CLAIMS

1. A fusion protein, comprising:
an insulin analog having the following general formula from the N-terminus to the C-terminus: B_1-L_1-A_1,
wherein
B_1 is an insulin B-chain analog comprising the following amino acid sequence:
FVX_1QHLCGX_2HLVEALX$_3$X$_4$VCGERGFX$_5$Y (SEQ ID NO: 1), wherein
X_1 is selected from the group consisting of N, G, and K,
X_2 is selected from the group consisting of S and E,
X_3 is selected from the group consisting of Y, H, and E,
X_4 is selected from the group consisting of H, R, L, and E, and
X_5 is selected from the group consisting of F and H;
A_1 is an insulin A-chain analog comprising the following amino acid sequence:
GIVEQCCZ_1SICSLZ$_2$QLENYCZ$_3$ (SEQ ID NO: 2), wherein
Z_1 is selected from the group consisting of T, H, and E,
Z_2 is selected from the group consisting of Y, D, S, and E, and
Z_3 is selected from the group consisting of G and N;
L_1 is a linker, preferably a GS linker and/or a linker having at least five G, more preferably a linker with the amino acid sequence set forth in SEQ ID NO: 3 or 52.

2. The fusion protein according to claim 1, wherein
X_1 is selected from the group consisting of N and K, X_2 is selected from the group consisting of S and E, X_3 is selected from the group consisting of Y and H, X_4 is selected from L, and X_5 is selected from H;
Z_1 is selected from the group consisting of T, H, and E, Z_2 is selected from E, and Z_3 is selected from the group consisting of G and N.

3. The fusion protein according to claim 1 or 2, wherein
the insulin B-chain analog comprises or is selected from the amino acid sequence set forth in any one of SEQ ID NOs: 31-36, and
the insulin A-chain analog comprises or is selected from the amino acid sequence set forth in any one of SEQ ID NOs: 37-42;
preferably, the fusion protein comprises the amino acid sequence set forth in any one of SEQ ID NOs: 4-9.

4. The fusion protein according to any one of claims 1-3, further comprising C_1, wherein the C_1 is selected from at least one of the following: an Fc region of an immunoglobulin, HSA, and an HSA-binding domain;
preferably, the C_1 is selected from an Fc region of IgG;
more preferably, the C_1 is selected from the group consisting of Fc regions of human

IgG1, IgG2 and IgG4.

5. The fusion protein according to claim 4, wherein the C_1 is located at the N-terminus or C-terminus of the insulin analog, preferably at the C-terminus of the insulin analog.

6. The fusion protein according to any one of claims 4-5, wherein the C_1 comprises or is the amino acid sequence set forth in any one of SEQ ID NOs: 17, 18, and 48-51, or an amino acid sequence having at least 90% identity thereto.

7. The fusion protein according to any one of claims 4-6, further comprising a linker L_2, wherein C_1 forms the fusion protein with B_1-L_1-A_1 via L_2;
preferably, the L_2 is selected from any one of the following: $(G_mQ_i)_n$, $(G_mA_i)_n$, $(G_mQ)_n$, $(G_mA)_n$, and $(PGPQ)_s$, wherein
each m is independently selected from the group consisting of integers of 1-10,
each n is independently selected from the group consisting of integers of 1-10, and
each i is independently selected from the group consisting of 0-4;
s is selected from the group consisting of integers of 1-10;
more preferably, the L_2 comprises or is the amino acid sequence set forth in any one of SEQ ID NOs: 10-16.

8. The fusion protein according to any one of claims 4-7, comprising or being the amino acid sequence set forth in any one of SEQ ID NOs: 19-27, or an amino acid sequence having at least 90% sequence identity thereto.

9. The fusion protein according to any one of claims 1-8, being a dimer, preferably a homodimer.

10. The fusion protein according to any one of claims 1-9, wherein the insulin analog is an insulin receptor agonist with insulin receptor agonistic activity.

11. An insulin analog, comprising an insulin B-chain analog and an insulin A-chain analog, wherein
the insulin B-chain analog comprises the following amino acid sequence:
$FVX_1QHLCGX_2HLVEALX_3X_4VCGERGFX_5Y$ (SEQ ID NO: 1), wherein X_1 is selected from the group consisting of N, G, and K, X_2 is selected from the group consisting of S and E, X_3 is selected from the group consisting of Y, H, and E, X_4 is selected from the group consisting of H, R, L, and E, and X_5 is selected from the group consisting of F and H;
the insulin A-chain analog comprises the following amino acid sequence:
$GIVEQCCZ_1SICSLZ_2QLENYCZ_3$ (SEQ ID NO: 2), wherein Z_1 is selected from the group consisting of T, H, and E, Z_2 is selected from the group consisting of Y, D, S, and

E, and Z_3 is selected from the group consisting of G and N;
preferably, X_1 is selected from the group consisting of N and K, X_2 is selected from the group consisting of S and E, X_3 is selected from the group consisting of Y and H, X_4 is selected from L, and X_5 is selected from H; Z_1 is selected from the group consisting of T, H, and E, Z_2 is selected from E, and Z_3 is selected from the group consisting of G and N.

12. The insulin analog according to claim 11, wherein
the insulin B-chain analog comprises or is selected from the amino acid sequence set forth in any one of SEQ ID NOs: 31-36, and
the insulin A-chain analog comprises or is selected from the amino acid sequence set forth in any one of SEQ ID NOs: 37-42;
preferably,
the insulin B-chain analog and the insulin A-chain analog respectively comprise or are selected from the amino acid sequences set forth in any one of the following groups:
SEQ ID NOs: 31 and 37;
SEQ ID NOs: 32 and 38;
SEQ ID NOs: 33 and 39;
SEQ ID NOs: 34 and 40; and
SEQ ID NOs: 36 and 42.

13. The insulin analog according to claim 11 or 12, wherein a disulfide bond is formed between the insulin A-chain analog and the insulin B-chain analog.

14. A glucose-responsive insulin, comprising the insulin analog according to any one of claims 11-13.

15. A polynucleotide, encoding the fusion protein according to any one of claims 1-10, or the insulin analog according to any one of claims 11-13, or the glucose-responsive insulin according to claim 14.

16. A host cell, comprising the polynucleotide according to claim 15.

17. A method for preparing a fusion protein or an insulin analog, comprising:
culturing the host cell according to claim 16;
collecting the fusion protein according to any one of claims 1-10 or the insulin analog according to any one of claims 11-13; and
optionally, purifying and/or modifying the fusion protein or the insulin analog.

18. A pharmaceutical composition, comprising the fusion protein according to any one of claims 1-10, the insulin analog according to any one of claims 11-13, or the glucose-responsive insulin according to claim 14; and one or more pharmaceutically acceptable

carriers, diluents or excipients.

19. Use of the fusion protein according to any one of claims 1-10, the insulin analog according to any one of claims 11-13, the glucose-responsive insulin according to claim 14, or the pharmaceutical composition according to claim 18 in the manufacture of a medicament for treating diabetes and a complication thereof or lowering blood glucose, wherein

preferably, the diabetes and the complication thereof are selected from the group consisting of: type I diabetes, type II diabetes, and complications thereof;

more preferably, the complication is selected from the group consisting of diabetes-related heart disease, stroke, retinopathy, neuropathy and kidney disease.