

CYCLIC PEPTIDE, AFFINITY CHROMATOGRAPHY SUPPORT, LABELED ANTIBODY, ANTIBODY DRUG CONJUGATE, AND PHARMACEUTICAL PREPARATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a cyclic peptide, an affinity chromatography support, a labeled antibody, an antibody drug conjugate, and a pharmaceutical preparation.

2. Description of the Related Art

[0002] Currently, antibody drugs are drawing attention as the most reliable molecular-targeted drugs and are rapidly broadening the field of new pharmaceutical products. In most of the antibody drugs that are being developed or used currently, antibodies belonging to the class of immunoglobulin G (IgG) are used.

[0003] In the related art, for the purification of IgG antibodies, proteins such as protein A or protein G derived from *Staphylococcus aureus* are used. Because these proteins also bind to IgG of a mouse and a rabbit, the proteins have been frequently used for IgG purification at the level of reagents for research. In recent years, the antibody drugs mainly exploiting human IgG1 have been used in the pharmaceutical field, and accordingly, the importance of the antibody drugs in the industrial and pharmaceutical use has increased further. Particularly, a protein A column plays a key role in the antibody drug purification, and many of the antibody drug manufacturers adopt a purification system mainly using this column.

[0004] However, some problems have been pointed out for the protein A column. One of the problems is that protein A is mixed into purified antibodies. Protein A is a protein derived from bacteria and exhibits high immunogenicity after being administered into the human body, and there is a concern over the mixing of endotoxin into this protein. For the affinity ligand, such as protein A as a ligand, used for the purification of pharmaceutical products, in order to avoid the intermixing of undesirable substances, a high degree of purification is required. Therefore, the cost of the protein A column used for the purification of pharmaceutical products increases.

[0005] In order to solve the problem, a new IgG antibody purification system is being developed.

[0006] For example, US Patent App. No. 2004/0087765 describes an immunoglobulin-binding polypeptide which has an amino acid sequence of

R^1 -X01-X02-X03-X04-X05-X06-X07-X08-X09-X10-X11-X12-X13- R^2 and includes about 11 to 13 residues. US Patent App. No. 2004/0087765 describes that the polypeptide may be a cyclic peptide cyclized by forming a disulfide bond (in a case where X02 = X12 = C) or an amide bond (in a case where one of X02 and X12 is Dpr, Dab, K, or Orn and the other is D or E; here, Dab represents diaminobutanoic acid, Dpr represents diaminopropionic acid, and Orn represents ornithine) between X02 and X12 ([0017] to [0034]).

[0007] Furthermore, for example, WO2013/027796A describes an IgG-binding polypeptide which is represented by (X_{1-3}) -C-(X₂)-H-R-G-(Xaa1)-L-V-W-C-(X₁₋₃) and includes 13 to 17 amino acid residues. WO2013/027796A describes that the polypeptide may be a cyclic peptide in which a disulfide bond is formed between two cysteine (C) residues ([0042] to [0044]).

[0008] Moreover, for example, JP2007-289200A describes an IgG-Fc-binding peptide which has

Formula

Xaa₁-Xaa₂-Xaa₃-Xaa₄-Cys-Xaa₅-Xaa₆-Xaa₇-Xaa₈-Gly-Glu-Leu-Val-Trp-Cys-Xaa₉-Xaa₁₀-Xaa₁₁-Xaa₁₂-Xaa₁₃ and has 11 to 20 amino acids (claim 39). JP2007-289200A describes that the peptide can be cyclized by the formation of a disulfide bond or a lactam bond, the residues which can form a disulfide bond include Cys, Pen, Mpr, Mpp, and the like, and the residues which can form a lactam bond include Asp, Glu, Lys, Orn, $\alpha\beta$ -diaminobutyric acid, diaminoacetic acid, aminobenzoic acid, mercaptobenzoic acid, and the like ([0039]).

SUMMARY OF THE INVENTION

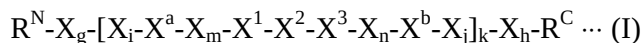
[0010] Focusing on improving the antibody binding properties by controlling the steric structure, the inventor of the present invention examined the binding activity and the chemical resistance of the antibody binding cyclic peptides described in US Patent App. No. 2004/0087765, WO2013/027796A, and JP2007-289200A. As a result, the inventor found that the binding activity and the chemical resistance of the peptides need to be further improved.

[0011] An object of the present invention is to provide a cyclic peptide having excellent antibody binding properties and improved chemical resistance, an affinity chromatography support, a labeled antibody, an antibody drug conjugate, and a pharmaceutical preparation.

[0012] In order to achieve the aforementioned object, the inventor of the present invention repeated intensive examinations. As a result, the inventor found that the amino acid residues in cross-linked portions play important roles for the chemical resistance, and accomplished the present invention.

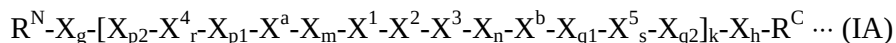
[0013] That is, the present invention provides [1] to [50] described below.

[1] A cyclic peptide represented by Formula (I).



In Formula (I), R^N represents an N-terminal group; R^C represents a C-terminal group; X^1 represents an L-leucine residue, an L-isoleucine residue, an L-methionine residue, an L-lysine residue, or an L-arginine residue; X^2 represents an L-valine residue or an L-isoleucine residue; X^3 represents an L-tryptophan residue; X^a and X^b each independently represent an amino acid residue derived from an amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain, and are bonded to each other through a disulfide bond, or, one of X^a and X^b represents an amino acid residue derived from an amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain, and the other represents an amino acid residue derived from an amino acid having a haloacetyl group on a side chain, and X^a and X^b are bonded to each other through a thioether bond; X_g , X_h , X_i , X_j , X_m , and X_n each represent g consecutive X's, h consecutive X's, i consecutive X's, j consecutive X's, m consecutive X's, and n consecutive X's; X represents an amino acid residue, and in a case where there is a plurality of X's, the plurality of X's may be the same as or different from each other; g, h, i, and j each independently represent an integer equal to or greater than 0; m and n are integers satisfying $0 \leq m \leq 9$, $0 \leq n \leq 9$, and $3 \leq m + n \leq 9$ simultaneously; and k is an integer equal to or greater than 1, and in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X_i , X_j , X_m , and X_n in a repeating unit $[X_i-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_j]$ each may be the same or different between the repeating units.

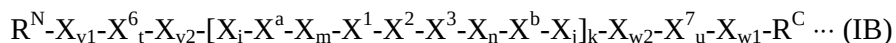
[2] The cyclic peptide described in [1] that is represented by Formula (IA).



In Formula (IA), R^N , R^C , X^1 , X^2 , X^3 , X^a , X^b , X_g , X_h , X_m , X_n , X, g, h, m, n, and k have the same definitions as those in Formula (I); X^4_r , X^5_s , X_{p1} , X_{p2} , X_{q1} , and X_{q2} each represent r consecutive X^4 's, s consecutive X^5 's, p1 consecutive X's, p2 consecutive X's, q1 consecutive X's, and q2 consecutive X's; X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid having a hydroxy group on a side chain, and in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other; p1, p2, q1, and q2 each independently represent an integer equal to or greater than 0; r and s each represent an integer satisfying $0 \leq r \leq 5$, $0 \leq s \leq 5$, and $1 \leq \text{Max}(r,s) \leq 5$, where $\text{Max}(r,s)$ represents a larger one between two numbers represented by r and s in a case where r

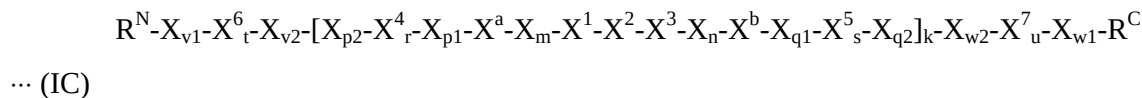
$\neq s$ and represents r or s in a case where $r = s$; and in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X^4_r , X^5_s , X_m , X_n , X_{p2} , X_{p1} , X_{q1} , and X_{q2} in a repeating unit $[X_{p2}-X^4_r-X_{p1}-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_{q1}-X^5_s-X_{q2}]$ each may be the same or different between the repeating units.

[3] The cyclic peptide described in [1] that is represented by Formula (IB).



In Formula (IB), R^N , R^C , X^1 , X^2 , X^3 , X^a , X^b , X_i , X_j , X_m , X_n , X , i , j , m , n , and k have the same definitions as those in Formula (I); X^6_t , X^7_u , X_{v1} , X_{v2} , X_{w1} , and X_{w2} each represent t consecutive X^6 's, u consecutive X^7 's, $v1$ consecutive X 's, $v2$ consecutive X 's, $w1$ consecutive X 's, and $w2$ consecutive X 's; X^6 and X^7 each independently represent an amino acid residue derived from an amino acid having an immobilizing functional group on a side chain, and in a case where there is a plurality of X^6 's or X^7 's, the plurality of X^6 's or X^7 's may be the same as or different from each other; t and u each represent an integer satisfying $0 \leq t \leq 5$, $0 \leq u \leq 5$, and $1 \leq \text{Max}(t, u) \leq 5$, where $\text{Max}(t, u)$ represents a larger one between two numbers represented by t and u in a case where $t \neq u$ and represents t or u in a case where $t = u$; $v1$, $v2$, $w1$, and $w2$ each independently represent an integer equal to or greater than 0; and in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X_i , X_j , X_m , and X_n in a repeating unit $[X_i-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_j]$ each may be the same or different between the repeating units.

[4] The cyclic peptide described in any one of [1] to [3] that is represented by Formula (IC).



In Formula (IC), R^N , R^C , X^1 , X^2 , X^3 , X^a , X^b , X_m , X_n , X , m , n , and k have the same definitions as those in Formula (I);

X_{p1} , X_{p2} , X_{q1} , X_{q2} , X^4_r , X^5_s , X^6_t , X^7_u , X_{v1} , X_{v2} , X_{w1} , and X_{w2} each represent $p1$ consecutive X 's, $p2$ consecutive X 's, $q1$ consecutive X 's, $q2$ consecutive X 's, r consecutive X^4 's, s consecutive X^5 's, t consecutive X^6 's, u consecutive X^7 's, $v1$ consecutive X 's, $v2$ consecutive X 's, $w1$ consecutive X 's, and $w2$ consecutive X 's; X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid having a hydroxy group on a side chain, and in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other; X^6 and X^7 each independently represent an amino acid residue derived from an amino acid having an immobilizing functional group on a side

chain, and in a case where there is a plurality of X^6 or X^7 , the plurality of X^6 's or X^7 's may be the same as or different from each other; p_1 , p_2 , q_1 , and q_2 each independently represent an integer equal to or greater than 0; r and s each represent an integer satisfying $0 \leq r \leq 5$, $0 \leq s \leq 5$, and $1 \leq \text{Max}(r,s) \leq 5$, where $\text{Max}(r,s)$ represents a larger one between two numbers represented by r and s in a case where $r \neq s$ and represents r or s in a case where $r = s$; t and u each represent an integer satisfying $0 \leq t \leq 5$, $0 \leq u \leq 5$, and $1 \leq \text{Max}(t,u) \leq 5$, where $\text{Max}(t,u)$ represents a larger one between two numbers represented by t and u in a case where $t \neq u$ and represents t or u in a case where $t = u$; v_1 , v_2 , w_1 , and w_2 each independently represent an integer equal to or greater than 0; and in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X^4_r , X^5_s , X_m , X_n , X_{p2} , X_{p1} , X_{q1} , and X_{q2} in a repeating unit $[X_{p2}-X^4_r-X_{p1}-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_{q1}-X^5_s-X_{q2}]$ each may be the same or different between the repeating units.

[5] The cyclic peptide described in [1], in which $8 \leq g + h + k \times (i + j + m + n + 5) \leq 50$.

[6] The cyclic peptide described in [2], in which $8 \leq g + h + k \times (m + n + p_1 + p_2 + q_1 + q_2 + 5) \leq 50$.

[7] The cyclic peptide described in [3], in which $8 \leq v_1 + v_2 + w_1 + w_2 + t + u + k \times (i + j + m + n + 5) \leq 50$.

[8] The cyclic peptide described in [4], in which $8 \leq v_1 + v_2 + w_1 + w_2 + t + u + k \times (m + n + p_1 + p_2 + q_1 + q_2 + 5) \leq 50$.

[9] The cyclic peptide described in [2], [4], [6], or [8], in which the amino acid having a carboxy group on a side chain is at least one kind of amino acid selected from the group consisting of L-aspartic acid, D-aspartic acid, L-glutamic acid, D-glutamic acid, L-homoglutamic acid, and D-homoglutamic acid, and the amino acid having a hydroxy group on a side chain is at least one kind of amino acid selected from the group consisting of L-serine, D-serine, L-homoserine, D-homoserine, L-tyrosine, D-tyrosine, L-threonine, D-threonine, L-allothreonine, and D-allothreonine.

[10] The cyclic peptide described in [9], in which the amino acid having a carboxy group on a side chain is L-aspartic acid, and the amino acid having a hydroxy group on a side chain is L-threonine.

[11] The cyclic peptide described in [3], [4], [7], or [8], in which the immobilizing functional group is an amino group or a thiol group.

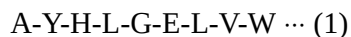
[12] The cyclic peptide described in [3], [4], [7], or [8], in which the amino acid

having an immobilizing functional group on a side chain is at least one kind of amino acid selected from the group consisting of L-lysine, D-lysine, L-cysteine, D-cysteine, L-homocysteine, and D-homocysteine.

[13] The cyclic peptide described in any one of [1] to [12], in which X^a is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, selected from the group consisting of (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine, X^b is an amino acid residue derived from L-homocysteine or D-homocysteine, and X^a and X^b are bonded to each other through a thioether bond.

[14] The cyclic peptide described in any one of [1] to [12], in which X^a is an amino acid residue derived from L-homocysteine or D-homocysteine, X^b is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, selected from the group consisting of (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine, and X^a and X^b are bonded to each other through a thioether bond.

[15] The cyclic peptide described in any one of [1] to [14], in which the partial amino acid sequence $X_m-X^1-X^2-X^3-X_n$ in Formula (I), (IA), (IB), or (IC) and an amino acid sequence (SEQ ID NO: 1) represented by Formula (1) share sequence homology equal to or higher than 70%.



In Formula (1), A represents an L-alanine residue; Y represents an L-tyrosine residue; H represents an L-histidine residue; L represents an L-leucine residue; G represents a glycine residue; E represents an L-glutamic acid residue; V represents an L-valine residue; and W represents an L-tryptophan residue.

[16] The cyclic peptide described in any one of [1] to [15], in which in Formula (I), (IA), (IB), or (IC), $k = 1$.

[17] The cyclic peptide described in [1] that is represented by Formula (II).



(II)

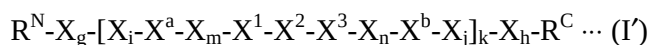
In Formula (II), X^a , X^b , X , R^N , and R^C have the same definitions as those in Formula (I); X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid having a hydroxy group on a side chain, and in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other; X^6 and X^7 each independently represent an amino acid residue derived from an amino acid having an immobilizing functional group on a side chain, and in a case where there is a plurality of X^6 's or X^7 's, the plurality of X^6 's or X^7 's may be the same as or different from each other; X^8 represents an L-leucine residue, a D-leucine residue, an L-arginine residue, or a D-arginine residue; $e0$ and $f0$ each represent an integer satisfying $0 \leq e0 \leq 10$ and $0 \leq f0 \leq 10$; $p0$ and $q0$ each represent an integer satisfying $0 \leq p0 \leq 5$ and $0 \leq q0 \leq 5$; $r0$ and $s0$ each represent an integer satisfying $0 \leq r0 \leq 5$ and $0 \leq s0 \leq 5$; $t0$ and $u0$ each represent an integer satisfying $0 \leq t0 \leq 5$ and $0 \leq u0 \leq 5$; $v0$ and $w0$ each represent an integer satisfying $0 \leq v0 \leq 5$ and $3 \leq w0 \leq 5$; $p0$, $q0$, $r0$, $s0$, $t0$, $u0$, $v0$, and $w0$ satisfy $0 \leq p0 + q0 + r0 + s0 + t0 + u0 + v0 + w0 \leq 39$; A represents an L-alanine residue or a D-alanine residue; Y represents an L-tyrosine residue or a D-tyrosine residue; H represents an L-histidine residue or a D-histidine residue; G represents a glycine residue; E represents an L-glutamic acid residue or a D-glutamic acid residue; L represents an L-leucine residue; V represents an L-valine residue; and W represents an L-tryptophan residue.

[18] The cyclic peptide described in [17], in which X^6 and X^7 each independently represent an amino acid residue derived from an amino acid selected from the group consisting of L-lysine, D-lysine, L-cysteine, D-cysteine, L-homocysteine, and D-homocysteine.

[19] The cyclic peptide described in [17] or [18], in which X^a is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, selected from the group consisting of (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine, X^b is an amino acid residue derived from L-homocysteine or D-homocysteine, and X^a and X^b are bonded to each other through a thioether bond.

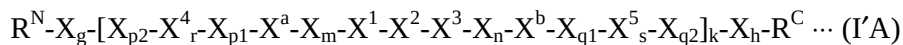
[20] The cyclic peptide described in [17] or [18], in which X^a is an amino acid residue derived from L-homocysteine or D-homocysteine, X^b is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, selected from the group consisting of (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine, and X^a and X^b are bonded to each other through a thioether bond.

[21] A cyclic peptide represented by Formula (I')



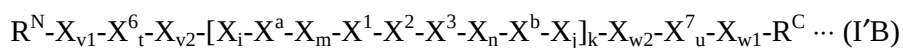
In Formula (I'), R^N represents an N-terminal group; R^C represents a C-terminal group; X^1 represents an L-leucine residue, an L-isoleucine residue, an L-methionine residue, an L-lysine residue, or an L-arginine residue; X^2 represents an L-valine residue or an L-isoleucine residue; X^3 represents an L-tryptophan residue; one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine and the other represents an amino acid residue derived from an amino acid having a haloacetyl group on a side chain, and X^a and X^b are bonded to each other through a thioether bond, or, one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, and the other represents an amino acid residue derived from an amino acid having a haloacetyl group on a side chain, and X^a and X^b are bonded to each other through a thioether bond; X_g , X_h , X_i , X_j , X_m , and X_n each represent g consecutive X's, h consecutive X's, i consecutive X's, j consecutive X's, m consecutive X's, and n consecutive X's; in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X represents an amino acid residue derived from an amino acid other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X represents an amino acid residue derived from an amino acid other than L-serine and D-serine, and in a case where there is a plurality of X's, the plurality of X's may be the same as or different from each other; g, h, i, and j each independently represent an integer equal to or greater than 0; m and n are integers satisfying $0 \leq m \leq 9$, $0 \leq n \leq 9$, and $3 \leq m + n \leq 9$ simultaneously; and k is an integer equal to or greater than 1, and in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X_i , X_j , X_m , and X_n in a repeating unit $[X_i-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_j]$ each may be the same or different between the repeating units.

[22] The cyclic peptide described in [21] that is represented by Formula (I'A).



In Formula (I'A), R^N , R^C , X^1 , X^2 , X^3 , X^a , X^b , X_g , X_h , X_m , X_n , g , h , m , n , and k have the same definitions as those in Formula (I'); X^4_r , X^5_s , X_{p1} , X_{p2} , X_{q1} , and X_{q2} each represent r consecutive X^4 's, s consecutive X^5 's, $p1$ consecutive X 's, $p2$ consecutive X 's, $q1$ consecutive X 's, and $q2$ consecutive X 's; in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X represents an amino acid residue derived from an amino acid other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X represents an amino acid residue derived from an amino acid other than L-serine and D-serine, and in a case where there is a plurality of X 's, the plurality of X 's may be the same as or different from each other; in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid, other than L-serine, D-serine, L-homoserine, and D-homoserine, having a hydroxy group on a side chain, in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid, other than L-serine or D-serine, having a hydroxy group on a side chain, and in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other; $p1$, $p2$, $q1$, and $q2$ each independently represent an integer equal to or greater than 0; r and s each represent an integer satisfying $0 \leq r \leq 5$, $0 \leq s \leq 5$, and $1 \leq \text{Max}(r,s) \leq 5$, where $\text{Max}(r,s)$ represents a larger one between two numbers represented by r and s in a case where $r \neq s$ and represents r or s in a case where $r = s$; and in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X^4_r , X^5_s , X_m , X_n , X_{p2} , X_{p1} , X_{q1} , and X_{q2} in a repeating unit $[X_{p2}-X^4_r-X_{p1}-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_{q1}-X^5_s-X_{q2}]$ each may be the same or different between the repeating units.

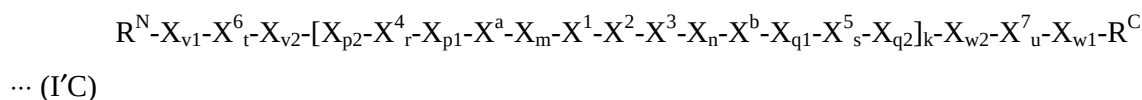
[23] The cyclic peptide described in [21] that is represented by Formula (I'B).



In Formula (I'B), R^N , R^C , X^1 , X^2 , X^3 , X^a , X^b , X_i , X_j , X_m , X_n , i , j , m , n , and k have the same definitions as those in Formula (I'); X^6_t , X^7_u , X_{v1} , X_{v2} , X_{w1} , and X_{w2} each represent t consecutive X^6 's, u consecutive X^7 's, $v1$ consecutive X 's, $v2$ consecutive X 's, $w1$ consecutive

X's, and w2 consecutive X's; in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X represents an amino acid residue derived from an amino acid other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X represents an amino acid residue derived from an amino acid other than L-serine and D-serine, and in a case where there is a plurality of X's, the plurality of X's may be the same as or different from each other; in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X^6 and X^7 each independently represent an amino acid residue derived from an amino acid, other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, having an immobilizing functional group on a side chain or each independently represent an amino acid residue derived from an amino acid having an immobilizing functional group on a side chain, in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^6 and X^7 each independently represent an amino acid residue derived from an amino acid, other than L-serine and D-serine, having an immobilizing functional group on a side chain, and in a case where there is a plurality of X^6 's or X^7 's, the plurality of X^6 's or X^7 's may be the same as or different from each other; t and u each represent an integer satisfying $0 \leq t \leq 5$, $0 \leq u \leq 5$, and $1 \leq \text{Max}(t,u) \leq 5$, where $\text{Max}(t,u)$ represents a larger one between two numbers represented by t and u in a case where $t \neq u$ and represents t or u in a case where $t = u$; v1, v2, w1, and w2 each independently represent an integer equal to or greater than 0; and in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X_i , X_j , X_m , and X_n in a repeating unit $[X_i-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_j]$ each may be the same or different between the repeating units.

[24] The cyclic peptide described in any one of [21] to [23] that is represented by Formula (I'C).



In Formula (I'C), R^N , R^C , X^1 , X^2 , X^3 , X^a , X^b , X_m , X_n , m, n, and k have the same definitions as those in Formula (I'); X_{p1} , X_{p2} , X_{q1} , X_{q2} , X_r^4 , X_s^5 , X_t^6 , X_u^7 , X_{v1} , X_{v2} , X_{w1} , and X_{w2} each represent p1 consecutive X's, p2 consecutive X's, q1 consecutive X's, q2 consecutive X's, r consecutive X^4 's, s consecutive X^5 's, t consecutive X^6 's, u consecutive X^7 's, v1 consecutive X's, v2 consecutive X's, w1 consecutive X's, and w2 consecutive X's; in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X represents an amino acid residue derived from an amino acid other than L-serine,

D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X represents an amino acid residue derived from an amino acid other than L-serine and D-serine, and in a case where there is a plurality of X's, the plurality of X's may be the same as or different from each other; in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid, other than L-serine, D-serine, L-homoserine, and D-homoserine, having a hydroxy group on a side chain, in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid, other than L-serine and D-serine, having a hydroxy group on a side chain, and in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other; in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X^6 and X^7 each independently represent an amino acid residue derived from an amino acid, other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, having an immobilizing functional group on a side chain or each independently represent an amino acid residue derived from an amino acid having an immobilizing functional group on a side chain, in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^6 and X^7 each independently represent an amino acid residue derived from an amino acid, other than L-serine and D-serine, having an immobilizing functional group on a side chain, and in a case where there is a plurality of X^6 's or X^7 's, the plurality of X^6 's or X^7 's may be the same as or different from each other; p1, p2, q1, and q2 each independently represent an integer equal to or greater than 0; r and s each represent an integer satisfying $0 \leq r \leq 5$, $0 \leq s \leq 5$, and $1 \leq \text{Max}(r,s) \leq 5$, where $\text{Max}(r,s)$ represents a larger one between two numbers represented by r and s in a case where $r \neq s$ and represents r or s in a case where $r = s$; t and u each represent an integer satisfying $0 \leq t \leq 5$, $0 \leq u \leq 5$, and $1 \leq \text{Max}(t,u) \leq 5$, where $\text{Max}(t,u)$ represents a larger one between two numbers represented by t and u in a case where $t \neq u$ and represents t or u in a case where $t = u$; v1, v2, w1, and w2 each independently represent an integer equal to or greater than 0; and in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X^4 , X^5 , X_m , X_n , X_{p2} , X_{p1} , X_{q1} , and X_{q2} in a repeating unit $[X_{p2}-X^4_r-X_{p1}-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_{q1}-X^5_s-X_{q2}]$ each may be the

same or different between the repeating units.

[25] The cyclic peptide described in [21], in which $8 \leq g + h + k \times (i + j + m + n + 5) \leq 50$.

[26] The cyclic peptide described in [22], in which $8 \leq g + h + k \times (m + n + p1 + p2 + q1 + q2 + 5) \leq 50$.

[27] The cyclic peptide described in [23], in which $8 \leq v1 + v2 + w1 + w2 + t + u + k \times (i + j + m + n + 5) \leq 50$.

[28] The cyclic peptide described in [24], in which $8 \leq v1 + v2 + w1 + w2 + t + u + k \times (m + n + p1 + p2 + q1 + q2 + 5) \leq 50$.

[29] The cyclic peptide described in [22], [24], [26], or [28], in which the amino acid having a carboxy group on a side chain is at least one kind of amino acid selected from the group consisting of L-aspartic acid, D-aspartic acid, L-glutamic acid, D-glutamic acid, L-homoglutamic acid, and D-homoglutamic acid, in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, the amino acid, other than L-serine, D-serine, L-homoserine, and D-homoserine, having a hydroxy group on a side chain is at least one kind of amino acid selected from the group consisting of L-tyrosine, D-tyrosine, L-threonine, D-threonine, L-allothreonine, and D-allothreonine, and in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, the amino acid, other than L-serine and D-serine, having a hydroxy group on a side chain is at least one kind of amino acid selected from the group consisting of L-homoserine, D-homoserine, L-tyrosine, D-tyrosine, L-threonine, D-threonine, L-allothreonine, and D-allothreonine.

[30] The cyclic peptide described in [22], [24], [26], or [28], in which the amino acid having a carboxy group on a side chain is L-aspartic acid, and the amino acid, other than L-serine, D-serine, L-homoserine, and D-homoserine, having a hydroxy group on a side chain and the amino acid residue derived from the amino acid, other than L-serine and D-serine, having a hydroxy group on a side chain are L-threonine.

[31] The cyclic peptide described in [23], [24], [27], or [28], in which the immobilizing functional group is an amino group or a thiol group.

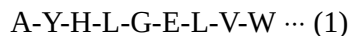
[32] The cyclic peptide described in [23], [24], [27], or [28], in which the amino acid, other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, having an immobilizing functional group on a side chain and the amino acid residue derived from an amino acid, other than L-serine and D-serine, having an immobilizing functional group on a side chain are at least one kind of amino acid selected from the group consisting of

L-lysine, D-lysine, L-cysteine, D-cysteine, L-homocysteine, and D-homocysteine.

[33] The cyclic peptide described in any one of [21] to [32], in which X^a is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, selected from the group consisting of (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine, X^b is an amino acid residue derived from L-cysteine or D-cysteine or an amino acid residue derived from L-penicillamine or D-penicillamine, and X^a and X^b are bonded to each other through a thioether bond.

[34] The cyclic peptide described in any one of [21] to [32] in which X^a is an amino acid residue derived from L-cysteine or D-cysteine or an amino acid residue derived from L-penicillamine or D-penicillamine, X^b is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, selected from the group consisting of (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine, and X^a and X^b are bonded to each other through a thioether bond.

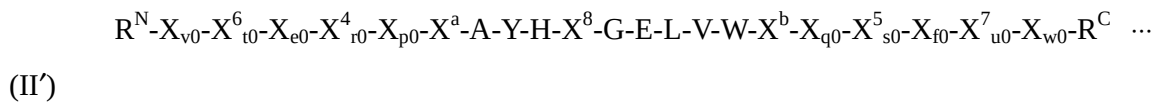
[35] The cyclic peptide described in any one of [21] to [34], in which the partial amino acid sequence $X_m-X^1-X^2-X^3-X_n$ in Formula (I'), (I'A), (I'B), or (I'C) and an amino acid sequence (SEQ ID NO: 1) represented by Formula (1) share sequence homology equal to or higher than 70%.



In Formula (1), A represents an L-alanine residue; Y represents an L-tyrosine residue; H represents an L-histidine residue; L represents an L-leucine residue; G represents a glycine residue; E represents an L-glutamic acid residue; V represents an L-valine residue; and W represents an L-tryptophan residue.

[36] The cyclic peptide described in any one of [21] to [35], in which in Formula (I'), (I'A), (I'B), or (I'C), $k = 1$.

[37] The cyclic peptide described in [21] that is represented by Formula (II').



In Formula (II'), X^a , X^b , X , R^N , and R^C have the same definitions as those in Formula (I'); in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid, other than L-serine, D-serine, L-homoserine, and D-homoserine, having a hydroxy group on a side chain, in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid, other than L-serine and D-serine, having a hydroxy group on a side chain, and in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other; in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X^6 and X^7 each independently represent an amino acid residue derived from an amino acid, other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, having an immobilizing functional group on a side chain or each independently represent an amino acid residue derived from an amino acid having an immobilizing functional group on a side chain, in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^6 and X^7 each independently represent an amino acid residue derived from an amino acid, other than L-serine and D-serine, having an immobilizing functional group on a side chain, and in a case where there is a plurality of X^6 's or X^7 's, the plurality of X^6 's or X^7 's may be the same as or different from each other; in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X^8 represents an L-leucine residue or a D-leucine residue, in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^8 represents an L-leucine residue, a D-leucine residue, an L-arginine residue, or a D-arginine residue; $e0$ and $f0$ each represent an integer satisfying $0 \leq e0 \leq 10$ and $0 \leq f0 \leq 10$; $p0$ and $q0$ each represent an integer satisfying $0 \leq p0 \leq 5$ and $0 \leq q0 \leq 5$; $r0$ and $s0$ each represent an integer satisfying $0 \leq r0 \leq 5$ and $0 \leq s0 \leq 5$; $t0$ and $u0$ each represent an integer satisfying $0 \leq t0 \leq 5$ and $0 \leq u0 \leq 5$; $v0$ and $w0$ each represent an integer satisfying $0 \leq v0 \leq 5$ and $3 \leq w0 \leq 5$; $p0$, $q0$, $r0$, $s0$, $t0$, $u0$, $v0$, and $w0$ satisfy $0 \leq p0 + q0 + r0 + s0 + t0 + u0 + v0 + w0 \leq 39$; A represents an L-alanine residue or a D-alanine residue; Y represents an L-tyrosine residue or a

D-tyrosine residue; H represents an L-histidine residue or a D-histidine residue; G represents a glycine residue; E represents an L-glutamic acid residue or a D-glutamic acid residue; L represents an L-leucine residue; V represents an L-valine residue; and W represents an L-tryptophan residue.

[38] The cyclic peptide described in [37], in which X^6 and X^7 each independently represent an amino acid residue derived from an amino acid selected from the group consisting of L-lysine, D-lysine, L-cysteine, D-cysteine, L-homocysteine, and D-homocysteine.

[39] The cyclic peptide described in [37] or [38], in which X^a is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain selected from the group consisting of (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine, X^b is an amino acid residue derived from L-cysteine or D-cysteine or an amino acid residue derived from L-penicillamine or D-penicillamine, and X^a and X^b are bonded to each other through a thioether bond.

[40] The cyclic peptide described in [37] or [38], in which X^a is an amino acid residue derived from L-cysteine or D-cysteine or an amino acid residue derived from L-penicillamine or D-penicillamine, X^b is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain selected from the group consisting of (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine, and X^a and X^b are bonded to each other through a thioether bond.

[41] The cyclic peptide described in any one of [1] to [40] that is an antibody binding ligand.

[42] The cyclic peptide described in any one of [1] to [40] that is a linker for labeling antibodies.

[43] The cyclic peptide described in any one of [1] to [40] that is a linker for antibody drug conjugates.

[44] The cyclic peptide described in any one of [1] to [40] that is a drug carrier.

[45] An affinity chromatography support comprising a water-insoluble support and the cyclic peptide described in any one of [1] to [40], in which the water-insoluble support and the cyclic peptide are directly or indirectly bonded to each other.

[46] A labeled antibody comprising an antibody, a labeling compound, and the cyclic peptide described in any one of [1] to [40], in which the antibody and the labeling compound are bonded to each other through the cyclic peptide.

[47] An antibody drug conjugate comprising an antibody, a drug, and the cyclic peptide described in any one of [1] to [40], in which the antibody and the drug are bonded to each other through the cyclic peptide.

[48] The antibody drug conjugate described in [47], in which the drug is a drug having undergone liposomization, polymer micellization, or PEGylation.

[49] A pharmaceutical preparation comprising a drug and the cyclic peptide described in any one of [1] to [40], in which the drug and the cyclic peptide are directly or indirectly bonded to each other.

[50] The pharmaceutical preparation described in [49], in which the drug is a drug having undergone liposomization, polymer micellization, or PEGylation.

[0014] According to the present invention there are provided a cyclic peptide having excellent antibody binding properties and improved chemical resistance, an affinity chromatography support, a labeled antibody, an antibody drug conjugate, and a pharmaceutical preparation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] [Cyclic peptide of present invention]

First, the characteristics of the present invention that are not found in the related art will be described.

US Patent App. No. 2004/0087765, WO2013/027796A, and JP2007-289200A describe cyclic peptides cyclized by forming a disulfide bond between two cysteine residues. According to the results of evaluating the relative binding activity and the chemical resistance in Comparative Example 2 which will be described later, although the antibody binding properties of the cyclic peptides cyclized by forming a disulfide bond between two cysteine residues are excellent, the chemical resistance thereof is poor, and hence a desired performance cannot be obtained.

US Patent App. No. 2004/0087765 describes a cyclic peptide cyclized by forming an amide bond between two amino acid residues through a reaction between a side-chain amino

group and a side-chain carboxy group. JP2007-289200A describes a cyclic peptide cyclized by forming a lactam bond (amide bond) between an N-terminal amino group or a side-chain amino group and a side-chain carboxy group. According to the results of evaluating the relative binding activity and the chemical resistance in Comparative Example 1 which will be described later, although the chemical resistance of the cyclic peptide cyclized by the amide bond between a side-chain amino group and a side-chain carboxy group is improved, the antibody binding properties thereof are poor, and hence a desired performance cannot be obtained.

On the contrary, in the present invention, because the constitutions which will be described later are adopted, a cyclic peptide having excellent antibody binding properties and improved chemical resistance could be obtained.

[0016] In the present specification, in a case where “to” is used for a range of numerical values, the numerical values listed on the left and right sides of “to” are included in the range of numerical values.

[0017] <Amino acid and amino acid residue>

In the present invention, in principle, amino acids are described using names, codes, and the like adopted by INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY and INTERNATIONAL UNION OF BIOCHEMISTRY AND MOLECULAR BIOLOGY IUPAC-IUB Joint Commission on Biochemical Nomenclature (JCBN). Furthermore, amino acid residues are described using the codes of amino acids from which the amino acid residues are derived. The amino acid residues include N-terminal amino acids (N-terminal residues) and C-terminal amino acids (C-terminal residues).

[0018] Unless otherwise specified, the amino acid sequence (referred to as “primary structure”) of a peptide or a protein is described by aligning amino acid residues in a line, such that the left end of the line becomes the N-terminal and the right end of the line becomes the C-terminal. In a case where an amino acid residue in the amino acid sequence of a peptide or a protein is identified, including the position thereof, sometimes a number showing which position the amino acid residue occupies from the N-terminal side is placed on the right side of the code of the amino acid residue. For example, the second L-lysine from the N-terminal is described as Lys2 in some cases.

[0019] In a case where an amino acid is described using its name, and the amino acid includes isomers having an enantiomeric relationship, that is, in a case where the amino acid includes an L-isomer and a D-isomer, except for a case where the L-isomer and the D-isomer are

clearly differentiated from each other, the amino acid represents the L-isomer in principle. For example, “isoleucine” represents “L-isoleucine”, and the enantiomer of “isoleucine” represents “D-isoleucine”. The same is true for amino acid residues.

[0020] In a case where an amino acid is described using its code (three-letter code or one-letter code), and the amino acid includes isomers having an enantiomeric relationship, that is, in a case where the amino acid includes an L-isomer and a D-isomer, except for a case where the L-isomer and the D-isomer are clearly differentiated from each other, the amino acid represents the L-isomer in principle. Here, “X” representing any amino acid is not limited thereto. For example, “Lys” and “L-Lys” both represent “L-lysine”, and “D-Lys” represents “D-lysine”. The same is true for amino acid residues.

[0021] In a case where an amino acid is described using its name, and the amino acid includes isomers having a diastereomeric relationship, the isomers are not included in the amino acid specified by its name. A diastereomer is described using a prefix “allo” and regarded as a different kind of amino acid. For example, “threonine” and “L-threonine” do not include “L-allothreonine”, and “D-threonine” does not include “D-allothreonine”. The same is true for amino acid residues.

[0022] Table 1 shows the names and the codes (one-letter code and three-letter code) of amino acids having officially recognized one-letter codes and three-letter codes.

[0023] [Table 1]

One-letter code	Three-letter code	Name	One-letter code	Three-letter code	Name
A	Ala	L-alanine	O	Pyl	L-pyrrolysine
B	Asx	L-aspartic acid or L-asparagine	P	Pro	L-proline
C	Cys	L-cysteine	Q	Gln	L-glutamine
D	Asp	L-aspartic acid	R	Arg	L-arginine
E	Glu	L-glutamic acid	S	Ser	L-serine
F	Phe	L-phenylalanine	T	Thr	L-threonine
G	Gly	Glycine	U	Sec	L-selenocysteine
H	His	L-histidine	V	Val	L-valine
I	Ile	L-isoleucine	W	Trp	L-tryptophan
K	Lys	L-lysine	X	Xaa	Any amino acid
L	Leu	L-leucine	Y	Tyr	L-tyrosine
M	Met	L-methionine	Z	Glx	L-glutamic acid or L-glutamine
N	Asn	L-asparagine			

[0024] The amino acids are not limited to those listed in Table 1, and the amino acids referred to as unusual amino acid can also be used. Examples of unusual amino acids are listed in Table 2 shown below, but the present invention is not limited thereto.

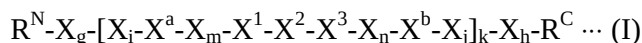
[0025] [Table 2]

Three-letter code	Name	Three-letter code	Name
Aad	Homoglutamic acid	Dpr	2,3-Diaminopropanoic acid
β Aad	3-Aminoadipic acid	Gla	4-Carboxyglutamic acid
Abu	2-Aminobutanoic acid	Glp	5-Oxoproline
A ₂ bu	2,4-Diaminobutanoic acid	Hcy	Homocysteine
Ahx	2-Aminohexanoic acid	Hse	Homoserine
Ahe	2-Aminoheptanoic acid	Hsl	Homoserine lactone
Aib	2-Aminoisobutyric acid	5Hyl	5-Hydroxylysine (Hyl)
ϵ Ahx	6-Aminohexanoic acid	aHyl	allo-Hydroxylysine
β Ala	β -Alanine	3Hyp	3-Hydroxyproline
Ape	2-Aminopentanoic acid	4Hyp	4-Hydroxyproline
A ₂ pr	2,3-Diaminopropanoic acid	alle	allo-Isoleucine
Apm	2-Aminopimelic acid	Nle	Norleucine
A ₂ pm	2,6-Diaminopimelic acid	Nva	Norvaline
Cit	Citrulline	Orn	Ornithine
Cya	Cysteic acid	Sar	Sarcosine
Dbu	2,4-Diaminobutanoic acid	aThr	allo-Threonine
Dpm	2,6-Diaminopimelic acid	Thx	Thyroxine
Pen	Penicillamine		

[0026] <Structure of cyclic peptide (I) of present invention>

Hereinafter, the cyclic peptide of the present invention will be specifically described.

The cyclic peptide of the present invention is a cyclic peptide represented by Formula (I).



[0027] In Formula (I), for example, X_n means that n X's are linked to each other. In other words, X_n means $-(X)_n-$. X_g , X_h , X_i , X_j , and X_m mean the same thing as X_n .

[0028] <<Cyclic portion, linear portion, cross-linked portion, and antibody binding portion>>

Regarding the cyclic peptide of the present invention, in a polypeptide chain, a ring portion closed by cross-linking is referred to as a cyclic portion, and a portion which is not included in the cyclic portion is referred to as a linear portion. Furthermore, in the cyclic portion, a portion forming a cross-linked structure in the molecule of the cyclic peptide of the present invention is referred to as a cross-linked portion, and a portion greatly favoring the antibody binding properties of the cyclic peptide of the present invention is referred to as an antibody binding portion.

In the cyclic peptide represented by Formula (I), " $X^a-X_m-X^1-X^2-X^3-X_n-X^b$ " is a cyclic portion, " X_g ", " X_h ", " X_i ", and " X_j " are linear portions, " X^a " and " X^b " are cross-linked portions, and " $X^1-X^2-X^3$ " is an antibody binding portion.

In Formula (1), $[X_i-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_j]$ is referred to as a repeating portion in

some cases.

[0029] <<N-terminal group>>

In Formula (I), R^N represents an N-terminal group.

Examples of the N-terminal group include an amino group, and the amino group may have undergone N-terminal modification such as N-acetylation, N-formylation, or N-acylation.

[0030] <<C-terminal group>>

In Formula (I), R^C represents a C-terminal group.

Examples of the C-terminal group include a carboxy group, and the carboxy group may have undergone C-terminal modification such as amidation.

[0031] <<< X^1 , X^2 , and X^3 >>>

In Formula (I), X^1 is an L-leucine residue, an L-isoleucine residue, an L-methionine residue, an L-lysine residue, or an L-arginine residue. X^1 is preferably an L-leucine residue or an L-isoleucine residue, and more preferably an L-leucine residue.

In Formula (I), X^2 is an L-valine residue or an L-isoleucine residue, and preferably an L-valine residue.

In Formula (I), X^3 is an L-tryptophan residue.

[0032] << X^a and X^b >>

In Formula (I), X^a and X^b are as explained in first to fourth embodiments described below.

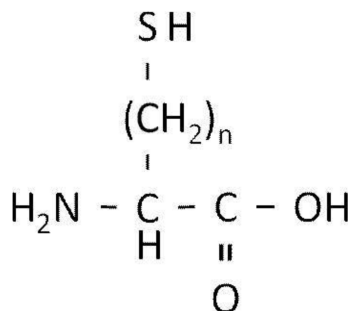
[0033] (First embodiment)

In Formula (I), X^a and X^b each independently represent an amino acid residue derived from an amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain, and are bonded to each other through a disulfide bond.

[0034] ((Type of amino acid and amino acid residue))

The amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain is not particularly limited as long as it is an amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain. Examples of the amino acid include an amino acid represented by the following formula.

[0035]



[0036] In the above formula, n is an integer equal to or greater than 2. n is preferably an integer satisfying $2 \leq n \leq 4$, more preferably an integer satisfying $2 \leq n \leq 3$, and even more preferably 2.

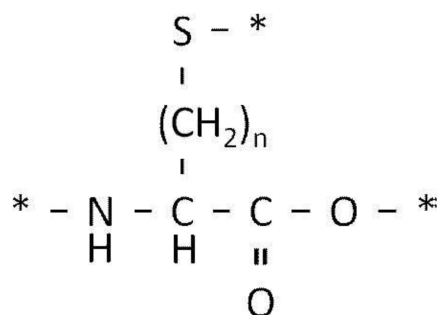
The amino acid represented by the above formula may be an L-isomer or a D-isomer, and is preferably an L-isomer.

[0037] Specifically, examples of the amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain include L-homocysteine, D-homocysteine, L-bishomocysteine, D-bishomocysteine, and the like, but the amino acid is not limited to these.

The amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain is preferably L-homocysteine or D-homocysteine, and more preferably L-homocysteine.

[0038] Examples of amino acid residues derived from the amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain include an amino acid residue represented by the following formula.

[0039]



[0040] In the above formula, n is an integer equal to or greater than 2. n is preferably an integer satisfying $2 \leq n \leq 4$, more preferably an integer satisfying $2 \leq n \leq 3$, and even more preferably 2; and * represents a binding point.

The amino acid residue represented by the above formula may be derived from an L-amino acid or a D-amino acid, and is preferably derived from an L-amino acid.

[0041] Specifically, examples of the amino acid residue derived from an amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain include amino acid

residues derived from L-homocysteine, D-homocysteine, L-bishomocysteine, D-bishomocysteine, and the like, but the amino acid residue is not limited to these.

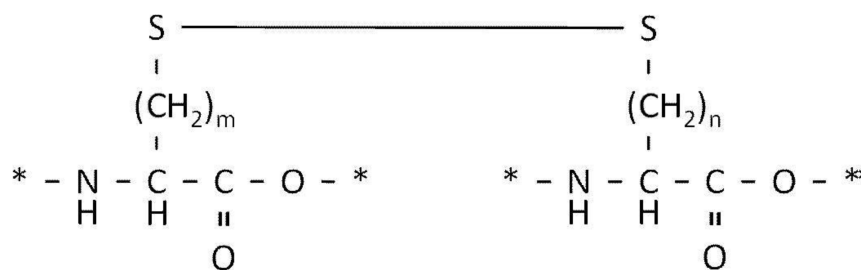
The amino acid residue derived from the amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain is preferably an amino acid residue derived from L-homocysteine or D-homocysteine, and more preferably an amino acid residue derived from L-homocysteine.

[0042] ((Disulfide bond))

In the first embodiment of the cyclic peptide of the present invention, between X^a and X^b , a cross-linked structure is formed by a disulfide bond formed between side-chain disulfide groups. That is, a disulfide bond is formed between a side-chain thiol group of a first amino acid residue, which is derived from an amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain, and a side-chain thiol group of a second amino acid residue derived from an amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain.

[0043] The following formula shows an example of the cross-linked structure formed by the formation of a disulfide bond between side-chain thiol groups of two amino acid residues derived from amino acids, other than L-cysteine and D-cysteine, having a thiol group on a side chain.

[0044]



[0045] In the above formula, m is an integer equal to or greater than 2, preferably an integer satisfying $2 \leq m \leq 4$, more preferably an integer satisfying $2 \leq m \leq 3$, and even more preferably 2; n is an integer equal to or greater than 2, preferably an integer satisfying $2 \leq n \leq 4$, more preferably an integer satisfying $2 \leq n \leq 3$, and even more preferably 2; it is particularly preferable that $m = n = 2$; and * represents a binding point.

[0046] (Second embodiment)

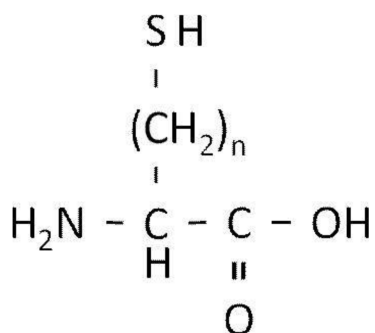
In Formula (I), one of X^a and X^b represents an amino acid residue derived from an amino acid, other than L-cysteine, D-cysteine, L-penicillamine, and D-penicillamine, having a thiol group on a side chain and the other represents an amino acid residue derived from an

amino acid having a haloacetyl group on a side chain, and X^a and X^b are bonded to each other through a thioether bond.

[0047] ((Type of amino acid and amino acid residue))

The amino acid, other than L-cysteine, D-cysteine, L-penicillamine, and D-penicillamine, having a thiol group on a side chain is not particularly limited as long as it is an amino acid, other than L-cysteine, D-cysteine, L-penicillamine, and D-penicillamine, having a thiol group on a side chain. Examples thereof include an amino acid represented by the following formula.

[0048]



[0049] In the above formula, n is an integer equal to or greater than 2, preferably an integer satisfying $2 \leq n \leq 4$, more preferably an integer satisfying $2 \leq n \leq 3$, and even more preferably 2.

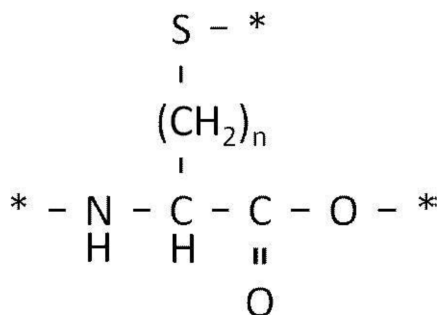
The amino acid represented by the above formula may be an L-isomer or a D-isomer, and is preferably an L-isomer.

[0050] Specifically, examples of the amino acid, other than L-cysteine, D-cysteine, L-penicillamine, and D-penicillamine, having a thiol group on a side chain include L-homocysteine, D-homocysteine, L-bishomocysteine, D-bishomocysteine, and the like, but the amino acid is not limited to these.

From the viewpoint of economic efficiency, the amino acid, other than L-cysteine, D-cysteine, L-penicillamine, and D-penicillamine, having a thiol group on a side chain is preferably L-homocysteine or D-homocysteine, and more preferably L-homocysteine.

[0051] Examples of the amino acid residue derived from the amino acid, other than L-cysteine, D-cysteine, L-penicillamine, and D-penicillamine, having a thiol group on a side chain include an amino acid residue represented by the following formula.

[0052]



[0053] In the above formula, n is an integer equal to or greater than 2, preferably an integer satisfying $2 \leq n \leq 4$, more preferably an integer satisfying $2 \leq n \leq 3$, and even more preferably 2; and * represents a binding point.

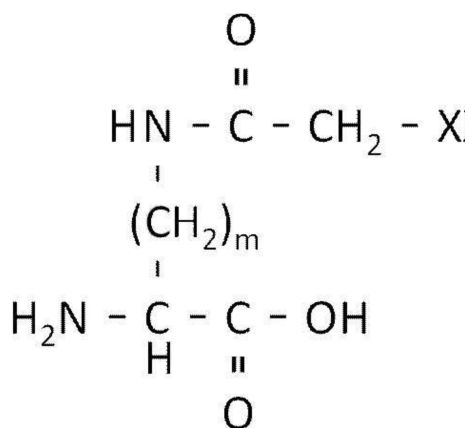
The amino acid residue represented by the above formula may be derived from an L-amino acid or a D-amino acid, and is preferably derived from an L-amino acid.

[0054] Specifically, examples of the amino acid residue derived from the amino acid, other than L-cysteine, D-cysteine, L-penicillamine, and D-penicillamine, having a thiol group on a side chain include amino acid residues derived from L-homocysteine, D-homocysteine, L-bishomocysteine, D-bishomocysteine, and the like, but the amino acid residue is not limited to these.

From the viewpoint of economic efficiency, the amino acid residue derived from the amino acid, other than L-cysteine, D-cysteine, L-penicillamine, and D-penicillamine, having a thiol group on a side chain is preferably an amino acid residue derived from L-homocysteine or D-homocysteine, and more preferably an amino acid residue derived from L-homocysteine.

[0055] The amino acid having a haloacetyl group on a side chain is not particularly limited as long as it is an amino acid having a haloacetyl group on a side chain. Examples thereof include an amino acid represented by the following formula.

[0056]



[0057] In the above formula, m is an integer equal to or greater than 1, preferably an integer

satisfying $1 \leq m \leq 4$, more preferably an integer satisfying $3 \leq m \leq 4$, and even more preferably 4; and X represents a halogen atom, preferably represents a chlorine atom or a bromine atom, and more preferably represents a chlorine atom.

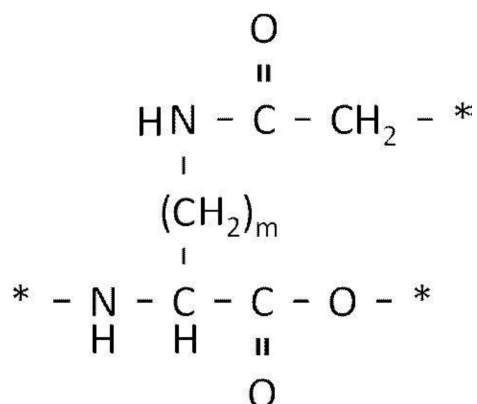
The amino acid represented by the above formula may be an L-isomer or a D-isomer, and is preferably an L-isomer.

[0058] In a case where $n = 1$, the above formula represents N³-haloacetyl-2,3-diaminopropanoic acid[2-amino-3-[(2-haloacetyl)amino]propanoic acid]; in a case where $n = 2$, the above formula represents N⁴-haloacetyl-2,4-diaminobutanoic acid[2-amino-4-[(2-haloacetyl)amino]butanoic acid]; in a case where $n = 3$, the above formula represents N- δ -haloacetyl ornithine; and in a case where $n = 4$, the above formula represents N- ϵ -haloacetyl lysine.

Here, the amino acid having a haloacetyl group on a side chain is not limited to these.

[0059] Examples of the amino acid residue derived from the amino acid having a haloacetyl group on a side chain include an amino acid residue represented by the following formula.

[0060]



[0061] In the above formula, m is an integer equal to or greater than 1, preferably an integer satisfying $1 \leq m \leq 4$, more preferably an integer satisfying $3 \leq m \leq 4$, and even more preferably 4; X represents a halogen atom, preferably represents a chlorine atom or a bromine atom, and more preferably represents a chlorine atom; and * represents a binding point.

The amino acid residue represented by the above formula may be derived from an L-amino acid or a D-amino acid, and is preferably derived from an L-amino acid.

[0062] Specifically, examples of the amino acid residue derived from the amino acid having a haloacetyl group on a side chain include amino acid residues derived from (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid,

(2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid,
 (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine,
 N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, N- ϵ -chloroacetyl-D-lysine, and the
 like, but the amino acid residue is not limited to these.

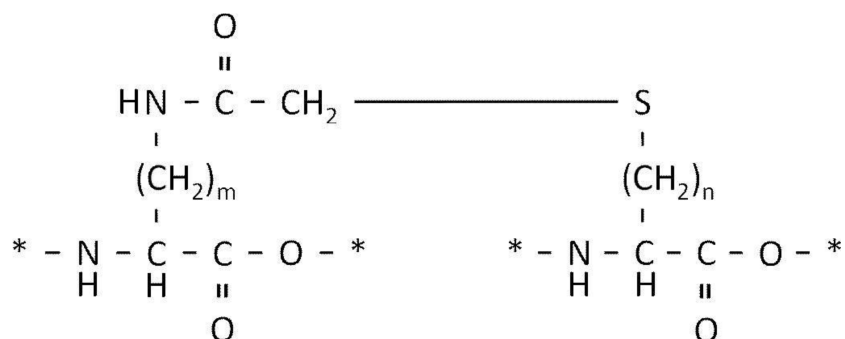
From the viewpoint of economic efficiency, the amino acid residue derived from the
 amino acid having a haloacetyl group on a side chain is preferably an amino acid residue
 derived from N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine,
 N- ϵ -chloroacetyl-L-lysine, or N- ϵ -chloroacetyl-D-lysine, and more preferably an amino acid
 residue derived from N- ϵ -chloroacetyl-D-lysine.

[0063] ((Thioether bond))

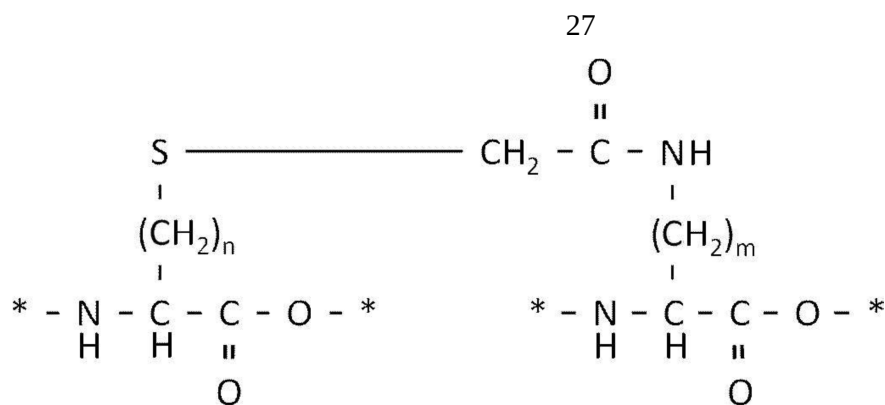
In the second embodiment of the cyclic peptide of the present invention, between X^a
 and X^b, a cross-linked structure is formed by a thioether bond formed between the side-chain
 thiol group and the side-chain haloacetyl group. That is, the thioether bond is formed
 between a thiol group of a first amino acid residue derived from an amino acid, other than
 L-cysteine, D-cysteine, L-penicillamine, and D-penicillamine, having a thiol group on a side
 chain, and a haloacetyl group of a second amino acid residue which is derived from an amino
 acid having a haloacetyl group on a side chain.

[0064] The following formulae show examples of the thioether bond formed between the
 side-chain thiol group of the amino acid residue, which is derived from the amino acid, other
 than L-cysteine, D-cysteine, L-penicillamine, and D-penicillamine, having a thiol group on a
 side chain and the side-chain haloacetyl group of the amino acid residue derived from the
 amino acid having a haloacetyl group on a side chain.

[0065]



[0066]



[0067] In the above formulae, m is an integer equal to or greater than 1, preferably an integer satisfying $1 \leq m \leq 4$, more preferably an integer satisfying $3 \leq m \leq 4$, and even more preferably 4; n is an integer equal to or greater than 2, preferably an integer satisfying $2 \leq n \leq 4$, more preferably an integer satisfying $2 \leq n \leq 3$, and even more preferably 2; it is particularly preferable that $m = 4$ and $n = 2$; and * represents a binding point.

[0068] Regarding X^a and X^b , X^a may be an amino acid residue derived from an amino acid having a haloacetyl group on a side chain, and X^b may be an amino acid residue derived from an amino acid, other than L-cysteine, D-cysteine, L-penicillamine, and D-penicillamine, having a thiol group on a side chain; or X^a may be an amino acid residue derived from amino acid, other than L-cysteine, D-cysteine, L-penicillamine, and D-penicillamine, having a thiol group on a side chain and X^b may be an amino acid residue derived from an amino acid having a haloacetyl group on a side chain.

[0069] A thioether bond is known to be a bond more stable than a disulfide bond.

[0070] (Third embodiment)

In Formula (I), one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine and the other represents an amino acid residue derived from an amino acid having a haloacetyl group on a side chain, and X^a and X^b are bonded to each other through a thioether bond.

[0071] ((Type of amino acid and amino acid residue))

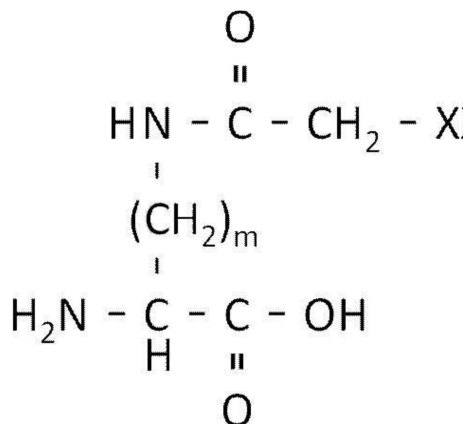
The amino acid having a haloacetyl group on a side chain is not particularly limited as long as it is an amino acid having a haloacetyl group on a side chain. Examples thereof include an amino acid represented by the following formula.

[0072] (Fourth embodiment)

In Formula (I), one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine and the other represents an amino acid residue derived from an amino acid having a haloacetyl group on a side chain, and X^a and X^b are bonded to

each other through a thioether bond.

[0073]



[0074] In the above formula, m is an integer equal to or greater than 1, preferably an integer satisfying $1 \leq m \leq 4$, more preferably an integer satisfying $3 \leq m \leq 4$, and even more preferably 4; and X represents a halogen atom, preferably represents a chlorine atom or a bromine atom, and even more preferably represents a chlorine atom.

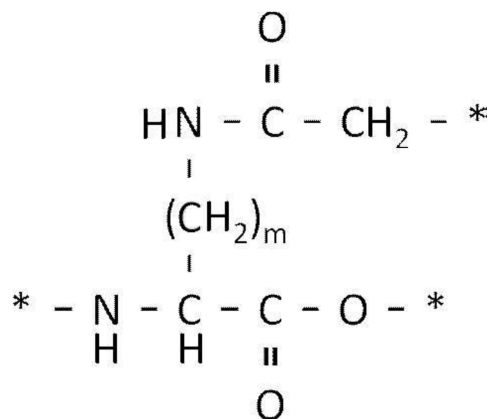
The amino acid represented by the above formula may be an L-isomer or a D-isomer, and is preferably an L-isomer.

[0075] In a case where $n = 1$, the above formula represents N^3 -haloacetyl-2,3-diaminopropanoic acid[2-amino-3-[(2-haloacetyl)amino]propanoic acid]; in a case where $n = 2$, the above formula represents N^4 -haloacetyl-2,4-diaminobutanoic acid[2-amino-4-[(2-haloacetyl)amino]butanoic acid]; in a case where $n = 3$, the above formula represents N- δ -haloacetyl ornithine; and in a case where $n = 4$, the above formula represents N- ϵ -haloacetyl lysine.

Here, the amino acid having a haloacetyl group on a side chain is not limited to these.

[0076] Examples of the amino acid residue derived from the amino acid having a haloacetyl group on a side chain include an amino acid residue represented by the following formula.

[0077]



[0078] In the above formula, m is an integer equal to or greater than 1, preferably an integer satisfying $1 \leq m \leq 4$, more preferably an integer satisfying $3 \leq m \leq 4$, and even more preferably 4; X represents a halogen atom, more preferably represents a chlorine atom or a bromine atom, and even more preferably represents a chlorine atom; and $*$ represents a binding point.

The amino acid residue represented by the above formula may be derived from an L-amino acid or a D-amino acid, and is preferably derived from an L-amino acid.

[0079] Specifically, examples of the amino acid residue derived from the amino acid having a haloacetyl group on a side chain include amino acid residues derived from (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, N- ϵ -chloroacetyl-D-lysine, and the like, but the amino acid residue is not limited to these.

From the viewpoint of economic efficiency, the amino acid residue derived from the amino acid having a haloacetyl group on a side chain is preferably an amino acid residue derived from N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, or N- ϵ -chloroacetyl-D-lysine, and more preferably an amino acid residue derived from N- ϵ -chloroacetyl-D-lysine.

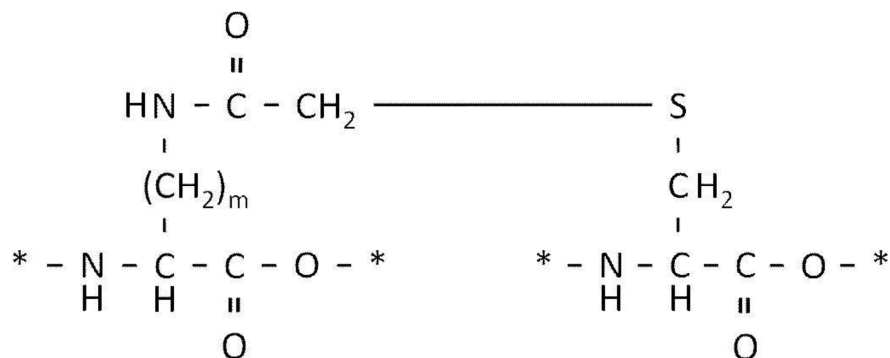
[0080] ((Thioether bond))

In the third embodiment of the cyclic peptide of the present invention, between X^a and X^b , a cross-linked structure is formed by a thioether bond formed between the side-chain thiol group and the side-chain haloacetyl group. That is, the thioether bond is formed between a thiol group of a first amino acid residue derived from L-cysteine or D-cysteine and

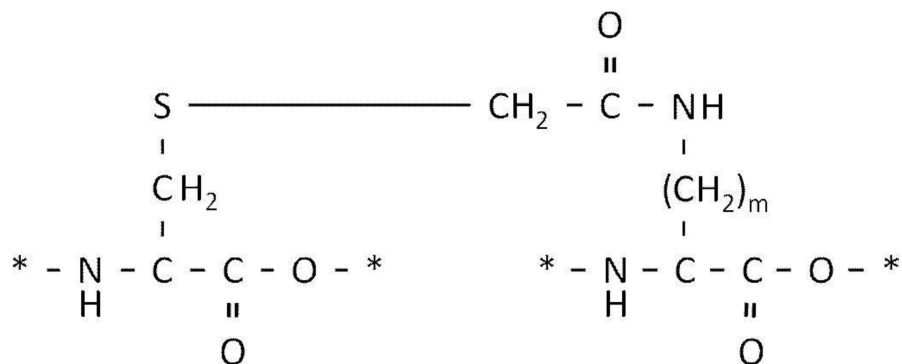
a haloacetyl group of a second amino acid residue derived from an amino acid having a haloacetyl group on a side chain.

[0081] The following formulae show examples of the thioether bond formed between the side-chain thiol group of the amino acid residue derived from L-cysteine or D-cysteine and the side-chain haloacetyl group of the amino acid residue derived from the amino acid having a haloacetyl group on a side chain.

[0082]



[0083]



[0084] In the above formulae, m is an integer equal to or greater than 1, preferably an integer satisfying $1 \leq m \leq 4$, more preferably an integer satisfying $3 \leq m \leq 4$, and even more preferably 4; and * represents a binding point.

[0085] Regarding X^a and X^b , X^a may be an amino acid residue derived from an amino acid having a haloacetyl group on a side chain, and X^b may be an amino acid residue derived from L-cysteine or D-cysteine; or X^a may be an amino acid residue derived from L-cysteine or D-cysteine, and X^b may be an amino acid residue derived from an amino acid having a haloacetyl group on a side chain.

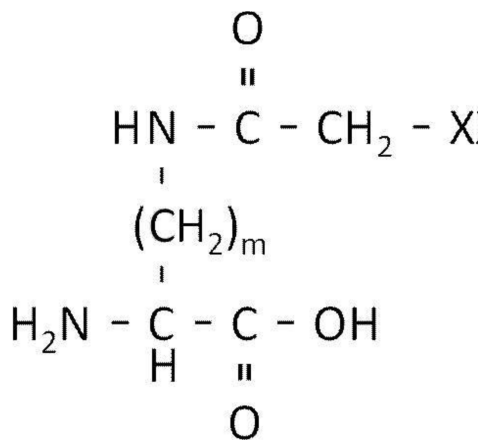
[0086] A thioether bond is known to be a bond more stable than a disulfide bond.

[0087] ((Type of amino acid and amino acid residue))

The amino acid having a haloacetyl group on a side chain is not particularly limited as

long as it is an amino acid having a haloacetyl group on a side chain. Examples thereof include an amino acid represented by the following formula.

[0088]



[0089] In the above formula, m is an integer equal to or greater than 1, preferably an integer satisfying $1 \leq m \leq 4$, more preferably an integer satisfying $3 \leq m \leq 4$, and even more preferably 4; and X represents a halogen atom, preferably represents a chlorine atom or a bromine atom, and more preferably represents a chlorine atom.

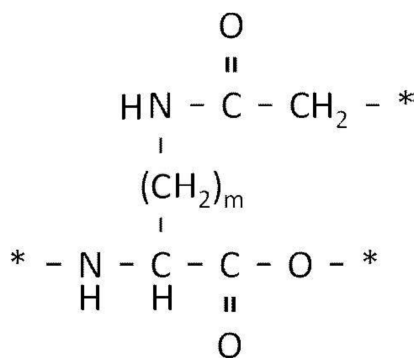
The amino acid represented by the above formula may be an L-isomer or a D-isomer, and is preferably an L-isomer.

[0090] In a case where $n = 1$, the above formula represents N^3 -haloacetyl-2,3-diaminopropanoic acid[2-amino-3-[(2-haloacetyl)amino]propanoic acid]; in a case where $n = 2$, the above formula represents N^4 -haloacetyl-2,4-diaminobutanoic acid[2-amino-4-[(2-haloacetyl)amino]butanoic acid]; in a case where $n = 3$, the above formula represents N- δ -haloacetyl ornithine; and in a case where $n = 4$, the above formula represents N- ϵ -haloacetyl lysine.

Here, the amino acid having a haloacetyl group on a side chain is not limited to these.

[0091] Examples of the amino acid residue derived from the amino acid having a haloacetyl group on a side chain include an amino acid residue represented by the following formula.

[0092]



[0093] In the above formula, m is an integer equal to or greater than 1, preferably an integer satisfying $1 \leq m \leq 4$, more preferably an integer satisfying $3 \leq m \leq 4$, and even more preferably 4; X represents a halogen atom, preferably represents a chlorine atom or a bromine atom, and more preferably represents a chlorine atom; and $*$ represents a binding point.

The amino acid residue represented by the above formula may be derived from an L-amino acid or a D-amino acid, and is preferably derived from an L-amino acid.

[0094] Specifically, examples of the amino acid residue derived from the amino acid having a haloacetyl group on a side chain include amino acid residues derived from (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, N- ϵ -chloroacetyl-D-lysine, and the like, but the amino acid residue is not limited to these.

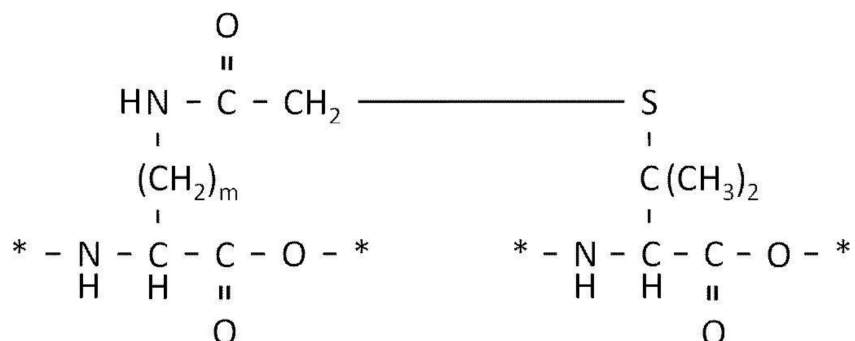
From the viewpoint of economic efficiency, the amino acid residue derived from the amino acid having a haloacetyl group on a side chain is preferably an amino acid residue derived from N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, or N- ϵ -chloroacetyl-D-lysine, and more preferably an amino acid residue derived from N- ϵ -chloroacetyl-D-lysine.

[0095] ((Thioether bond))

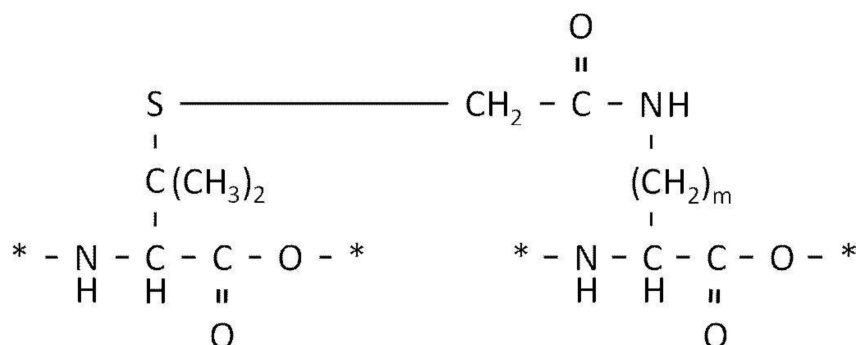
In the fourth embodiment of the cyclic peptide of the present invention, between X^a and X^b , a cross-linked structure is formed by a thioether bond formed between the side-chain thiol group and the side-chain haloacetyl group. That is, the thioether bond is formed between a thiol group of a first amino acid residue derived from L-penicillamine or D-penicillamine and a haloacetyl group of a second amino acid residue derived from an amino acid having a haloacetyl group on a side chain.

[0096] The following formulae show examples of the thioether bond formed between the side-chain thiol group of the amino acid residue derived from L-penicillamine or D-penicillamine and the side-chain haloacetyl group of the amino acid residue derived from the amino acid having a haloacetyl group on a side chain.

[0097]



[0098]



[0099] In the above formulae, m is an integer equal to or greater than 1, preferably an integer satisfying $1 \leq m \leq 4$, more preferably an integer satisfying $3 \leq m \leq 4$, and even more preferably 4; and * represents a binding point.

[0100] Regarding X^a and X^b , X^a may be an amino acid residue derived from an amino acid having a haloacetyl group on a side chain, and X^b may be an amino acid residue derived from L-penicillamine or D-penicillamine; or X^a may be an amino acid residue derived from L-penicillamine or D-penicillamine, and X^b may be an amino acid residue derived from an amino acid having a haloacetyl group on a side chain.

[0101] A thioether bond is known to be a bond more stable than a disulfide bond.

[0102] $\langle\langle X_g, X_h, X_i, X_j, X_m, \text{ and } X_n \rangle\rangle$

In Formula (I), X_g , X_h , X_i , X_j , X_m , and X_n each represent g consecutive X's, h consecutive X's, i consecutive X's, j consecutive X's, m consecutive X's, and n consecutive X's.

[0103] In Formula (I), in a case where X represents an amino acid residue, and there is a

plurality of X's, the plurality of X's may be the same as or different from each other.

In Formula (I), X is not particularly limited as long as it is an amino acid residue. X is preferably an amino acid residue derived from an amino acid selected from the group consisting of amino acids (excluding B, Z, and X) shown in Table 1 and amino acids shown in Table 2, and more preferably an amino acid residue derived from an amino acid selected from the group consisting of amino acids (excluding B, Z, and X) shown in Table 1. In a case where there is an enantiomer or a diastereomer of these amino acids, X may be an amino acid residue derived from the enantiomer or the diastereomer.

[0104] In Formula (I), g, h, i, and j each independently represent an integer equal to or greater than 0.

g preferably satisfies $0 \leq g \leq 20$, more preferably satisfies $0 \leq g \leq 10$, and even more preferably satisfies $0 \leq g \leq 5$.

h preferably satisfies $0 \leq h \leq 20$, more preferably satisfies $0 \leq h \leq 10$, and even more preferably satisfies $0 \leq h \leq 5$.

i preferably satisfies $0 \leq i \leq 20$, more preferably satisfies $0 \leq i \leq 10$, and even more preferably satisfies $0 \leq i \leq 5$.

j preferably satisfies $0 \leq j \leq 20$, more preferably satisfies $0 \leq j \leq 10$, and even more preferably satisfies $0 \leq j \leq 5$.

[0105] In Formula (I), m and n are integers satisfying $0 \leq m \leq 9$ and $0 \leq n \leq 9$. m and n satisfy $3 \leq m + n \leq 9$, preferably satisfy $4 \leq m + n \leq 8$, and more preferably satisfy $5 \leq m + n \leq 7$.

[0106] <<Number of amino acid residues in cyclic portion>>

In Formula (I), the number of amino acid residues [(m + n + 5) residues] in the cyclic portion [$X^a-X_m-X^1-X^2-X^3-X_n-X^b$] is 8 to 14, preferably 9 to 13, and more preferably 10 to 12.

In a case where the number of amino acid residues in the cyclic portion is within the above range, the intramolecular strain of the cyclic peptide does not excessively increase, and the high-order structure such as α -helix is stabilized. Therefore, the antibody binding properties of the cyclic peptide of the present invention become excellent.

[0107] <<Number of repeating units>>

k is an integer satisfying $k \geq 1$. k preferably satisfies $1 \leq k \leq 3$, more preferably satisfies $1 \leq k \leq 2$, and even more preferably satisfies $k = 1$.

Although the number of repeating units is not particularly limited, the larger the number of repeating units, the more the cyclic portions can be included in the cyclic peptide.

Accordingly, it is possible to improve the antibody binding properties of the cyclic peptide. The smaller the number of repeating units, the further the total number of amino acid residues can be reduced. Accordingly, it is possible to inhibit the antigenicity of the cyclic peptide. From the viewpoint the synthesis cost of the cyclic peptide, it is preferable that the number of amino acid residues and the number of repeating units are small.

[0108] In a case where $k \geq 2$, that is, in a case where the cyclic peptide represented by Formula (I) includes two or more repeating units $[X_i-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_j]$, X^1 , X^2 , X^3 , X^a , X^b , X_i , X_j , X_m , and X_n in the repeating unit each may be the same or different between the repeating units.

[0109] <<<Total number of amino acid residues in cyclic peptide>>>

The total number of amino acid residues in the cyclic peptide represented by Formula (I) is preferably 8 to 50, more preferably 9 to 40, even more preferably 10 to 30, and still more preferably 10 to 20.

That is, in Formula (I), g , h , i , j , m , n , and k preferably satisfy $8 \leq g + h + (i + j + m + n + 5) \times k \leq 50$, more preferably satisfy $9 \leq g + h + (i + j + m + n + 5) \times k \leq 40$, even more preferably satisfy $10 \leq g + h + (i + j + m + n + 5) \times k \leq 30$, and still more preferably satisfy $10 \leq g + h + (i + j + m + n + 5) \times k \leq 20$.

Generally, the larger the number of amino acid residues, the higher the manufacturing cost. Therefore, from the viewpoint of economic efficiency, it is preferable that the total number of amino acid residues is small.

[0110] <<Molecular weight of cyclic peptide>>

The molecular weight of the cyclic peptide represented by Formula (I) is not particularly limited. However, from the viewpoint of antigenicity, the molecular weight of the cyclic peptide of the present invention is preferably about equal to or smaller than 5,000, more preferably about equal to or smaller than 4,000, even more preferably about equal to or smaller than 3,000, and most preferably about equal to or smaller than 2,000. "About" means that the molecular weight includes a margin of $\pm 2\%$.

[0111] <<Exception in third embodiment>>

In the third embodiment of the present invention, X in Formula (I) represents an amino acid residue derived from an amino acid other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, and in a case where there is a plurality of X 's, the plurality of X 's may be the same as or different from each other.

In the third embodiment of the present invention, due to this difference, Formula (I) is

referred to as Formula (I') in some cases.

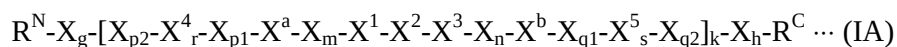
[0112] <<Exception in fourth embodiment>>

In the fourth embodiment of the present invention, X in Formula (I) represents an amino acid residue derived from an amino acid other than L-serine and D-serine, and in a case where there is a plurality of X's, the plurality of X's may be the same as or different from each other.

In the fourth embodiment of the present invention, due to this difference, Formula (I) is referred to as Formula (I') in some cases.

[0113] <Structure of cyclic peptide (IA) of present invention>

The cyclic peptide of the present invention is preferably a cyclic peptide represented by Formula (IA).



[0114] In Formula (IA), all of R^N , R^C , X^1 , X^2 , X^3 , X^a , X^b , X_g , X_h , X_m , X_n , X , g , h , m , n , and k have the same definitions as those in Formula (I).

In Formula (IA), similarly to X_n in Formula (I), X_n means that n X's are linked to each other. The same is true for X_m , X_{p1} , X_{p2} , X_{q1} , and X_{q2} .

In Formula (IA), X_r^4 and X_s^5 each mean that r X^4 's are linked to each other, and s X^5 's are linked to each other.

[0115] <<Cyclic portion, linear portion, cross-linked portion, and antibody binding portion>>

In the cyclic peptide represented by Formula (IA), " X_g ", " X_h ", " $X_{p2}-X_r^4-X_{p1}$ ", and " $X_{q1}-X_s^5-X_{q2}$ " are linear portions. The cyclic portion, the cross-linked portion, and the antibody binding portion are the same as those in the cyclic peptide represented by Formula (I).

In Formula (IA), $[X_{p2}-X_r^4-X_{p1}-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_{q1}-X_s^5-X_{q2}]$ is a repeating unit.

[0116] << X_r^4 and X_s^5 >>

In Formula (IA), X_r^4 and X_s^5 each mean r consecutive X^4 's and s consecutive X^5 's.

[0117] In Formula (IA), X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid having a hydroxy group on a side chain.

In a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other.

[0118] In Formula (IA), r and s each represent an integer satisfying $0 \leq r \leq 5$, $0 \leq s \leq 5$, and $1 \leq$

$\text{Max}(r,s) \leq 5$. r and s preferably each represent an integer satisfying $0 \leq r \leq 4$, $0 \leq s \leq 4$, and $1 \leq \text{Max}(r,s) \leq 4$, and more preferably each represent an integer satisfying $0 \leq r \leq 3$, $0 \leq s \leq 3$, and $1 \leq \text{Max}(r,s) \leq 3$.

$\text{Max}(r,s)$ represents a larger one between two numbers represented by r and s in a case where $r \neq s$ and represents r or s in a case where $r = s$.

[0119] (Amino acid having carboxy group on side chain)

Examples of the amino acid having a carboxy group on a side chain include L-aspartic acid, D-aspartic acid, L-glutamic acid, D-glutamic acid, L-homoglutamic acid, D-homoglutamic acid, and the like.

[0120] (Amino acid having hydroxy group on side chain)

Examples of the amino acid having a hydroxy group on a side chain include L-serine, D-serine, L-homoserine, D-homoserine, L-tyrosine, D-tyrosine, L-threonine, D-threonine, L-allothreonine, D-allothreonine, and the like.

[0121] (Preferred amino acid residues)

X^4 and X^5 preferably each independently represent an amino acid residue selected from the group consisting of an L-serine residue, a D-serine residue, an L-homoserine residue, a D-homoserine residue, an L-aspartic acid residue, a D-aspartic acid residue, an L-glutamic acid residue, a D-glutamic acid residue, an L-homoglutamic acid residue, a D-homoglutamic acid residue, an L-tyrosine residue, a D-tyrosine residue, an L-homotyrosine residue, a D-homotyrosine residue, an L-threonine residue, a D-threonine residue, an L-allothreonine residue, and a D-allothreonine residue, and more preferably each independently represent an amino acid residue selected from the group consisting of an L-aspartic acid residue, a D-aspartic acid residue, an L-threonine residue, and a D-threonine residue. It is even more preferable that X^4 represents an L-aspartic acid residue and X^5 represents an L-threonine residue.

[0122] It is considered that in a case where X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid having a hydroxy group on a side chain, due to a hydrogen bond and/or an electrostatic interaction, the interaction between the antibody binding portion of the cyclic portion and an antibody can become stronger, and hence the antibody binding properties are improved.

[0123] $\langle\langle X_{p1}, X_{p2}, X_{q1}, \text{ and } X_{q2} \rangle\rangle$

In Formula (IA), X_{p1} , X_{p2} , X_{q1} , and X_{q2} each represent $p1$ consecutive X 's, $p2$

consecutive X's, q1 consecutive X's, and q2 consecutive X's.

In Formula (IA), p1, p2, q1, and q2 each independently represent an integer equal to or greater than 0.

p1 preferably satisfies $0 \leq p1 \leq 20$, more preferably satisfies $0 \leq p1 \leq 10$, even more preferably satisfies $0 \leq p1 \leq 5$, and still more preferably satisfies $0 \leq p1 \leq 2$.

p2 preferably satisfies $0 \leq p2 \leq 20$, more preferably satisfies $0 \leq p2 \leq 10$, even more preferably satisfies $0 \leq p2 \leq 5$, and still more preferably satisfies $0 \leq p2 \leq 2$.

q1 preferably satisfies $0 \leq q1 \leq 20$, more preferably satisfies $0 \leq q1 \leq 10$, even more preferably satisfies $0 \leq q1 \leq 5$, and still more preferably satisfies $0 \leq q1 \leq 2$.

q2 preferably satisfies $0 \leq q2 \leq 20$, more preferably satisfies $0 \leq q2 \leq 10$, even more preferably satisfies $0 \leq q2 \leq 5$, and still more preferably satisfies $0 \leq q2 \leq 2$.

[0124] <<<Number of amino acid residues in cyclic portion>>>

In Formula (IA), the number of amino acid residues [(m + n + 5) residues] in the cyclic portion $[X^a-X_m-X^1-X^2-X^3-X_n-X^b]$ is 8 to 14, preferably 9 to 13, and more preferably 10 to 12, similarly to Formula (I).

In a case where the number of amino acid residues in the cyclic portion is within the above range, the intramolecular strain of the cyclic peptide does not excessively increase, and the high-order structure such as α -helix is stabilized. Therefore, the antibody binding properties of the cyclic peptide of the present invention become excellent.

[0125] <<Number of repeating units>>

In a case where $k \geq 2$, that is, in a case where the cyclic peptide represented by Formula (IA) includes two or more repeating units $[X_{p2}-X^4_r-X_{p1}-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_{q1}-X^5_s-X_{q2}]$, X^1 , X^2 , X^3 , X^a , X^b , X^4_r , X^5_s , X_m , X_n , X_{p2} , X_{p1} , X_{q1} , and X_{q2} in the repeating unit each may be the same or different between the repeating units.

[0126] <<Total number of amino acid residues in cyclic peptide>>

The total number of amino acid residues in the cyclic peptide represented by Formula (IA) is preferably 8 to 50, more preferably 9 to 40, even more preferably 10 to 30, and still more preferably 10 to 20.

That is, in Formula (IA), g, h, m, n, p1, p2, q1, q2, r, s, and k preferably satisfy $8 \leq g + h + (m + n + p1 + p2 + q1 + q2 + r + s + 5) \times k \leq 50$, more preferably satisfy $9 \leq g + h + (m + n + p1 + p2 + q1 + q2 + r + s + 5) \times k \leq 40$, even more preferably satisfy $10 \leq g + h + (m + n + p1 + p2 + q1 + q2 + r + s + 5) \times k \leq 30$, and still more preferably satisfy $10 \leq g + h + (m + n$

$$+ p1 + p2 + q1 + q2 + r + s + 5) \times k \leq 20.$$

Generally, the larger the number of amino acid residues, the higher the manufacturing cost. Therefore, from the viewpoint of economic efficiency, it is preferable that the total number of amino acid residues is small.

[0127] <<Exception in third embodiment>>

In the third embodiment of the present invention, X in Formula (IA) represents an amino acid residue derived from an amino acid other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, and in a case where there is a plurality of X's, the plurality of X's may be the same as or different from each other; X⁴ and X⁵ in Formula (IA) each independently represent "an amino acid residue derived from an amino acid having a carboxy group on a side chain" or "an amino acid residue derived from an amino acid, 'other than include L-serine, D-serine, L-homoserine, and D-homoserine', having a hydroxy group on a side chain", and in a case where there is a plurality of X⁴'s or X⁵'s, the plurality of X⁴'s or X⁵'s may be the same as or different from each other.

In the third embodiment of the present invention, due to these differences, Formula (IA) is referred to as Formula (I'A) in some cases.

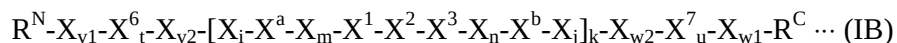
[0128] <<Exception in fourth embodiment>>

In the fourth embodiment of the present invention, X in Formula (IA) represents an amino acid residue derived from an amino acid other than L-serine and D-serine, and in a case where there is a plurality of X's, the plurality of X's may be the same as or different from each other; X⁴ and X⁵ in Formula (IA) each independently represent "an amino acid residue derived from an amino acid having a carboxy group on a side chain" or "an amino acid residue derived from an amino acid, 'other than include L-serine and D-serine', having a hydroxy group on a side chain", and in a case where there is a plurality of X⁴'s or X⁵'s, the plurality of X⁴'s or X⁵'s may be the same as or different from each other.

In the fourth embodiment of the present invention, due to these differences, Formula (IA) is referred to as Formula (I'A) in some cases.

[0129] <Structure of cyclic peptide (IB) of present invention>

The cyclic peptide of the present invention is preferably a cyclic peptide represented by Formula (IB).



[0130] In Formula (IB), all of R^N, R^C, X¹, X², X³, X^a, X^b, X_i, X_j, X_m, X_n, X, i, j, m, n, and k have the same definitions as those in Formula (I).

In Formula (IB), similarly to X_n in Formula (I), X_n means that n X 's are linked to each other. The same is true for X_m , X_{v1} , X_{v2} , X_{w1} , and X_{w2} .

In Formula (IB), X_t^6 and X_u^7 each mean that t X^6 's are linked to each other, and u X^7 's are linked to each other.

[0131] <<Cyclic portion, linear portion, cross-linked portion, and antibody binding portion>>

In the cyclic peptide represented by Formula (IB), " X_i ", " X_j ", " $X_{v1}-X_t^6-X_{v2}$ ", and " $X_{w2}-X_u^7-X_{w1}$ " are linear portions. The cyclic portion, the cross-linked portion, and the antibody binding portion are the same as those in the cyclic peptide represented by Formula (I).

In Formula (IB), $[X_i-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_j]$ is a repeating unit, similarly to Formula (I).

[0132] << X_t^6 and X_u^7 >>

In Formula (IB), X_t^6 and X_u^7 each represent t consecutive X^6 's and u consecutive X^7 's.

[0133] In Formula (IB), X^6 and X^7 each independently represent an amino acid residue derived from an amino acid having an immobilizing functional group on a side chain.

In a case where there is a plurality of X^6 's or X^7 's, the plurality of X^6 's or X^7 's may be the same as or different from each other.

[0134] In Formula (IB), t and u each represent an integer satisfying $0 \leq t \leq 5$, $0 \leq u \leq 5$, and $1 \leq \text{Max}(t, u) \leq 5$, preferably each represent an integer satisfying $0 \leq t \leq 4$, $0 \leq u \leq 4$, and $1 \leq \text{Max}(t, u) \leq 4$, and more preferably each represent an integer satisfying $0 \leq t \leq 3$, $0 \leq u \leq 3$, and $1 \leq \text{Max}(t, u) \leq 3$.

$\text{Max}(t, u)$ represents a larger one between two numbers represented by t and u in a case where $t \neq u$ and represents t or u in a case where $t = u$.

[0135] (Immobilizing functional group)

The aforementioned "immobilizing functional group" is a functional group which can form a covalent bond by reacting with a functional group on a support (described later).

Examples of the immobilizing functional group include an amino group, a carboxy group, a hydroxy group, a thiol group, an aldehyde group (formyl group), a carbamoyl group, an azide group, an alkynyl group, and the like.

Examples of the combination of the immobilizing functional group that the cyclic peptide of the present invention has and the functional group on the support include an amino group and a carboxy group (amide bond forming reaction), an amino group and an aldehyde

group (reductive amination reaction), an amino group and an epoxy group, a hydroxy group and an epoxy group, a carboxy group and a hydroxy group (ester bond forming reaction), a thiol group and a thiol group (disulfide bond), a thiol group and an epoxy group, an azide group and an alkynyl group (Huisgen cycloaddition reaction), and the like.

In a case where the immobilizing functional group that the cyclic peptide of the present invention has and the functional group on the support form a covalent bond by reacting with each other, the cyclic peptide of the present invention is immobilized on the support. At least some of the immobilizing functional groups that the cyclic peptide of the present invention has may form a covalent bond by reacting with the functional group on the support, and it is not necessary for all the immobilizing functional groups to react with the functional group on the support.

[0136] In the aforementioned amino acid having an immobilizing functional group on a side chain, the immobilizing functional group is preferably at least one kind of functional group selected from the group consisting of an amino group, a thiol group, and an aldehyde group, and more preferably at least one kind of functional group selected from the group consisting of an amino group and a thiol group.

[0137] (Amino acid having immobilizing functional group on side chain)

The amino acid having an immobilizing functional group on a side chain is preferably at least one kind of amino acid selected from the group consisting of L-lysine, D-lysine, L-cysteine, D-cysteine, L-homocysteine, and D-homocysteine.

[0138] In a case where an amino group is used as the immobilizing functional group, the amino group can be bonded to a carboxy group on the support through an amide bond, and the cyclic peptide of the present invention as an affinity ligand can be easily immobilized.

[0139] In a case where a thiol group is used as the immobilizing functional group, the thiol group can be bonded to an epoxy group on the support through a covalent bond, and the cyclic peptide of the present invention as an affinity ligand can be easily immobilized.

[0140] Examples of the amino acid having an amino group on a side chain include L-lysine, D-lysine, and the like, and examples of the amino acid having a thiol group on a side chain include L-cysteine and D-cysteine. Because these amino acids are relatively cheap, the manufacturing cost of the cyclic peptide of the present invention can be reduced. Therefore, from the viewpoint of economic efficiency, these amino acids are preferable.

[0141] (Support)

In the present invention, “support” refers to a substrate on which the cyclic peptide of

the present invention can be immobilized. The support has a functional group which can form a covalent bond by reacting with the immobilizing functional group that the cyclic peptide of the present invention has. The functional group is appropriately selected according to the immobilizing functional group.

[0142] (Material constituting support)

Examples of the material constituting the support include polysaccharides such as agarose, dextran, starch, cellulose, pullulan, chitin, chitosan, cellulose triacetate, and cellulose diacetate, derivatives of these, vinyl-based polymers such as polyacrylamide, polymethacrylamide, polyacrylate, polymethacrylate, polyalkyl vinyl ether, and polyvinyl alcohol, and the like. These materials may form a cross-linked structure because then mechanical strength can be secured. It is preferable that the support is formed of one kind of material or two or more kinds of materials among these.

The support is preferably porous, more preferably a porous film or a porous particle, and even more preferably a porous particle.

[0143] $\langle\langle X_{v1}, X_{v2}, X_{w1}, \text{ and } X_{w2} \rangle\rangle$

In Formula (IB), X_{v1} , X_{v2} , X_{w1} , and X_{w2} each represent $v1$ consecutive X's, $v2$ consecutive X's, $w1$ consecutive X's, and $w2$ consecutive X's.

In Formula (IB), $v1$, $v2$, $w1$, and $w2$ each independently represent an integer equal to or greater than 0.

$v1$ preferably satisfies $0 \leq v1 \leq 20$, more preferably satisfies $0 \leq v1 \leq 10$, even more preferably satisfies $0 \leq v1 \leq 5$, and still more preferably satisfies $0 \leq v1 \leq 2$.

$v2$ preferably satisfies $0 \leq v2 \leq 20$, more preferably satisfies $0 \leq v2 \leq 10$, even more preferably satisfies $0 \leq v2 \leq 5$, and still more preferably satisfies $0 \leq v2 \leq 2$.

$w1$ preferably satisfies $0 \leq w1 \leq 20$, more preferably satisfies $0 \leq w1 \leq 10$, even more preferably satisfies $0 \leq w1 \leq 5$, and still more preferably satisfies $0 \leq w1 \leq 2$.

$w2$ preferably satisfies $0 \leq w2 \leq 20$, more preferably satisfies $0 \leq w2 \leq 10$, even more preferably satisfies $0 \leq w2 \leq 5$, and still more preferably satisfies $0 \leq w2 \leq 2$.

[0144] $\langle\langle \text{Number of amino acid residues in cyclic portion} \rangle\rangle$

In Formula (IB), the number of amino acid residues $[(m + n + 5) \text{ residues}]$ in the cyclic portion $[X^a-X_m-X^1-X^2-X^3-X_n-X^b]$ is 8 to 14, preferably 9 to 13, and more preferably 10 to 12, similarly to Formula (I).

In a case where the number of amino acid residues in the cyclic portion is within the above range, the intramolecular strain of the cyclic peptide does not excessively increase, and

the high-order structure such as α -helix is stabilized. Therefore, the antibody binding properties of the cyclic peptide of the present invention become excellent.

[0145] <<Number of repeating units>>

In a case where $k \geq 2$, that is, in a case where the cyclic peptide represented by Formula (IB) includes two or more repeating units $[X_i-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_j]$, X^1 , X^2 , X^3 , X^a , X^b , X_m , X_n , X_i , and X_j in the repeating unit each may be the same or different between the repeating units.

[0146] <<Total number of amino acid residues in cyclic peptide>>

The total number of amino acid residues in the cyclic peptide represented by Formula (IB) is preferably 8 to 50, more preferably 9 to 40, even more preferably 10 to 30, and still more preferably 10 to 20.

That is, in Formula (IB), i , j , m , n , t , u , v_1 , v_2 , w_1 , w_2 , and k preferably satisfy $8 \leq (i + j + m + n + 5) \times k + t + u + v_1 + v_2 + w_1 + w_2 \leq 50$, more preferably satisfy $9 \leq (i + j + m + n + 5) \times k + t + u + v_1 + v_2 + w_1 + w_2 \leq 40$, even more preferably satisfy $10 \leq (i + j + m + n + 5) \times k + t + u + v_1 + v_2 + w_1 + w_2 \leq 30$, and still more preferably satisfy $10 \leq (i + j + m + n + 5) \times k + t + u + v_1 + v_2 + w_1 + w_2 \leq 20$.

Generally, the larger the number of amino acid residues, the higher the manufacturing cost. Therefore, from the viewpoint of economic efficiency, it is preferable that the total number of amino acid residues is small.

[0147] <<Exception in third embodiment>>

In the third embodiment of the present invention, X in Formula (IB) represents an amino acid residue derived from an amino acid other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, in a case where there is a plurality of X 's, the plurality of X 's may be the same as or different from each other; and X^6 and X^7 in Formula (IB) each independently represents "an amino acid residue derived from an amino acid, 'other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine', having an immobilizing functional group on a side chain", and in a case where there is a plurality of X^6 's and X^7 's, the plurality of X^6 's or X^7 's may be the same as or different from each other.

In the third embodiment of the present invention, due to these differences, Formula (IB) is referred to as Formula (I'B) in some cases.

[0148] <<Exception in fourth embodiment>>

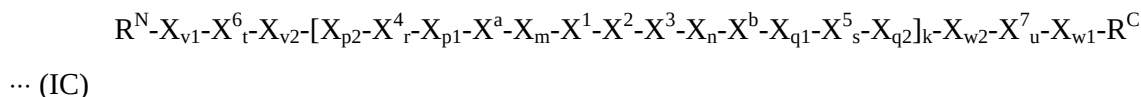
In the fourth embodiment of the present invention, X in Formula (IB) represents an amino acid residue derived from an amino acid other than L-serine and D-serine, and in a case

where there is a plurality of X's, the plurality of X's may be the same as or different from each other; and X⁶ and X⁷ in Formula (IB) each independently represent "an amino acid residue derived from an amino acid, 'other than L-serine and D-serine', having an immobilizing functional group on a side chain, and in a case where there is a plurality of X⁶'s or X⁷'s, the plurality of X⁶'s or X⁷'s may be the same as or different from each other.

In the fourth embodiment of the present invention, due to these differences, Formula (IB) is referred to as Formula (I'B) in some cases.

[0149] <Structure of cyclic peptide (IC) of present invention>

The cyclic peptide of the present invention is more preferably a cyclic peptide represented by Formula (IC).



[0150] In Formula (IC), all of R^N, R^C, X¹, X², X³, X^a, X^b, X_m, X_n, X, m, n, and k have the same definitions as those in Formula (I), all of X⁴, X⁵, p₁, p₂, q₁, q₂, r, and s have the same definitions as those in Formula (IA), and all of X⁶, X⁷, t, u, v₁, v₂, w₁, and w₂ have the same definitions as those in Formula (IB).

In Formula (IC), similarly to X_n in Formula (I), X_n means that n X's are linked to each other. The same is true for X_m, X_{p1}, X_{p2}, X_{q1}, X_{q2}, X_{v1}, X_{v2}, X_{w1}, and X_{w2}.

In Formula (IC), X_r⁴, X_s⁵, X_t⁶, and X_u⁷ each mean that r X⁴'s are linked to each other, s X⁵'s are linked to each other, t X⁶'s are linked to each other, and u X⁷'s are linked to each other.

[0151] <<Cyclic portion, linear portion, cross-linked portion, and antibody binding portion>>

In the cyclic peptide represented by Formula (IC), "X_{v1}-X_t⁶-X_{v2}", "X_{w2}-X_u⁷-X_{w1}", "X_{p2}-X_r⁴-X_{p1}", and "X_{q1}-X_s⁵-X_{q2}" are linear portions. The cyclic portion, the cross-linked portion, and the antibody binding portion are the same as those in the cyclic peptide represented by Formula (I).

In Formula (IC), [X_{p2}-X_r⁴-X_{p1}-X^a-X_m-X¹-X²-X³-X_n-X^b-X_{q1}-X_s⁵-X_{q2}] is a repeating unit, similarly to Formula (IA).

[0152] <<Number of amino acid residues in cyclic portion>>

In Formula (IC), the number of amino acid residues [(m + n + 5) residues] in the cyclic portion [X^a-X_m-X¹-X²-X³-X_n-X^b] is 8 to 14, preferably 9 to 13, and even more preferably 10 to 12, similarly to Formula (I).

In a case where the number of amino acid residues in the cyclic portion is within the

above range, the intramolecular strain of the cyclic peptide does not excessively increase, and the high-order structure such as α -helix is stabilized. Therefore, the antibody binding properties of the cyclic peptide of the present invention become excellent.

[0153] <<Number of repeating units>>

In a case where $k \geq 2$, that is, in a case where the cyclic peptide represented by Formula (IC) includes two or more repeating units $[X_{p2}-X^4_r-X_{p1}-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_{q1}-X^5_s-X_{q2}]$, X^1 , X^2 , X^3 , X^a , X^b , X^4_r , X^5_s , X_m , X_n , X_{p2} , X_{p1} , X_{q1} , and X_{q2} in the repeating unit each may be the same or different between the repeating units.

[0154] <<Total number of amino acid residues in cyclic peptide>>

The total number of amino acid residues in the cyclic peptide represented by Formula (IC) is preferably 8 to 50, more preferably 9 to 40, even more preferably 10 to 30, and still more preferably 10 to 20.

That is, in Formula (IC), m , n , $p1$, $p2$, $q1$, $q2$, r , s , t , u , $v1$, $v2$, $w1$, $w2$, and k preferably satisfy $8 \leq (m + n + p1 + p2 + q1 + q2 + r + s + 5) \times k + t + u + v1 + v2 + w1 + w2 \leq 50$, more preferably satisfy $9 \leq (m + n + p1 + p2 + q1 + q2 + r + s + 5) \times k + t + u + v1 + v2 + w1 + w2 \leq 40$, even more preferably satisfy $10 \leq (m + n + p1 + p2 + q1 + q2 + r + s + 5) \times k + t + u + v1 + v2 + w1 + w2 \leq 30$, and still more preferably satisfy $10 \leq (m + n + p1 + p2 + q1 + q2 + r + s + 5) \times k + t + u + v1 + v2 + w1 + w2 \leq 20$.

Generally, the larger the number of amino acid residues, the higher the manufacturing cost. Therefore, from the viewpoint of economic efficiency, it is preferable that the total number of amino acid residues is small.

[0155] <<Exception in third embodiment>>

In the third embodiment of the present invention, X in Formula (IC) represents an amino acid residue derived from an amino acid other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, and in a case where there is a plurality of X 's, the plurality of X 's may be the same as or different from each other; X^4 and X^5 in Formula (IC) each independently represent "an amino acid residue derived from an amino acid having a carboxy group on a side chain" or "an amino acid residue derived from an amino acid, 'other than L-serine, D-serine, L-homoserine, and D-homoserine', having a hydroxy group on a side chain, and in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other; and X^6 and X^7 in Formula (IC) each independently represent "an amino acid residue derived from an amino acid, 'other than L-serine, D-serine,

L-homoserine, D-homoserine, L-arginine, and D-arginine', having an immobilizing functional group on a side chain", and in a case where there is a plurality of X^6 's or X^7 ', the plurality of X^6 's or X^7 's may be the same as or different from each other.

In the third embodiment of the present invention, due to these differences, Formula (IC) is referred to as Formula (I'C) in some cases.

[0156] <<Exception in fourth embodiment>>

In the fourth embodiment of the present invention, X in Formula (IC) represents an amino acid residue derived from an amino acid other than L-serine and D-serine, and in a case where there is a plurality of X's, the plurality of X's may be the same as or different from each other; X^4 and X^5 in Formula (IC) each independently represent "an amino acid residue derived from an amino acid having a carboxy group on a side chain" or "an amino acid residue derived from an amino acid, 'other than L-serine and D-serine', having a hydroxy group on a side chain", and in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other; and X^6 and X^7 in Formula (IC) each independently represent "an amino acid residue derived from an amino acid, 'other than L-serine and D-serine', having an immobilizing functional group on a side chain", and in a case where there is a plurality of X^6 's or X^7 's, the plurality of X^6 's or X^7 's may be the same as or different from each other.

In the fourth embodiment of the present invention, due to these differences, Formula (IC) is referred to as Formula (I'C) in some cases.

[0157] <Preferred partial amino acid sequence>

The partial amino acid sequence $X_m-X^1-X^2-X^3-X_n$ in Formula (I), (IA), (IB), or (IC) and an amino acid sequence (SEQ ID NO: 1) represented by Formula (1) preferably share sequence homology of equal to or higher than 70%, more preferably share sequence homology of equal to or higher than 75%, even more preferably share sequence homology of equal to or higher than 85%, and still more preferably share sequence homology of equal to or higher than 90%.

A-Y-H-L-G-E-L-V-W ... (1)

In Formula (1), A represents an L-alanine residue; Y represents an L-tyrosine residue; H represents an L-histidine residue; L represents an L-leucine residue; G represents a glycine residue; E represents an L-glutamic acid residue; V represents an L-valine residue; and W represents an L-tryptophan residue.

[0158] The partial amino acid sequence $X_m-X^1-X^2-X^3-X_n$ in Formula (I), (IA), (IB), or (IC)

and an amino acid sequence (SEQ ID NO: 2) represented by Formula (2) preferably share sequence homology of equal to or higher than 70%, more preferably share sequence homology of equal to or higher than 75%, even more preferably share sequence homology of equal to or higher than 85%, and still more preferably share sequence homology of equal to or higher than 90%.

A-Y-H-R-G-E-L-V-W ... (2)

In Formula (2), A represents an L-alanine residue; Y represents an L-tyrosine residue; H represents an L-histidine residue; R represents an L-arginine residue; G represents a glycine residue; E represents an L-glutamic acid residue; L represents an L-leucine residue; V represents an L-valine residue; and W represents an L-tryptophan residue.

[0159] The sequence homology between two amino acid sequences is determined as below.

(i) Performing alignment of two amino acid sequences

By assigning a score of +1 to matches, a score of -1 to mismatches, and a score of -1 to gaps, alignment is performed such that the alignment score is maximized.

(ii) Calculating sequence homology

Based on the obtained alignment, the sequence homology is calculated by the following expression.

Sequence homology [%] = (number of matching positions/total number of positions) × 100 [%]

The total number of positions is the length of an alignment, and the number of matching positions is the number of positions in which the types of amino acids are matched.

Whether or not the types of amino acid residues are matched is determined according to whether or not the structure of a side chain of an amino acid (amino acid side chain) from which the amino acid residues are derived is the same. The structures of side chains of amino acids having an enantiomeric relationship are not the same as each other.

(iii) Calculation example of sequence homology

For example, suppose that there are amino acid sequences shown below.

Sequence A AYHRGELVW

Sequence B AWHLGELVW

In a case where alignment is performed under the conditions described above, the following result is obtained. Herein, the sites where the types of amino acids (residues) are the same between the sequences A and B are marked with a homology string “|” such that the sites are easily recognized. Furthermore, “-” is a gap.

Sequence A	A	Y	H	R	G	E	L	V	W
Sequence B	A	W	H	L	G	E	L	V	W

The scores of this alignment is that matches $(+1) \times 7$ + mismatches $(-1) \times 1$ + gaps $(-1) \times 1 = 5$.

In this example, the total number of positions is 9, the number of matching positions is 7. Therefore, the sequence homology calculated according to the above expression is $7/9 \times 100 = 77.8\%$.

[0160] <Preferred number of repeating units>

In the present invention, k in Formulae (I) to (IC) is preferably 1.

[0161] In a case where the cyclic peptide has one cyclic portion-including portion, the total length of the cyclic peptide can be shortened, and hence the cyclic peptide is easily synthesized. Furthermore, by the Huisgen reaction at the time of cyclization, it is possible to avoid the formation of a cross-link at an unintended site.

[0162] <Structure of cyclic peptide (II) of present invention>

The cyclic peptide of the present invention is particularly preferably a cyclic peptide represented by Formula (II).



(II)

In Formula (II), X^a , X^b , R^N , and R^C have the same definitions as those in Formula (I).

[0163] <<Cyclic portion, linear portion, cross-linked portion, and antibody binding portion>>

In the cyclic peptide represented by Formula (II), " $X^a-A-Y-H-X^8-G-E-L-V-W-X^b$ " is a cyclic portion, " $X_{v0}-X_{t0}^6-X_{e0}-X_{r0}^4-X_{p0}-$ " and " $X_{q0}-X_{s0}^5-X_{f0}-X_{u0}^7-X_{w0}$ " are linear portions, " X^a " and " X^b " are cross-linked portions, and "L-V-W" is an antibody binding portion.

[0164] << X_{r0}^4 and X_{s0}^5 >>

In Formula (II), X_{r0}^4 and X_{s0}^5 each represent r_0 consecutive X^4 's and s_0 consecutive X^5 's.

In Formula (II), X^4 and X^5 have the same definitions as those in Formula (IA).

In Formula (II), r_0 and s_0 each represent an integer satisfying $0 \leq r_0 \leq 5$ and $0 \leq s_0 \leq 5$.

r_0 preferably satisfies $0 \leq r_0 \leq 3$, and more preferably satisfies $0 \leq r_0 \leq 2$.

s_0 preferably satisfies $0 \leq s_0 \leq 3$, and more preferably satisfies $0 \leq s_0 \leq 2$.

[0165] << X_{t0}^6 and X_{u0}^7 >>

In Formula (II), X_{t0}^6 and X_{u0}^7 each represent t_0 consecutive X^6 's and u_0 consecutive

X^7 's.

In Formula (II), X^6 and X^7 have the same definitions as those in Formula (IB).

In Formula (II), t_0 and u_0 each represent an integer satisfying $0 \leq t_0 \leq 5$ and $0 \leq u_0 \leq$

5.

t_0 preferably satisfies $0 \leq t_0 \leq 3$, and more preferably satisfies $0 \leq t_0 \leq 2$.

u_0 preferably satisfies $0 \leq u_0 \leq 3$, and more preferably satisfies $0 \leq u_0 \leq 2$.

[0166] $\langle\langle X_{e0}, X_{f0}, X_{p0}, X_{q0}, X_{v0}, \text{ and } X_{w0} \rangle\rangle$

X_{e0} , X_{f0} , X_{p0} , X_{q0} , X_{v0} , and X_{w0} each represent e_0 consecutive X's, f_0 consecutive X's, p_0 consecutive X's, q_0 consecutive X's, v_0 consecutive X's, and w_0 consecutive X's.

X has the same definition as that in Formula (I).

e_0 and f_0 each represent an integer satisfying $0 \leq e_0 \leq 10$ and $0 \leq f_0 \leq 10$.

e_0 preferably satisfies $0 \leq e_0 \leq 5$, more preferably satisfies $0 \leq e_0 \leq 3$, and even more preferably satisfies $0 \leq e_0 \leq 2$.

f_0 preferably satisfies $0 \leq f_0 \leq 5$, more preferably satisfies $0 \leq f_0 \leq 3$, and even more preferably satisfies $0 \leq f_0 \leq 2$.

p_0 and q_0 each represent an integer satisfying $0 \leq p_0 \leq 5$ and $0 \leq q_0 \leq 5$.

p_0 preferably satisfies $0 \leq p_0 \leq 3$, and more preferably satisfies $0 \leq p_0 \leq 2$.

q_0 preferably satisfies $0 \leq q_0 \leq 3$, and more preferably satisfies $0 \leq q_0 \leq 2$.

v_0 and w_0 each represent an integer satisfying $0 \leq v_0 \leq 5$ and $3 \leq w_0 \leq 5$.

v_0 preferably satisfies $0 \leq v_0 \leq 3$, and more preferably satisfies $0 \leq v_0 \leq 2$.

w_0 preferably satisfies $0 \leq w_0 \leq 3$, and more preferably satisfies $0 \leq w_0 \leq 2$.

[0167] X^8 represents an L-leucine residue, a D-leucine residue, an L-arginine residue, or a D-arginine residue.

[0168] In Formula (II), A represents an L-alanine residue or a D-alanine residue; Y represents an L-tyrosine residue or a D-tyrosine residue; H represents an L-histidine residue or a D-histidine residue; G represents a glycine residue; E represents an L-glutamic acid residue or a D-glutamic acid residue; L represents an L-leucine residue; V represents an L-valine residue; and W represents an L-tryptophan residue.

[0169] $\langle\langle \text{Total number of amino acid residues in cyclic peptide} \rangle\rangle$

In Formula (II), the total number of amino acid residues in the cyclic peptide is 11 to 50, preferably 11 to 40, more preferably 11 to 30, and even more preferably 11 to 20.

That is, in Formula (II), e_0 , f_0 , p_0 , q_0 , r_0 , s_0 , t_0 , u_0 , v_0 , and w_0 satisfy $0 \leq e_0 + f_0 +$

$p_0 + q_0 + r_0 + s_0 + t_0 + u_0 + v_0 + w_0 \leq 39$, preferably satisfy $0 \leq e_0 + f_0 + p_0 + q_0 + r_0 + s_0 + t_0 + u_0 + v_0 + w_0 \leq 29$, more preferably satisfy $0 \leq e_0 + f_0 + p_0 + q_0 + r_0 + s_0 + t_0 + u_0 + v_0 + w_0 \leq 19$, and even more preferably satisfy $0 \leq e_0 + f_0 + p_0 + q_0 + r_0 + s_0 + t_0 + u_0 + v_0 + w_0 \leq 9$.

[0170] <Antibody binding properties>

The cyclic peptide of the present invention has excellent antibody binding properties. The antibody binding properties refer to binding activity with respect to antibodies and/or antibody derivatives. The higher the binding activity is, the more the antibodies are adsorbed onto the cyclic peptide in a case where the cyclic peptide is used as an affinity ligand for affinity chromatography for antibody purification, and hence a large amount of antibodies can be purified at a time. An antibody refers to immunoglobulin or an analogue, a fragment, or a conjugate of the antibody. The analogue refers to a natural protein or protein conjugate or to an artificially prepared protein or protein conjugate which keeps the structure or function of immunoglobulin in at least a portion thereof. The fragment refers to a protein which is prepared by an enzymatic treatment or designed by genetic engineering and has a partial structure of immunoglobulin. The conjugate refers to a protein prepared by fusing a functional portion of proteins having a biological activity such as various cytokines or cytokine receptors with the entirety or a portion of immunoglobulin through genetic engineering. The antibody is preferably a monoclonal antibody or a conjugate having an Fc region of immunoglobulin, and more preferably a monoclonal antibody. In the present invention, the immunoglobulin may be of any of five classes (isotypes) including immunoglobulin G (IgG), immunoglobulin M (IgM), immunoglobulin A (IgA), immunoglobulin D (IgD), and immunoglobulin E (IgE). Among these, IgG or IgM is preferable, and IgG is more preferable.

[0171] <Alkali resistance>

The cyclic peptide of the present invention has excellent temporal stability or chemical resistance. Particularly, the cyclic peptide of the present invention has excellent alkali resistance. Because the cyclic peptide has excellent chemical resistance, for example, in a case where a support for affinity chromatography, in which the cyclic peptide of the present invention is used as an affinity ligand, is used for antibody purification, even if the support is repeatedly washed with a chemical, particularly, an alkali, the antibody binding properties are maintained. Therefore, the antibody purification cost can be further reduced.

[0172] <<Exception in third embodiment>>

In the third embodiment of the present invention, X in Formula (II) represents an amino acid residue derived from an amino acid other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, and in a case where there is a plurality of X's, the plurality of X's may be the same as or different from each other; X⁴ and X⁵ in Formula (II) each independently represent "an amino acid residue derived from an amino acid having a carboxy group on a side chain" or "an amino acid residue derived from an amino acid, 'other than L-serine, D-serine, L-homoserine, and D-homoserine', having a hydroxy group on a side chain", and in a case where there is a plurality of X⁴'s or X⁵'s, the plurality of X⁴'s or X⁵'s may be the same as or different from each other; X⁶ and X⁷ in Formula (II) each independently represent "an amino acid residue derived from an amino acid, 'other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine', having an immobilizing functional group on a side chain, and in a case where there is a plurality of X⁶'s or X⁷'s, the plurality of X⁶'s or X⁷'s may be the same as or different from each other; and X⁸ in Formula (II) represents an L-leucine residue or a D-leucine residue.

In the third embodiment of the present invention, due to these differences, Formula (II) is referred to as Formula (II') in some cases.

[0173] <<Exception in fourth embodiment>>

In the fourth embodiment of the present invention, X in Formula (II) represents an amino acid residue derived from an amino acid other than L-serine and D-serine, in a case where there is a plurality of X's, the plurality of X's may be the same as or different from each other; X⁴ and X⁵ in Formula (II) each independently represent "an amino acid residue derived from an amino acid having a carboxy group on a side chain" or "an amino acid residue derived from an amino acid, 'other than L-serine and D-serine', having a hydroxy group on a side chain", and in a case where there is a plurality of X⁴'s or X⁵'s, the plurality of X⁴'s or X⁵'s may be the same as or different from each other; and X⁶ and X⁷ in Formula (II) each independently represent "an amino acid residue derived from an amino acid, 'other than L-serine and D-serine', having an immobilizing functional group on a side chain", and in a case where there is a plurality of X⁶'s or X⁷'s, the plurality of X⁶'s or X⁷'s may be the same as or different from each other.

In the fourth embodiment of the present invention, due to these differences, Formula (II) is referred to as Formula (II') in some cases.

[0174] [Method for synthesizing cyclic peptide]

The method for synthesizing the cyclic peptide of the present invention is not

particularly limited. For example, the cyclic peptide can be synthesized by a peptide synthesis method based on synthetic organic chemistry or by a peptide synthesis method based on genetic engineering.

As the peptide synthesis method based on synthetic organic chemistry, any of a liquid-phase synthesis method and a solid-phase synthesis method can be used. As the method for synthesizing the polypeptide of the present invention, a solid-phase synthesis method in which an automatic peptide synthesis device is used is preferable because this method is convenient.

The peptide synthesis method based on genetic engineering is a method of synthesizing a peptide by introducing a gene into a cell. As the cell, bacteria, eelworm cells, insect cells, mammal cells, animal cells, and the like are used.

For example, by introducing a non-natural amino acid into a cell by using a four-base codon method, the cyclic peptide can be synthesized. Furthermore, by synthesizing a linear peptide and causing cyclization by reacting a crosslinking functional group on a side chain of an amino acid residue introduced into a cyclic portion, the cyclic peptide can be synthesized.

In a case where a disulfide bond needs to be formed, for example, by reacting side-chain thiol groups of two amino acid residues, which are derived from an amino acid having a thiol group on a side chain, under oxidizing conditions, a disulfide bond can be formed. Specifically, for example, by forming a disulfide bond between side-chain thiol groups of two L-homocysteine residues, a linear polypeptide can be cyclized.

In a case where a thioether bond needs to be formed, for example, by reacting a side-chain thiol group of an amino acid residue derived from an amino acid having a thiol group on a side chain with a side-chain chloroacetyl group of an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, a thioether bond can be formed. Specifically, for example, by forming a thioether bond between a side-chain thiol group of an L-homocysteine residue and a side-chain chloroacetyl group of an N- ϵ -chloroacetyl-L-lysine residue, a linear polypeptide can be cyclized.

Instead of an amino acid having a haloacetyl group such as a chloroacetyl group on a side chain, it is possible to use an amino acid having a haloalkanoyl group such as a chloropropionyl group, which has more methylene units compared to a haloacetyl group, on a side chain. However, it is preferable to use the amino acid having a haloacetyl group on a side chain, because the smaller the number of methylene units, the higher the cyclization efficiency. For example, between a halopropionyl group ($-\text{C}(=\text{O})-(\text{CH}_2)_2-\text{X}$; X represents a

halogen atom, having two methylene units) and an acetyl group ($-\text{C}(=\text{O})-\text{CH}_2-\text{X}$; X represents a halogen atom, having one methylene unit), the acetyl group is preferable because it has a higher cyclization efficiency.

[0175] [Use of cyclic peptide of present invention]

The cyclic peptide of the present invention can be used as an antibody binding ligand, a linker for labeling antibodies, a linker for an antibody drug conjugate, a drug carrier (linker for pharmaceutical products), and the like, but the use of the cyclic peptide of the present invention is not limited to these.

[0176] <Antibody binding ligand and affinity chromatography support>

The cyclic peptide of the present invention can be used as an antibody binding ligand in the technical field of affinity chromatography.

Examples of applications of the cyclic peptide of the present invention used as an antibody binding ligand include an antibody or antibody derivative adsorbing material in which the cyclic peptide of the present invention is immobilized on a water-insoluble support and an affinity chromatography support.

[0177] “Water-insoluble support” refers to a support which is substantially insoluble in water. Examples of such a support include polysaccharides such as crystalline cellulose, cross-linked cellulose, cross-linked agarose, cross-linked dextran, and cross-linked pullulan, organic supports such as an acrylate-based polymer and a styrene-based polymer, inorganic supports such as glass beads and silica gel, composite supports such as an organic-organic composite support and an organic-inorganic composite support obtained by combining the above supports, and the like. From the viewpoint of alkali resistance, as the water-insoluble support, polysaccharides or an acrylate-based polymer is more preferable, and polysaccharides such as agarose or cellulose are more preferable. Examples of commercial products that can be used as the water-insoluble support include porous cellulose gel such as Cellufine GCL2000 (manufactured by JNC Corporation) (CELLUFINE is a registered trademark) and Cellfine MAX (manufactured by JNC Corporation), Sephacryl S-1000 SF (manufactured by GE Healthcare) obtained by cross-linking allyl dextran to methylenebisacrylamide through a covalent bond (SEPHACRYL is a registered trademark), acrylate-based supports such as TOYOPEARL (manufactured by Tosoh Corporation) (TOYOPEARL is a registered trademark), TOYOPEARL AF-Carboxy-650 (manufactured by Tosoh Corporation), and TOYOPEARL GigaCap CM-650 (manufactured by Tosoh Corporation), an agarose-based cross-linked support such as Sepharose CL4B (manufactured by GE Healthcare)

(SEPHAROSE is a registered trademark), polymethacrylamide activated by an epoxy group such as Eupergit C250L (manufactured by Sigma-Aldrich Co., LLC.) (EUPERGIT is a registered trademark), and the like. Here, the water-insoluble support in the present invention is not limited to the supports or the activated supports described above. Considering the purpose of use of the original adsorbing material and how to use the original absorbing material, it is preferable that the water-insoluble support used in the present invention has a large surface area and is porous support having a number of pores with an appropriate size. The shape of the support is not particularly limited. The support can be any of a bead-like support, a fibrous support, a film-like support, and hollow fibrous support, and it is possible to select any shape.

[0178] The method for immobilizing the cyclic peptide of the present invention on the water-insoluble support is not particularly limited. For example, generally, it is possible to adopt a method that is adopted in a case where a protein or a polypeptide is immobilized on a support.

For example, the cyclic peptide can be immobilized by a method of activating a support by reacting the support with cyanogen bromide, epichlorohydrin, diglycidyl ether, tosyl chloride, tresyl chloride, hydrazine, and the like or introducing a reactive functional group into the surface of the support and immobilizing the support by reacting the support with a compound immobilized as a ligand, or a method of causing condensation by adding a condensation reagent such as carbodiimide or a reagent having a plurality of functional groups in a molecule such as glyceraldehyde to a system including a support and a compound immobilized as a ligand and cross-linking the condensate.

[0179] In the present invention, “ligand” refers to a molecule which has a certain degree of affinity with a specific substance and binds to the substance. The specific substance is not particularly limited, and is preferably an antibody or an antibody derivative. The binding site at which the ligand binds to an antibody or an antibody derivative is not particularly limited. From the viewpoint of versatility, the binding site is preferably a constant region of an antibody or an antibody derivative. The constant region is not particularly limited, and is preferably fragment crystallizable (Fc) regions, constant regions of a light chain (CL regions), or constant regions of a heavy chain (CH regions). In the present invention, the ligand which can bind to an antibody or an antibody derivative is referred to as “antibody binding ligand” in some cases.

[0180] At the time of immobilizing a ligand on a support, it is preferable to dissolve (disperse)

the ligand in an aqueous solvent (aqueous dispersion medium) or an organic solvent (organic dispersion medium). The aqueous solvent (aqueous dispersion medium) is not particularly limited, and examples thereof include a 4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid (HEPES) buffer solution, an acetic acid buffer solution, a phosphoric acid buffer solution, a citric acid buffer solution, a tris-hydrochloric acid buffer solution, and the like. The organic solvent (organic dispersion medium) is not particularly limited. The organic solvent is particularly preferably an organic polar solvent such as dimethyl sulfoxide (DMSO), N,N-dimethylformamide (DMF), or alcohol, and examples thereof include methanol, ethanol, isopropyl alcohol (IPA), 2,2,2-trifluoroethanol (TFE), 1,1,1,3,3,3-hexafluoro-2-propanol (HFIP), and the like.

The pH condition at the time of immobilizing the ligand is not particularly limited, and any of acidic, neutral, and alkaline conditions can be adopted. For example, the pH condition can be appropriately set according to the solvent (dispersion medium) to be used.

For example, in a case where the pH condition needs to be made alkaline, a base such as diazabicycloundecene (DBU) may be added to dimethyl sulfoxide (DMSO) or an alcohol.

[0181] In a case where the aforementioned adsorbing material is used as a filler for affinity chromatography, the density of antibody binding ligands is not particularly limited. However, the density is preferably 0.1 to 1,000 mmol/1 L of filler, more preferably 0.1 to 100 mmol/1 L of filler, and even more preferably 0.5 to 20 mmol/1 L of filler. In a case where the density is within the above range, the amount of the antibody binding ligand used and the antibody purification performance are balanced well, and it is possible to efficiently purify antibodies at lower costs.

[0182] <Linker for labeling antibodies and labeled antibody>

In the technical field of immunoassay, the cyclic peptide of the present invention can be used as a linker for labeling antibodies.

Examples of applications of the cyclic peptide of the present invention used as the linker for labeling antibodies include a labeled antibody which includes an antibody, a labeling compound, and the cyclic peptide of the present invention and in which the antibody and the labeling compound are bonded to each other through the cyclic peptide of the present invention.

Immunoassay is an analysis method for detecting or quantifying a trace substance by using an immune reaction (antigen-antibody reaction), and features high specificity and high sensitivity.

In the immunoassay, in order to detect an antibody (primary antibody) having bonded to a trace substance (antigen), a method of directly labeling the primary antibody, a method of labeling an antibody (secondary antibody) binding to the primary antibody, and the like are used. The cyclic peptide of the present invention can be used as a linker for causing a labeling substance to bind to a primary antibody or as a linker for causing a labeling substance to bind to a secondary antibody. The cyclic peptide of the present invention has antibody binding properties (immunoglobulin G (IgG) binding properties). Therefore, the labeled cyclic peptide of the present invention can also be used instead of a labeled secondary antibody.

There are various labels. A system in which a radioisotope is used as a label is called radioimmunoassay (RIA), a system in which an enzyme such as peroxidase is used as a label is called enzyme immunoassay (EIA), a system in which a chemiluminescent substance such as luminol is used as a label is called chemiluminescent immunoassay (CLIA), and a system in which a fluorescent substance (fluorescent dye) such as fluorescein isothiocyanate (FITC) is used as a labeling substance is called fluorescent immunoassay (FIA). The cyclic peptide of the present invention can be used as a linker for labeling antibodies in any of the systems.

In order to improve the detection sensitivity of immunoassay, a number of labels need to be attached to one antibody molecule. With the linker for labeling antibodies of the related art, in a case where a number of the linkers bind to an antibody, the antibody binding activity deteriorate. Accordingly, the specificity and the sensitivity which are advantages of immunoassay are likely to be impaired. In contrast, according to the cyclic peptide of the present invention, even in a case where a number of the cyclic peptides bind to an antibody, the structural integrity of the antibody can be maintained, and the antibody binding activity is not reduced. Therefore, even in a case where a number of the cyclic peptides bind to an antibody, the detection sensitivity could be improved without impairing the specificity and the sensitivity which are advantages of immunoassay. In addition, because the cyclic peptide binds to an antibody through an antigen-antibody reaction, the separation of the cyclic peptide after labeling that was difficult to perform in the related art can be conducted, and hence reversible labeling can be realized.

[0183] <Linker for antibody drug conjugates and antibody drug conjugate>

In the technical field of antibody drug conjugates, the cyclic peptide of the present invention can be used as a linker for antibody drug conjugates.

Examples of applications of the cyclic peptide of the present invention used as a linker for antibody drug conjugates include an antibody drug conjugate which includes an antibody, a drug, and the cyclic peptide of the present invention and in which the antibody binds to the drug through the cyclic peptide of the present invention.

The antibody drug conjugate (ADC) is also called by another name “armed antibody”. ADC is a drug obtained by binding an antibody recognizing a cell to a drug (low-molecular weight drug) which is a main active component by using an appropriate linker. The mechanism of action of the antibody drug conjugate is roughly as below.

(1) The antibody portion of an antibody drug conjugate binds to a target molecule on the surface of a target cell.

(2) The antibody drug conjugate infiltrates into the cell.

(3) The linker of the antibody drug conjugate is cleaved in the cell.

(4) The drug (low-molecular weight drug) exerts its efficacy in the cell.

With the antibody drug conjugate, because the efficacy is exerted only in the cell expressing a molecule that the antibody targets, it is possible to inhibit the systemic side effects and to cause the efficacy to be exerted mainly in a target cell. Therefore, the antibody drug conjugate is more efficacious and causes less side effects compared to simple drugs. For example, the anticancer agent developed for attacking cancer cells in which cell division vigorously occurs also attacks the cells, in which cell division vigorously occurs as in the cancer cells but the function thereof is maintained, specifically, the cells responsible for immunity, the cells of the gastrointestinal tract, the hair follicle cells, and the like. Consequently, as side effects, the symptoms such as vulnerability to infectious diseases, diarrhea, and hair loss occur in some cases. However, with the antibody drug conjugate, the anticancer agent can be selectively carried to target cancer cells, and accordingly, it is possible to inhibit the side effects caused in a case where the anticancer agent attacks cells other than the target cells.

[0184] A linker for antibody drug conjugates is required to link the antibody portion of the antibody drug conjugates to the drug portion, be stable in the blood, and cut off the drug from the antibody in a cell such that the drug is released. Furthermore, the linker for antibody drug conjugates is also required not to impair the binding activity of the antibody. In order to improve the drug carrying efficiency, a number of drugs need to be attached to one antibody molecule. However, with the linker for antibody drug conjugates of the related art, in a case where a number of the linkers bind to an antibody, the antibody binding activity deteriorates.

As a result, the selectivity which is the advantage of an antibody drug conjugate is impaired, and the drug is likely to be carried to target cells with low efficiency. However, with the cyclic peptide of the present invention, even in a case where a number of the cyclic peptides bind to an antibody, the structural integrity of the antibody can be maintained, and the antibody binding activity is not reduced. Accordingly, even in a case where a number of the cyclic peptides bind to an antibody, the selectivity which is the advantage of an antibody drug conjugate is not impaired, and the drug could be carried to target cells with improved efficiency. Furthermore, because the temporal stability of the cyclic peptide of the present invention is higher than that of the cyclic peptide of the related art, the stability of the cyclic peptide in the blood could be improved. In addition, by modifying the side-chain portion of a disulfide bond which is a cyclic portion, the drug releasing properties in a cell could be controlled.

[0185] The drug may be a liposomized drug, a polymerically micellized drug, or a polyethylene glycolated (PEGylated) drug.

By liposomizing, polymerically micellizing, or PEGylating the drug, in many cases, it is possible to improve the in vivo stability of active components, the pharmacokinetics including a tissue migration profile, the intracellular pharmacokinetics, and the like.

[0186] <Drug carrier and pharmaceutical preparation>

The cyclic peptide of the present invention can be used as a drug carrier in a drug delivery system.

Examples of applications of the cyclic peptide of the present invention used as a drug carrier include a pharmaceutical preparation which includes a drug and the cyclic peptide of the present invention and in which the drug and the cyclic peptide of the present invention are directly or indirectly bonded to each other.

In a case where the cyclic peptide of the present invention binds to IgG present in a biological body, the same effects as those brought about by the aforementioned antibody drug conjugate could be obtained. The drug may bind to the cyclic peptide as it is or bind to the cyclic peptide as a drug having undergone liposomization, polymer micellization, or polyethylene glycolation (PEGylation). Furthermore, the drug may bind to the cyclic peptide through polysaccharides such as dextran or a hydrophilic polymer.

[0187] As the method for binding a drug to the cyclic peptide of the present invention, the use of a disulfide bond between amino acid residues in the cross-linked portion can be considered.

Specifically, this is a method of reducing a disulfide bond ($-S-S-$) such that it is

cleaved ($-S^-S^-$) and adding the two ions to a compound in a manner of cross-linking.

As this method, for example, ThioBridge (trademark) is known.

Examples

[0188] Hereinafter, the present invention will be more specifically described based on examples, but the present invention is not limited to the examples.

[0189] [Example 1]

(1) Synthesis of cyclic peptide

A cyclic peptide (SEQ ID NO: 3; hereinafter, this cyclic peptide will be referred to as “cyclic peptide 1” in some cases) represented by Formula (3) was synthesized using a full automatic peptide synthesis device (PSSM-8, manufactured by Shimadzu Corporation).



X^a represents an amino acid residue derived from N- ϵ -chloroacetyl-L-lysine, and X^b represents an amino acid residue derived from L-homocysteine. Between X^a and X^b , a thioether bond is formed by a reaction between a side-chain chloroacetyl group of N- ϵ -chloroacetyl-L-lysine and a side-chain thiol group of L-homocysteine.

[0190] (2) Ligand immobilization

A commercially available CM5 (carboxymethyl dextran introduction-type, manufactured by GE Healthcare) sensor chip was set in Biacore 3000 (Biacore is a registered trademark) as a surface plasmon resonance device manufactured by GE Healthcare, a 4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid (HEPES) buffer solution (20 mM HEPES-HCl, 150 mM NaCl, pH 7.4) for surface plasmon resonance (SPR) was stabilized at a flow rate of 10 μ L/min, and 70 μ L of an aqueous mixed solution of 0.2 M 1-(3-Dimethylaminopropyl)-3-ethylcarbodiimide (EDC) and 0.04 M of N-Hydroxysuccinimide (NHS) was added thereto. Thereafter, 100 μ L of a sample solution of the cyclic peptide 1, which was diluted with a HEPES buffer solution at 0.2 g/L and treated with a polytetrafluoroethylene (PTFE) filter (manufactured by Advantec MFS, Inc.) having a diameter of 0.20 μ m, was supplied to the sensor chip, a blocking treatment was then performed using an ethanolamine solution, and the sensor chip was washed with an aqueous sodium hydroxide solution, thereby performing immobilization. Likewise, 70 μ L of an aqueous mixed solution of 0.2 M EDC and 0.04 M NHS was added to the same sensor chip without immobilizing the sample in another flow channel, and then the blocking treatment and the washing treatment were performed. Hereinafter, the obtained immobilized sensor chip will be referred to as “immobilized sensor chip A”.

[0191] (3) Evaluation of binding activity

At 25°C, 3,000 nM of human immunoglobulin G (IgG) antibodies were added for 10 minutes to the immobilized sensor chip A prepared in (1) described above. Immediately after the addition, the antibody binding amount was measured, and from the difference in the antibody binding amount between the flow channel in which the cyclic peptide was immobilized and the flow channel in which the cyclic peptide was not immobilized and the amount of the immobilized cyclic peptide, the activity of the cyclic peptide was calculated. Furthermore, by regarding the activity of a cyclic peptide 5 in Comparative Example 1 as 1, the relative binding activity with respect to the human IgG antibodies was calculated.

(Evaluation standards for relative binding activity)

The relative binding activity was higher than 2,000% of the binding activity of the cyclic peptide 5. S

The relative binding activity was higher than 800% of the binding activity of the cyclic peptide 5. A

The relative binding activity was higher than 400% and equal to or lower than 800% of the binding activity of the cyclic peptide 5. B

The relative binding activity was higher than 200 % and equal to or lower than 400% of the binding activity of the cyclic peptide 5. C

The relative binding activity was higher than 100% and equal to or lower than 200% of the binding activity of the cyclic peptide 5. D

The relative binding activity was equal to or lower than 100% of the binding activity of the cyclic peptide 5. E

The grades A, B, and C show that the immobilization brings about a sufficient improving effect, and the grades D and E show that sufficient binding activity is not exhibited. The grade S shows that the cyclic peptide brings about a particularly excellent improving effect among the cyclic peptides graded A, and such a cyclic peptide is described as “A (S)”.

In a case where a cyclic peptide exhibiting sufficient binding activity is used, the cyclic peptide can specifically bind to antibodies, antibodies are more efficiently purified, and the antibody purification cost can be reduced.

[0192] (4) Ligand immobilization

1 mL of HiTrap NHS-activated HP Columns (coupling columns for ligand immobilization, manufactured by GE Healthcare) (HITRAP is a registered trademark) was reacted with 1 mL of 10 mg/mL cyclic peptide solution, which was prepared by dissolving the

cyclic peptide 1 in an immobilization buffer (200 mM NaHCO₃, 500 mM NaCl, pH 8.3), for 1 hour at 25°C. The reaction product was blocked by an aqueous ethanolamine solution and washed, thereby obtaining a cyclic peptide 1-immobilized support. Hereinafter, the obtained immobilized support will be referred to as “immobilized support A”.

[0193] (5) Evaluation of chemical resistance

The immobilized support A prepared in (4) described above was connected to a chromatography system AKTA avant 25 (manufactured by GE Healthcare) (AKTAAVANT is a registered trademark), and the antibody binding capacity was measured. The columns were equilibrated using an equilibration solution (20 mM phosphoric acid buffer, 150 mM NaCl, pH 7.4), and then 15 mL of a human IgG antibody solution, of which the concentration was adjusted to be 5 mg/mL by using a standard buffer (20 mM phosphoric acid buffer, 150 mM NaCl, pH 7.4), was added thereto at a flow rate of 0.21 mL/min. Thereafter, the columns were washed with 5 mL of a postloading wash solution (20 mM phosphoric acid buffer, 150 mM NaCl, pH 7.4) caused to flow at the same flow rate and then washed with 5 mL of a pre-elution wash solution (20 mM phosphoric acid buffer, 1 M NaCl, pH 7.4) at the same flow rate. Then, 5 mL of an elution solution (100 mM citric acid buffer, pH 3.2) was caused to flow at the same flow rate. Subsequently, 5 mL of a cleaning in place (CIP) solution (0.1 M sodium hydroxide) was caused to flow at the same flow rate, and then 5 mL of a reequilibration solution (20 mM phosphoric acid buffer, 150 mM NaCl, pH 7.4) was caused to flow at the same flow rate. At this time, by using an immunoglobulin G (IgG) elution peak obtained by monitoring absorbance at 280 nm, the amount of antibodies binding to the support until 10% of the antibody stock solution leaked out of the support was measured as the antibody binding capacity. Then, the immobilized support A was filled with a 0.2 M aqueous NaOH solution for 6 hours at 25°C and left to stand, the antibody binding capacity of the support was measured in the same manner, and a rate of change in the binding amount was calculated from the antibody binding amount before and after the alkali treatment.

(Evaluation standards of rate of change in binding amount)

The rate of change in the binding amount was higher than 90% A

The rate of change in the binding amount was higher than 80% and equal to or lower than 90% B

The rate of change in the binding amount was higher than 70% and equal to or lower than 80% C

The rate of change in the binding amount was higher than 50% and equal to or lower

than 70% D

The rate of change in the binding amount was equal to or lower than 50% E

The grades A, B, and C show that the chemical resistance is sufficient, and the grades D and E show that sufficient chemical resistance is not exhibited. In a case where a cyclic peptide exhibiting sufficient chemical resistance is used, the cyclic peptide can repeatedly specifically bind to antibodies even after washing, antibodies can be purified for a long period of time, and the antibody purification costs can be reduced.

[0194] Table 3 shows the structures of the cyclic peptides of Example 1 and the evaluation results of the relative binding activity and the chemical resistance.

[0195] [Examples 2 and 6]

Based on Example 1, a cyclic peptide 2 and a cyclic peptide 6 were synthesized, and the relative binding activity and the chemical resistance were evaluated.

The following code in Table 3 means the following substance.

Hcy: amino acid residue derived from L-homocysteine

Due to the reaction between side-chain thiol groups, a disulfide bond is formed between the amino acid residues in the cross-linked portion, and hence the amino acid residues are cross-linked.

Table 3 shows the structures of the cyclic peptides of Example 2 and Example 6 and the evaluation results of the relative binding activity and the chemical resistance.

[0196] [Examples 3 to 5]

Based on Example 1, cyclic peptides 3 to 5 were synthesized, and the relative binding activity and the chemical resistance were evaluated.

The following codes in Table 3 mean the following substances.

Hcy: amino acid residue derived from L-homocysteine

Orn (acetyl): amino acid residue derived from N- δ -chloroacetyl-L-ornithine

Lys (acetyl): amino acid residue derived from N- ϵ -chloroacetyl-L-lysine

Due to the reaction between a chloroacetyl group and a thiol group, a thioether bond is formed between the amino acid residues in the cross-linked portion, and hence the amino acid residues are cross-linked.

Table 3 shows the structures of the cyclic peptides of Examples 3 to 5 and the evaluation results of the relative binding activity and the chemical resistance.

[0197] [Examples 7 to 12]

Based on Example 1, cyclic peptides 7 to 12 were synthesized, and the relative

binding activity and the chemical resistance were evaluated.

The following codes in Table 3 mean the following substances.

Dap (acetyl): amino acid residue derived from N³-haloacetyl-L-2,3-diaminopropanoic acid[(2S)-2-amino-3-[(2-haloacetyl)amino]propanoic acid]

Dab (acetyl): amino acid residue derived from N⁴-haloacetyl-L-2,4-diaminobutanoic acid[(2S)-2-amino-4-[(2-haloacetyl)amino]butanoic acid]

Orn (acetyl): amino acid residue derived from N- δ -chloroacetyl-L-ornithine

Lys (acetyl): amino acid residue derived from N- ϵ -chloroacetyl-L-lysine

Hcy: amino acid residue derived from L-homocysteine

Due to the reaction between a chloroacetyl group and a thiol group, a thioether bond is formed between the amino acid residues in the cross-linked portion, and hence the amino acid residues are cross-linked.

Table 3 shows the structures of the cyclic peptides of Examples 7 to 12 and the evaluation results of the relative binding activity and the chemical resistance.

[0198] [Table 3]

		Cyclic peptide						Performance evaluation		SEQ ID NO:
		Identification name	Amino acid sequence (N terminal → C terminal)	Amino acid residue in cross-linked portion		Special amino acid residue	Cross-linked structure	Relative binding activity	Chemical resistance	
				X ^a	X ^b	X ^α				
Example	1	Cyclic peptide 1	DX ^a AYHRGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	3
	2	Cyclic peptide 2	DX ^a AYHRGELVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	B	4
	3	Cyclic peptide 3	DX ^a AYHRGELVWX ^b TKK	Hcy	Om (acetyl)	-	Thioether bond	A	A	5
	4	Cyclic peptide 4	KKDX ^a AYHRGELVWX ^b T	Lys (acetyl)	Hcy	-	Thioether bond	A	A	6
	5	Cyclic peptide 5	DX ^a AYHLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	7
	6	Cyclic peptide 6	DX ^a AYHLGELVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	A	8
	7	Cyclic peptide 7	DX ^a AYHLGELVWX ^b TKK	Dap (acetyl)	Hcy	-	Thioether bond	A	A	9
	8	Cyclic peptide 8	DX ^a AYHLGELVWX ^b TKK	Dab (acetyl)	Hcy	-	Thioether bond	A	A	10
	9	Cyclic peptide 9	DX ^a AYHLGELVWX ^b TKK	Om (acetyl)	Hcy	-	Thioether bond	A	A	11
	10	Cyclic peptide 10	DX ^a AYHLGELVWX ^b TKK	Hcy	Dab (acetyl)	-	Thioether bond	A	A	12
	11	Cyclic peptide 11	DX ^a AYHLGELVWX ^b TKK	Hcy	Om (acetyl)	-	Thioether bond	A	A	13
	12	Cyclic peptide 12	DX ^a AYHLGELVWX ^b TKK	Hcy	Lys (acetyl)	-	Thioether bond	A	A	14

[0199] [Examples 13 to 22]

Based on Example 1, cyclic peptides 13 to 22 were synthesized, and the relative binding activity and the chemical resistance were evaluated.

The following codes in Table 4 mean the following substances.

Lys (acetyl): amino acid residue derived from N- ϵ -chloroacetyl-L-lysine

Hcy: amino acid residue derived from L-homocysteine

HmS: amino acid residue derived from L-homoserine

HmY: amino acid residue derived from L-homotyrosine

Due to the reaction between a chloroacetyl group and a thiol group, a thioether bond is formed between the amino acid residues in the cross-linked portion, and hence the amino acid residues are cross-linked.

Table 4 shows the structures of the cyclic peptides of Examples 13 to 22 and the evaluation results of the relative binding activity and the chemical resistance.

[0200] [Table 4]

		Cyclic peptide						Performance evaluation		SEQ ID NO:
		Identification name	Amino acid sequence (N terminal → C terminal)	Amino acid residue in cross-linked portion		Special amino acid residue	Cross-linked structure	Relative binding activity	Chemical resistance	
				X ^a	X ^b	X ^α				
Example	13	Cyclic peptide 13	DX ^a AYHLGELVWX ^b SKK	Lys (acetyl)	Hcy	-	Thioether bond	A	B	15
	14	Cyclic peptide 14	DX ^a AYHLGELVWX ^b X ^α KK	Lys (acetyl)	Hcy	HmS	Thioether bond	A	A	16
	15	Cyclic peptide 15	DX ^a AYHLGELVWX ^b DKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	17
	16	Cyclic peptide 16	DX ^a AYHLGELVWX ^b EKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	18
	17	Cyclic peptide 17	DX ^a AYHLGELVWX ^b YKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	19
	18	Cyclic peptide 18	DX ^a AYHLGELVWX ^b X ^α KK	Lys (acetyl)	Hcy	HmY	Thioether bond	A	A	20
	19	Cyclic peptide 19	SX ^a AYHLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	B	21
	20	Cyclic peptide 20	TX ^a AYHLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	22
	21	Cyclic peptide 21	X ^α X ^a AYHLGELVWX ^b TKK	Lys (acetyl)	Hcy	HmS	Thioether bond	A	A	23
	22	Cyclic peptide 22	EX ^a AYHLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	24

[0201] [Examples 23 to 53]

Based on Example 1, cyclic peptides 23 to 53 were synthesized, and the relative binding activity and the chemical resistance were evaluated.

The following codes in Table 5 mean the following substances.

Lys (acetyl): amino acid residue derived from N- ϵ -chloroacetyl-L-lysine

Hcy: amino acid residue derived from L-homocysteine

Due to the reaction between a chloroacetyl group and a thiol group, a thioether bond is formed between the amino acid residues in the cross-linked portion, and hence the amino acid residues are cross-linked.

Table 5 shows the structures of the cyclic peptides of Examples 23 to 53 and the evaluation results of the relative binding activity and the chemical resistance.

[0202] [Table 5]

		Cyclic peptide						Performance evaluation		SEQ ID NO:
		Identification name	Amino acid sequence (N terminal → C terminal)	Amino acid residue in cross-linked portion		Special amino acid residue X ^α	Cross-linked structure	Relative binding activity	Chemical resistance	
				X ^a	X ^b					
Example	23	Cyclic peptide 23	DX ^a AAYHLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	25
	24	Cyclic peptide 24	DX ^a AAAYHLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	26
	25	Cyclic peptide 25	DX ^a AAAAYHLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	B	A	27
	26	Cyclic peptide 26	DX ^a SYHLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	B	28
	27	Cyclic peptide 27	DX ^a TYHLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	29
	28	Cyclic peptide 28	DX ^a AFHLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	30
	29	Cyclic peptide 29	DX ^a AHHLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	31
	30	Cyclic peptide 30	DX ^a AVHLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	32
	31	Cyclic peptide 31	DX ^a AMHLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	33
	32	Cyclic peptide 32	DX ^a AYYLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	34
	33	Cyclic peptide 33	DX ^a AYWLGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	35
	34	Cyclic peptide 34	DX ^a AYHMGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	36
	35	Cyclic peptide 35	DX ^a AYHFGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	37
	36	Cyclic peptide 36	DX ^a AYHHGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	38
	37	Cyclic peptide 37	DX ^a AYHVGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	39
	38	Cyclic peptide 38	DX ^a AYHIGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	40
	39	Cyclic peptide 39	DX ^a AYHNGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	41
	40	Cyclic peptide 40	DX ^a AYHWGELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	42
	41	Cyclic peptide 41	DX ^a AYHLDLVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	43
	42	Cyclic peptide 42	DX ^a AYHLEELVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	44
	43	Cyclic peptide 43	DX ^a AYHLGDLVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	45
	44	Cyclic peptide 44	DX ^a AYHLGKLVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	46
	45	Cyclic peptide 45	DX ^a AYHLGRLVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	47
	46	Cyclic peptide 46	DX ^a AYHLGHLVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	48
	47	Cyclic peptide 47	DX ^a AYHLGMLVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	49
	48	Cyclic peptide 48	DX ^a AYHLGNLVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	50
	49	Cyclic peptide 49	DX ^a AYHLGEIVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	51
	50	Cyclic peptide 50	DX ^a AYHLGEMVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	52
	51	Cyclic peptide 51	DX ^a AYHLGEKVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	53
	52	Cyclic peptide 52	DX ^a AYHLGERVWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	B	B	54
	53	Cyclic peptide 53	DX ^a AYHLGELIWX ^b TKK	Lys (acetyl)	Hcy	-	Thioether bond	A	A	55

[0203] [Examples 54 to 71]

Based on Example 1, cyclic peptides 54 to 71 were synthesized, and the relative binding activity and the chemical resistance were evaluated.

The following code in Table 6 means the following substance.

Hcy: amino acid residue derived from L-homocysteine

Due to the reaction between side-chain thiol groups, a disulfide bond is formed between the amino acid residues in the cross-linked portion, and hence the amino acid residues are cross-linked.

Table 6 shows the structures of the cyclic peptides of Examples 54 to 71 and the evaluation results of the relative binding activity and the chemical resistance.

[0204] [Comparative Example 1]

Based on Example 1, a cyclic peptide 91 was synthesized, and the relative binding activity and the chemical resistance were evaluated.

The following codes in Table 6 mean the following substances.

Glu: amino acid residue derived from L-glutamic acid

Lys: amino acid residue derived from L-lysine

Due to the reaction between a carboxy group and an amino group, an amide bond is formed between the amino acid residues in the cross-linked portion, and hence the amino acid residues are cross-linked.

Table 6 shows the structure of the cyclic peptide of Comparative Example 1 and the evaluation results of the relative binding activity and the chemical resistance.

[0205] [Comparative Example 2]

Based on Example 1, a cyclic peptide 92 was synthesized, and the relative binding activity and the chemical resistance were evaluated.

The following code in Table 6 means the following substance.

Cys: amino acid residue derived from L-cysteine

Due to the reaction between side-chain thiol groups, a disulfide bond is formed between the amino acid residues in the cross-linked portion, and hence the amino acid residues are cross-linked.

Table 6 shows the structure of the cyclic peptide of Comparative Example 2 and the evaluation results of the relative binding activity and the chemical resistance.

[0206] [Table 6]

		Cyclic peptide						Performance evaluation		SEQ ID NO:
		Identification name	Amino acid sequence (N terminal → C terminal)	Amino acid residue in cross-linked portion		Special amino acid residue	Cross-linked structure	Relative binding activity	Chemical resistance	
				X ^a	X ^b	X ^α				
Example	54	Cyclic peptide 54	DX ^a SYHLGELVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	B	56
	55	Cyclic peptide 55	DX ^a TYHLGELVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	B	57
	56	Cyclic peptide 56	DX ^a AWHLGELVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	A	58
	57	Cyclic peptide 57	DX ^a AFHLGELVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	A	59
	58	Cyclic peptide 58	DX ^a AHHLGELVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	B	A	60
	59	Cyclic peptide 59	DX ^a AYYLGELVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	A	61
	60	Cyclic peptide 60	DX ^a AYHMGELVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	A	62
	61	Cyclic peptide 61	DX ^a AYHFGELVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	A	63
	62	Cyclic peptide 62	DX ^a AYHHGELVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	A	64
	63	Cyclic peptide 63	DX ^a AYHLGDLVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	A	65
	64	Cyclic peptide 64	DX ^a AYHLGMLVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	A	66
	65	Cyclic peptide 65	DX ^a AYHLGHLVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	A	67
	66	Cyclic peptide 66	DX ^a AYHLGNLVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	A	68
	67	Cyclic peptide 67	DX ^a AYHLGEIVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	A	69
	68	Cyclic peptide 68	DX ^a AYHLGEMVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	A	A	70
	69	Cyclic peptide 69	DX ^a AYHLGEKVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	B	A	71
	70	Cyclic peptide 70	DX ^a AYHLGERVWX ^b TKK	Hcy	Hcy	-	Disulfide bond	B	B	72
	71	Cyclic peptide 71	DX ^a AYHLGELIWX ^b TKK	Hcy	Hcy	-	Disulfide bond	B	A	73
Comparative Example	1	Cyclic peptide 91	DX ^a AYHRGELVWX ^b TKK	Glu	Lys	-	Amide bond	E (standard)	D	86
	2	Cyclic peptide 92	DX ^a AYHRGELVWX ^b TKK	Cys	Cys	-	Disulfide bond	A	E	87

[0207] [Examples 72 to 75 and Comparative Example 3]

Based on Example 1, cyclic peptides 72 to 75 and a cyclic peptide 93 were synthesized, and the relative binding activity and the chemical resistance were evaluated.

The following codes in Table 7 mean the following substances.

Lys (acetyl): amino acid residue derived from N- ϵ -chloroacetyl-L-lysine

Pen: amino acid residue derived from L-penicillamine

HmS: amino acid residue derived from L-homoserine

Due to the reaction between a chloroacetyl group and a thiol group, a thioether bond is formed between the amino acid residues in the cross-linked portion, and hence the amino acid residues are cross-linked.

Table 7 shows the structures of the cyclic peptides of Examples 72 to 75 and Comparative Example 3 and the evaluation results of the relative binding activity and the chemical resistance.

[0208] [Examples 76 to 83 and Comparative Examples 4 to 6]

Based on Example 1, cyclic peptides 78 to 91 were synthesized, and the relative binding activity and the chemical resistance were evaluated.

The following codes in Table 7 mean the following substances.

Dap (acetyl): amino acid residue derived from N³-haloacetyl-L-2,3-diaminopropanoic acid[(2S)-2-amino-3-[(2-haloacetyl)amino]propanoic acid]

Dab (acetyl): amino acid residue derived from N⁴-haloacetyl-L-2,4-diaminobutanoic acid[(2S)-2-amino-4-[(2-haloacetyl)amino]butanoic acid]

Orn (acetyl): amino acid residue derived from N- δ -chloroacetyl-L-ornithine

Lys (acetyl): amino acid residue derived from N- ϵ -chloroacetyl-L-lysine

HmS: amino acid residue derived from L-homoserine

Due to the reaction between a chloroacetyl group and a thiol group, a thioether bond is formed between the amino acid residues in the cross-linked portion, and hence the amino acid residues are cross-linked.

Table 7 shows the structures of the cyclic peptides of Examples 72, 73, 74, and 75 and Comparative Example 3 and the evaluation results of the relative binding activity and the chemical resistance.

[0209] [Table 7]

		Cyclic peptide						Performance evaluation		SEQ ID NO:
		Identification name	Amino acid sequence (N terminal → C terminal)	Amino acid residue in cross-linked portion		Special amino acid residue	Cross-linked structure	Relative binding activity	Chemical resistance	
				X ^a	X ^b	X ^α				
Example	72	Cyclic peptide 72	DX ^a AYHLGELVWX ^b TKK	Lys (acetyl)	Pen	-	Thioether bond	A (S)	A	74
	73	Cyclic peptide 73	DX ^a AYHLGELVWX ^b TKK	Pen	K (acetyl)	-	Thioether bond	A	A	75
	74	Cyclic peptide 74	DX ^a AYHRGELVWX ^b TKK	Lys (acetyl)	Pen	-	Thioether bond	A (S)	B	76
	75	Cyclic peptide 75	DX ^a AYHLGELVWX ^b X ^α KK	Lys (acetyl)	Pen	HmS	Thioether bond	A (S)	B	77
	76	Cyclic peptide 76	DX ^a AYHLGELVWX ^b TKK	Dap (acetyl)	Cys	-	Thioether bond	A (S)	B	78
	77	Cyclic peptide 77	DX ^a AYHLGELVWX ^b TKK	Dab (acetyl)	Cys	-	Thioether bond	A (S)	B	79
	78	Cyclic peptide 78	DX ^a AYHLGELVWX ^b TKK	Orn (acetyl)	Cys	-	Thioether bond	A	B	80
	79	Cyclic peptide 79	DX ^a AYHLGELVWX ^b TKK	Lys (acetyl)	Cys	-	Thioether bond	A (S)	B	81
	80	Cyclic peptide 80	DX ^a AYHLGELVWX ^b TKK	Cys	Dap (acetyl)	-	Thioether bond	A (S)	B	82
	81	Cyclic peptide 81	DX ^a AYHLGELVWX ^b TKK	Cys	Dab (acetyl)	-	Thioether bond	A (S)	B	83
	82	Cyclic peptide 82	DX ^a AYHLGELVWX ^b TKK	Cys	Orn (acetyl)	-	Thioether bond	A	B	84
	83	Cyclic peptide 83	DX ^a AYHLGELVWX ^b TKK	Cys	Lys (acetyl)	-	Thioether bond	A (S)	B	85
Comparative Example	3	Cyclic peptide 93	DX ^a SYHLGELVWX ^b TKK	Lys (acetyl)	Pen	-	Thioether bond	A	D	88
	4	Cyclic peptide 94	DX ^a SYHLGELVWX ^b TKK	Lys (acetyl)	Cys	-	Thioether bond	A	E	89
	5	Cyclic peptide 95	DX ^a AYHRGELVWX ^b TKK	Lys (acetyl)	Cys	-	Thioether bond	A	E	90
	6	Cyclic peptide 96	X ^α X ^a AYHRGELVWX ^b TKK	Lys (acetyl)	Cys	HmS	Thioether bond	A	E	91

[0210] [Description of results of examples and comparative examples]

<Examples 1 to 6>

All of the cyclic peptides 1 to 6 of Examples 1 to 6 were graded A by the evaluation of the relative binding activity and had excellent relative binding activity.

Except for the cyclic peptide 2 of Example 2, the cyclic peptides 1 to 6 of Examples 1 to 6 were graded A by the evaluation of the chemical resistance and had excellent chemical resistance.

Although both the cyclic peptide 2 of Example 2 and the cyclic peptide 6 of Example 6 had a cross-linked structure formed by a disulfide bond, they had a difference in that the cyclic peptide 2 was graded B by the evaluation of the chemical resistance while the cyclic peptide 6 was graded A by the evaluation of the chemical resistance. Presumably, this is because the cyclic peptide 2 had an amino acid sequence of AYHRGELVW in the cyclic portion while the cyclic peptide 6 had an amino acid sequence of AYHLGELVW in the cyclic portion. At this point in time, the mechanism that makes the cyclic peptides exhibit different levels of chemical resistance cannot be clearly explained.

[0211] <Examples 7 to 12>

Examples 7 to 9 and Examples 10 to 12 are obtained by changing the type of amino acid residue derived from an amino acid having a chloroacetyl group on a side chain. Examples 7 to 9 and Examples 10 to 12 have a relationship established by changing the positions of the amino acid residue derived from an amino acid having a chloroacetyl group on a side chain and the amino acid residue derived from an amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain.

All of the cyclic peptides 7 to 12 of Examples 7 to 12 were graded A by the evaluation of the relative binding activity and the chemical resistance, and had excellent relative binding activity and chemical resistance.

[0212] <Examples 13 to 22>

The cyclic peptides 13 to 22 of Examples 13 to 22 are examples obtained by changing the amino acid residue derived from an amino acid having a carboxy group on a side chain on the outside of the cyclic portion or an amino acid residue derived from an amino acid having a hydroxy group on a side chain.

The cyclic peptide 13 (Example 13) having the amino acid residue derived from L-serine (amino acid having a hydroxy group on a side chain) on the C-terminal side of the cyclic portion and the cyclic peptide 19 (Example 19) having the same amino acid residue on

the N-terminal side were graded B by the evaluation of the chemical resistance. Except for these cyclic peptides, all of the cyclic peptides 14 to 18 (Examples 14 to 18) and the cyclic peptides 20 to 22 (Examples 20 to 22) were graded A by the evaluation of the relative binding activity and the chemical resistance, and these cyclic peptides had excellent relative binding activity and chemical resistance.

[0213] <Examples 23 to 53>

The cyclic peptides 23 to 53 of Examples 23 to 53 are examples obtained by changing the type of amino acid residue on the inside of the cyclic portion in a case where the cross-linked structure is a thioether bond.

[0214] <Examples 54 to 71>

The cyclic peptides 54 to 71 of Examples 54 to 71 are examples obtained by changing the type of amino acid residue on the inside of the cyclic portion in a case where the cross-linked structure is a disulfide bond.

[0215] <Examples 72 to 75 and Comparative Example 3>

The cyclic peptides 72 to 75 of Examples 72 to 75 and the cyclic peptide 93 of Comparative Example 3 are examples obtained in a case where the cross-linked structure is a thioether bond. In these cyclic peptides, the amino acid having a thiol group on a side chain is L-penicillamine.

The cyclic peptide 93 of Comparative Example 3 including L-serine in the cyclic portion was graded A by the evaluation of the relative binding activity but graded D by the evaluation of the chemical resistance.

[0216] <Examples 76 to 83 and Comparative Examples 4 to 6>

The cyclic peptides 76 to 83 of Examples 76 to 83 and the cyclic peptides 94 to 96 of Comparative Examples 4 to 6 are examples obtained in a case where the cross-linked structure is a thioether bond. In these cyclic peptides, the amino acid having a thiol group on a side chain is L-cysteine.

All of Comparative Example 4 including L-serine in the cyclic portion, Comparative Example 5 including L-aspartic acid in the cyclic portion, and Comparative Example 6 including L-homoserine on the outside of the N-terminal side of the cyclic portion were graded E by the evaluation of chemical resistance, and had poor chemical resistance.

Presumably, this is because either or both of the hydroxy group and the carboxy group on a side chain of the amino acid residue exert an influence. However, at this point in time, why the chemical resistance of the above examples is significantly poorer than that of

Examples 76 to 83 cannot be clearly explained.

[0217] <Summary>

To summarize, as a cross-linked structure, a thioether bond in which an L-homocysteine residue is involved tends to exhibit the highest stability, a disulfide bond between L-homocysteine residues tends to exhibit the second highest stability, a thioether bond in which L-penicillamine is involved tends to exhibit the third highest stability, and a thioether bond in which L-cysteine is involved tends to exhibit the fourth highest stability.

[0218] [Example A]

<Results of experiment performed in human plasma>

<<Evaluation of plasma stability>>

The stability of the cyclic peptide 5 manufactured in Example 5 in human plasma (manufactured by ProMedDX) was evaluated.

Each of the peptides was prepared as a 5 μM aqueous solution, and 2 μL of each of the aqueous solutions was added to 20 μL of the human plasma and left to stand for 20 minutes at room temperature. After 20 minutes, 100 μL of methanol (manufactured by Wako Pure Chemical Industries, Ltd.) was added thereto such that the reaction stopped. After being stirred, the solution was subjected to centrifugation, and the supernatant was collected and named 20-minute sample. Meanwhile, 100 μL of methanol was added to 20 μL of the human plasma, 2 μL of the aqueous peptide solution was added thereto, the solution was stirred and subjected to centrifugation, and the supernatant was collected. The collected supernatant was named 0-minute sample.

Each of the samples was quantified using a mass spectrometer TRIPLE QUAD 5500 (manufactured by AB Sciex Pte. Ltd.). By regarding the quantified value of the 0-minute sample as 100%, the quantified value of the 20-minute sample was calculated as a residual rate.

[0219] (Evaluation standards for residual rate)

The rate of change in the binding amount was higher than 90% A

The rate of change in the binding amount was higher than 80% and equal to or lower than 90% B

The rate of change in the binding amount was higher than 70% and equal to or lower than 80% C

The rate of change in the binding amount was higher than 50% and equal to or lower than 70% D

The rate of change in the binding amount was equal to or lower than 50% E

The structure of the cyclic peptide and the evaluation result are shown in the corresponding column in Table 8.

[0220] [Example B]

The stability of the cyclic peptide 6 manufactured in Example 6 in the human plasma was evaluated in the same manner as in Example A. The structure of the cyclic peptide and the evaluation result are shown in the corresponding column in Table 8.

[0221] [Comparative Example C]

The stability of the cyclic peptide 91 manufactured in Comparative Example 1 in the human plasma was evaluated in the same manner as in Example A. The structure of the cyclic peptide and the evaluation result are shown in the corresponding column in Table 8.

[0222] [Table 8]

	Cyclic peptide					Rate of change in binding amount (evaluation)	SEQ ID NO:
	Identification name	Amino acid sequence (N terminal → C terminal)	Amino acid residue in cross-linked portion		Cross-linked structure		
			X ^a	X ^b			
Example A	Cyclic peptide 5	DX ^a AYHLGELVWX ^b TKK	Lys (acetyl)	Hcy	Thioether bond	A	7
Example B	Cyclic peptide 6	DX ^a AYHLGELVWX ^b TKK	Hcy	Hcy	Disulfide bond	A	8
Comparative Example C	Cyclic peptide 91	DX ^a AYHRGELVWX ^b TKK	Glu	Lys	Amide bond	E	86

[0223] <<Description of results>>

The rate of change in the binding amount (residual rate) of the cyclic peptide 5 (Example A) and the cyclic peptide 6 (Example B) in the human plasma was higher than 90%. The cyclic peptides 5 and 6 exhibited excellent stability in the human plasma.

In contrast, the rate of change in the binding amount (residual rate) of the cyclic peptide 91 (Comparative Example C) was equal to or lower than 50%. The cyclic peptide 91 exhibited poor stability in the human plasma.

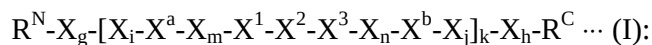
The stability in the human plasma is a characteristic which is important in a case where the cyclic peptide of the present invention is used as an antibody drug conjugate or a pharmaceutical preparation. The higher the rate of change in the binding amount (residual rate) is, the more difficult it is for the cyclic peptide to be dissociated from the drug in the blood. Therefore, a high residual rate is advantageous for accurate drug delivery to a target and for inhibiting side effects.

[Sequence list]

International Patent Application No. W-5923PCT based on International Patent Cooperation Treaty, Cyclic Peptide, Affinity ChroJP16081353 20161021----00260157151602210379normal20161021161101201609151052110950 P1AP10 1_W- 25.app

WHAT IS CLAIMED IS:

1. A cyclic peptide represented by Formula (I),



in Formula (I),

R^N represents an N-terminal group;

R^C represents a C-terminal group;

X^1 represents an L-leucine residue, an L-isoleucine residue, an L-methionine residue, an L-lysine residue, or an L-arginine residue;

X^2 represents an L-valine residue or an L-isoleucine residue;

X^3 represents an L-tryptophan residue;

X^a and X^b each independently represent an amino acid residue derived from an amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain, and are bonded to each other through a disulfide bond, or, one of X^a and X^b represents an amino acid residue derived from an amino acid, other than L-cysteine and D-cysteine, having a thiol group on a side chain, and the other represents an amino acid residue derived from an amino acid having a haloacetyl group on a side chain, and X^a and X^b are bonded to each other through a thioether bond;

X_g , X_h , X_i , X_j , X_m , and X_n each represent g consecutive X's, h consecutive X's, i consecutive X's, j consecutive X's, m consecutive X's, and n consecutive X's;

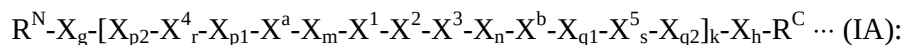
X represents an amino acid residue, and in a case where there is a plurality of X's, the plurality of X's may be the same as or different from each other;

g, h, i, and j each independently represent an integer equal to or greater than 0;

m and n are integers satisfying $0 \leq m \leq 9$, $0 \leq n \leq 9$, and $3 \leq m + n \leq 9$ simultaneously; and

k is an integer equal to or greater than 1, and in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X_i , X_j , X_m , and X_n in a repeating unit $[X_i-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_j]$ each may be the same or different between the repeating units.

2. The cyclic peptide according to claim 1 that is represented by Formula (IA),



in Formula (IA),

R^N , R^C , X^1 , X^2 , X^3 , X^a , X^b , X_g , X_h , X_m , X_n , X, g, h, m, n, and k have the same

definitions as those in Formula (I);

X^4_r , X^5_s , X_{p1} , X_{p2} , X_{q1} , and X_{q2} each represent r consecutive X^4 's, s consecutive X^5 's, $p1$ consecutive X 's, $p2$ consecutive X 's, $q1$ consecutive X 's, and $q2$ consecutive X 's;

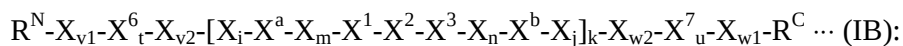
X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid having a hydroxy group on a side chain, and in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other;

$p1$, $p2$, $q1$, and $q2$ each independently represent an integer equal to or greater than 0;

r and s each represent an integer satisfying $0 \leq r \leq 5$, $0 \leq s \leq 5$, and $1 \leq \text{Max}(r,s) \leq 5$, where $\text{Max}(r,s)$ represents a larger one between two numbers represented by r and s in a case where $r \neq s$ and represents r or s in a case where $r = s$; and

in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X^4_r , X^5_s , X_m , X_n , X_{p2} , X_{p1} , X_{q1} , and X_{q2} in a repeating unit $[X_{p2}-X^4_r-X_{p1}-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_{q1}-X^5_s-X_{q2}]$ each may be the same or different between the repeating units.

3. The cyclic peptide according to claim 1 that is represented by Formula (IB),



in Formula (IB),

R^N , R^C , X^1 , X^2 , X^3 , X^a , X^b , X_i , X_j , X_m , X_n , X , i , j , m , n , and k have the same definitions as those in Formula (I);

X^6_t , X^7_u , X_{v1} , X_{v2} , X_{w1} , and X_{w2} each represent t consecutive X^6 's, u consecutive X^7 's, $v1$ consecutive X 's, $v2$ consecutive X 's, $w1$ consecutive X 's, and $w2$ consecutive X 's;

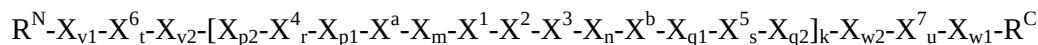
X^6 and X^7 each independently represent an amino acid residue derived from an amino acid having an immobilizing functional group on a side chain, and in a case where there is a plurality of X^6 's or X^7 's, the plurality of X^6 's or X^7 's may be the same as or different from each other;

t and u each represent an integer satisfying $0 \leq t \leq 5$, $0 \leq u \leq 5$, and $1 \leq \text{Max}(t,u) \leq 5$, where $\text{Max}(t,u)$ represents a larger one between two numbers represented by t and u in a case where $t \neq u$ and represents t or u in a case where $t = u$;

$v1$, $v2$, $w1$, and $w2$ each independently represent an integer equal to or greater than 0; and

in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X_i , X_j , X_m , and X_n in a repeating unit $[X_i-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_j]$ each may be the same or different between the repeating units.

4. The cyclic peptide according to any one of claims 1 to 3 that is represented by Formula (IC),



... (IC):

in Formula (IC),

R^N , R^C , X^1 , X^2 , X^3 , X^a , X^b , X_m , X_n , X , m , n , and k have the same definitions as those in Formula (I);

X_{p1} , X_{p2} , X_{q1} , X_{q2} , X_r^4 , X_s^5 , X_t^6 , X_u^7 , X_{v1} , X_{v2} , X_{w1} , and X_{w2} each represent $p1$ consecutive X 's, $p2$ consecutive X 's, $q1$ consecutive X 's, $q2$ consecutive X 's, r consecutive X^4 's, s consecutive X^5 's, t consecutive X^6 's, u consecutive X^7 's, $v1$ consecutive X 's, $v2$ consecutive X 's, $w1$ consecutive X 's, and $w2$ consecutive X 's';

X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid having a hydroxy group on a side chain, and in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other;

X^6 and X^7 each independently represent an amino acid residue derived from an amino acid having an immobilizing functional group on a side chain, and in a case where there is a plurality of X^6 or X^7 , the plurality of X^6 's or X^7 's may be the same as or different from each other;

$p1$, $p2$, $q1$, and $q2$ each independently represent an integer equal to or greater than 0;

r and s each represent an integer satisfying $0 \leq r \leq 5$, $0 \leq s \leq 5$, and $1 \leq \text{Max}(r,s) \leq 5$, where $\text{Max}(r,s)$ represents a larger one between two numbers represented by r and s in a case where $r \neq s$ and represents r or s in a case where $r = s$;

t and u each represent an integer satisfying $0 \leq t \leq 5$, $0 \leq u \leq 5$, and $1 \leq \text{Max}(t,u) \leq 5$, where $\text{Max}(t,u)$ represents a larger one between two numbers represented by t and u in a case where $t \neq u$ and represents t or u in a case where $t = u$;

$v1$, $v2$, $w1$, and $w2$ each independently represent an integer equal to or greater than 0; and

in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X_r^4 , X_s^5 , X_m , X_n , X_{p2} , X_{p1} , X_{q1} , and X_{q2} in a repeating unit $[X_{p2}-X_r^4-X_{p1}-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_{q1}-X_s^5-X_{q2}]$ each may be the same or different between the repeating units.

5. The cyclic peptide according to claim 1,
wherein $8 \leq g + h + k \times (i + j + m + n + 5) \leq 50$.
6. The cyclic peptide according to claim 2,
wherein $8 \leq g + h + k \times (m + n + p1 + p2 + q1 + q2 + 5) \leq 50$.
7. The cyclic peptide according to claim 3,
wherein $8 \leq v1 + v2 + w1 + w2 + t + u + k \times (i + j + m + n + 5) \leq 50$.
8. The cyclic peptide according to claim 4,
wherein $8 \leq v1 + v2 + w1 + w2 + t + u + k \times (m + n + p1 + p2 + q1 + q2 + 5) \leq 50$.
9. The cyclic peptide according to claim 2, 4, 6, or 8,
wherein the amino acid having a carboxy group on a side chain is at least one kind of amino acid selected from the group consisting of L-aspartic acid, D-aspartic acid, L-glutamic acid, D-glutamic acid, L-homoglutamic acid, and D-homoglutamic acid, and the amino acid having a hydroxy group on a side chain is at least one kind of amino acid selected from the group consisting of L-serine, D-serine, L-homoserine, D-homoserine, L-tyrosine, D-tyrosine, L-threonine, D-threonine, L-allothreonine, and D-allothreonine.
10. The cyclic peptide according to claim 9,
wherein the amino acid having a carboxy group on a side chain is L-aspartic acid, and the amino acid having a hydroxy group on a side chain is L-threonine.
11. The cyclic peptide according to claim 3, 4, 7, or 8,
wherein the immobilizing functional group is an amino group or a thiol group.
12. The cyclic peptide according to claim 3, 4, 7, or 8,
wherein the amino acid having an immobilizing functional group on a side chain is at least one kind of amino acid selected from the group consisting of L-lysine, D-lysine, L-cysteine, D-cysteine, L-homocysteine, and D-homocysteine.
13. The cyclic peptide according to any one of claims 1 to 12,

wherein X^a is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, selected from the group consisting of
 (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid,
 (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid,
 (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid,
 (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine,
 N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine,
 X^b is an amino acid residue derived from L-homocysteine or D-homocysteine, and
 X^a and X^b are bonded to each other through a thioether bond.

14. The cyclic peptide according to any one of claims 1 to 12,

wherein X^a is an amino acid residue derived from L-homocysteine or D-homocysteine,

X^b is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, selected from the group consisting of
 (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid,
 (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid,
 (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid,
 (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine,
 N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine, and
 X^a and X^b are bonded to each other through a thioether bond.

15. The cyclic peptide according to any one of claims 1 to 14,

wherein the partial amino acid sequence $X_m-X^1-X^2-X^3-X_n$ in Formula (I), (IA), (IB), or (IC) and an amino acid sequence (SEQ ID NO: 1) represented by Formula (1) share sequence homology equal to or higher than 70%,

A-Y-H-L-G-E-L-V-W ... (1):

in Formula (1),

A represents an L-alanine residue;

Y represents an L-tyrosine residue;

H represents an L-histidine residue;

L represents an L-leucine residue;

G represents a glycine residue;

E represents an L-glutamic acid residue;

V represents an L-valine residue; and

W represents an L-tryptophan residue.

16. The cyclic peptide according to any one of claims 1 to 15,
wherein in Formula (I), (IA), (IB), or (IC), $k = 1$.

17. The cyclic peptide according to claim 1 that is represented by Formula (II),



(II):

in Formula (II),

X^a , X^b , X , R^N , and R^C have the same definitions as those in Formula (I);

X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid having a hydroxy group on a side chain, and in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other;

X^6 and X^7 each independently represent an amino acid residue derived from an amino acid having an immobilizing functional group on a side chain, and in a case where there is a plurality of X^6 's or X^7 's, the plurality of X^6 's or X^7 's may be the same as or different from each other;

X^8 represents an L-leucine residue, a D-leucine residue, an L-arginine residue, or a D-arginine residue;

$e0$ and $f0$ each represent an integer satisfying $0 \leq e0 \leq 10$ and $0 \leq f0 \leq 10$;

$p0$ and $q0$ each represent an integer satisfying $0 \leq p0 \leq 5$ and $0 \leq q0 \leq 5$;

$r0$ and $s0$ each represent an integer satisfying $0 \leq r0 \leq 5$ and $0 \leq s0 \leq 5$;

$t0$ and $u0$ each represent an integer satisfying $0 \leq t0 \leq 5$ and $0 \leq u0 \leq 5$;

$v0$ and $w0$ each represent an integer satisfying $0 \leq v0 \leq 5$ and $3 \leq w0 \leq 5$;

$p0$, $q0$, $r0$, $s0$, $t0$, $u0$, $v0$, and $w0$ satisfy $0 \leq p0 + q0 + r0 + s0 + t0 + u0 + v0 + w0 \leq$

39;

A represents an L-alanine residue or a D-alanine residue;

Y represents an L-tyrosine residue or a D-tyrosine residue;

H represents an L-histidine residue or a D-histidine residue;

G represents a glycine residue;

E represents an L-glutamic acid residue or a D-glutamic acid residue;

L represents an L-leucine residue;

V represents an L-valine residue; and

W represents an L-tryptophan residue.

18. The cyclic peptide according to claim 17,

wherein X^6 and X^7 each independently represent an amino acid residue derived from an amino acid selected from the group consisting of L-lysine, D-lysine, L-cysteine, D-cysteine, L-homocysteine, and D-homocysteine.

19. The cyclic peptide according to claim 17 or 18,

wherein X^a is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, selected from the group consisting of (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine,

X^b is an amino acid residue derived from L-homocysteine or D-homocysteine, and

X^a and X^b are bonded to each other through a thioether bond.

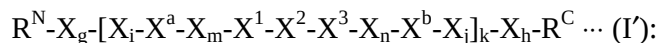
20. The cyclic peptide according to claim 17 or 18,

wherein X^a is an amino acid residue derived from L-homocysteine or D-homocysteine,

X^b is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, selected from the group consisting of (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine, and

X^a and X^b are bonded to each other through a thioether bond.

21. A cyclic peptide represented by Formula (I'),



in Formula (I'),

R^N represents an N-terminal group;

R^C represents a C-terminal group;

X^1 represents an L-leucine residue, an L-isoleucine residue, an L-methionine residue, an L-lysine residue, or an L-arginine residue;

X^2 represents an L-valine residue or an L-isoleucine residue;

X^3 represents an L-tryptophan residue;

one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine and the other represents an amino acid residue derived from an amino acid having a haloacetyl group on a side chain, and X^a and X^b are bonded to each other through a thioether bond, or, one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, and the other represents an amino acid residue derived from an amino acid having a haloacetyl group on a side chain, and X^a and X^b are bonded to each other through a thioether bond;

X_g , X_h , X_i , X_j , X_m , and X_n each represent g consecutive X's, h consecutive X's, i consecutive X's, j consecutive X's, m consecutive X's, and n consecutive X's;

in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X represents an amino acid residue derived from an amino acid other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine,

in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X represents an amino acid residue derived from an amino acid other than L-serine and D-serine, and

in a case where there is a plurality of X's, the plurality of X's may be the same as or different from each other;

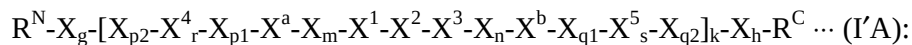
g, h, i, and j each independently represent an integer equal to or greater than 0;

m and n are integers satisfying $0 \leq m \leq 9$, $0 \leq n \leq 9$, and $3 \leq m + n \leq 9$ simultaneously;

and

k is an integer equal to or greater than 1, and in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X_i , X_j , X_m , and X_n in a repeating unit $[X_i-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_j]$ each may be the same or different between the repeating units.

22. The cyclic peptide according to claim 21 that is represented by Formula (I'A),



in Formula (I'A),

R^N , R^C , X^1 , X^2 , X^3 , X^a , X^b , X_g , X_h , X_m , X_n , g , h , m , n , and k have the same definitions as those in Formula (I');

X^4_r , X^5_s , X_{p1} , X_{p2} , X_{q1} , and X_{q2} each represent r consecutive X^4 's, s consecutive X^5 's, $p1$ consecutive X 's, $p2$ consecutive X 's, $q1$ consecutive X 's, and $q2$ consecutive X 's;

in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X represents an amino acid residue derived from an amino acid other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine,

in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X represents an amino acid residue derived from an amino acid other than L-serine and D-serine, and

in a case where there is a plurality of X 's, the plurality of X 's may be the same as or different from each other;

in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid, other than L-serine, D-serine, L-homoserine, and D-homoserine, having a hydroxy group on a side chain,

in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid, other than L-serine or D-serine, having a hydroxy group on a side chain, and

in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other;

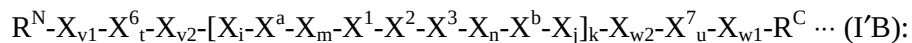
$p1$, $p2$, $q1$, and $q2$ each independently represent an integer equal to or greater than 0;

r and s each represent an integer satisfying $0 \leq r \leq 5$, $0 \leq s \leq 5$, and $1 \leq \text{Max}(r,s) \leq 5$, where $\text{Max}(r,s)$ represents a larger one between two numbers represented by r and s in a case where $r \neq s$ and represents r or s in a case where $r = s$; and

in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X^4_r , X^5_s , X_m , X_n , X_{p2} , X_{p1} , X_{q1} , and X_{q2} in a repeating unit $[X_{p2}-X^4_r-X_{p1}-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_{q1}-X^5_s-X_{q2}]$ each may be the same or

different between the repeating units.

23. The cyclic peptide according to claim 21 that is represented by Formula (I'B),



in Formula (I'B),

R^N , R^C , X^1 , X^2 , X^3 , X^a , X^b , X_i , X_j , X_m , X_n , i , j , m , n , and k have the same definitions as those in Formula (I');

X^6_t , X^7_u , X_{v1} , X_{v2} , X_{w1} , and X_{w2} each represent t consecutive X^6 's, u consecutive X^7 's, $v1$ consecutive X 's, $v2$ consecutive X 's, $w1$ consecutive X 's, and $w2$ consecutive X 's;

in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X represents an amino acid residue derived from an amino acid other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine,

in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X represents an amino acid residue derived from an amino acid other than L-serine and D-serine, and

in a case where there is a plurality of X 's, the plurality of X 's may be the same as or different from each other;

in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X^6 and X^7 each independently represent an amino acid residue derived from an amino acid, other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, having an immobilizing functional group on a side chain or each independently represent an amino acid residue derived from an amino acid having an immobilizing functional group on a side chain,

in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^6 and X^7 each independently represent an amino acid residue derived from an amino acid, other than L-serine and D-serine, having an immobilizing functional group on a side chain, and

in a case where there is a plurality of X^6 's or X^7 's, the plurality of X^6 's or X^7 's may be the same as or different from each other;

t and u each represent an integer satisfying $0 \leq t \leq 5$, $0 \leq u \leq 5$, and $1 \leq \text{Max}(t, u) \leq 5$, where $\text{Max}(t, u)$ represents a larger one between two numbers represented by t and u in a case where $t \neq u$ and represents t or u in a case where $t = u$;

$v1$, $v2$, $w1$, and $w2$ each independently represent an integer equal to or greater than 0;

and

in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X_i , X_j , X_m , and X_n in a repeating unit $[X_i-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_j]$ each may be the same or different between the repeating units.

24. The cyclic peptide according to any one of claims 21 to 23 that is represented by Formula (I'C),

$$R^N-X_{v1}-X^6_t-X_{v2}-[X_{p2}-X^4_r-X_{p1}-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_{q1}-X^5_s-X_{q2}]_k-X_{w2}-X^7_u-X_{w1}-R^C$$

... (I'C);

in Formula (I'C),

R^N , R^C , X^1 , X^2 , X^3 , X^a , X^b , X_m , X_n , m , n , and k have the same definitions as those in Formula (I');

X_{p1} , X_{p2} , X_{q1} , X_{q2} , X^4_r , X^5_s , X^6_t , X^7_u , X_{v1} , X_{v2} , X_{w1} , and X_{w2} each represent $p1$ consecutive X's, $p2$ consecutive X's, $q1$ consecutive X's, $q2$ consecutive X's, r consecutive X^4 's, s consecutive X^5 's, t consecutive X^6 's, u consecutive X^7 's, $v1$ consecutive X's, $v2$ consecutive X's, $w1$ consecutive X's, and $w2$ consecutive X's;

in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X represents an amino acid residue derived from an amino acid other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine,

in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X represents an amino acid residue derived from an amino acid other than L-serine and D-serine, and

in a case where there is a plurality of X's, the plurality of X's may be the same as or different from each other;

in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid, other than L-serine, D-serine, L-homoserine, and D-homoserine, having a hydroxy group on a side chain,

in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid, other than L-serine and D-serine, having a hydroxy group on a side chain, and

in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other;

in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X^6 and X^7 each independently represent an amino acid residue derived from an amino acid, other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, having an immobilizing functional group on a side chain or each independently represent an amino acid residue derived from an amino acid having an immobilizing functional group on a side chain,

in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^6 and X^7 each independently represent an amino acid residue derived from an amino acid, other than L-serine and D-serine, having an immobilizing functional group on a side chain, and

in a case where there is a plurality of X^6 's or X^7 's, the plurality of X^6 's or X^7 's may be the same as or different from each other;

$p1$, $p2$, $q1$, and $q2$ each independently represent an integer equal to or greater than 0;

r and s each represent an integer satisfying $0 \leq r \leq 5$, $0 \leq s \leq 5$, and $1 \leq \text{Max}(r,s) \leq 5$, where $\text{Max}(r,s)$ represents a larger one between two numbers represented by r and s in a case where $r \neq s$ and represents r or s in a case where $r = s$;

t and u each represent an integer satisfying $0 \leq t \leq 5$, $0 \leq u \leq 5$, and $1 \leq \text{Max}(t,u) \leq 5$, where $\text{Max}(t,u)$ represents a larger one between two numbers represented by t and u in a case where $t \neq u$ and represents t or u in a case where $t = u$;

$v1$, $v2$, $w1$, and $w2$ each independently represent an integer equal to or greater than 0; and

in a case where $k \geq 2$, X^1 , X^2 , X^3 , X^a , X^b , X^4 , X^5 , X_m , X_n , X_{p2} , X_{p1} , X_{q1} , and X_{q2} in a repeating unit $[X_{p2}-X^4_r-X_{p1}-X^a-X_m-X^1-X^2-X^3-X_n-X^b-X_{q1}-X^5-X_{q2}]$ each may be the same or different between the repeating units.

25. The cyclic peptide according to claim 21,

wherein $8 \leq g + h + k \times (i + j + m + n + 5) \leq 50$.

26. The cyclic peptide according to claim 22,

wherein $8 \leq g + h + k \times (m + n + p1 + p2 + q1 + q2 + 5) \leq 50$.

27. The cyclic peptide according to claim 23,
wherein $8 \leq v1 + v2 + w1 + w2 + t + u + k \times (i + j + m + n + 5) \leq 50$.
28. The cyclic peptide according to claim 24,
wherein $8 \leq v1 + v2 + w1 + w2 + t + u + k \times (m + n + p1 + p2 + q1 + q2 + 5) \leq 50$.
29. The cyclic peptide according to claim 22, 24, 26, or 28,
wherein the amino acid having a carboxy group on a side chain is at least one kind of amino acid selected from the group consisting of L-aspartic acid, D-aspartic acid, L-glutamic acid, D-glutamic acid, L-homoglutamic acid, and D-homoglutamic acid,
in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, the amino acid, other than L-serine, D-serine, L-homoserine, and D-homoserine, having a hydroxy group on a side chain is at least one kind of amino acid selected from the group consisting of L-tyrosine, D-tyrosine, L-threonine, D-threonine, L-allothreonine, and D-allothreonine, and
in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, the amino acid, other than L-serine and D-serine, having a hydroxy group on a side chain is at least one kind of amino acid selected from the group consisting of L-homoserine, D-homoserine, L-tyrosine, D-tyrosine, L-threonine, D-threonine, L-allothreonine, and D-allothreonine.
30. The cyclic peptide according to claim 22, 24, 26, or 28,
wherein the amino acid having a carboxy group on a side chain is L-aspartic acid, and
the amino acid, other than L-serine, D-serine, L-homoserine, and D-homoserine, having a hydroxy group on a side chain and the amino acid residue derived from the amino acid, other than L-serine and D-serine, having a hydroxy group on a side chain are L-threonine.
31. The cyclic peptide according to claim 23, 24, 27, or 28,
wherein the immobilizing functional group is an amino group or a thiol group.
32. The cyclic peptide according to claim 23, 24, 27, or 28,
wherein the amino acid, other than L-serine, D-serine, L-homoserine, D-homoserine,

L-arginine, and D-arginine, having an immobilizing functional group on a side chain and the amino acid residue derived from an amino acid, other than L-serine and D-serine, having an immobilizing functional group on a side chain are at least one kind of amino acid selected from the group consisting of L-lysine, D-lysine, L-cysteine, D-cysteine, L-homocysteine, and D-homocysteine.

33. The cyclic peptide according to any one of claims 21 to 32,

wherein X^a is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, selected from the group consisting of
 (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid,
 (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid,
 (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid,
 (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine,
 N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine,

X^b is an amino acid residue derived from L-cysteine or D-cysteine or an amino acid residue derived from L-penicillamine or D-penicillamine, and

X^a and X^b are bonded to each other through a thioether bond.

34. The cyclic peptide according to any one of claims 21 to 32,

wherein X^a is an amino acid residue derived from L-cysteine or D-cysteine or an amino acid residue derived from L-penicillamine or D-penicillamine,

X^b is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, selected from the group consisting of
 (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid,
 (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid,
 (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid,
 (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine,
 N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine, and

X^a and X^b are bonded to each other through a thioether bond.

35. The cyclic peptide according to any one of claims 21 to 34,

wherein the partial amino acid sequence $X_m-X^1-X^2-X^3-X_n$ in Formula (I'), (I'A), (I'B), or (I'C) and an amino acid sequence (SEQ ID NO: 1) represented by Formula (1) share

sequence homology equal to or higher than 70%,

A-Y-H-L-G-E-L-V-W ... (1):

in Formulae (1) and (2),

A represents an L-alanine residue;

Y represents an L-tyrosine residue;

H represents an L-histidine residue;

L represents an L-leucine residue;

G represents a glycine residue;

E represents an L-glutamic acid residue;

V represents an L-valine residue; and

W represents an L-tryptophan residue.

36. The cyclic peptide according to any one of claims 21 to 35,

wherein in Formula (I'), (I'A), (I'B), or (I'C), $k = 1$.

37. The cyclic peptide according to claim 21 that is represented by Formula (II'),

$$R^N-X_{v0}-X_{t0}^6-X_{e0}-X_{r0}^4-X_{p0}-X^a-A-Y-H-X^b-G-E-L-V-W-X^b-X_{q0}-X_{s0}^5-X_{f0}-X_{u0}^7-X_{w0}-R^C \dots$$

(II'):

in Formula (II'),

X^a , X^b , X , R^N , and R^C have the same definitions as those in Formula (I');

in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid, other than L-serine, D-serine, L-homoserine, and D-homoserine, having a hydroxy group on a side chain,

in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^4 and X^5 each independently represent an amino acid residue derived from an amino acid having a carboxy group on a side chain or an amino acid residue derived from an amino acid, other than L-serine and D-serine, having a hydroxy group on a side chain, and

in a case where there is a plurality of X^4 's or X^5 's, the plurality of X^4 's or X^5 's may be the same as or different from each other;

in a case where one of X^a and X^b represents an amino acid residue derived from

L-cysteine or D-cysteine, X^6 and X^7 each independently represent an amino acid residue derived from an amino acid, other than L-serine, D-serine, L-homoserine, D-homoserine, L-arginine, and D-arginine, having an immobilizing functional group on a side chain or each independently represent an amino acid residue derived from an amino acid having an immobilizing functional group on a side chain,

in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^6 and X^7 each independently represent an amino acid residue derived from an amino acid, other than L-serine and D-serine, having an immobilizing functional group on a side chain, and

in a case where there is a plurality of X^6 's or X^7 's, the plurality of X^6 's or X^7 's may be the same as or different from each other;

in a case where one of X^a and X^b represents an amino acid residue derived from L-cysteine or D-cysteine, X^8 represents an L-leucine residue or a D-leucine residue,

in a case where one of X^a and X^b represents an amino acid residue derived from L-penicillamine or D-penicillamine, X^8 represents an L-leucine residue, a D-leucine residue, an L-arginine residue, or a D-arginine residue;

e_0 and f_0 each represent an integer satisfying $0 \leq e_0 \leq 10$ and $0 \leq f_0 \leq 10$;

p_0 and q_0 each represent an integer satisfying $0 \leq p_0 \leq 5$ and $0 \leq q_0 \leq 5$;

r_0 and s_0 each represent an integer satisfying $0 \leq r_0 \leq 5$ and $0 \leq s_0 \leq 5$;

t_0 and u_0 each represent an integer satisfying $0 \leq t_0 \leq 5$ and $0 \leq u_0 \leq 5$;

v_0 and w_0 each represent an integer satisfying $0 \leq v_0 \leq 5$ and $3 \leq w_0 \leq 5$;

$p_0, q_0, r_0, s_0, t_0, u_0, v_0$, and w_0 satisfy $0 \leq p_0 + q_0 + r_0 + s_0 + t_0 + u_0 + v_0 + w_0 \leq$

39;

A represents an L-alanine residue or a D-alanine residue;

Y represents an L-tyrosine residue or a D-tyrosine residue;

H represents an L-histidine residue or a D-histidine residue;

G represents a glycine residue;

E represents an L-glutamic acid residue or a D-glutamic acid residue;

L represents an L-leucine residue;

V represents an L-valine residue; and

W represents an L-tryptophan residue.

38. The cyclic peptide according to claim 37,

wherein X^6 and X^7 each independently represent an amino acid residue derived from an amino acid selected from the group consisting of L-lysine, D-lysine, L-cysteine, D-cysteine, L-homocysteine, and D-homocysteine.

39. The cyclic peptide according to claim 37 or 38,

wherein X^a is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain, selected from the group consisting of (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine,

X^b is an amino acid residue derived from L-cysteine or D-cysteine or an amino acid residue derived from L-penicillamine or D-penicillamine, and

X^a and X^b are bonded to each other through a thioether bond.

40. The cyclic peptide according to claim 37 or 38,

wherein X^a is an amino acid residue derived from L-cysteine or D-cysteine or an amino acid residue derived from L-penicillamine or D-penicillamine,

X^b is an amino acid residue derived from an amino acid having a chloroacetyl group on a side chain selected from the group consisting of (2S)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2R)-2-amino-3-[(2-chloroacetyl)amino]propanoic acid, (2S)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, (2R)-2-amino-4-[(2-chloroacetyl)amino]butanoic acid, N- δ -chloroacetyl-L-ornithine, N- δ -chloroacetyl-D-ornithine, N- ϵ -chloroacetyl-L-lysine, and N- ϵ -chloroacetyl-D-lysine, and

X^a and X^b are bonded to each other through a thioether bond.

41. The cyclic peptide according to any one of claims 1 to 40 that is an antibody binding ligand.

42. The cyclic peptide according to any one of claims 1 to 40 that is a linker for labeling antibodies.

43. The cyclic peptide according to any one of claims 1 to 40 that is a linker for antibody drug conjugates.
44. The cyclic peptide according to any one of claims 1 to 40 that is a drug carrier.
45. An affinity chromatography support comprising:
a water-insoluble support; and
the cyclic peptide according to any one of claims 1 to 40,
wherein the water-insoluble support and the cyclic peptide are directly or indirectly bonded to each other.
46. A labeled antibody comprising:
an antibody;
a labeling compound; and
the cyclic peptide according to any one of claims 1 to 40,
wherein the antibody and the labeling compound are bonded to each other through the cyclic peptide.
47. An antibody drug conjugate comprising:
an antibody;
a drug; and
the cyclic peptide according to any one of claims 1 to 40,
wherein the antibody and the drug are bonded to each other through the cyclic peptide.
48. The antibody drug conjugate according to claim 47,
wherein the drug is a drug having undergone liposomization, polymer micellization, or PEGylation.
49. A pharmaceutical preparation comprising:
a drug; and
the cyclic peptide according to any one of claims 1 to 40,

wherein the drug and the cyclic peptide are directly or indirectly bonded to each other.

50. The pharmaceutical preparation according to claim 49,

wherein the drug is a drug having undergone liposomization, polymer micellization, or PEGylation.