C by irradiation of microwaves and reacted for 20 minutes. The sample obtained after the completion of the reaction was

filtered to remove palladium powder and the solvent was removed by using an evaporator. Purification was carried out by using a silica gel column. The solvent for elution was varied from $CHCl_3$:MeOH = 95:5 to 9:1 to obtain a product as a white solid (80 mg, 0.31 mmol, 56%). From the results of ^1H NMR analysis, it was identified as 5-vinyl-2' -deoxyuridine (^{V}U), i.e. , the compound shown in Fig. 4.

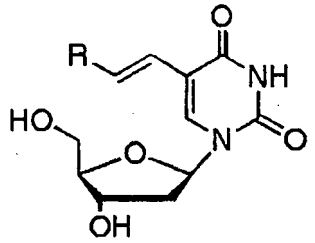
^1H NMR (DMSO 300 MHz) δ11.4 (br. s, 1H, 3NH); 8.11 (s, 1H, H-C(6)); 6.36 (dd, 1H, J=17.7, 11.5 Hz, CH=CH); 6.15 (t, 1H, J=6.3, H-C(1')); 5.82-5.78 (m, 1H, vinyl *cis*); 5.26-5.09 (m, 3H, vinyl *trans,* 3'-OH, 5'-OH); 4.25 (t, 1H, J=4.0Hz, H-C(3')) 3.79-3.78 (m, 1H, H-C(4')); 3.65-3.54 (m, 2H, H-C(5')); 2.18- 2.10 (m,2H, H-C(2')).

HRMS (MALDI) cald. for $C_{11}H_{14}N_2O_5Na$ [$(M+Na)^+$]: 277.080, found:277.066.

[Summary 1]

[0054] The yield and time for the reactions of the Examples 1 to 4 above and the yield and time for each reaction that is carried out by conventional method (i.e. , Comparative examples 1 to 4) are summarized in Table 1 below.

[Chemical Formula 36]



[Table 1]

Entry	R	Conventional method	Microwave
1	COOMe (^{CV}U)	For 120 minutes 65%	For 4 minutes 98%
2	$CONH_2$ (^{CMV}U)	-	For 4 minutes 85%
3	CN (^{CNV}U)	For 180 minutes 70%	For 4 minutes 54%
4	H (^{V}U)	For 1500 minutes 56%	For 20 minutes 56%

[0055] According to the method of the present invention, the reaction time was shortened up to 1/75 and the yield was increased by 30% compared to the conventional method. Furthermore, there are lots of side reactions in the conventional method. However, according to the present invention, the side reactions were also decreased significantly.

[Synthesis of a photoresponsive nucleic acid from oligodeoxynucleotide (ODN) having 5-iodo-2'-deoxyuridine (^{I}U)]

[0056] Post-synthesis of a photoresponsive nucleic acid from oligodeoxynucleotide (ODN) having 5-iodo-2' -deoxyuridine (^{I}U) was carried out.

[Synthesis of ODN having ^{I}U]

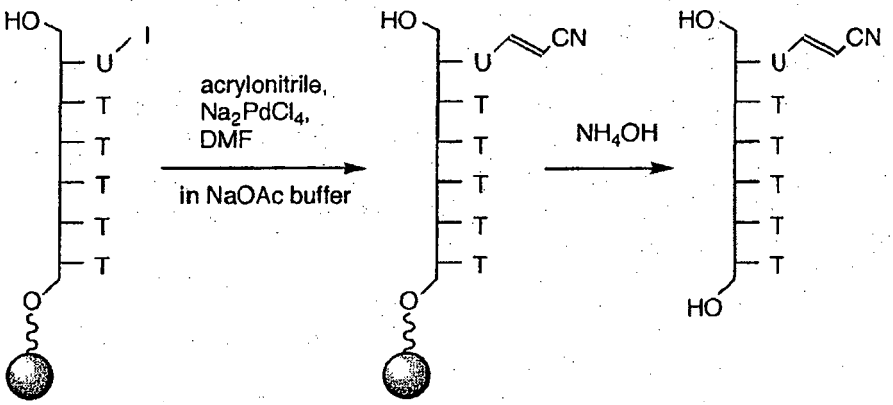
[0057] ODN1 (^{I}U) (5'-^{I}UTTTTT-3') or ODN2 (^{I}U) (5'-^{I}UGCGTGA-3') was synthesized by using ABI 3400 DNA synthesizer. Without performing separation from a support using an aqueous ammonia solution, it was obtained as CPG.

[Example 5]

[Post-synthesis of ODN having 5-cyanovinyl-2'-deoxyuridine (^{CNV}U)]

[0058] Post-synthesis of ODN having 5-cyanovinyl-2'-deoxyuridine (^{CNV}U) was carried out according to the Scheme (2).

[Chemical Formula 37]



Scheme (2)

[0059] 0.1 M sodium acetate butter solution (180 μL, pH = 5.2) was added to ODN1 (^{I}U) -CPG (2 mg, approximately 100 nmol loading), further added with DMF solution (180 μL) of acrylonitrile (12 mg, 226 μmol) and DMF solution (180 μL) of Na_2PdCl_4 (5.8 mg, 20 μmol), and then the reaction solution was heated at 80°C for 10 minutes by using microwaves. The supernatant solution was removed and washed four times with DMF (250 μL × 4). To the reaction mixture, 0. 1 M sodium acetate butter solution (180 μL, pH = 5.2) was further added, DMF solution (180 μL) of acrylonitrile (12 mg, 226 μmol) and DMF solution (180 μL) of Na_2PdCl_4 (5.8 mg, 20 μmol) were added thereto, and then the reaction solution was heated at 80°C for 10 minutes by using microwaves. The supernatant solution was removed and washed four times with DMF (250 μL × 4). By using an aqueous ammonia solution (300 μL), separation from the support was carried out by incubation at room temperature for 12 hours. After removing ammonia by using SpeedVac, the HPLC analysis was carried out (Fig. 5). HPLC conditions (elution with a solvent mixture of 50 mM ammonium formate, pH 7.0, linear gradient over 30 min from 3% to 20% acetonitrile, detection at 300 nm). Peaks derived from ODN1 (^{CNV}U) were fractionated and measured with
MALDI-TOF-MS.
calcd. for ODN1(^{CNV}U): [(M+H)$^{+}$] 1801.22, found 1801.46.

[0060] From the results of MALDI-TOF-MS analysis, successful post-synthesis of ODN was confirmed.

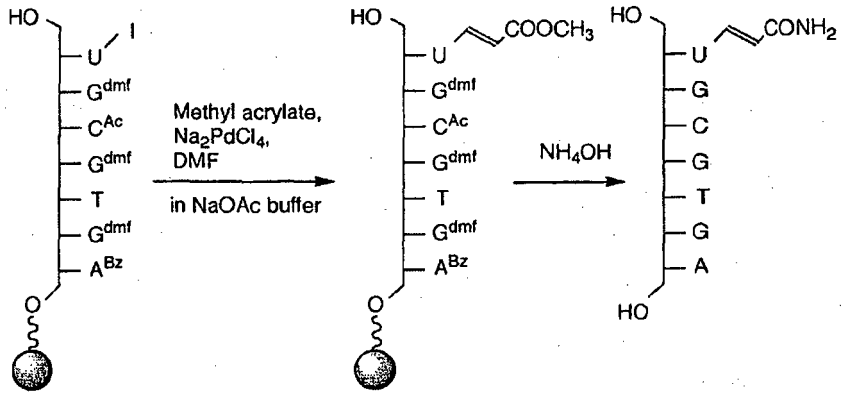
[Example 6]

[Post-synthesis of ODN having

5-carbamoylvinyl-2'-deoxyuridine (^{CV}U)]

[0061] 5-carbamoylvinyl-2'-deoxyuridine (^{CV}U) was synthesized according to the Scheme (3).

[Chemical Formula 38]



Scheme (3)

[0062] 0.1 M sodium acetate butter solution (180 μL, pH = 5.2) was added to ODN2 (^{I}U) -CPG (2 mg, approximately 100 nmol loading), further added with DMF solution (180 μL) of methylacrylate (19.5 mg, 226 μmol) and DMF, solution (180 μl) of Na_2PdCl_4 (5.8 mg, 20 μmol), and then the reaction solution was heated at 80°C for 10 minutes by using microwaves. The supernatant solution was removed and washed four times with DMF (500 μL × 4). The same procedure was repeated for the resulting reaction mixture. The supernatant solution was removed and washed four times with DMF (500 μL × 4) and four times with H_2O (500 μL × 4). With respect to the reaction mixture, separation from the support was carried out using an aqueous ammonia solution (500 μL) by incubating at 55°C for 10 hours. After removing ammonia by using SpeedVac, the HPLC analysis was carried out (Fig. 6). HPLC conditions (elution with a solvent mixture of 50 mM ammonium formate, pH 7.0, linear gradient over 30 min from 3% to 20% acetonitrile, detection at 320 nm). Peaks derived from ODN2 (^{CV}U) were fractionated and measured with MALDI-TOF-MS. calcd. for ODN2 (^{CV}U): [$(M+H)^+$] 2192.47, found 2192.51.

[0063] From the results of MALDI-TOF-MS analysis, successful post-synthesis of ODN including A, G, C or T was also confirmed.

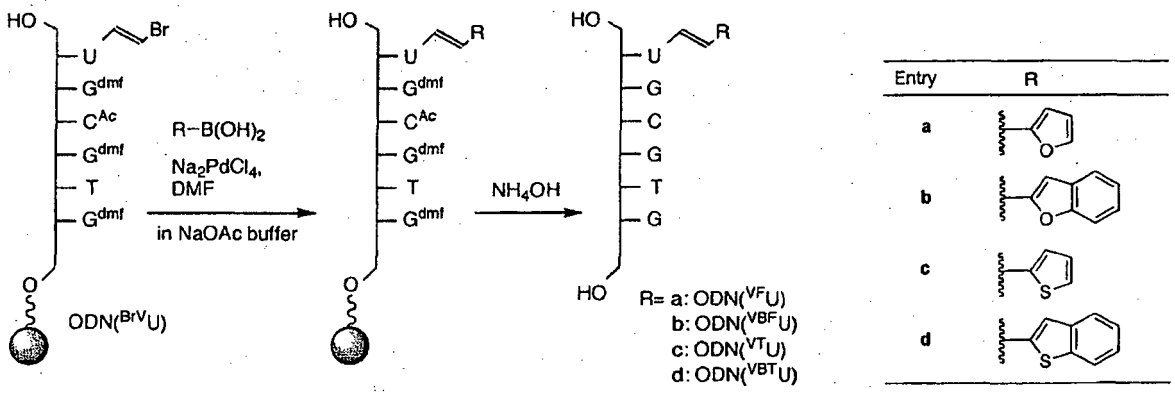
[Synthesis of a photoresponsive nucleic acid from oligodeoxynucleotide (ODN) having 5-bromovinyl-2'-deoxyuridine (^{BrV}U)]

[Example 7]

[Post-synthesis of ODN having 5-vinylfuran-2'-deoxyuridine] Post-synthesis of ODN having

[0064] 5-vinylfuran-2' -deoxyuridine was carried out according to the Scheme (4).

[Chemical Formula 39]



Scheme (4)

[0065] DMF (150 μL), 2-furan boronic acid (44.8 mg, 400 μmol), $PdCl_2(PPh_3)_2$ (14.0 mg, 20 μmol) and triethyl amine (100 μL) were added in the order to ODN (^{BrV}U)-CPG (2 mg, approximately 100 nmol loading), and then the reaction solution was heated at 100°C for 10 minutes by using microwaves. The supernatant solution was removed and washed four times with DMF (500 μL × 4) and four times with H_2O (500 μL × 4). The transparent solution and the aqueous washing solution were admixed with each other. To the CPG obtained after the reaction, an aqueous ammonia solution (500 μL) was added, and separation from the support was carried out by incubation at 65°C for 4 hours. After removing ammonia by using SpeedVac, the HPLC analysis was carried out (Fig. 7). HPLC conditions (elution with a solvent mixture of 50 mM ammonium formate, pH 7.0, linear gradient over 30 min from 3% to 20% acetonitrile, detection at 350 nm).

[0066] Mass analysis was carried out by MALDI-TOF-MS, and as a result, a data corresponding to the mass of the target compound, i.e., ODN (^{VF}U), was obtained.
calcd. for ODN(^{VF}U):[$(M+H)^+$] 1902.30, found 1902.85

[Example 8]

[Post-synthesis of ODN having

5-vinylbenzofuran-2'-deoxyuridine]

Post-synthesis of ODN having 5-vinylbenzofuran-2'-deoxyuridine was carried out.

[0067] DMF (150 μL), 2-benzofuran boronic acid (64.8 mg, 400 μmol), $PdCl_2(PPh_3)_2$ (14.0 mg, 20 μmol) and triethyl amine (100 μL) were added in this order to ODN (^{BrV}U)-CPG (2 mg, approximately 100 nmol loading), and then the reaction solution was heated at 100°C for 10 minutes by using microwaves. The supernatant solution was removed and washed four times with DMF (500 μL x 4) and four times with H_2O (500 μL × 4). The transparent solution and the aqueous washing solution were admixed with each other. To the CPG obtained after the reaction, an aqueous ammonia solution (500 μL) was added, and separation from the support was carried out by incubation at 65°C for 4 hours. After removing ammonia by using SpeedVac, the HPLC analysis was carried out (Fig. 8).

[0068] 9 corresponds to the mass analysis based on MALDI-TOF MS of ODN including ^{VBF}U as a sample in a crude state, which has been synthesized before and analyzed by HPLC. As a result, a data corresponding to the mass of the target compound, i.e., ODN (^{VBF}U), was obtained.
calcd. for ODN(^{VBF}U):[$(M+H)^+$] 1952. 36, found 1952. 05

[Example 9]

[Post-synthesis of ODN having 5-vinylthiophene-2'-deoxyuridine]

Post-synthesis of ODN having 5-vinylthiophene-2'-deoxyuridine was carried out according to the Scheme (4).

[0069] DMF (150 μL), 2-thiophen boronic acid (51.2 mg, 400 μmol), $PdCl_2(PPh_3)_2$ (14.0 mg, 20 μmol) and tri-ethyl amine (100 μL) were added in this order to ODN (^{BrV}U) -CPG (2 mg, approximately 100 nmol loading), and then the reaction solution was heated at 100°C for 10 minutes by using microwaves. The supernatant solution was removed and washed four times with DMF (500 μL × 4) and four times with H_2O (500 μL × 4). The transparent solution and the aqueous washing solution were admixed with each other. To the CPG obtained after the reaction, an aqueous ammonia solution (500 μL) was added, and separation from the support was carried out by incubation at 65°C for 4 hours. After removing ammonia by using SpeedVac, purification was carried out by HPLC.

[0070] Mass analysis was carried out based on MALDI-TOF-MS, and as a result, a data corresponding to the mass of the target compound, i.e., ODN (^{VT}U) having 5-vinylthiophen-dU, was obtained.
calcd. for ODN(^{VT}U):[$(M+H)^+$] 1916.33, found 1916.77

[Example 10]

[Post-synthesis of ODN having 5-vinylbenzothiophene-2'-deoxyuridine]

[0071] Post-synthesis of ODN having 5-vinylbenzothiophene-2'-deoxyuridine was carried out according to the Scheme (4).

[0072] DMF (150 μL), 2-tbenzothiophen boronic acid (71.2 mg, 400 μmol), $PdCl_2(PPh_3)_2$ (14.0 mg, 20 μmol) and

triethyl amine (100 μL) were added in this order to ODN (^{Brv}U)-CPG (2 mg, approximately 100 nmol loading), and then the reaction solution was heated at 100°C for 10 minutes by using microwaves. The supernatant solution was removed and washed four times with DMF (500 μL × 4) and four times with H_2O (500 μL × 4). The transparent solution and the aqueous washing solution were admixed with each other. To the CPG obtained after the reaction, an aqueous ammonia solution (500 μL) was added, and separation from the support was carried out by incubation at 65°C for 4 hours. After removing ammonia by using SpeedVac, purification was carried out by HPLC.

[0073] Mass analysis was carried out based on MALDI-TOF-MS, and as a result, a data corresponding to the mass of the target compound, i.e., ODN (^{VT}U) having 5-vinylthiophen-dU, was obtained.
calcd. for ODN (^{VBF}U): [$(M+H)^+$] 1967.34, found 1967.20

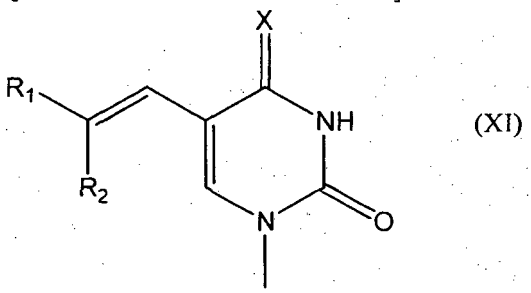
[Summary 2]

[0074] According to the post-synthetic method of the Example 5 to 10 above, various photoresponsive nucleic acids can be manufactured in a day. On the contrary, according to conventional synthesis of photoresponsive nucleic acids based on a phosphoroamidite process, as a time for synthesis, about a week or so is required for any kind of photoresponsive nucleic acids.

Claims

1. A method of manufacturing a nucleic acid having a group represented by the following Formula XI:

[Chemical Formula 49]

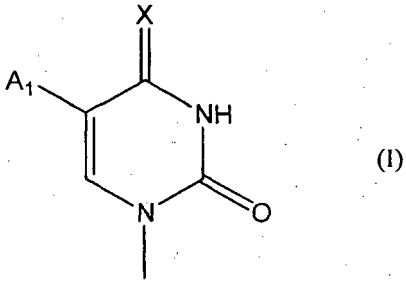


(XI)

(in the Formula XI, X represents O, S or NH,
R1 represents a hydrogen atom, a cyano group, a carboxamide group, an alkoxycarbonyl group, or a monovalent group of a substituted or unsubstituted aromatic compound, and
R2 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group.),
wherein the method comprises the following step (a):

(a) a nucleic acid having the Formula I as a base moiety:

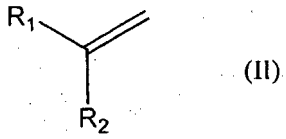
[Chemical Formula 40]



(I)

(in the Formula I, X represents O, S or NH, and
A1 represents a halogen atom.)
is reacted with the compound that is represented by the following Formula II

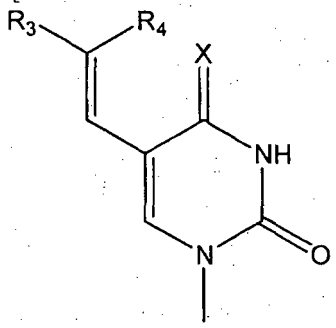
[Chemical Formula 44]



(II)

(in the Formula II, R1 represents a hydrogen atom, a cyano group, a carboxamide group, an alkoxycarbonyl group, or a monovalent group of a substituted or unsubstituted aromatic compound, and
R2 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group.)
in the presence of a palladium complex catalyst, a basic substance and a solvent by microwave heating; or
a method of manufacturing a nucleic acid having a group represented by the following Formula XV:

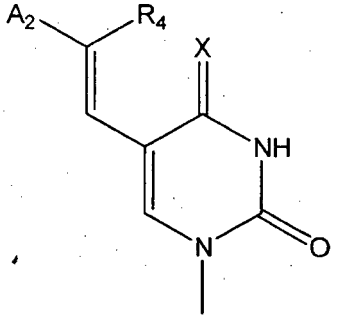
[Chemical Formula 53]



(XV)

(in the Formula XV, X represents O, S or NH,
R4 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group, and
R3 represents a monovalent group of a substituted or unsubstituted aromatic compound, a hydrogen atom, a cyano group, a carboxamide group or an alkoxycarbonyl group.),
wherein the method comprises the following step (b):
(b) a nucleic acid having the Formula VI as a base moiety:

[Chemical Formula 45]



(VI)

(in the Formula VI, X represents O, S or NH,
R4 represents a hydrogen atom, a C1 to C6 alkyl group, a C1 to C6 alkoxy group, a cyano group or a C1 to C6 acyl group, and
A2 represents a halogen atom.)
is reacted with the compound that is represented by the following Formula VII:

$$R_3\text{-}B(OH)_2 \qquad \text{(VII)}$$

(in the Formula VII, R3 represents a monovalent group of a substituted or unsubstituted aromatic compound, a hydrogen atom, a cyano group, a carboxamide group or an alkoxycarbonyl group.)

in the presence of a palladium complex catalyst, a basic substance and a solvent by microwave heating.

2. The method according to Claim 1, comprising the step (a).

3. The method according to Claim 1, comprising the step (b).

4. The method according to Claim 1 or 2, wherein the step (a) is carried out by heating by microwaves in the presence of a palladium complex catalyst, a basic substance, a solvent, and an aqueous solution of carboxylate.

5. The method according to Claim 1 or 3, wherein the step (b) is carried out by heating by microwaves in the presence of a palladium complex catalyst, a basic substance, a solvent, and an aqueous solution of carboxylate.

6. The method according to any one of Claims 1 to 5, wherein the basic substance is trialkylamine having a C1 to C6 alkyl group.

7. The method according to Claim 1 or 2, wherein the step (a) is carried out by heating by microwaves in the presence of a palladium complex catalyst, a solvent, and an aqueous solution of carboxylate.

8. The method according to Claim 1 or 3, wherein the step (b) is carried out by heating by microwaves in the presence of a palladium complex catalyst, a solvent, and an aqueous solution of carboxylate.

9. The method according to any one of Claims 4 to 8, wherein the aqueous solution of carboxylate is an aqueous solution of an alkali metal salt of C1 to C3 carboxylic acid.

10. The method according to any one of Claims 4 to 9, wherein the aqueous solution of carboxylate is a buffer solution having a pH range of 4.5 to 6.0.

11. The method according to any one of Claims 1 to 10, wherein the heating by microwaves is carried out in the temperature range of 70 to 140°C.

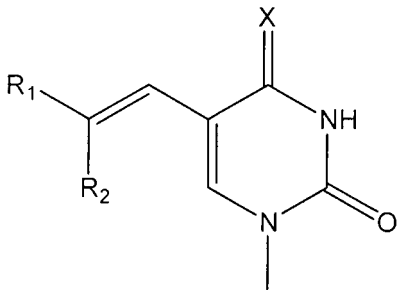
12. The method according to any one of Claims 1 to 11, wherein the heating by microwaves is carried out in the time range of 1 to 30 minutes.

13. The method according to any one of Claims 1 to 12, wherein the solvent is an aprotic polar solvent.

Patentansprüche

1. Verfahren zur Herstellung einer Nucleinsäure, die eine durch die folgende Formel XI dargestellte Gruppe hat:

[Chemische Formel 49]



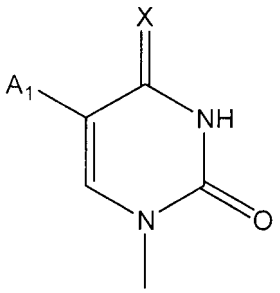
(XI)

(in der Formel XI stellt X O, S oder NH dar,
stellt R1 ein Wasserstoffatom, eine Cyanogruppe, eine Carboxamidgruppe, eine Alkoxycarbonylgruppe oder eine monovalente Gruppe einer substituierten oder unsubstituierten aromatischen Verbindung dar und
stellt R2 ein Wasserstoffatom, eine C_1-C_6-Alkylgruppe, eine C_1-C_6-Alkoxygruppe, eine Cyanogruppe oder C_1-C_6-Acylgruppe dar),

wobei das Verfahren den folgenden Schritt (a) umfasst:

(a) eine Nucleinsäure, die die Formel I als eine Basengruppierung hat:

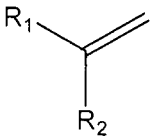
[Chemische Formel 40]



(I)

(in der Formel I stellt X O, S oder NH dar und stellt A1 ein Halogenatom dar)
wird mit der Verbindung, die durch die folgende Formel II dargestellt wird

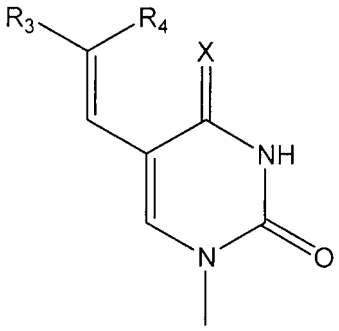
[Chemische Formel 44]



(II)

(in der Formel II stellt R1 ein Wasserstoffatom, eine Cyanogruppe, eine Carboxamidgruppe, eine Alkoxycarbonylgruppe oder eine monovalente Gruppe einer substituierten oder unsubstituierten aromatischen Verbindung dar, und stellt R2 ein Wasserstoffatom, eine C_1-C_6-Alkylgruppe, eine C_1-C_6-Alkoxygruppe, eine Cyanogruppe oder eine C_1-C_6-Acylgruppe dar)
in der Gegenwart eines Palladiumkomplex-Katalysators, einer basischen Substanz und eines Lösungsmittels durch Mikrowellenerwärmen umgesetzt; oder
ein Verfahren zur Herstellung einer Nucleinsäure, die eine durch die folgende Formel XV dargestellte Gruppe hat:

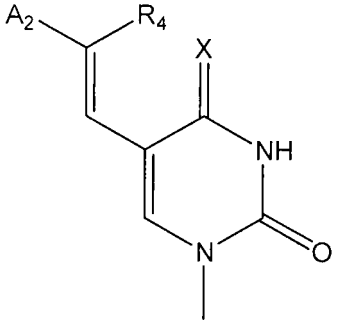
[Chemische Formel 53]



(XV)

(in der Formel XV stellt X O, S oder NH dar,
stellt R4 ein Wasserstoffatom, eine C_1-C_6-Alkylgruppe, eine C_1-C_6-Alkoxygruppe, eine Cyanogruppe oder eine C_1-C_6-Acylgruppe dar und
stellt R3 eine monovalente Gruppe einer substituierten oder unsubstituierten aromatischen Verbindung, ein Wasserstoffatom, eine Cyanogruppe, eine Carboxamidgruppe oder eine Alkoxycarbonylgruppe dar),
wobei das Verfahren den folgenden Schritt (b) umfasst:
(b) eine Nucleinsäure, die die Formel VI als eine Basengruppierung hat:

[Chemische Formel 45]



(VI)

(in der Formel VI stellt X O, S oder NH dar,
stellt R4 ein Wasserstoffatom, eine C_1-C_6-Alkylgruppe, eine C_1-C_6-Alkoxygruppe, eine Cyanogruppe oder eine C_1-C_6-Acylgruppe dar und
stellt A2 ein Halogenatom dar)
wird mit der Verbindung, die durch die folgende Formel VII dargestellt wird:

$$R_3\text{-}B(OH)_2 \qquad \text{(VII)}$$

(in der Formel VII stellt R3 eine monovalente Gruppe einer substituierten oder unsubstituierten aromatischen Verbindung, ein Wasserstoffatom, eine Cyanogruppe, eine Carboxamidgruppe oder eine Alkoxycarbonylgruppe dar)
in der Gegenwart eines Palladiumkomplex-Katalysators, einer basischen Substanz und eines Lösungsmittels durch Mikrowellenerwärmen umgesetzt.

2. Verfahren gemäß Anspruch 1, das den Schritt (a) umfasst.

3. Verfahren gemäß Anspruch 1, das den Schritt (b) umfasst.

4. Verfahren gemäß Anspruch 1 oder 2, wobei der Schritt (a) durch Erwärmen durch Mikrowellen in Gegenwart eines Platinkomplex-Katalysators, einer basischen Substanz, eines Lösungsmittels und einer wässrigen Lösung von Carboxylat durchgeführt wird.

5. Verfahren gemäß Anspruch 1 oder 3, wobei der Schritt (b) durch Erwärmen durch Mikrowellen in Gegenwart eines Palladiumkomplex-Katalysators, einer basischen Substanz, eines Lösungsmittels und einer wässrigen Lösung von Carboxylat durchgeführt wird.

6. Verfahren gemäß einem der Ansprüche 1 bis 5, wobei die basische Substanz Trialkylamin, das eine C_1-C_6-Alkylgruppe hat, ist.

7. Verfahren gemäß Anspruch 1 oder 2, wobei der Schritt (a) durch Erwärmen durch Mikrowellen in Gegenwart eines Palladiumkomplex-Katalysators, eines Lösungsmittels und einer wässrigen Lösung von Carboxylat durchgeführt wird.

8. Verfahren gemäß Anspruch 1 oder 3, wobei der Schritt (b) durch Erwärmen durch Mikrowellen in Gegenwart eines Palladiumkomplex-Katalysators, eines Lösungsmittels und einer wässrigen Lösung von Carboxylat durchgeführt wird.

9. Verfahren gemäß einem der Ansprüche 4 bis 8, wobei die wässrige Lösung von Carboxylat eine wässrige Lösung eines Alkalimetallsalzes von C_1-C_3-Carbonsäure ist.

10. Verfahren gemäß einem der Ansprüche 4 bis 9, wobei die wässrige Lösung von Carboxylat eine Pufferlösung ist, die einen pH-Bereich von 4,5 bis 6,0 hat.

11. Verfahren gemäß einem der Ansprüche 1 bis 10, wobei das Erwärmen durch Mikrowellen im Temperaturbereich von 70 bis 140°Cdurchgeführt wird.

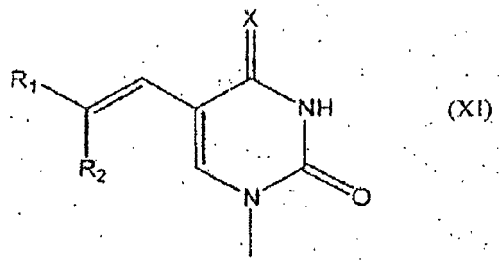
12. Verfahren gemäß einem der Ansprüche 1 bis 11, wobei das Erwärmen durch Mikrowellen im Zeitbereich von 1 bis 30 Minuten durchgeführt wird.

13. Verfahren gemäß einem der Ansprüche 1 bis 12, wobei das Lösungsmittel ein aprotisches polares Lösungsmittel ist.

Revendications

1. Procédé de fabrication d'un acide nucléique ayant un groupe représenté par la formule XI suivante :

[Formule chimique 49]

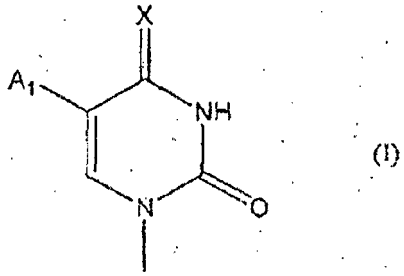


(XI)

(dans la formule XI, X représente O, S ou NH,
R1 représente un atome d'hydrogène, un groupe cyano, un groupe carboxamide, un groupe alcoxycarbonyle, ou un groupe monovalent d'un composé aromatique substitué ou non substitué, et
R2 représente un atome d'hydrogène, un groupe alkyle en C1 à C6, un groupe alcoxy en C1 à C6, un groupe cyano ou un groupe acyle en C1 à C6),
dans lequel le procédé comprend l'étape (a) suivante :

(a) un acide nucléique ayant la formule I en tant que fraction de base :

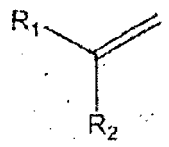
[Formule chimique 40]



(I)

(dans la formule I, X représente O, S ou NH et
A1 représente un atome d'halogène)
est mis à réagir avec le composé qui est représenté par la formule II suivante

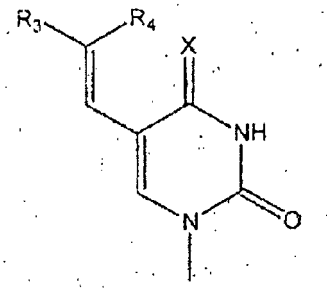
[Formule chimique 44]



(II)

(dans la formule II, R1 représente un atome d'hydrogène, un groupe cyano, un groupe carboxamide, un groupe alcoxycarbonyle, ou un groupe monovalent d'un composé aromatique substitué ou non substitué, et
R2 représente un atome d'hydrogène, un groupe alkyle en C1 à C6, un groupe alcoxy en C1 à C6, un groupe cyano ou un groupe acyle en C1 à C6)
en présence d'un catalyseur complexe de palladium, d'une substance basique et d'un solvant par chauffage par micro-ondes ; ou
un procédé de fabrication d'un acide nucléique ayant un groupe représenté par la formule XV suivante :

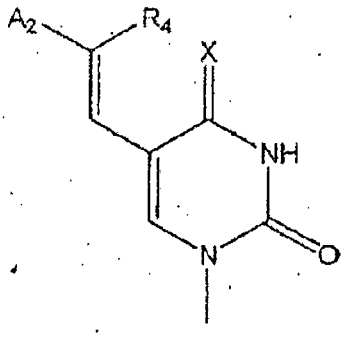
[Formule chimique 53]



(XV)

(dans la formule XV, X représente O, S ou NH,
R4 représente un atome d'hydrogène, un groupe alkyle en C1 à C6, un groupe alcoxy en C1 à C6, un groupe cyano ou un groupe acyle en C1 à C6, et
R3 représente un groupe monovalent d'un composé aromatique substitué ou non substitué, un atome d'hydrogène, un groupe cyano, un groupe carboxamide ou un groupe alcoxycarbonyle),
dans lequel le procédé comprend l'étape (b) suivante :
(b) un acide nucléique ayant la formule VI en tant que fraction de base :

[Formule chimique 45]



(VI)

(dans la formule VI, X représente O, S ou NH,
R4 représente un atome d'hydrogène, un groupe alkyle en C1 à C6, un groupe alcoxy en C1 à C6, un groupe cyano

ou un groupe acyle en C1 à C6, et
A2 représente un atome d'halogène),
est mis à réagir avec le composé qui est représenté par la formule VII suivante :

$$R_3\text{-}B(OH)_2 \qquad \text{(VII)}$$

(dans la formule VII, R3 représente un groupe monovalent d'un composé aromatique substitué ou non substitué, un atome d'hydrogène, un groupe cyano, un groupe carboxamide ou un groupe alcoxycarbonyle),
en présence d'un catalyseur complexe de palladium, d'une substance basique et d'un solvant par chauffage par micro-ondes.

2. Procédé selon la revendication 1, comprenant l'étape (a).

3. Procédé selon la revendication 1, comprenant l'étape (b).

4. Procédé selon la revendication 1 ou 2, dans lequel l'étape (a) est réalisée par chauffage par micro-ondes en présence d'un catalyseur complexe de palladium, d'une substance basique, d'un solvant et d'une solution aqueuse de carboxylate.

5. Procédé selon la revendication 1 ou 3, dans lequel l'étape (b) est réalisée par chauffage par micro-ondes en présence d'un catalyseur complexe de palladium, d'une substance basique, d'un solvant et d'une solution aqueuse de carboxylate.

6. Procédé selon l'une quelconque des revendications 1 à 5, dans lequel la substance basique est une trialkylamine ayant un groupe alkyle en C1 à C6.

7. Procédé selon la revendication 1 ou 2, dans lequel l'étape (a) est réalisée par chauffage par micro-ondes en présence d'un catalyseur complexe de palladium, d'un solvant et d'une solution aqueuse de carboxylate.

8. Procédé selon la revendication 1 ou 3, dans lequel l'étape (b) est réalisée par chauffage par micro-ondes en présence d'un catalyseur complexe de palladium, d'un solvant et d'une solution aqueuse de carboxylate.

9. Procédé selon l'une quelconque des revendications 4 à 8, dans lequel la solution aqueuse de carboxylate est une solution aqueuse d'un sel de métal alcalin d'un acide carboxylique en C1 à C3.

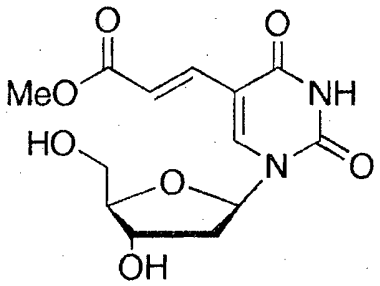
10. Procédé selon l'une quelconque des revendications 4 à 9, dans lequel la solution aqueuse de carboxylate est une solution tampon ayant un pH dans la plage de 4,5 à 6,0.

11. Procédé selon l'une quelconque des revendications 1 à 10, dans lequel le chauffage par micro-ondes est réalisé dans la plage de température de 70 à 140°C.

12. Procédé selon l'une quelconque des revendications 1 à 11, dans lequel le chauffage par micro-ondes est réalisé dans la plage de temps de 1 à 30 minutes.

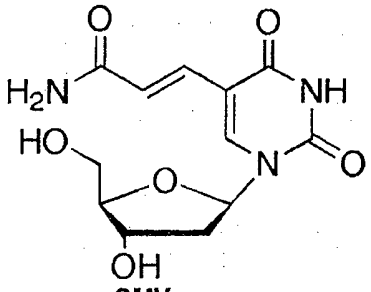
13. Procédé selon l'une quelconque des revendications 1 à 12, dans lequel le solvant est un solvant polaire aprotique.

[Fig. 1]



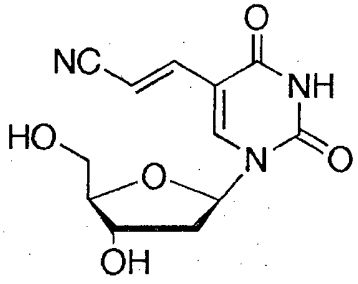
^{CV}U

[Fig. 2]



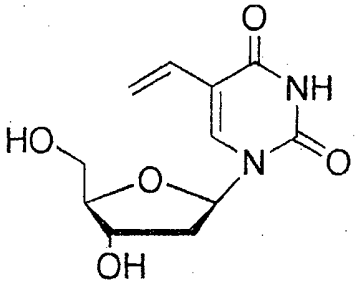
^{CMV}U

[Fig. 3]



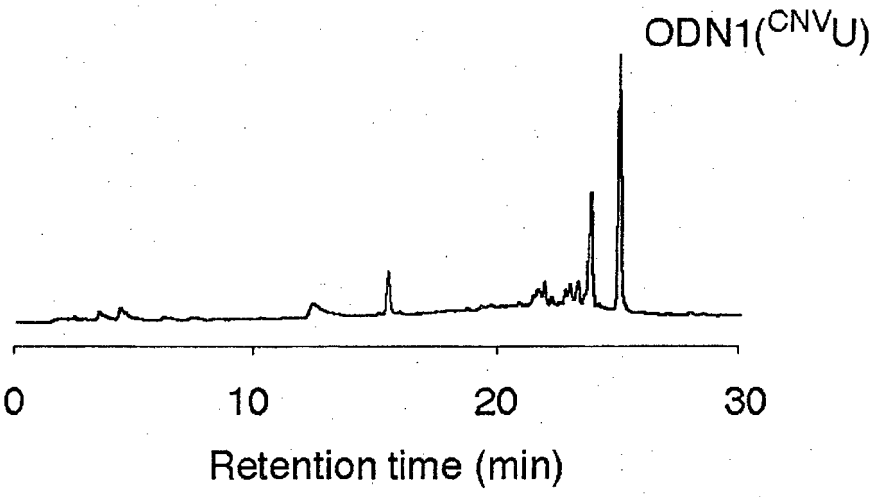
^{CNV}U

[Fig. 4]

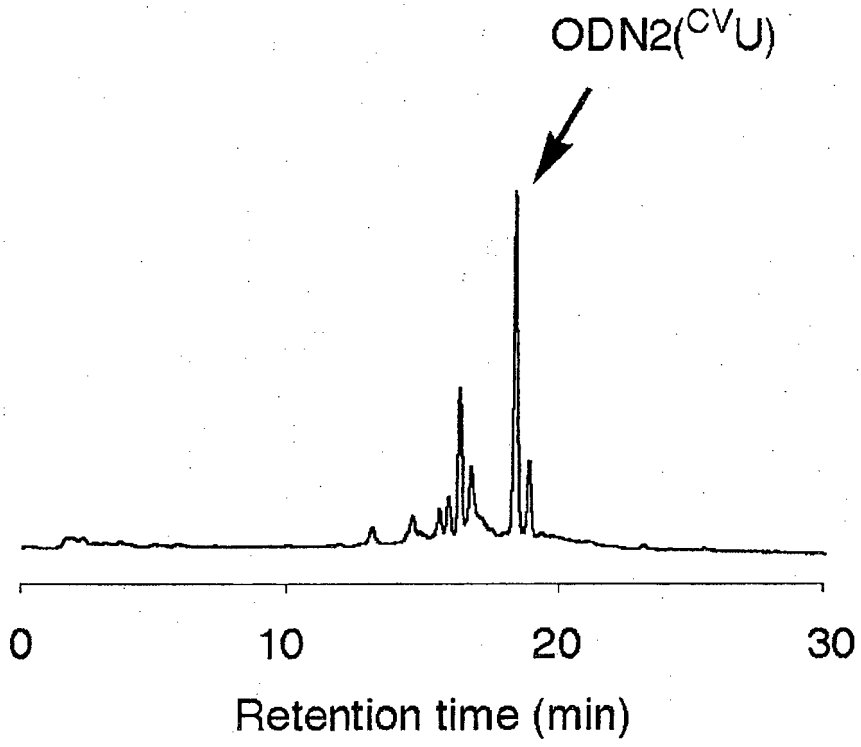


^{V}U

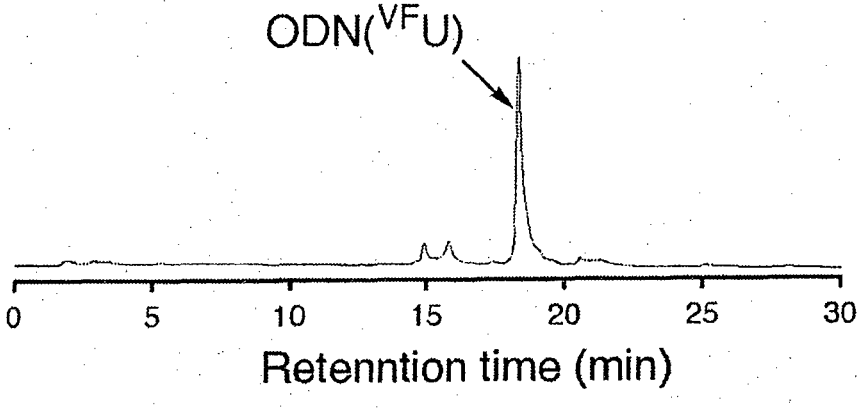
[Fig. 5]


ODN1(CNVU)
0
10
20
30
Retention time (min)

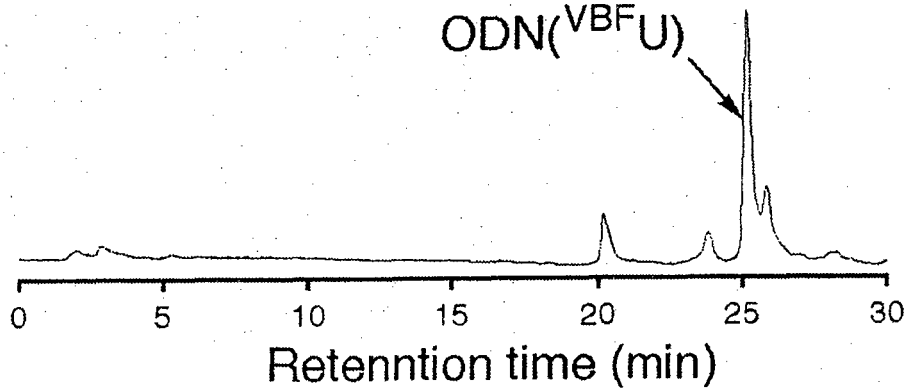
[Fig. 6]


ODN2(CVU)
0
10
20
30
Retention time (min)

[Fig. 7]


ODN(VFU)
0
5
10
15
20
25
30
Retenntion time (min)

[Fig. 8]


ODN(VBFU)
0
5
10
15
20
25
30
Retenntion time (min)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 3753938 B **[0005] [0006]**
- JP 3753942 B **[0005] [0006]**