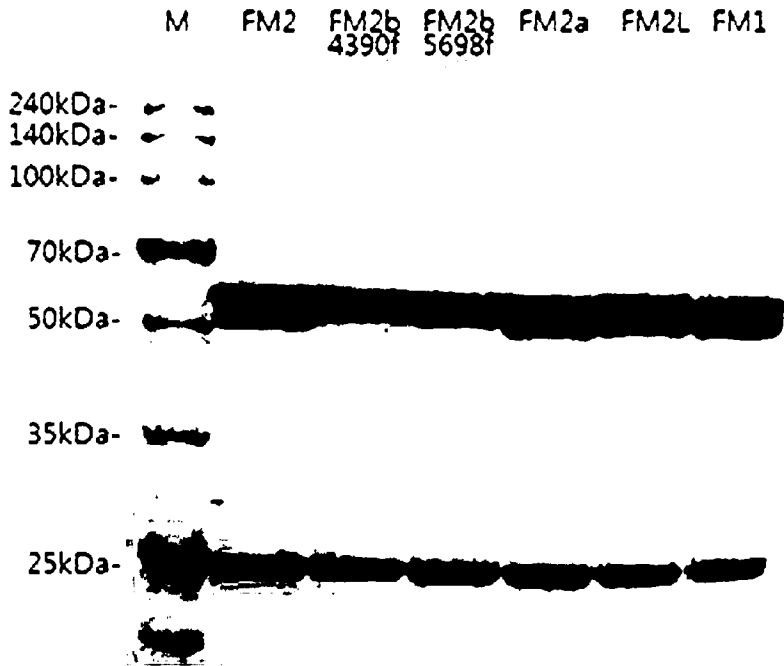




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(54) Titre : CONJUGUE ANTICORPS-MEDICAMENT COMPRENANT UN ANTICORPS MODIFIE
 (54) Title: ANTIBODY-DRUG CONJUGATES COMPRISING ANTIBODIES MODIFIED WITH METAL ION-BINDING
 MOTIFS



Conjugation 率
10 % SDS-PAGE gel (R)

(57) Abrégé/Abstract:

The present invention relates to: an antibody-drug conjugate in which a modified antibody, containing a motif of a specific structure at an end of the antibody, is coupled to a drug through a linker; and a composition containing the same and, specifically, to: a modified antibody-drug conjugate (mADC) comprising a modified antibody coupled to the C-terminus of heavy chain or light chain so as to have a remarkably increased drug conjugation yield; and a composition containing the same.

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OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, — 명세서의 서열목록 부분과 함께 (규칙 5.2(a))
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공개:

— 국제조사보고서와 함께 (조약 제 21 조(3))

**ANTIBODY-DRUG CONJUGATES COMPRISING ANTIBODIES
MODIFIED WITH METAL ION-BINDING MOTIFS**

TECHNICAL FIELD

The present disclosure relates to an antibody-drug
5 conjugate in which a modified antibody comprising a motif
having a specific structure at the end of the antibody is
conjugated to a drug via a linker, and a composition
comprising the same, and more particularly to a modified
antibody-drug conjugate (mADC) comprising a modified antibody
10 that has a significantly increased conjugation yield of drug
due to a motif bound to the heavy chain or light chain C-
terminus of the antibody, and to a composition comprising the
same.

15 **BACKGROUND ART**

Drugs that are used in anticancer chemotherapies often
show toxicities, particularly, bone marrow toxicity, mucosal
toxicity and neurotoxicity. Therefore, it is required to
develop anticancer agents that show specificity for cancer
20 cells while showing strong anticancer activity and being
safer. Anticancer agents having reduced side effects while
acting specifically on cancer cells have been developed in
various ways.

In this respect, therapeutic agents based on antibodies
25 that bind specifically to targets, that is, antigens that are

expressed specifically in specific diseases, are currently being most actively studied among biopharmaceuticals. In particular, it is required to identify tumor-related antigens that are expressed specifically on the surface of cancer
5 cells. Methods for diagnosing and treating tumors using antibodies that bind to these antigens to inhibit cancer cell growth or induce apoptosis, that is, anticancer antibodies, are widely used today, and their future prospects are also very bright.

10 Although these anticancer antibodies have very high target specificity, their effects on cancer cell killing are lower in many cases than conventional cytotoxic drugs (anticancer agents), that is, anticancer drugs. For this reason, in many cases, these anticancer antibodies are used
15 in combination therapy with cytotoxic drugs and other drugs for inhibiting cancer cell growth. Anticancer drugs show significantly higher cytotoxicity than anticancer antibodies, but have a low level of target specificity to cancer cells, and thus show very high side effects compared to anticancer
20 therapeutic agents. Thus, combination therapy of an anticancer antibody and an anticancer drug shows a higher therapeutic effect than individual administration of each drug, but has fundamental limitations in that the side effects of the anticancer drug always occur.

In addition, anticancer drugs have very high cytotoxicity, and for this reason, among these anticancer drugs, drugs that may be used alone as anticancer therapeutic agents are limited to taxol-based drugs or cisplatin-based
5 drugs, which have relatively low toxicity. Most anticancer drugs are virtually impossible to prescribe as single drugs, due to their very high cytotoxicity. When an anticancer drug that cannot be used as a single therapy is conjugated with an antibody having very high target specificity for cancer cells,
10 the anticancer drug can be delivered only to target cancer cells without side effects on normal cells. Therefore, antibody-drug conjugates are attracting attention as a method capable of increasing the therapeutic efficacy of anticancer drugs that could not previously be used.

15 Antibody-drug conjugates put on the market today include Adcetris[®], a therapeutic agent for the treatment of Hodgkin's lymphoma, and Kadcylla[®], a therapeutic agent for the treatment of metastatic breast cancer. These antibody-drug conjugates have a structure in which an antibody is conjugated to a
20 tubulin inhibitor that binds to tubulin, an intracellular microtubule involved in the cell division process to inhibit cell division, thereby inhibiting the growth and division of cancer. The antibody-drug conjugates have either a structure in which a drug is conjugated to the lysine of an antibody
25 (Kadcyla), or a structure in which a drug is conjugated to a

cysteine group obtained by reducing a disulfide bond between a heavy chain and a heavy chain or between a heavy chain and a light chain, which maintains the structural stability of the antibody (Adcetris). In the method of conjugating the anticancer drugs used in these first-generation antibody-drug conjugates, the number of drugs conjugated per antibody cannot be controlled, and positional isomers with different sites of drug conjugation are produced even in antibody-drug conjugates having the same number of conjugated drugs. The number of drugs conjugated per antibody is a factor that influences not only the cytotoxicity of the antibody-drug conjugate, but also the stability of the antibody-drug conjugate, the possibility of aggregate formation, and the like. In general, as the number of conjugated drugs increases, the stability of the antibody itself decreases and the possibility of aggregate formation increases.

In addition, for the first-generation antibody-drug conjugates, the number of drugs conjugated per antibody cannot be controlled, and thus the number of drugs conjugated per antibody has an average value. For example, for Kadcyra, the number of drugs conjugated per antibody has a distribution of 1 to 8, the average number of drugs conjugated is 3.5. Even in antibody-drug conjugates having the same number of drugs conjugated, the characteristics of the antibody-drug conjugates may vary depending on the sites

of drug conjugation. If a drug is conjugated near the Fab or near the hinge of the Fc, the stability of the antibody or the antigen-antibody reactivity can also be reduced due to a difference in its binding affinity for the antigen or the Fcγ or FcRn receptor. As the number of drugs conjugated per antibody increases, the number of positional isomers with different sites of drug conjugation also increases proportionately, and this result can have a significant impact on maintaining the consistent properties of the antibody-drug conjugates between production batches.

Thus, in recent years, various conjugation techniques for site-specific drug conjugation have been developed in order to overcome the disadvantages of the first-generation antibody-drug conjugates as described above. Genetech developed a technique for conjugating a drug using the ThioMabTM technology, in which a cysteine group is introduced by replacing the amino acid of an antibody, and then the drug is site-specifically conjugated to the introduced cysteine group. This showed that the antibody-drug conjugate obtained by site-specific drug conjugation had better *in vivo* activity than the first-generation antibody-drug conjugates (Junutula et al., Nature Biotechnology, 2008, 26, 925-932). Site-specific conjugation is a drug conjugation method employing protein enzymes having a very high substrate specificity, and has also been attempted by several companies.

It was reported that a desired number of drugs could be site-specifically conjugated to an antibody by methods, including site-specific conjugation employing formylglycine-generating enzyme (Drake et al., *Bioconjugate Chemistry*, 2014, 25, 1331-1341), conjugation employing glutamine transferase (Strop et al., *Chemistry & Biology*, 2013, 20, 161-167), and the like. However, these conjugation methods employing protein enzymes have a disadvantage in that conjugation is performed in the presence of an excessive amount of a drug at 37 °C for 72 hours or in that a high concentration of a conjugation enzyme is required.

A conjugation method employing a non-natural amino acid, which is another site-specific conjugation method, is based on a technology capable of introducing a side chain absent in a natural amino acid into a protein by synthesizing a tRNA capable of a non-natural amino acid into the protein through a mutant of tRNA synthetase (Wang et al., *Proc. Natl. Acad. Sci. USA*, 2003, 100, 56-61). By virtue of this method, a drug can be conjugated to a desired site by site-specific conjugation to the introduced non-natural amino acid residue (Zimmerman et al., *Bioconjugate Chem.* 2014, 25, 351-361). However, this method requires a highly difficult task that controls the translation pathway through a highly advanced genetic engineering technique.

This site-specific conjugation requires a very large amount of time and cost for a site-specific conjugation reaction, because the transcription system should be modified using a complex genetic engineering technique or an excessive amount of a conjugation enzyme should be added. In view of the basic concept of antibody-drug conjugates, by which the antibody serves as a carrier that specifically delivers the anticancer drug to cancer cells and the drug should remain stably bound to the antibody until it is delivered to the cancer cells, questions cannot help being raised on whether producing an antibody-drug conjugate by use of this complicated, time-consuming and costly conjugation method is indeed necessary. A conjugation method having high economic efficiency while being capable of achieving site-specific conjugation in the production of an antibody-drug conjugate can be an excellent alternative that can overcome the limitations of not only the conventional conjugation method for producing the first-generation antibody-drug conjugates, but also the newly proposed site-specific conjugation method.

Antibody-drug conjugates exhibit significantly better *in vitro* and *in vivo* efficacies compared to conventional antibody drugs. However, the results of some clinical tests performed to use antibody-drug conjugates as first-line therapeutic agents failed to show the difference of significant clinical usefulness compared to combination

vivo anticancer effects due to site-specific conjugation and, at the same time, can be produced in a more economic manner.

DISCLOSURE OF INVENTION

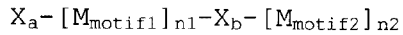
TECHNICAL PROBLEM

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The present disclosure has been made to solve the above-described problems, and it is an object of the present disclosure to provide an antibody having a drug binding site formed by attaching a motif having a specific structure to a
10 parent antibody. Hereinafter, this type of antibody will be referred to as modified antibody. This modified antibody is produced by modifying a conventional modified antibody having a metal ion-binding motif, and has a higher drug conjugation yield while retaining the property of site-specific
15 conjugation. The present disclosure also provides a method for producing an antibody-drug conjugate and an anticancer drug using this modified antibody.

TECHNICAL SOLUTION

20 To achieve the above object, the present disclosure provides an antibody-drug conjugate in which a modified antibody comprising a motif, represented by the following structural formula (1), at the end of the antibody, is bound to a drug by a linker:

25 Structural Formula (1)



wherein:

M_{motif1} and M_{motif2} each independently comprises a sequence of any one of ACGHA (SEQ ID NO: 1), AHGCA (SEQ ID NO: 2),
 5 AXGHA (SEQ ID NO: 3) and AHGXA (SEQ ID NO: 4), wherein X in SEQ ID NO: 3 or 4 comprises an amino acid residue other than cysteine;

X_a and X_b are each independently a peptide consisting of 0 to 20 amino acid residues selected from the group
 10 consisting of A (alanine), S (serine), and G (glycine); and

$n1$ and $n2$ are each an integer ranging from 1 to 10.

The present disclosure also provides a composition for preventing or treating cancer, which comprises the above-described antibody-drug conjugate.

15

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the results of SDS-PAGE of samples obtained by conjugating MC-vc-PAB-MMAE to each of FM2, FM2b (lot no: 4390f), FM2b (lot no: 5698f), FM2a, FM2L and FM1, which are
 20 antibody variants that target folate receptor. The drug was conjugated to a cysteine-containing motif introduced into the heavy chain of the antibody, and appeared as two bands in the heavy chain near 50 kDa on SDS-PAGE.

FIG. 2 shows the results of SDS-PAGE of samples obtained
 25 by conjugating br-vc-PAB-MMAE (which is a drug-linker

conjugate obtained by connecting MMAE to bromoacetamide) to each of FM2, FM2b, FM2a, FM2L and FM1, which are antibody variants that target folate receptor. The drug was conjugated to a cysteine-containing motif introduced into the heavy chain of the antibody, and appeared as two bands in the heavy chain near 50 kDa on SDS-PAGE.

FIG. 3 shows the results of a cell growth inhibition assay performed using KB-cells overexpressing folate receptor. It compares cell growth inhibitory activity between the parent antibody Fwt, the modified antibody-drug conjugate FM2-D2 (a modified antibody (FM2)-drug (MMAE) conjugate having a DAR of 2), and FM2b-D2 (or FM2b-S-D2) (a modified antibody (FM2b-S)-drug (MMAE) conjugate having a DAR of 2). FM2-D2 and FM2b-D2 show almost the same intracellular activity.

FIG. 4 shows the results of a cell growth inhibition assay performed using KB-cells overexpressing folate receptor. It shows cell growth inhibitory activity between FM2b-S-D2, FM2b-F-D2, and FM2b-Y-D2. FM2b-S-D2, FM2b-F-D2, and FM2b-Y-D2 show almost the same intracellular activity.

FIG. 5 shows the results of measuring changes in the number of drugs conjugated (DAR) and aggregate formation after storing FM2b-S-D2, FM2b-F-D2, FM2b-K-D2 and FM2b-Y-D2 at 25°C and 50°C for 0, 1, 3, 5, 7 and 14 days. At 25°C, changes in DAR and monomer were hardly observed, but at 50°C,

it was observed that the content of DAR2 decreased and an aggregate was formed with time. However, differences in DAR change and aggregate formation between the variants were not observed.

5

BEST MODE FOR CARRYING OUT THE INVENTION

Unless defined otherwise, all the technical and scientific terms used herein have the same meaning as those generally understood by one of ordinary skill in the art to which the invention pertains. Generally, the nomenclature used herein and the experiment methods, which will be described below, are those well known and commonly employed in the art.

An antibody-drug conjugate requires that the anticancer drug should remain stably bound to the antibody until the anticancer drug is delivered to target cancer cells. The anticancer drug delivered to the target cancer cells should be released from the antibody and should induce the death of the cancer cells. To this end, the anticancer drug should be stably bound to the antibody by a linker, and this drug-linker structure should have sufficient cytotoxicity so that the drug will induce the death of cancer cells when it is released in the cancer cells. In addition, the drug should be site-specifically conjugated to the antibody, and the

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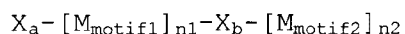
antibody-drug conjugate should have anticancer efficacy and show uniformity in its production process.

To this end, the present inventors showed that a drug could be site-specifically conjugated by introducing a peptide including a metal ion-binding motif into the C-terminus of an antibody, and that a uniform ratio of antibody-drug conjugation could be achieved (Korean Patent No. 1541764). Thus, it was shown that while the drug was site-specifically bound to the modified antibody, the characteristics of the parent antibody were maintained, and the drug-antibody conjugate could exhibit a very high target specificity and drug effect. However, due to the significantly high production cost of the drug-antibody conjugate compared to those of synthetic drugs or monoclonal antibody treatments, it is urgently required to increase the economic efficiency by increasing the conjugation yield of the drug.

Accordingly, in the present disclosure, it was attempted to demonstrate that the conjugation ratio of drug to antibody can be significantly increased by using a modified antibody comprising a peptide motif including a metal ion-binding motif, that is, according to the sequence and primary structure of the metal ion-binding motif introduced into the end of the parent antibody.

In one aspect, the present disclosure is directed to an antibody-drug conjugate in which a modified antibody comprising a motif, represented by the following structural formula (1), at the end of the antibody, is bound to a drug by a linker:

Structural Formula (1)



wherein:

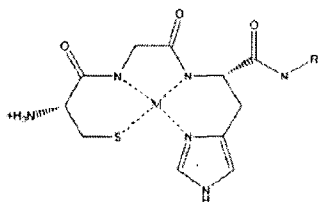
M_{motif1} and M_{motif2} each independently comprises a sequence of any one of ACGHA (SEQ ID NO: 1), AHGCA (SEQ ID NO: 2), AXGHA (SEQ ID NO: 3) and AHGXA (SEQ ID NO: 4), wherein X in SEQ ID NO: 3 or 4 comprises an amino acid residue other than cysteine;

X_a and X_b are each independently a peptide consisting of 0 to 20 amino acid residues selected from the group consisting of A (alanine), S (serine), and G (glycine); and

$n1$ and $n2$ are each an integer ranging from 1 to 10.

The motif represented by the above structural formula (1) is a peptide comprising a CGH motif which is a metal ion-binding motif. The CGH motif has a structure represented by the following formula 1:

Formula (1)



wherein M represents a metal ion, and R represent an amino acid residue other than cysteine, preferably alanine.

In the motif according to the present disclosure, M_{motif1} and M_{motif2} each comprises ACGHA (SEQ ID NO: 1) comprising alanine located at the C-terminus and N-terminus thereof, or AXGHA (SEQ ID NO: 3) obtained by replacing the cysteine of the ACGHA with an amino acid residue other than cysteine. The motif still has the metal ion-binding property even when the positions of the N-terminus and the C-terminus of each of M_{motif1} and M_{motif2} are reversed, and thus AHGCA (SEQ ID NO: 2) or AHGXA (SEQ ID NO: 4) having the reversed positions of the N-terminus and the C-terminus in ACGHA (SEQ ID NO: 1) or AXGHA (SEQ ID NO: 3) falls within the scope of the M_{motif1} or M_{motif2} of the motif according to the present disclosure.

M_{motif1} and M_{motif2} in the motif according to the present disclosure may comprise the same sequence or different sequences.

In one example of the present disclosure, when the M_{motif1} or M_{motif2} corresponds to AXGHA or AHGXA, X in AXGHA or AHGXA may be an amino acid residue selected from the group consisting of serine (S), alanine (A), threonine (T),

tyrosine (Y), aspartic acid (D), lysine (K), and phenylalanine (F).

In one example of the present disclosure, it was found that the case where M_{motif2} comprises AXGHA (SEQ ID NO: 3) and
5 X in AXGHA is an amino acid residue other than cysteine can show a higher drug conjugation ability than the case where M_{motif2} comprises ACGHA. When the M_{motif2} corresponds to AXGHA, X in AXGHA may be an amino acid residue other than cysteine, for example, an amino acid residue selected from the group
10 consisting of serine (S), alanine (A), threonine (T), tyrosine (Y), aspartic acid (D), lysine (K), and phenylalanine (F).

X_a is an amino acid residue sequence present at the 5' end of the motif M_{motif1} . In some cases, it may be a peptide
15 located for connection with the end of the antibody. X_a is a peptide consisting of 0 to 20 amino acid residues selected from the group consisting of A (alanine), S (serine), and G (glycine). If the amino acid residue number of X_a is 0, the motif will not include X_a , and the motif M_{motif1} may be bound
20 directly to the antibody. The amino acid residue number of X_a may be more than one, two, three, four, or five. For example, the amino acid residue number of X_a may be 2 to 20, 2 to 18, 2 to 16, 2 to 14, 2 to 12, 2 to 10, 2 to 8, 2 to 6, 2, 3, 4, 5, 6, 7, 8, 9, or 10.

X_b is a linker for connecting M_{motif1} and M_{motif2} to each other, and is a peptide consisting of 0 to 20 amino acid residues selected from the group consisting of A (alanine), S (serine), and G (glycine). If the amino acid residue number of X_b is 0, the motif will not include X_b , and M_{motif1} and M_{motif2} may be bound directly to the antibody. The amino acid residue number of X_b may be more than one, two, three, four, or five. For example, the amino acid residue number of X_b may be 2 to 20, 2 to 18, 2 to 16, 2 to 14, 2 to 12, 2 to 10, 2 to 8, 2 to 6, 2, 3, 4, 5, 6, 7, 8, 9, or 10.

n_1 and n_2 represent the numbers of repeats of M_{motif1} and M_{motif2} , respectively, and are each an integer ranging from 1 to 10. The n_1 and n_2 may each be 1, and in this case, M_{motif1} and M_{motif2} , which comprise the sequence of any one of ACGHA (SEQ ID NO: 1), AHGCA (SEQ ID NO: 2), AXGHA (SEQ ID NO: 3) and AHGXA (SEQ ID NO: 4), may be connected to each other without the linker X_b or by the linker X_b . For example, the $[M_{\text{motif1}}]_{n_1}-X_b-[M_{\text{motif2}}]_{n_2}$ structure may be ACGHAACGHA (SEQ ID NO: 5), ACGHAAHGCA (SEQ ID NO: 6), ACGHAAAXGHA (SEQ ID NO: 7), ACGHAAHGXA (SEQ ID NO: 8), AHGCAAHGCA (SEQ ID NO: 9), AHGCAACGHA (SEQ ID NO: 10), AHGCAAXGHA (SEQ ID NO: 11), AHGCAAHGXAXGHA (SEQ ID NO: 12), AXGHAAXGHA (SEQ ID NO: 13), AXGHAACGHA (SEQ ID NO: 14), AXGHAAHGCA (SEQ ID NO: 15), AXGHAAHGXA (SEQ ID NO: 16), AHGXAAHGXA (SEQ ID NO: 17), AHGXAAACGHA (SEQ ID NO: 18), AHGXAAHGCA (SEQ ID NO: 19), or

AHGXAAXGHA (SEQ ID NO: 20), if the linker X_b is not present, and motifs essentially comprising C (cysteine) for conjugation with the drug may be selected as M_{motif1} and M_{motif2} .

If X_b is present, a peptide consisting of 1 to 20 amino acid residues may additionally be included at position 6 (6th) of the 5' end of each of the above-described amino acid sequences. In this case, X may be selected from the group consisting of serine (S), alanine (A), threonine (T), tyrosine (Y), aspartic acid (D), lysine (K), and phenylalanine (F).

The $[M_{\text{motif1}}]_{n1}-X_b-[M_{\text{motif2}}]_{n2}$ structure may be ACGHAASGHA (SEQ ID NO: 21), ACGHAAHGSA (SEQ ID NO: 22), AHGCAASGHA (SEQ ID NO: 23), AHGCAAHGSA (SEQ ID NO: 24), ASGHAASGHA (SEQ ID NO: 25), ASGHAACGHA (SEQ ID NO: 26), ASGHAAHGCA (SEQ ID NO: 27), ASGHAAHGSA (SEQ ID NO: 28), AHGSAAHGSA (SEQ ID NO: 29), AHGSAACGHA (SEQ ID NO: 30), AHGSAAHGCA (SEQ ID NO: 31), or AHGSAASGHA (SEQ ID NO: 32), which comprises serine at position X of SEQ ID NOS: 7, 8, 11 to 20 comprising X, for example, if X is serine (S) when the linker X_b is not present.

The $[M_{\text{motif1}}]_{n1}-X_b-[M_{\text{motif2}}]_{n2}$ structure may be ACGHAAAGHA (SEQ ID NO: 33), ACGHAAHGAA (SEQ ID NO: 34), AHGCAAAGHA (SEQ ID NO: 35), AHGCAAHGAA (SEQ ID NO: 36), AAGHAAAGHA (SEQ ID NO: 37), AAGHAAACGHA (SEQ ID NO: 38), AAGHAAHGCA (SEQ ID NO: 39), AAGHAAHGAA (SEQ ID NO: 40), AHGAAAHGAA (SEQ ID NO: 41), AHGAAACGHA (SEQ ID NO: 42), AHGAAAHGCA (SEQ ID NO: 43), or

AHGAAAAGHA (SEQ ID NO: 44) when, for example, X is alanine (A) if the linker X_b is not present.

The $[M_{\text{motif1}}]_{n1}-X_b-[M_{\text{motif2}}]_{n2}$ structure may be ACGHAATGHA (SEQ ID NO: 45), ACGHAAHGTA (SEQ ID NO: 46), AHGCAATGHA (SEQ ID NO: 47), AHGCAAHGTA (SEQ ID NO: 48), ATGHAATGHA (SEQ ID NO: 49), ATGHAACGHA (SEQ ID NO: 50), ATGHAAHGCA (SEQ ID NO: 51), ATGHAAHGTA (SEQ ID NO: 52), AHGTAAHGTA (SEQ ID NO: 53), AHGTAACGHA (SEQ ID NO: 54), AHGTAAHGCA (SEQ ID NO: 55), or AHGTAATGHA (SEQ ID NO: 56), for example, if X is threonine (T) when the linker X_b is not present.

The $[M_{\text{motif1}}]_{n1}-X_b-[M_{\text{motif2}}]_{n2}$ structure may be ACGHAAAYGHA (SEQ ID NO: 57), ACGHAAHGYA (SEQ ID NO: 58), AHGCAAYGHA (SEQ ID NO: 59), AHGCAAHGYA (SEQ ID NO: 60), AYGHAAYGHA (SEQ ID NO: 61), AYGHAACGHA (SEQ ID NO: 62), AYGHAAHGCA (SEQ ID NO: 63), AYGHAAHGYA (SEQ ID NO: 64), AHGYAAHGYA (SEQ ID NO: 65), AHGYAACGHA (SEQ ID NO: 66), AHGYAAHGCA (SEQ ID NO: 67), or AHGYAAYGHA (SEQ ID NO: 68), for example, if X is tyrosine (Y) when the linker X_b is not present.

The $[M_{\text{motif1}}]_{n1}-X_b-[M_{\text{motif2}}]_{n2}$ structure may be ACGHAADGHA (SEQ ID NO: 69), ACGHAAHGDA (SEQ ID NO: 70), AHGCAADGHA (SEQ ID NO: 71), AHGCAAHGDA (SEQ ID NO: 72), ADGHAADGHA (SEQ ID NO: 73), ADGHAACGHA (SEQ ID NO: 74), ADGHAAHGCA (SEQ ID NO: 75), ADGHAAHGDA (SEQ ID NO: 76), AHGDAAHGDA (SEQ ID NO: 77), AHGDAACGHA (SEQ ID NO: 78), AHGDAAHGCA (SEQ ID NO: 79), or

AHGDAADGHA (SEQ ID NO: 80) when, for example, X is aspartic acid (D) if the linker X_b is not present.

The $[M_{\text{motif1}}]_{n1}-X_b-[M_{\text{motif2}}]_{n2}$ structure may be ACGHAAKGHA (SEQ ID NO: 81), ACGHAAHGKA (SEQ ID NO: 82), AHGCAAAGHA (SEQ ID NO: 83), AHGCAAHGKA (SEQ ID NO: 84), AKGHAAKGHA (SEQ ID NO: 85), AKGHAAAGHA (SEQ ID NO: 86), AKGHAAHGKA (SEQ ID NO: 87), AKGHAAHGKA (SEQ ID NO: 88), AHGKAAHGKA (SEQ ID NO: 89), AHGKAAAGHA (SEQ ID NO: 90), AHGKAAHGKA (SEQ ID NO: 91), or AHGKAAKGHA (SEQ ID NO: 92), for example, if X is lysine (K) when the linker X_b is not present.

The $[M_{\text{motif1}}]_{n1}-X_b-[M_{\text{motif2}}]_{n2}$ structure may be ACGHAAFGHA (SEQ ID NO: 93), ACGHAAHGFA (SEQ ID NO: 94), AHGCAAAGHA (SEQ ID NO: 95), AHGCAAHGFA (SEQ ID NO: 96), AFGHAAFGHA (SEQ ID NO: 97), AFGHAAAGHA (SEQ ID NO: 98), AFGHAAHGFA (SEQ ID NO: 99), AFGHAAHGFA (SEQ ID NO: 100), AHGFAAHGFA (SEQ ID NO: 101), AHGFAAGHA (SEQ ID NO: 102), AHGFAAHGFA (SEQ ID NO: 103), or AHGFAAFGHA (SEQ ID NO: 104), for example, if X is phenylalanine (F) when the linker X_b is not present.

If X_b is present, a peptide consisting of 1 to 20 amino acid residues may additionally be included at position 6 of the 5' end of each of the above-described amino acid sequences of SEQ ID NOS: 5 to 104. In this case, X may be selected from the group consisting of serine (S), alanine (A), threonine (T), tyrosine (Y), aspartic acid (D), lysine (K), and phenylalanine (F). In this case, X may be selected from

the group consisting of serine (S), alanine (A), threonine (T), tyrosine (Y), aspartic acid (D), lysine (K), and phenylalanine (F).

n1 and n2 may each be 2 or greater. For example, if n1
5 and n2 are each 2 and M_{motif1} and M_{motif2} comprise the same amino acid sequence, M_{motif1} and M_{motif2} may comprise two repeats of the sequence of any one of ACGHA (SEQ ID NO: 1), AHGCA (SEQ ID NO: 2), AXGHA (SEQ ID NO: 3) and AHGXA (SEQ ID NO: 4). If M_{motif1} and M_{motif2} comprise different amino acid sequences, they
10 may comprise, for example, two repeats of each of ACGHA and AHGCA, ACGHA and AXGHA, ACGHA and AHGXA, AHGCA and ACGHA, AHGCA and AXGHA, AHGCA and AHGXA, AXGHA and ACGHA, AXGHA and AHGCA, AXGHA and AHGXA, AHGXA and ACGHA, AHGXA and AHGCA, or AHGXA and AXGHA, respectively. If n1 and n2 are each an
15 integer ranging from 3 to 10, M_{motif1} and M_{motif2} may comprise 3 to 10 repeats of either the same sequence corresponding to any one of, or different sequences selected from among from, ACGHA (SEQ ID NO: 1), AHGCA (SEQ ID NO: 2), AXGHA (SEQ ID NO: 3) and AHGXA (SEQ ID NO: 4).

20 Preferably, n1 and n2 may each be 1, and the linker X_b may not be present. In this case, the motif may comprise one or more sequences selected from the group consisting of SEQ ID NOS: 5 to 104.

The motif may be bound to the heavy-chain or light-chain
25 C-terminus of the antibody, particularly the heavy-chain C-

terminus, thereby providing a modified antibody having a significantly increased conjugation yield of the drug or a drug conjugate comprising the same. By increasing the conjugation yield of the drug, the production yield of the antibody-drug conjugate can be increased. The drug conjugated in high yield may be delivered specifically to target cancer cells by means of the modified antibody, thereby increasing therapeutic effects. In addition, due to the high conjugation yield of the antibody-drug conjugate, the production cost of the antibody-drug conjugate as a therapeutic agent can be reduced.

The motif can be fused directly to the parent antibody by an amide bond. Alternatively, the terminal functional group of the motif can be chemically bound to the terminal functional group of the parent antibody. Alternatively, the motif can also be bound to the parent antibody in a linker mediated manner by using a linker that links the terminal functional group of the motif and a drug.

The linker may be configured to connect a specific residue in the motif to the drug, and may have a reactive site having an electrophilic group that reacts with a nucleophilic residue (e.g., cysteine) present on the motif of the modified antibody. The linker may comprise, for example, a reactive functional group, an amino acid, and a self-cleavage spacer, which bind to the motif.

The functional group may be i) a maleimide group, an acetamide group, or derivatives thereof, ii) an aziridine group, an aryl halide group, an acryloyl group, or derivatives thereof, or iii) an alkylating reactive group, an
5 arylating reactive group, pyridyl disulfide, thionitrobenzoic acid, or derivatives thereof. Specifically, the linker may be in the form of i) a maleimide polyimide group or its derivative-valine-citrulline-para-aniline benzoic acid (PABA); or ii) an acetamide group or its derivative-valine-
10 citrulline-para-aniline benzoic acid (PABA), but is not limited thereto.

Binding of the cysteine residue to a drug by the linker may be performed by using a known method, for example, alkylation, disulfide exchange or transthioesterification
15 reaction. This enables the drug to be conjugated to the antibody by the thiol group of the cysteine residue in the motif.

In an embodiment of the present disclosure, a maleimide group that is generally used for linking thiol and a linker
20 is used to specifically conjugate a drug to cysteine, because the nucleophilic reactivity of the thiol group of a cysteine residue for the maleimide group is about 1,000 times higher than that of other amino acid functional group present in a protein, for example, the amino group or N-terminal amino
25 group of a lysine residue. Thus, it can be seen that in the

case of a modified antibody-drug conjugate based on a maleimide group or its derivative, or an acetamide group or its derivative, for example, a bromoacetamide group or an iodoacetamide group, cysteine is bound to the drug by a thioether bond.

The antibody may be one or more selected from the group consisting of a monoclonal antibody, a bispecific antibody, a chimeric antibody, a human antibody, and a humanized antibody. In addition, modified antibodies such as bispecific antibodies, or fragments of the antibodies, may also be used in the present disclosure. As used herein, the term "fragment of the antibody" refers to a fragment that at least retains a binding affinity to an antigen. Examples of the antibody fragment include single-chain antibodies, diabodies, triabodies, tetrabodies, Fab fragments, F(ab')₂ fragments, Fd, scFv, domain antibodies, minibodies, single-chain antibodies (scAb), derivatives of antibody constant regions, and artificial antibodies based on protein scaffolds.

In some embodiments, the antibody may be selected from the group consisting of IgA, IgD, IgE, IgG, and IgM.

The antibody may have a binding affinity and specificity for specifically, cancer-specific antigens, cell surface receptor proteins, cell surface proteins, transmembrane proteins, signaling proteins, cell survival regulators, cell proliferation regulators, molecules associated with tissue

development or differentiation, lymphokines, cytokines, molecules involved in cell cycle regulation, molecules involved in vasculogenesis, or molecules associated with angiogenesis. For example, the antibody may have a binding
5 affinity for one or more targets selected from the group consisting of, but are not limited to:

- (1) BMPRII (bone morphogenetic protein receptor-type II; Genbank Accession No. NM_001203);
- (2) E16 (LAT1, SLC7A5; Genbank Accession No. NM_003486);
- 10 (3) STEAP1 (six transmembrane epithelial antigen of prostate; Genbank Accession No. NM_012449);
- (4) 0772P (CA125, MUC16; Genbank Accession No. AF361486);
- (5) MPF (MPF, MSLN, SMR, megakaryocyte potentiating
15 factor, mesothelin; Genbank Accession No. NM_005823);
- (6) Napi3b (NAPI-3B, NPTIIB, SLC34A2, solute carrier family 34 (sodium phosphate), member 2, type II sodium-dependent phosphate transporter 3b; Genbank Accession No. NM_006424);
- 20 (7) Sema 5b (FLJ10372, KIAA1445, Mm.42015, SEMA5B, SEMAG, Semaphorin 5b Hlog, sema domain, seven thrombospondin repeats (type 1 and type 1-like), transmembrane domain (TM) and short cytoplasmic domain, (semaphorin) 5B; Genbank Accession No. AB040878);

- (8) PSCA hlg (2700050C12Rik, C530008016Rik, RIKEN cDNA 2700050C12, RIKEN cDNA 2700050C12 gene; Genbank Accession No. AY358628);
- (9) ETBR (Endothelin type B receptor; Genbank Accession
5 No. AY275463);
- (10) MSG783 (RNF124, hypothetical protein FLJ20315; Genbank Accession No. NM_017763);
- (11) STEAP2 (HGNC_8639, IPCA-1, PCANAP1, STAMP1, STEAP2, STMP, prostate cancer associated gene 1, prostate cancer
10 associated protein 1, six-transmembrane epithelial antigen of prostate 2, six-transmembrane prostate protein; Genbank Accession No. AF455138);
- (12) TrpM4 (BR22450, FLJ20041, TRPM4, TRPM4B, transient receptor potential cation channel, subfamily M, member 4;
15 Genbank Accession No. NM_017636);
- (13) CRIPTO (CR, CR1, CRGF, CRIPTO, TDGF1, teratocarcinoma-derived growth factor; Genbank Accession No. NP_003203 or NM_003212);
- (14) CD21 (CR2 (Complement receptor 2) or C3DR
20 (C3d/Epstein Barr virus receptor) or Hs.73792; Genbank Accession No. M26004);
- (15) CD79b (CD79B, CD79 β , Igb (immunoglobulin-associated beta), B29; Genbank Accession No. NM_000626);

- (16) FcRH2 (IFGP4, IRTA4, SPAP1A (SH2 domain containing phosphatase anchor protein 1a), SPAP1B, SPAP1C; Genbank Accession No. NM_030764);
- (17) HER2 (Genbank Accession No. M11730);
- 5 (18) ErbB receptor selected from among EGFR, HER3 and HER4
- (19) NCA (Genbank Accession No. M18728);
- (20) MDP (Genbank Accession No. BC017023);
- (21) IL20R α (Genbank Accession No. AF184971);
- 10 (22) Brevican (Genbank Accession No. AF229053);
- (23) EphB2R (Genbank Accession No. NM_004442);
- (24) ASLG659 (Genbank Accession No. AX092328);
- (25) PSCA (Genbank Accession No. AJ297436);
- (26) GEDA (Genbank Accession No. AY260763);
- 15 (27) BAFF-R (B cell-activating factor receptor, BLyS receptor, BR3; NP_443177.1);
- (28) CD22 (B-cell receptor CD22-B isoform; NP-001762.1);
- (29) CD79a (CD79A, CD79 α , immunoglobulin-associated alpha, a B cell-specific protein that covalently interacts
- 20 with Ig beta (CD79B) and forms a complex on the surface with IgM molecules, transduces a signal involved in B-cell differentiation; Genbank Accession No. NP_001774.1);
- (30) CXCR5 (Burkitt's lymphoma receptor 1, a G protein-coupled receptor that is activated by the CXCL 13 chemokine,
- 25 functions in lymphocyte migration and humoral defense, plays

a role in HIV-2 infection and regarded for development of AIDS, lymphoma, myeloma, and leukemia; Genbank Accession No. NP_001707.1);

(31) HLA-DOB (Beta subunit of MHC class II molecule (Ia antigen) that binds peptides and presents them to CD4+ T lymphocytes; Genbank Accession No. NP_002111.1);

(32) P2X5 (Purinergic receptor P2X ligand-gated ion channel 5, an ion channel gated by extracellular ATP, may be involved in synaptic transmission and neurogenesis, and its deficiency may contribute to the pathophysiology of idiopathic detrusor instability; Genbank Accession No. NP_002552.2);

(33) CD72 (B-cell differentiation antigen CD72, Lyb-2; Genbank Accession No. NP_001773.1);

(34) LY64 (Lymphocyte antigen 64 (RP105), type I membrane protein of the leucine rich repeat (LRR) family, regulates B-cell activation and apoptosis, loss of function is associated with increased disease activity in patients with systemic lupus erythematosus; Genbank Accession No. NP_005573.1);

(35) FcRH1 (Fc receptor-like protein 1, a putative receptor for the immunoglobulin Fc domain that contains C2 type Ig-like and ITAM domains, may have a role in B-lymphocyte differentiation; Genbank Accession No. NP_443170.1);

(36) IRTA2 (Immunoglobulin superfamily receptor translocation associated 2, a putative immunoreceptor with possible roles in B cell development and lymphomagenesis; deregulation of the gene by translocation occurs in some B cell malignancies; Genbank Accession No. NP_112571.1);

(37) TENB2 (putative transmembrane proteoglycan, related to the EGF/hereregulin family of growth factors and follistatin; Genbank Accession No. AF179274);

(38) MAGE-C1/CT7 (protein overexpressed in testicular cancer);

(39) androgen receptor, PTEN, human kallikrein-related peptidase 3 (protein overexpressed in prostate cancer);

(40) CD20;

(41) CD30;

15 (42) CD33;

(43) CD52;

(44) EpCam;

(45) CEA;

(46) gpA33;

20 (47) Mucins;

(48) TAG-72;

(49) Carbonic anhydrase IX;

(50) PSMA;

(51) folate receptor (protein family overexpressed by FOLR gene. It has a binding affinity for folic acid, and intracellularly delivers 5-methyltetrahydrofolate);

(52) gangliosides (GD2, GD3, GM2);

5 (53) hydrate/saccharide Lewis-Y;

(54) VEGF;

(55) VEGFR;

(56) α V β 3;

(57) α 5 β 1;

10 (58) ERB3;

(59) c-MET;

(60) EphA3;

(61) TRAIL-R1, TRAIL-R2;

(62) RANKL;

15 (63) FAP; and

(64) Tenascin.

In an embodiment of the present disclosure, an antibody (Farletuzumab) binding to a folate receptor comprising a heavy chain of SEQ ID NO: 115 and a light chain of SEQ ID NO: 20 116 was used as a parent antibody. Various modified antibodies with various peptide motif sequences and arrangements were produced by introducing metal ion-binding motifs into the heavy-chain end of the parent antibody, and then the difference in the conjugation yield of drug between the 25 modified antibodies was measured. The modified antibody may

comprise one or more heavy chains selected from the group consisting of SEQ ID NOS: 117 to 121.

In addition, in another example of the present disclosure, an antibody (Trastuzumab) specifically binding to
5 Her2 was used as a parent antibody. Various modified antibodies with various peptide motif sequences and arrangements were produced by introducing metal ion-binding motifs into the heavy-chain end of the parent antibody, and then the difference in the conjugation yield of drug between
10 the modified antibodies was measured.

As a result, in antibody-drug conjugates according to the present disclosure, it was shown that when the motif was introduced into Farletuzumab and Trastuzumab, these antibodies had the equivalent level of drug conjugation yield.
15 Therefore, the motif according to the present disclosure may be used as a platform technology for conjugating a drug to an antibody in the production of antibody-drug conjugates, regardless of the type of antibody.

In one embodiment, the antibody may comprise both the
20 variable region of the parent antibody or the modified antibody and the CH1, CH2 and CH3 of IgG2 or IgG4. For example, the antibody may use the VH and VL of Farletuzumab, or Trastuzumab, or its modified antibody, and may comprise the CH1, CH2 and CH3 of IgG2 or IgG4. For example, the
25 variable region of the Farletuzumab antibody may comprise the

heavy-chain variable region of SEQ ID NO: 122 and/or the light-chain variable region of SEQ ID NO: 123.

In another embodiment, the antibody may comprise both the Fab of the parent antibody or the modified antibody and the Fc of IgG2 or IgG4. Specifically, it may comprise a fusion of the Fab region of Farletuzumab, Trastuzumab, or its modified antibody with the Fc region of IgG2 or IgG4. For example, the Fab of the Farletuzumab antibody may comprise the heavy-chain variable region of SEQ ID NO: 122 and the light-chain variable region of SEQ ID NO: 124 comprising the CH1 and/or SEQ ID NO: 124. The Trastuzumab antibody may comprise the heavy chain of SEQ ID NO: 127 and/or the light chain of SEQ ID NO: 128.

A drug that is bound to the modified antibody of the present disclosure may be any drug having disease therapeutic effects. Particularly, it is preferably a cancer therapeutic drug having the effect of inhibiting the proliferation of tumor cells.

The drug may be conjugated to a cysteine group or a serine group of a motif introduced into the end of the modified antibody.

Specifically, a drug that may be used in the modified antibody-drug conjugate of the present disclosure comprises any compound, moiety or group that has a cytotoxic or cytostatic effect, and examples thereof include: (i)

chemotherapeutic agents capable of functioning as microtubulin inhibitors, mitotic inhibitors, topoisomerase inhibitors, or DNA intercalators; (ii) protein toxins capable of functioning as enzymes; (iii) micro-RNA (miRNA), siRNA, or 5 shRNA, which can inhibit the expression of a specific oncogene; and (iv) radioisotopes.

Such a drug may be one or more selected from the group consisting of, but is not limited thereto, maytansinoid, auristatin, aminopterin, actinomycin, bleomycin, talisomycin, 10 camptothecin, N⁸-acetyl spermidine, 1-(2 chloroethyl)-1,2-dimethyl sulfonyl hydrazide, esperamicin, etoposide, 6-mercaptapurine, dolastatin, trichothecene, calicheamicin, taxane, methotrexate, vincristine, vinblastine, doxorubicin, melphalan, mitomycin A, mitomycin C, chlorambucil, duocamycin, 15 nucleolytic enzymes, toxins of bacterial, plant or animal origin, cisplatin, irinotecan, paclitaxel, and docetaxel.

In some embodiments, the drug may comprise one or more nucleophilic groups selected from the group consisting of amine, thiol, hydroxyl, hydrazide, oxime, hydrazine, 20 thiosemicarbazone, hydrazine carboxylate, and aryl hydrazide groups, which can react with the linker and an electrophilic group on the linker reagent to form a covalent bond.

In another aspect, the present disclosure provides a therapeutic composition comprising the above-described 25 antibody-drug conjugate as an active ingredient. In the

composition, the drug conjugated to a modified antibody-drug conjugate may be a cytotoxic agent, a cell proliferation inhibitor, a chemotherapeutic agent, an immune inhibitor, an anti-inflammatory agent or the like, but is not limited
5 thereto. In cancer therapy, the use of the antibody-drug conjugate for local delivery of a drug that kills or inhibits tumor cells allows the targeted delivery of the drug moiety into tumor cells by antibody-antigen interactions and the intracellular accumulation of the drug moiety.

10 The present disclosure also provides a method of inhibiting the proliferation of target cells with cancer, autoimmune, inflammatory or infectious disease by contacting the target cells using a modified antibody-drug conjugate as an active ingredient.

15 Cancer that can be treated according to the present disclosure may be one or more selected from among, but is not limited to, liver cancer, gastric cancer, breast cancer, colon cancer, bone cancer, pancreatic cancer, head and neck cancer, uterine cancer, ovarian cancer, rectal cancer,
20 esophageal cancer, small intestine cancer, anal cancer, fallopian tube cancer, endometrial cancer, cervical cancer, vaginal cancer, vulva cancer, Hodgkin's disease, prostate cancer, bladder cancer, renal cancer, ureter cancer, renal cell carcinoma, renal pelvis cancer, and cancer of the
25 central nervous system. In a specific example, proliferation

of folate receptor-amplified cancer KB cells can be inhibited by bringing the modified antibody-drug conjugate into contact with the cells in vitro. Therefore, it is evident that the inventive method of inhibiting the proliferation of target
5 cells using the modified antibody-drug conjugate as an active ingredient has the effect of killing cells related to the above-described disease or reducing and inhibiting the proliferation rate of the cells.

Unless otherwise defined, the technical or scientific
10 terms as used herein have the same meanings as understood by those having ordinary knowledge in the technical field to which the present disclosure pertains. Also, the detailed description of the same construction and effect as those of the prior art will be omitted herein.

15

EXAMPLES

Hereinafter, the present disclosure will be described in further detail with reference to examples. It will be obvious to a person having ordinary skill in the art that these
20 examples are not to be construed to limit the scope of the present disclosure, and various modifications and changes can be made within the technical idea and scope of the present disclosure.

25 Example 1: Construction of Expression Vector pAV4

For expression vector cloning, a pAV4 was used, which was developed by improving the parent vector pSGHV0 (GenBank Accession No. AF285183) according to the intended use so as to be capable of being used in antibody production in the industrial field. When a human protein is expressed using bacteria such as *E. coli*, it is overexpressed in the cells, but there are proteins difficult to obtain as physiologically active substances. Thus, the parent vector is a research vector developed for the purpose of extracellularly expressing the physiologically active protein of interest using animal cells and easily purifying the expressed protein. However, since there are various restrictions on the use of this vector in industrial production, this vector was improved so that it could be used in the industrial field, in order to use a high expression level, which is the biggest advantage of this vector, in production. In addition, for antibodies, two proteins (a heavy chain and a light chain) should be co-expressed, and for this reason, a vector suitable for this purpose was developed.

20

Example 2: Construction of Vectors for Parent Antibody Having Binding Affinity for Folate Receptor and Modified Antibody Comprising Modified Ion-Binding Motif ACGHA

To construct a parent antibody (Fwt) vector having binding affinity for folate receptor, a cDNA encoding a heavy

25

chain of SEQ ID NO: 125 and a cDNA encoding a light chain of
 SEQ ID NO: 126 were synthesized as codon-optimized sequences
 so that their expressions in CHO cells would be maximized.
 These genes were cloned into the XhoI/NotI and ApaI/SmaI of
 5 the pAV4 vector, respectively, thereby constructing a parent
 antibody vector (pFwt).

[Table 1] Amino acid sequence of Fwt antibody

	Sequences	SED ID NO S:
Heavy chain	EVQLVESGGGVVQPGRSLRLSCSASGFTFSGYGLSWVRQAPGKGLEWVAMIS SGGSYTYADSVKGRFAISRDNKNTLFLQMDSLRPEDTGVYFCARHGDDPA WFAYWGQGTPTVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPV TVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKP SNTKVDKKEPKSCDKTHTCPPCPAPELGGPSVFLFPPKPKDTLMISRTPE VTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTKSKAKGQPREPQVYTLPPSRDELTKNQ VSLTCLVKGFPYSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDK SRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK	SED ID NO: 115
Light chain	DIQLTQSPSSLSASVGDRVTITCSVSSSISNNLHWYQQKPGK APKPWIYGTSNLAGVPSRFSGSGSGTDYTFITISLQPEDIAI YYCQQWSSYPYMYTFGQGTKVEIKRTVAAPSVFIFPPSDEQLK SGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSK DSTYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRG EC	SED ID NO: 116

2-1: Construction of Modified Antibody FM2 from Folate
 10 Receptor-Binding Parent Antibody Fwt

To construct the modified antibody FM2 (Fwt-ACGHAACGHA
 (SED ID NO: 5), FM2) having two metal ion-binding motifs
 (ACGHA) from Fwt, PCR amplification was performed using the
 parent antibody Fwt vector (pFwt) as a template, an XhoI-Q5-F
 15 forward primer (5'-GCTCCTCGAGGCCACCATGGGATGGAGCTGT ATCATCC-
 3': SED ID NO: 105) and an M2 reverse primer (5'-

CCATGCGGCCGCTCATTTAGGCATGGCCA

CAAGCAGCATGGCCACAGGCACCCGGAGACAGGGAGAGGC-3': SED ID NO: 106).

The amplified nucleotide was cleaved with two restriction enzymes (XhoI and NotI) at the ends, and ligated with the expression vector pFwt having XhoI/NotI cleavage sites, thereby constructing a modified antibody vector (pFM2).

2-2: Construction of Folate Receptor-Binding Modified Antibody FM1

To construct the modified trastuzumab antibody FM1 (Fwt-GGGACGHA, pFM1) having only one metal ion-binding motif (ACGHA), PCR amplification was performed by the site-directed mutagenesis (Enzynomics co Ltd., EzChangeTM Site-directed mutagenesis kit, Ez004S) method using the above-constructed FM2 as a template, a forward primer (5'-GCTCCTCGAGGCCACCATGGGATGGAGCTGT ATCATCC-3': SED ID NO: 107) and a reverse primer (5'-CCATGCGGCCGCTCATTAGGCATGGCC ACAAGCA CCTC CACCACCCGGAGACAGGGAGA-3': SED ID NO: 108). The amplified nucleotide was cleaved with two restriction enzymes (XhoI and NotI) at the ends, and ligated with the expression vector pFwt having XhoI/NotI cleavage sites, thereby constructing a modified antibody vector (pFM1).

2-3: Construction of Folate Receptor-Binding Modified Antibody FM2L

To construct the modified antibody FM2L (Fwt-ACGHAGGGACGHA, pFM2L) comprising metal ion-binding motifs (ACGHA) connected by a linker consisting of 3 amino acid residues, PCR was performed by the site-directed mutagenesis (Enzymomics co Ltd., EzChange Site-directed mutagenesis kit, Ez004S) method using the above-constructed modified antibody FM2 as a template, a forward primer (5'-GCTCCTCGAGGCCACCATGGGATGGAGCTGTATCATCC-3': SED ID NO: 109) and a reverse primer (5'-CCATGCGGCCGCTCATTTAGGCATGGCCACAAGCACCTCCACCAGCATGGCCACAGGCACC CGGAGACAGGGAGAGGC-3': SED ID NO: 110), thereby adding a glycine linker between two metal ion-binding motifs. The amplified nucleotide was cleaved with two restriction enzymes (XhoI and NotI) at the ends, and ligated with the expression vector pFwt having XhoI/NotI cleavage sites, thereby constructing a modified antibody vector (pFM2L).

2-4: Construction of Folate Receptor-Binding Modified Antibody FM2a

To construct a modified antibody FM2a (Fwt-ASGHAACGHA (SED ID NO: 26), pFM2a) having only one metal ion-binding motif by replacing the inner cysteine in ACGHAACGHA (SEQ ID NO: 5), which consists of two metal ion-binding motifs present in the FM2 modified antibody, with serine, PCR was performed using the above-constructed modified antibody FM2

as a template, a forward primer (5'-
 GCTCCTCGAGGCCACCATGGGATGGAGCTGT ATCATCC-3': SED ID NO: 111)
 and a reverse primer (5'-
 CAGATTGCGGCCGCTCATTAGGCATGGCCACAAGCAGCATGGCCTG
 5 AGGCACCCGGAGACAGG-3': SED ID NO: 112), thereby replacing the
 inner cysteine with serine. The amplified nucleotide was
 cleaved with two restriction enzymes (XhoI and NotI) at the
 ends, and ligated with the expression vector pFwt having
 XhoI/NotI cleavage sites, thereby constructing a modified
 10 antibody vector (pFM2a)

2-5: Construction of Folate Receptor-Binding Modified
 Antibody FM2b

To construct a modified antibody FM2b (Fwt-ACGHAASGHA
 15 (SED ID NO: 21), pFM2b) having only one metal ion-binding
 motif by replacing the outer cysteine in ACGHAACGHA, which
 consists of two metal ion-binding motifs present in the FM2
 modified antibody, with serine, PCR was performed by the
 site-directed mutagenesis (Enzymomics co Ltd., EzChange Site-
 20 directed mutagenesis kit, Ez004S) method using the above-
 constructed modified antibody FM2 as a template, a forward
 primer (5'-GCTCCTCGAGGCCACCATGGGATGGAGCTGTATCATCC-3': SED ID
 NO: 113) and a reverse primer (5'-
 CAGATTGCGGCCGCTCATTAGGCATGGCCTGAAGCAGCATGGCCACA
 25 GGCACCCGGAGACAGG-3': SED ID NO: 114), thereby replacing the

outer cysteine with serine. The amplified nucleotide was cleaved with two restriction enzymes (XhoI and NotI) at the ends, and ligated with the expression vector pFwt having XhoI/NotI cleavage sites, thereby constructing a modified antibody vector (pFM2b)

[Table 2] FM antibody

	Sequences	SED ID NOS:
FM2 heavy chain	EVQLVESGGGVVQPGRSLRLSCSASGFTFSGYGLSWVRQAPGKGLEWVAMISS GGSYTTYADSVKGRFAISRDNKNTLFLQMDSLRLPEDTGVYFCARHGDDPAWF AYWGQGTPTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVS WNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVV VDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNG KEYKCKVSNKALPAPIEKTIISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLV KGFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNV FSCVMHEALHNHYTQKSLSLSPGACGHAACGHA	SED ID NO: 117
FM2a heavy chain	EVQLVESGGGVVQPGRSLRLSCSASGFTFSGYGLSWVRQAPGKGLEWVAMISS GGSYTTYADSVKGRFAISRDNKNTLFLQMDSLRLPEDTGVYFCARHGDDPAWF AYWGQGTPTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVS WNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVV VDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNG KEYKCKVSNKALPAPIEKTIISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLV KGFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNV FSCVMHEALHNHYTQKSLSLSPGASGHAACGHA	SED ID NO: 118
FM2b heavy chain	EVQLVESGGGVVQPGRSLRLSCSASGFTFSGYGLSWVRQAPGKGLEWVAMISS GGSYTTYADSVKGRFAISRDNKNTLFLQMDSLRLPEDTGVYFCARHGDDPAWF AYWGQGTPTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVS WNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVV VDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNG KEYKCKVSNKALPAPIEKTIISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLV KGFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNV FSCVMHEALHNHYTQKSLSLSPGACGHAASGHA	SED ID NO: 119
FM1 heavy chain	EVQLVESGGGVVQPGRSLRLSCSASGFTFSGYGLSWVRQAPGKGLEWVAMISS GGSYTTYADSVKGRFAISRDNKNTLFLQMDSLRLPEDTGVYFCARHGDDPAWF AYWGQGTPTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVS WNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVV VDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNG KEYKCKVSNKALPAPIEKTIISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLV KGFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNV FSCVMHEALHNHYTQKSLSLSPGGGACGHA	SED ID NO: 120
FM2L heavy	EVQLVESGGGVVQPGRSLRLSCSASGFTFSGYGLSWVRQAPGKGLEWVAMISS	SED ID

chain	GGSYTYADSVKGRFAISRDNKNTLFLQMDSLRPEDTGVYFCARHGDDPAWF AYWQGQTPVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVS WNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKHTHTCPPCPAPELGGPSVFLFPPKPKDTLMISRTPEVTCVV VDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNG KEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLV KGFYPSDIAVEWESNGQPENNYKTTPVLDSDGSFFLYSKLTVDKSRWQQGNV FSCSVMEALHNHYTQKSLSLSPGACGHAGGGACGHA	NO: 121
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Example 3: Expression and Purification of Folate Receptor-Binding Parent Antibody Fwt and Modified Antibodies

Using Chinese hamster ovary cells (CHO-K1), protein
5 expression of Fwt and its metal ion-binding motif modified
antibodies (FM1, FM2, FM2L, FM2a, and FM2b), constructed in
Example 2, was analyzed. CHO-K1 was cultured in DMEM
(Dulbecco's Modified Eagle Media) containing 10% FBS (Fetal
Bovine Serum) and an antibiotic in a 5% CO₂ incubator at 37°C.
10 On day before introduction of Fwt and its modified antibody
expression vectors, the cells were inoculated into a 100 mm
culture dish at a concentration of 5 x 10⁶ cells/ml and
cultured, and then a mixture of 800 µl of FBS-free DMEM and
10 µg of Fwt or each modified antibody expression vector was
15 kept at room temperature for 1 minute, and then mixed with 20
µg of PEI (polyethylenimine, linear, Polysciences Inc (Cat.
no: 23966, MW~25,000)), followed by incubation at room
temperature for about 10 to 15 minutes. At this time, the
cells cultured before one day were washed with PBS, and 6 ml
20 of fresh DMEM medium was added thereto. The Fwt or its
modified antibody expression vector, incubated at room

temperature for 10 to 15 minutes, was added to the culture dish. On the next day, the cells were washed with PBS, and FBS-free IMDM medium (Cat. No 12200-028, Gibco, Iscove's Modified Dulbecco's Medium) was added thereto, followed by
5 analysis of protein expression.

The Fwt and its metal ion-binding motif modified antibodies were purified as follows. Specifically, to purify the Fwt and its metal ion-binding motif modified antibodies secreted into the cell culture media, each of the culture
10 media was centrifuged, and the cells were removed, after which the supernatant was collected, injected into an HiTrapTM Protein A HP (GE Healthcare, USA) column equilibrated with equilibration buffer. Then, the supernatant was sufficiently washed with equilibration buffer, after which the pH was
15 altered by addition of glycine buffer (100mM Glycine, pH 2.8), thereby eluting the protein. The resulting solution was dialyzed against phosphate buffer, and then concentrated using Vivaspin20TM (Sartorius, USA), and finally, highly purified protein was obtained.

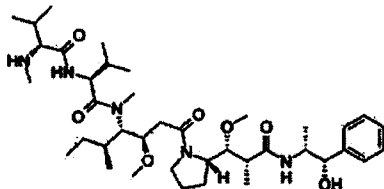
20

Example 4: Production of Antibody-Drug Conjugates by Reaction between Modified Antibody of Fwt, Maleimide Group and Cysteine

In the present disclosure, MMAE was conjugated to the
25 modified antibody Fwt, thereby producing an FMx (metal ion-

binding motif variant of Fwt)-MMAE conjugate. Monomethyl Auristatin E (known as MMAE; see Formula 2 below), a conjugatable derivative of Auristatin, is linked to a maleimide group, which binds selectively to a thiol group, via valine-citruilline, which is degraded by protease in cells, and para-aniline benzoic acid (PABA) which is a self-cleavage spacer group.

Formula 2



10 This linked structure is generally referred to as MC (maleimido caproic acid)-VC (valine-citruilline)-PAB-MMAE, and Auristatin, a highly cytotoxic compound, is known to have an IC_{50} value of 200 to 300 pM in cell proliferation inhibition assay.

15 In the present disclosure, 3 equivalents of the reducing agent TCEP was added per equivalent of the purified modified antibody and allowed to react at 4°C for 30 minutes so as to reduce the thiol group, and then 3 equivalents of MC-vc-PAB-MMAE was added thereto and allowed to react at room
20 temperature for 2 hours. The reaction was stopped by addition of an excess of cysteine, and an excess of MC-vc-PAB-MMAE and TCEP were removed by centrifugation, filtration and dialysis

in phosphate buffered saline, thereby producing resulting purified FMx-MC-vc-PAB-MMAE.

The yield of conjugation to the heavy chain of each modified antibody is shown in Table 3 below.

5 Table 3: Yield of conjugation to each modified antibody via maleimide group

Modified antibody	FM1	FM2	FM2a	FM2b	FM2L
Conjugation yield	62.7%	64.1%	64.5%	97.5%	66.3%

As can be seen in Table 3 above, the yield of conjugation of the drug to the heavy chain did significantly differ between the modified antibodies. The modified antibodies, including FM1, FM2, FM2a and FM2L, showed a conjugation yield of about 63 to 66% under drug conjugation conditions, whereas FM2b showed a very high drug conjugation yield of 97.5%. FM2b showed substantially similar conjugation yields in samples collected from two different transient transfection batches.

20 Example 5: Production of Antibody-Drug Conjugates by Reaction between Modified Antibody of Fwt, Bromoacetamide Group and Cysteine

In this Example, antibody-drug conjugates were produced by conjugation to the thiol group of cysteine via a bromoacetamide group. Bromoacetamide was bound to MMAE via valine-citurulline, which is degraded by protease in cells, and para-aniline benzoic acid (PABA) which is a self-cleavage spacer group, and MMAE was conjugated to each modified antibody by binding between bromoacetamide and a thiol group. The produced conjugate was named br (bromo acetamide)-VC (valine-citurulline)-PAB-MMAE.

In the present disclosure, 3 equivalents of the reducing agent TCEP was added per equivalent of the purified modified antibody and allowed to react at 4°C for 30 minutes so as to reduce the thiol group, and then 3 equivalents of br-vc-PAB-MMAE was added thereto and allowed to react at 37°C for 2 hours. The reaction was stopped by addition of an excess of cysteine, and an excess of br-vc-PAB-MMAE and TCEP were removed by centrifugation, filtration and dialysis in phosphate buffered saline, thereby producing resulting purified FMx-acetamide-vc-PAB-MMAE.

The yield of conjugation to the heavy chain of each modified antibody is shown in Table 4 below.

Table 4: Yield of conjugation to each modified antibody via bromoacetamide group

Modified	FM1	FM2	FM2a	FM2b	FM2L

antibody					
Conjugation yield	42%	44%	38%	73%	49%

As can be seen in Table 4 above, in the yield of conjugation of the drug to the heavy chain between the modified antibodies, FM2b shows a significantly excellent conjugation yield compared to other modified antibodies. Even in the conjugation reaction via iodoacetamide group, FM2b shows a significantly excellent conjugation yield compared to other modified antibodies.

Table 5: Yield of conjugation to each modified antibody via iodoacetamide group

Modified antibody	FM1	FM2	FM2a	FM2b	FM2L
Conjugation yield	51%	53%	44%	80%	55%

Example 6: Production of Modified Trastuzumab Antibodies

According to the method used in Example 2 above, a modified antibody was produced by introducing a metal ion-binding motif including cysteine into the C-terminus of trastuzumab.

6-1. Construction of Modified Antibody HM2 from Trastuzumab

To construct the modified antibody HM2 (HR-ACGHAACGHA (SED ID NO: 5), HM2) having two metal ion-binding motifs (ACGHA) from trastuzumab, PCR amplification was performed using the parent antibody trastuzumab vector (pHR) as a
 5 template, an XhoI-Q5-F forward primer (5'-GCTCCTCGAGGCCACCATGGGATGGAGCTGT ATCATCC-3': SED ID NO: 111) and an M2 reverse primer (5'-CCATGCGGCCGCTCATTAGGCATGGCCA CAAGCAGCATGGCCACAGGCACCCGGAGACAGGGAGAGGC-3': SED ID NO: 112). The amplified nucleotide was cleaved with two restriction
 10 enzymes (XhoI and NotI) at the ends, and ligated with the expression vector pHR having XhoI/NotI cleavage sites, thereby constructing a modified antibody vector (pHM2).

6-2. Construction of Modified Antibody HM2a from
 15 Trastuzumab

To construct a modified antibody HM2a (HR-ASGHAACGHA (SED ID NO: 26), pHM2a) having only one metal ion-binding motif by replacing the inner cysteine in ACGHAACGHA (SEQ ID NO: 5), which consists of two metal ion-binding motifs
 20 present in the HM2 modified antibody, with serine, PCR was performed using the above-constructed modified antibody HM2 as a template, a forward primer (5'-GCTCCTCGAGGCCACCATGGGATGGAGCTGT ATCATCC-3': SED ID NO: 111) and a reverse primer (5'-
 25 CAGATTGCGGCCGCTCATTAGGCATGGCCACAAGCAGCATGGCCTG

AGGCACCCGGAGACAGG-3': SED ID NO: 112), thereby replacing the inner cysteine with serine. The amplified nucleotide was cleaved with two restriction enzymes (XhoI and NotI) at the ends, and ligated with the expression vector pHR having XhoI/NotI cleavage sites, thereby constructing a modified antibody vector (pHM2a).

6-3. Construction of Modified Antibody HM2b from Trastuzumab

To construct a modified antibody HM2b (HR-ACGHAASGHA (SED ID NO: 21), pHM2b) having only one metal ion-binding motif by replacing the outer cysteine in ACGHAACGHA, which consists of two metal ion-binding motifs present in the HM2 modified antibody, with serine, PCR was performed by the site-directed mutagenesis (Enzymomics co Ltd., EzChange Site-directed mutagenesis kit, Ez004S) method using the above-constructed modified antibody HM2 as a template, a forward primer (5'-GCTCCTCGAGGCCACCATGGGATGGAGCTGTATCATCC-3': SED ID NO: 113) and a reverse primer (5'-CAGATTGCGGCCGCTCATTAGGCATGGCCTGAAGCAGCATGGCCACA GGCACCCGGAGACAGG-3': SED ID NO: 114), thereby replacing the outer cysteine with serine. The amplified nucleotide was cleaved with two restriction enzymes (XhoI and NotI) at the ends, and ligated with the expression vector pHR having

XhoI/NotI cleavage sites, thereby constructing a modified antibody vector (pHM2b).

5 Example 7: Expression and Purification of Modified
Trastuzumab Antibodies

Using Chinese hamster ovary cells (CHO-K1), protein expression of the modified trastuzumab antibodies (HM2, HM2a, HM2b), constructed in Example 6, was analyzed. CHO-K1 was cultured in DMEM (Dulbecco's Modified Eagle Media) containing 10% FBS (Fetal Bovine Serum) and an antibiotic in a 5% CO₂ incubator at 37°C. On day before introduction of Fwt and its modified antibody expression vectors, the cells were inoculated into a 100 mm culture dish at a concentration of 5 x 10⁶ cells/ml and cultured, and then a mixture of 800 µl of FBS-free DMEM and 10 µg of Fwt or each modified antibody expression vector was kept at room temperature for 1 minute, and then mixed with 20 µg of PEI (polyethylenimine, linear, Polysciences Inc (Cat. no: 23966, MW of about 25,000)), followed by incubation at room temperature for about 10 to 15 minutes. At this time, the cells cultured before one day were washed with PBS, and 6 ml of fresh DMEM medium was added thereto. The Fwt or its modified antibody expression vector, incubated at room temperature for 10 to 15 minutes, was added to the culture dish. On the next day, the cells were washed with PBS, and FBS-free IMDM medium (Cat. No 12200-028, Gibco,

Iscove's Modified Dulbecco's Medium) was added thereto, followed by analysis of protein expression.

The modified antibodies were purified as follows. Specifically, to purify the modified antibodies secreted into the cell culture media, each of the culture media was centrifuged, and the cells were removed, after which the supernatant was collected, injected into an HiTrap Protein A HP (GE Healthcare, USA) column equilibrated with equilibration buffer. Then, the supernatant was sufficiently washed with equilibration buffer, after which the pH was altered by addition of glycine buffer (100mM Glycine, pH 2.8), thereby eluting the protein. The resulting solution was dialyzed against phosphate buffer, and then concentrated using Vivaspin20 (Sartorius, USA), and finally, highly purified protein was obtained.

Example 8: Production of Antibody-Drug Conjugates by Conjugation of MC-vc-PAB-MMAE to Modified Trastuzumab Antibodies

In the present disclosure, HMx (metal ion-binding motif variant of trastuzumab)-MMAE conjugates were produced by conjugating MMAE to the modified trastuzumab antibodies produced in Examples 6 and 7. In the present disclosure, 3 equivalents of the reducing agent TCEP was added per equivalent of the purified modified antibody and allowed to

react at 4°C for 30 minutes so as to reduce the thiol group, and then 2.5 equivalents of MC-vc-PAB-MMAE was added thereto and allowed to react at room temperature for 2 hours. The reaction was stopped by addition of an excess of cysteine, and an excess of MC-vc-PAB-MMAE and TCEP were removed by centrifugation, filtration and dialysis in phosphate buffered saline, thereby producing resulting purified FMx-MC-vc-PAB-MMAE.

The yield of conjugation to the heavy chain of each modified antibody is shown in Table 6 below.

Table 6: Yield of conjugation to each modified antibody via maleimide group

Modified antibody	HM2	HM2a	HM2b
Conjugation yield	55.5%	62.4%	85.5%

As can be seen in Table 6 above, the yield of conjugation of the drug to the heavy chain did significantly differ between the modified antibodies. The modified antibodies, HM2 and HM2a, showed a conjugation yield of about 55 to 62% under the same drug conjugation conditions, whereas HM2b showed a very high drug conjugation yield of 85.5%. These results indicate that even when the sequence of M2b is introduced into not only Farletuzumab, but also other antibodies, the conjugation yield is also high.

Example 9: Production of Modified Antibodies by Replacement of Serine in M2b (ACGHAASGHA; SEQ ID NO: 21) Sequence

From the Examples above, it could be seen that M2b (ACGHAASGHA) obtained by replacing the inner cysteine in the metal ion-binding motif M2 (ACGHAACGHA) with serine showed a significantly higher drug conjugation ability than the M2 sequence. In order to examine whether this serine replacement site shows the same effect even in replacement of other amino acids, modified antibodies were produced by replacing this site with various amino acid residues.

Table 7: Modified antibodies obtained by replacing serine site of M2b sequence with other amino acid residues

Modified antibodies	Metal ion-binding motif sequence of C-terminus
M2b or M2b-S	ACGHAASGHA (SEQ ID NO: 21)
M2b-A	ACGHAAAGHA (SEQ ID NO: 33)
M2b-T	ACGHAATGHA (SEQ ID NO: 45)
M2b-Y	ACGHAAYGHA (SEQ ID NO: 57)
M2b-D	ACGHAADGHA (SEQ ID NO: 69)
M2b-K	ACGHAAKGA (SEQ ID NO: 81)
M2b-F	ACGHAAFAGHA (SEQ ID NO: 93)

Each of the modified antibodies having the C-terminal sequences shown in Table 7 above was introduced into FM2b or

FM2b-S, thereby producing modified antibodies, including FM2b-A, FM2b-T, FM2b-Y, FM2b-D, FM2b-K and FM2b-F.

5 Example 10: Production of Antibody-Drug Conjugates by
Conjugation of MC-vc-PAB-MMAE to FM2b Modified Antibodies

In the present disclosure, FM2b-X-MMAE conjugates were produced by conjugating MMAE to the modified antibody FM2b-X (X = A, T, Y, D, K, or F) produced in Example 9. In the present disclosure, 3 equivalents of the reducing agent TCEP
 10 was added per equivalent of the purified modified antibody and allowed to react at 4°C for 30 minutes so as to reduce the thiol group, and then 2.5 equivalents of MC-vc-PAB-MMAE was added thereto and allowed to react at room temperature for 2 hours. The reaction was stopped by addition of an
 15 excess of cysteine, and an excess of MC-vc-PAB-MMAE and TCEP were removed by centrifugation, filtration and dialysis in phosphate buffered saline, thereby producing resulting purified FM2b-X-MC-vc-PAB-MMAE.

The yield of conjugation to the heavy chain of each
 20 modified antibody is shown in Table 8 below.

Table 8: DAR2 Yield upon Conjugation of MC-vc-PAB-MMAE to FM2b-X Modified Antibodies

Modified antibody	FM2b	FM2b-A	FM2b-T	FM2b-Y	FM2b-D	FM2b-K	FM2b-F
Conjugation yield	72.8%	62.5%	69%	74.5%	58.9%	75.3%	72.9%

As can be seen in Table 8 above, even when the inner serine site of the M2b sequence ACGHAASGHA was replaced with other amino acid residues, the results similar to those shown by FM2b were obtained.

5

Example 11: Purification of Antibody-Drug Conjugate Having DAR of 2

The modified antibody-drug conjugates produced in Example 4 above had different numbers of drugs conjugated per modified antibody (drug-to-antibody ratio; DAR), and for this reason, it would not be easy to compare the cytotoxicity of the drug *in vitro*. Thus, in order to purify modified antibody-drug conjugates having the same DAR, modified antibody-drug conjugates were purified by hydrophobic chromatography. Using phenyl column chromatography, modified antibody-drug conjugates having a DAR of 2 were purified. The column was equilibrated with buffer (containing 10 mM sodium succinate, 0.5M NaCl, pH 5.0), and then each modified antibody-drug conjugate was injected into the column. The column was washed with the same buffer, and then the buffer containing 30% acetonitrile was added thereto, and the modified antibody-drug conjugate was eluted according to the DAR. The eluted modified antibody-drug conjugate was subjected to dialysis in buffer (containing 10 mM sodium succinate, 30 mM sucrose, pH 6.0).

Example 12: Test for *In Vitro* Stability of Antibody-Drug Conjugates

As described in Examples 9, 10 and 11 above, FM2b-S-D2, FM2b-F-D2, FM2b-K-D2 and FM2b-Y-D2, which are antibody-drug
5 conjugates comprising two MC-vc-PAB-MMAE drugs, were produced. Each of the produced antibody-drug conjugates was incubated at temperatures of 25°C and 50°C, the change in the number of drugs conjugated and the change in aggregation were measured.

For each antibody-drug conjugate, 12 test samples were
10 prepared at each of concentrations of 1 mg/mL and 110 µL. For each antibody-drug conjugate, changes in the DAR and the monomer purity were measured while 6 samples were stored at 25°C and the remaining 6 samples were stored at 60°C for 0, 1, 3, 5, 7 and 14 days. At 25°C, a decrease in DAR2 content of
15 about 1.5-2% was observed in each sample, and a decrease in monomer purity of about 0.3-4% was observed in each sample, but the difference in DAR2 content and monomer purity between the samples was not significant. The changes in DAR2 content and monomer purity, observed at 50°C, were greater than the
20 values observed at 25°C, but the difference between the samples was not significant. This suggests that the differences between the antibody variants were not significant.

Table 9: Monomer contents of FM2b-S-D2, FM2b-F-D2, FM2b-K-D2 and FM2b-Y-D2 on days 0, 1, 3, 5, 7 and 15 under storage conditions of 25°C and 50°C

Storage temperature	Sample	Day 0	Day 1	Day 3	Day 5	Day 7	Day 15
25°C	FM2b-S-D2	97.6	97.6	97.2	96.4	95.6	95.1
	FM2b-F-D2	97	97.8	97.2	96.6	96.1	95
	FM2b-K-D2	97.6	97.6	97.3	96.6	96.1	96.3
	FM2b-Y-D2	96.7	96.6	97	95.8	95.4	94.9
50°C	FM2b-S-D2	97.6	93.9	88.8	82.8	79.1	68.9
	FM2b-F-D2	97	93.7	86.9	80.9	76.9	63.5
	FM2b-K-D2	97.6	93.9	87.7	81.8	77.8	66.8
	FM2b-Y-D2	96.7	93.9	88.4	82.7	77.9	66.6

5 Table 10: DAR2 contents of FM2b-S-D2, FM2b-F-D2, FM2b-K-D2 and FM2b-Y-D2 on days 0, 1, 3, 5, 7 and 15 under storage conditions of 25°C and 50°C

Storage temperature	DAY	Day 0	Day 1	Day 3	Day 5	Day 7	Day 15
25°C	FM2b-S-D2	98.9	98.6	98.6	98.2	98.4	98.1
	FM2b-F-D2	98.2	98.4	98.4	98.2	98.3	97.9
	FM2b-K-D2	97.9	97.4	97.5	97.3	97.3	97
	FM2b-Y-D2	97.6	97.6	97.4	96.6	95.5	93.2
50°C	FM2b-S-D2	98.9	97.1	93.6	91.8	90.7	87.9
	FM2b-F-D2	98.2	96.5	93.2	89.4	88.3	85.1
	FM2b-K-D2	97.9	96.2	94.6	91.8	90.8	88.9
	FM2b-Y-D2	97.6	95.8	91.3	89.4	87.6	84.4

Example 13: Test for *In Vitro* Cell Growth Inhibition

10 To compare the *in vitro* cell growth inhibition abilities of the modified antibody-drug conjugates, a cell growth

inhibition test was performed using KB-cells overexpressing folate receptor. KB-cells were diluted in 10% FBS-containing DMEM/F12 medium, and then 100 μ l of the cell dilution was added to each well of a 96-well plate at a density of 1×10^4 cells/well. Next, the well plate was incubated in an incubator under 5% carbon dioxide at 37°C for 24 hours to attach the cells to the plate. Each test sample was diluted in medium, and then added to each well to concentrations of 6.45 nM, 3.23 nM, 1.61 nM, 0.806 nM, 0.403 nM, 0.202 nM, 0.101 nM, 0.0504 nM, 0.0252 nM and 0.0126 nM, and medium (without drug) was also added to a control well. After 5 days of incubation, 20 μ l/well of CellTiter 96-AQueousTM One Solution reagent [MTS-based assay; MTS forms purple formazan by dehydrogenase of living cells, and growth is measured by the amount of purple formazan produced] was added to each well, and then incubated in an incubator at 37°C for 2 hours. The cell lysate was measured by an absorption spectrometer at an O.D. of 490 nm, thereby determining viability (%).

20 13-1: Test for Comparison of Cell Growth Inhibitory Activity between FM2-D2 and FM2b-D2 (or FM2b-S-D2)

The parent antibody Fwt, FM2-D2 (a modified antibody (FM2)-drug (MMAE) conjugate having a DAR of 2) and FM2b-D2 (a modified antibody (FM2b)-drug (MMAE) having a DAR of 2), 25 obtained by conjugating MMAE in the above Examples and

performing purification to have the same DAR, were prepared, and KB cells were treated with each of the prepared conjugates, after which the cell growth inhibitory activity of the drug was compared between the conjugates.

5 As can be seen in FIG. 3, the antibody-drug conjugates (FM2-D2 and FM2b-D2) showed significantly better anticancer effects than the parent antibody. FM2-D2 and FM2b-D2 showed almost the same inhibitory effect against cancer cell growth. These results indicate that when the modified antibody-drug
10 conjugates have the same DAR, there is no difference in cancer cell inhibitory activity between the modified antibodies, FM2 and FM2b.

13-2: Test for Comparison of Cell Growth Inhibitory
15 Activity between FM2-D2 and FM2b-D2 (or FM2b-S-D2)

To compare cell growth inhibitory activity between antibody-drug conjugates based on FM2b-S and other variants, MC-vc-PAB-MMAE was conjugated to each of FM2b-S, -F and -Y variants, and then the conjugates were purified to have the
20 same DAR, after which KB cells were treated with each of the conjugates, and then the cell growth inhibitory activity of the drug was compared between the conjugates.

As can be seen in FIG. 4, FM2b-S-D2, FM2b-F-D2 and FM2b-Y-D2 shows almost the same cell growth inhibitory activity.
25 The measured IC₅₀ values were 0.25 nM for FM2b-S-D2, 0.26 nM

for FM2b-F-D2, and 0.24 nM for FM2b-Y-D2. These results indicate that there is no difference in cancer cell growth inhibitory activity between the antibody-drug conjugates based on the antibody variants obtained by replacing the
5 serine of FM2b-S with each of phenylalanine and tyrosine.

These results show that when an antibody-drug conjugate is produced using the antibody including the M2b sequence, it shows a significantly better yield of drug conjugation compared to other modified antibodies, while the anticancer
10 activity thereof has no difference from the anticancer activities of other modified antibodies. In addition, it could be seen that even when the serine site in the M2b sequence ACGHA-ASGHA was replaced with other amino acid residues, there was no difference in the conjugation yield,
15 stability or anticancer activity of the drug. This suggests that when the motif ACGHA-AXGHA (X is an amino acid other than cysteine) as used in FM2b or HM2b is introduced into the end of the heavy chain of an antibody, the modified antibody has a significantly better conjugation yield, making it
20 possible to produce an antibody-drug conjugate in a more efficient and economic manner.

INDUSTRIAL APPLICABILITY

The antibody-drug conjugate produced by the antibody
25 variants according to the present disclosure can increase the

conjugation yield of the drug, thereby increasing the productivity of the antibody-drug conjugate. In addition, a drug conjugated to the end of an antibody does not hinder the structural stability of the parent antibody, so that the
5 intrinsic antigen specificity and structural stability of the parent antibody can be maintained, and the drug conjugated to the antibody can be delivered specifically to cancer cells owing to a high antigen specificity of the parent antibody.

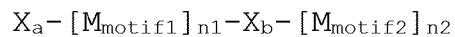
Although the present disclosure has been described in
10 detail with reference to the specific features, it will be apparent to those skilled in the art that this description is only for a preferred embodiment and does not limit the scope of the present disclosure. Thus, the substantial scope of the present disclosure will be defined by the appended claims
15 and equivalents thereof.

Claims

【Claim 1】

An antibody-drug conjugate in which a modified antibody comprising a motif, represented by the following structural formula (1), at an end of the antibody, is bound to a drug by a linker:

Structural Formula (1)



wherein:

10 M_{motif1} is a sequence of ACGHA (SEQ ID NO: 1) or AHGCA (SEQ ID NO: 2), M_{motif2} is AXGHA (SEQ ID NO: 3) or AHGXA (SEQ ID NO: 4), wherein X in SEQ ID NO: 3 or 4 is an amino acid residue selected from the group consisting of serine (S), alanine (A), threonine (T), tyrosine (Y), aspartic acid (D), lysine (K),
15 and phenylalanine (F), or

M_{motif1} is a sequence of AXGHA (SEQ ID NO: 3) or AHGXA (SEQ ID NO: 4), wherein X in SEQ ID NO: 3 or 4 is an amino acid residue selected from the group consisting of serine (S), alanine (A), threonine (T), tyrosine (Y), aspartic acid (D),
20 lysine (K), and phenylalanine (F), and M_{motif2} is a sequence of a sequence of ACGHA (SEQ ID NO: 1) or AHGCA (SEQ ID NO: 2)

X_a and X_b independently are each a peptide consisting of 0 to 20 amino acid residues selected from the group consisting of A (alanine), S (serine), and G (glycine); and

25 $n1$ and $n2$ are each an integer ranging from 1 to 10.

【Claim 2】

The antibody-drug conjugate of claim 1, wherein the motif represented by the structural formula (1) is a sequence selected from the group consisting of SEQ ID NOS: 21 to 104.

5 **【Claim 3】**

The antibody-drug conjugate of claim 1, wherein the motif is introduced to the heavy-chain C-terminus of the antibody.

【Claim 4】

10 The antibody-drug conjugate of claim 1, wherein the linker comprises a reactive functional group, which bind to the motif, an amino acid, and a self-cleavage spacer.

【Claim 5】

The antibody-drug conjugate of claim 1, wherein the drug
15 is selected from among a maytansinoid, an auristatin, aminopterin, actinomycin, bleomycin, talisomycin, camptothecin, N⁸-acetyl spermidine, 1-(2 chloroethyl)-1,2-dimethyl sulfonyl hydrazide, esperamicin, etoposide, 6-mercaptopurine, dolastatin, trichothecene, calicheamicin, a taxane,
20 methotrexate, vincristine, vinblastine, doxorubicin, melphalan, mitomycin A, mitomycin C, chlorambucil, duocamycin, a nucleolytic enzyme, a toxin of bacterial, plant or animal origin, cisplatin, irinotecan, paclitaxel, and docetaxel.

25

【Claim 6】

The antibody-drug conjugate of claim 1, wherein the antibody is selected from the group consisting of a monoclonal antibody, a bispecific antibody, a chimeric antibody, a human antibody, and a humanized antibody.

【Claim 7】

The antibody-drug conjugate of claim 1, wherein the antibody is selected from the group consisting of IgA, IgD, IgE, IgG, and IgM.

10 【Claim 8】

The antibody-drug conjugate of claim 1, wherein the antibody has a binding affinity and specificity for a cancer-specific antigen, a cell surface receptor protein, a cell surface protein, a transmembrane protein, a signaling protein, a cell survival regulator, a cell proliferation regulator, a molecule associated with tissue development or differentiation, a lymphokine, a cytokine, a molecule involved in cell cycle regulation, a molecule involved in vasculogenesis, or a molecule associated with angiogenesis.

20 【Claim 9】

The antibody-drug conjugate of claim 1, wherein the antibody has a binding affinity for a target selected from the group consisting of:

(1) BMPRI_B (bone morphogenetic protein receptor-type IB; Genbank Accession No. NM_001203);

- (2) E16 (LAT1, SLC7A5; Genbank Accession No. NM_003486);
- (3) STEAP1 (six transmembrane epithelial antigen of prostate; Genbank Accession No. NM_012449);
- (4) 0772P (CA125, MUC16; Genbank Accession No. AF361486);
- (5) MPF (MPF, MSLN, SMR, megakaryocyte potentiating factor, mesothelin; Genbank Accession No. NM_005823);
- (6) Napi3b (NAPI-3B, NPTIIb, SLC34A2, solute carrier family 34 (sodium phosphate), member 2, type II sodium-dependent phosphate transporter 3b; Genbank Accession No. NM_006424);
- (7) Sema 5b (FLJ10372, KIAA1445, Mm.42015, SEMA5B, SEMAG, Semaphorin 5b Hlog, sema domain, seven thrombospondin repeats (type 1 and type 1-like), transmembrane domain (TM) and short cytoplasmic domain, (semaphorin) 5B; Genbank Accession No. AB040878);
- (8) PSCA hlg (2700050C12Rik, C530008016Rik, RIKEN cDNA 2700050C12, RIKEN cDNA 2700050C12 gene; Genbank Accession No. AY358628);
- (9) ETBR (Endothelin type B receptor; Genbank Accession No. AY275463);
- (10) MSG783 (RNF124, hypothetical protein FLJ20315; Genbank Accession No. NM_017763);
- (11) STEAP2 (HGNC_8639, IPCA-1, PCANAP1, STAMP1, STEAP2, STMP, prostate cancer associated gene 1, prostate cancer

associated protein 1, six-transmembrane epithelial antigen of prostate 2, six-transmembrane prostate protein; Genbank Accession No. AF455138);

5 (12) TrpM4 (BR22450, FLJ20041, TRPM4, TRPM4B, transient receptor potential cation channel, subfamily M, member 4; Genbank Accession No. NM_017636);

(13) CRIPTO (CR, CR1, CRGF, CRIPTO, TDGF1, teratocarcinoma-derived growth factor; Genbank Accession No. NP_003203 or NM_003212);

10 (14) CD21 (CR2 (Complement receptor 2) or C3DR (C3d/Epstein Barr virus receptor) or Hs.73792; Genbank Accession No. M26004);

(15) CD79b (CD79B, CD79 β , Igb (immunoglobulin-associated beta), B29; Genbank Accession No. NM_000626);

15 (16) FcRH2 (IFGP4, IRTA4, SPAP1A (SH2 domain containing phosphatase anchor protein 1a), SPAP1B, SPAP1C; Genbank Accession No. NM_030764);

(17) HER2 (Genbank Accession No. M11730);

(18) ErbB receptor selected from among EGFR, HER3 and
20 HER4

(19) NCA (Genbank Accession No. M18728);

(20) MDP (Genbank Accession No. BC017023);

(21) IL20R α (Genbank Accession No. AF184971);

(22) Brevican (Genbank Accession No. AF229053);

25 (23) EphB2R (Genbank Accession No. NM_004442);

- (24) ASLG659 (Genbank Accession No. AX092328);
- (25) PSCA (Genbank Accession No. AJ297436);
- (26) GEDA (Genbank Accession No. AY260763);
- (27) BAFF-R (B cell-activating factor receptor, BLyS
5 receptor, BR3; NP_443177.1);
- (28) CD22 (B-cell receptor CD22-B isoform; NP-001762.1);
- (29) CD79a (CD79A, CD79 α , immunoglobulin-associated
alpha, a B cell-specific protein that covalently interacts
with Ig beta (CD79B) and forms a complex on the surface with
10 IgM molecules, transduces a signal involved in B-cell
differentiation; Genbank Accession No. NP_001774.1);
- (30) CXCR5 (Burkitt's lymphoma receptor 1, a G protein-
coupled receptor that is activated by the CXCL 13 chemokine,
functions in lymphocyte migration and humoral defense, plays
15 a role in HIV-2 infection and regarded for development of
AIDS, lymphoma, myeloma, and leukemia; Genbank Accession No.
NP_001707.1);
- (31) HLA-DOB (Beta subunit of MHC class II molecule (Ia
antigen) that binds peptides and presents them to CD4+ T
20 lymphocytes; Genbank Accession No. NP_002111.1);
- (32) P2X5 (Purinergic receptor P2X ligand-gated ion
channel 5, an ion channel gated by extracellular ATP, may be
involved in synaptic transmission and neurogenesis, and its
deficiency may contribute to the pathophysiology of

idiopathic detrusor instability; Genbank Accession No. NP_002552.2);

(33) CD72 (B-cell differentiation antigen CD72, Lyb-2; Genbank Accession No. NP_001773.1);

5 (34) LY64 (Lymphocyte antigen 64 (RP105), type I membrane protein of the leucine rich repeat (LRR) family, regulates B-cell activation and apoptosis, loss of function is associated with increased disease activity in patients with systemic lupus erythematosus; Genbank Accession No. 10 NP_005573.1);

(35) FcRH1 (Fc receptor-like protein 1, a putative receptor for the immunoglobulin Fc domain that contains C2 type Ig-like and ITAM domains, may have a role in B-lymphocyte differentiation; Genbank Accession No. 15 NP_443170.1);

(36) IRTA2 (Immunoglobulin superfamily receptor translocation associated 2, a putative immunoreceptor with possible roles in B cell development and lymphomagenesis; deregulation of the gene by translocation occurs in some B 20 cell malignancies; Genbank Accession No. NP_112571.1);

(37) TENB2 (putative transmembrane proteoglycan, related to the EGF/hereregulin family of growth factors and follistatin; Genbank Accession No. AF179274);

(38) MAGE-C1/CT7 (protein overexpressed in testicular 25 cancer);

(39) androgen receptor, PTEN, human kallikrein-related peptidase 3 (protein overexpressed in prostate cancer);

(40) CD20;

(41) CD30;

5 (42) CD33;

(43) CD52;

(44) EpCam;

(45) CEA;

(46) gpA33;

10 (47) Mucins;

(48) TAG-72;

(49) Carbonic anhydrase IX;

(50) PSMA;

(51) folate receptor (protein family overexpressed by
15 FOLR gene. It has a binding affinity for folic acid, and
intracellularly delivers 5-methyltetrahydrofolate);

(52) gangliosides (GD2, GD3, GM2);

(53) hydrate/saccharide Lewis-Y;

(54) VEGF;

20 (55) VEGFR;

(56) α V β 3;

(57) α 5 β 1;

(58) ERB3;

(59) c-MET;

25 (60) EphA3;

(61) TRAIL-R1, TRAIL-R2;

(62) RANKL;

(63) FAP; and

(64) Tenascin.

5 **【Claim 10】**

The antibody-drug conjugate of claim 1, wherein the antibody comprises either the variable region and the CH1, CH2 and CH3 of IgG2 or IgG4, or the Fab and the Fc of IgG2 or IgG4.

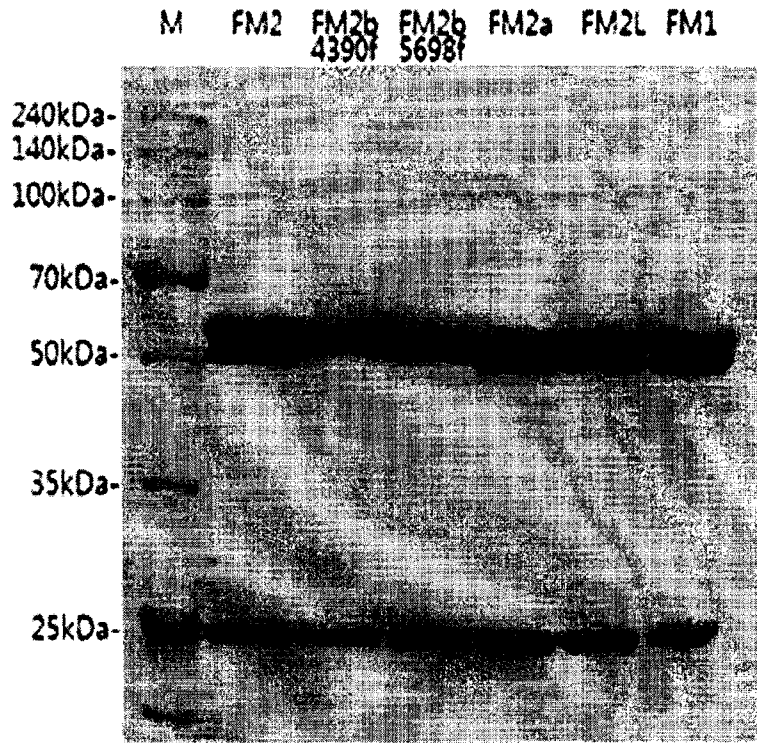
10 **【Claim 11】**

The antibody-drug conjugate of claim 1, wherein the drug is conjugated to the cysteine residue or X in the motif.

【Claim 12】

15 A composition for preventing or treating cancer, which comprises the antibody-drug conjugate of claim 1, and a pharmaceutically acceptable excipient, wherein the drug is as defined in claim 5 and the antibody has a binding affinity as defined in claim 9 or 10.

Fig. 1



After Conjugation
10 % SDS-PAGE gel (R)

Fig. 2

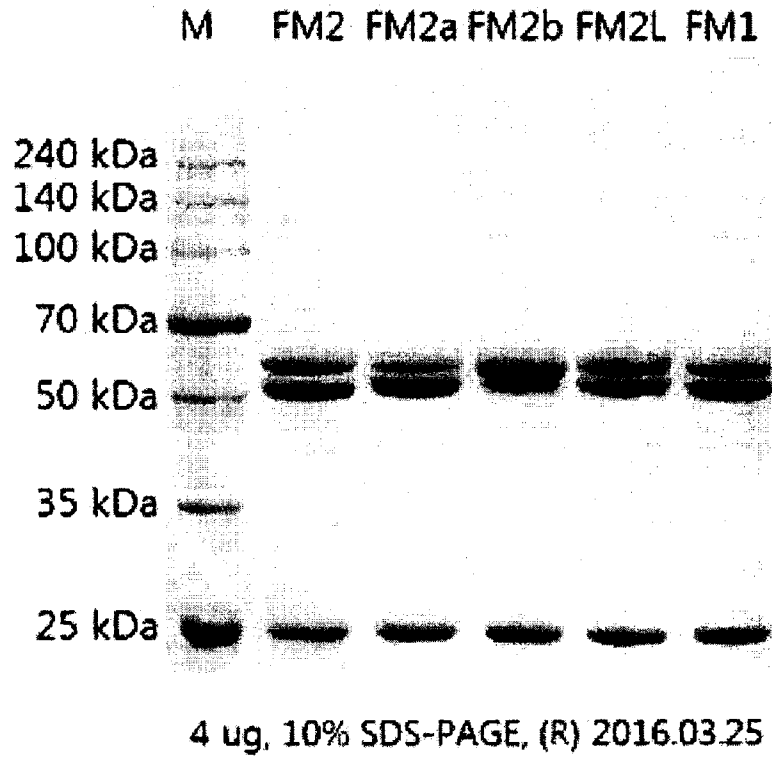


Fig. 3

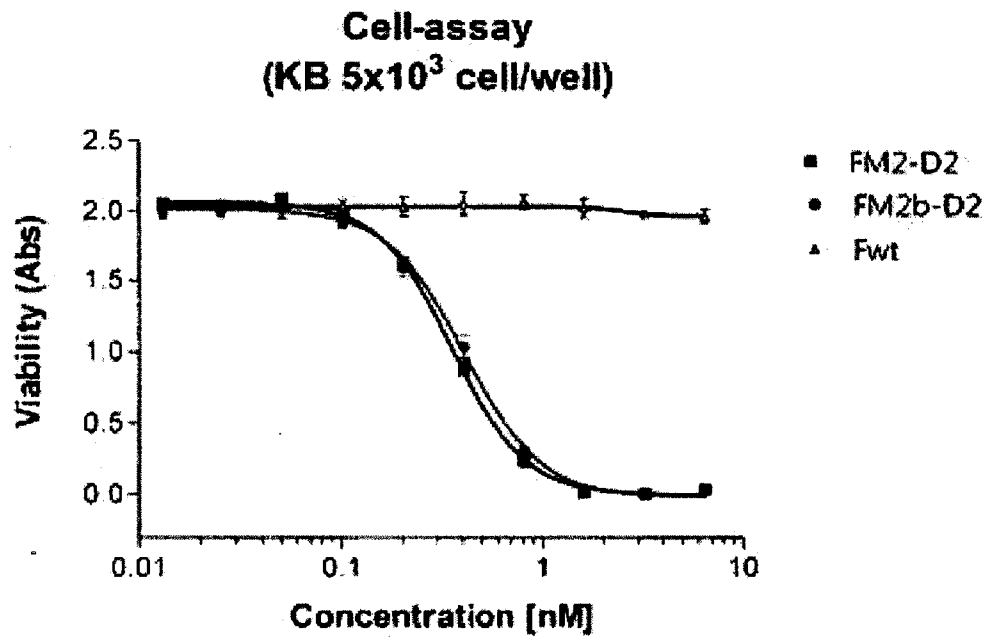


Fig. 4

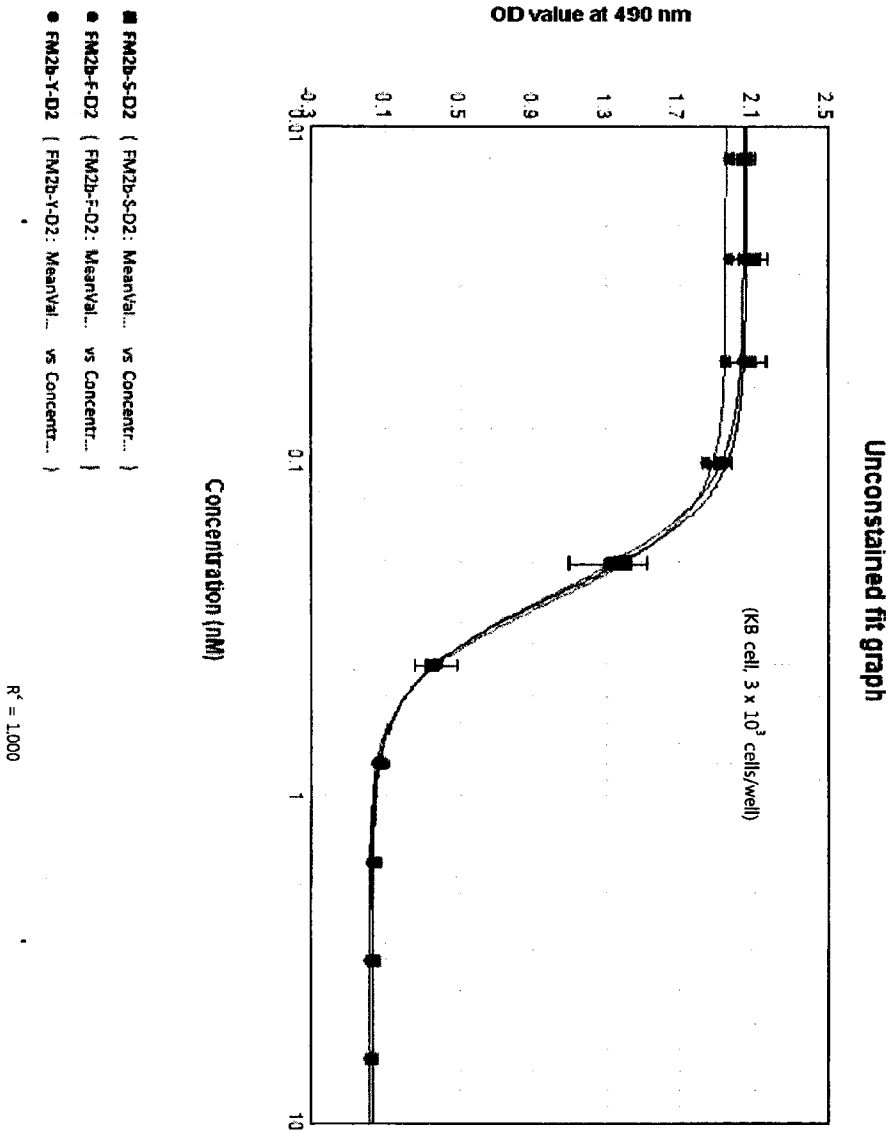
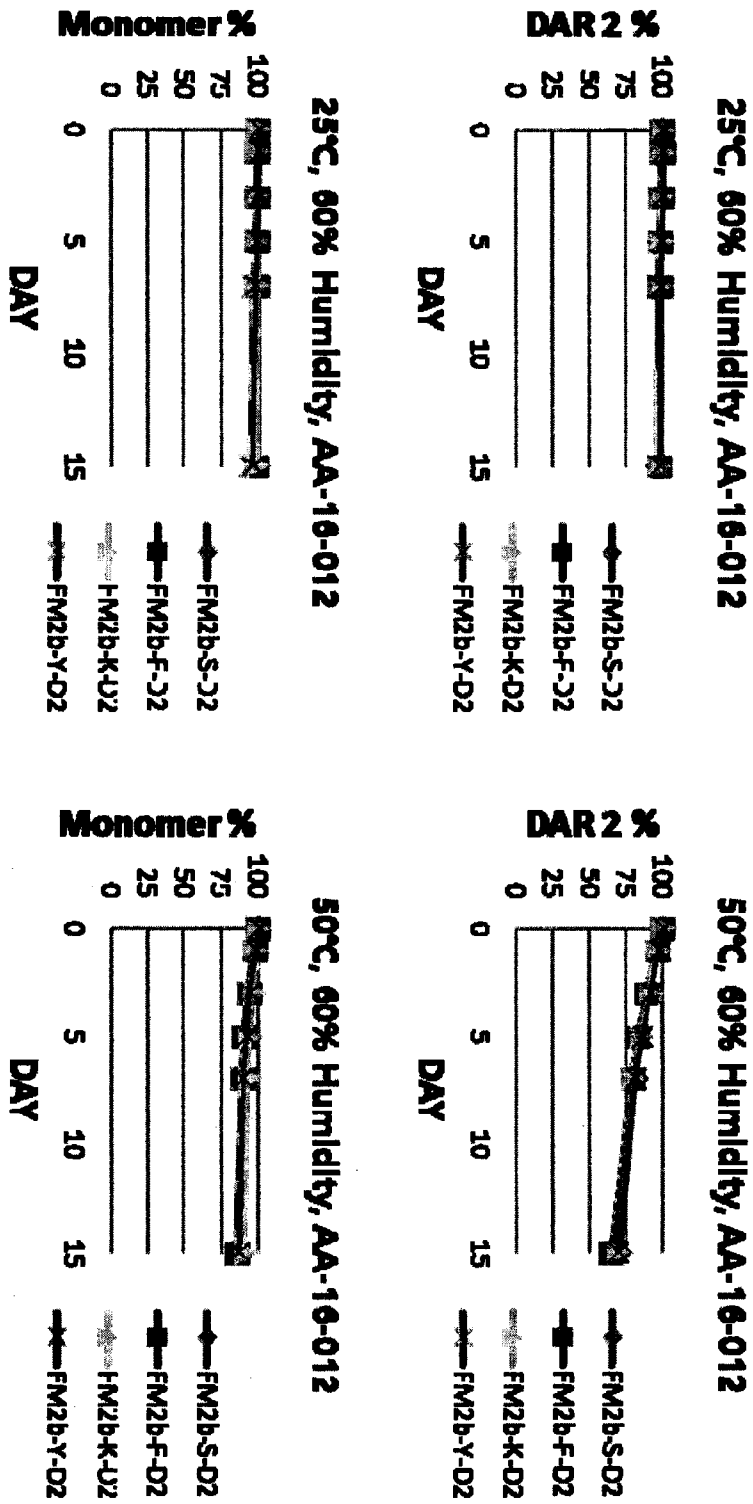
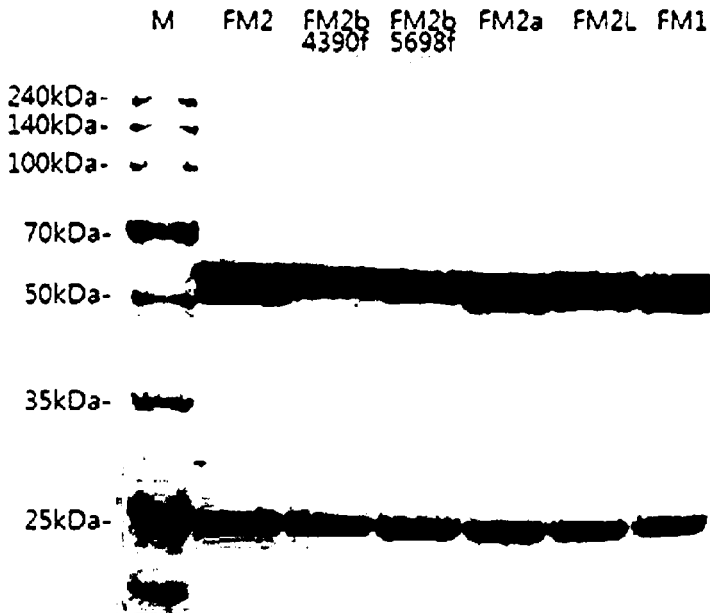


Fig. 5





Conjugation 率
10 % SDS-PAGE gel (R)