
CLAIMS

1. A fusion protein, which comprises a cell-penetrating peptide, a pH-sensitive fusogenic peptide and a protease recognition sequence, wherein the protease recognition sequence comprises a furin recognition sequence and a cathepsin L recognition sequence.

2. The fusion protein according to claim 1, wherein the furin recognition sequence comprises R-X₁-X₂-R (SEQ ID NO: 1) or R-R-X₁-X₂-R (SEQ ID NO: 2) or SEQ ID NO: 3 or SEQ ID NO: 4, wherein X₁ is any amino acid, and X₂ is K or R.

3. The fusion protein according to claim 1, wherein the cathepsin L recognition sequence comprises a sequence shown in SEQ ID NO:6.

4. The fusion protein according to claim 1, wherein the protease recognition sequence comprises SEQ ID NO: 4 and SEQ ID NO: 6.

5. The fusion protein according to claim 1, wherein the pH-sensitive fusogenic peptide is selected from HA2, INF7, KALA, GALA, melittin, and any combination thereof.

6. The fusion protein according to claims 5, wherein, the pH-sensitive fusogenic peptide comprises INF7 or a sequence shown in SEQ ID NO: 8.

7. The fusion protein according to claim 1, wherein the cell-penetrating peptide is selected from the group consisting of penetratin, Tat-derived peptide, Rev(34-50), VP22, transportan, Pep-1, Pep-7, and any combination thereof.

8. The fusion protein according to claim 7, wherein the cell-penetrating peptide comprises Tat(48-60) or Tat(47-57) or comprises a sequence shown in SEQ ID NO: 10.

9. The fusion protein according to claim 1, wherein the fusion protein comprises the pH-sensitive fusogenic peptide, cell penetrating peptide, and protease recognition sequence from

N-terminus to C-terminus; or, the fusion protein comprises the cell-penetrating peptide, pH-sensitive fusogenic peptide and protease recognition sequence from N-terminus to C-terminus;

and the protease recognition sequence comprises the furin recognition sequence and cathepsin L recognition sequence from N-terminus to C-terminus, or comprises the cathepsin L recognition sequence and furin-recognition sequence from N-terminus to C-terminus.

10. The fusion protein according to claim 1, wherein the fusion protein comprises a sequence shown in any one of SEQ ID NOs: 12 to 14.

11. The fusion protein according to any one of claims 1 to 10, wherein the fusion protein further comprises a specific binding sequence, the specific binding sequence allows another molecule to specifically bind thereto.

12. The fusion protein according to claim 11, which is characterized by one of the following:

(i) the specific binding sequence comprises a leucine zipper peptide which is able to form a heterodimer with its complementary peptide;

(ii) the specific binding sequence comprises leucine zipper NZ or CZ;

(iii) the specific binding sequence comprises a sequence shown in SEQ ID NO: 49 or 50; or

(iv) the specific binding sequence is located at the C-terminus of the protease recognition sequence.

13. A complex, which comprises the fusion protein according to any one of claims 1 to 12, and a cargo molecule.

14. The complex according to claim 13, which is characterized by one of the following:

(i) the cargo molecule is selected from the group consisting of nucleic acid, peptide or protein, carbohydrate, lipid, chemical compound and any mixture thereof;

(ii) the cargo molecule comprises a detectable label; or

(iii) the cargo molecule comprises an epitope tag, reporter gene sequence and/or nuclear localization signal (NLS) sequence.

15. The complex according to claim 13, which is characterized by one of the following:

- (i) the fusion protein is fused with the cargo molecule, and the cargo molecule is a peptide or protein;
- (ii) the fusion protein is chemically coupled to the cargo molecule;
- (iii) the fusion protein is non-covalently linked to the cargo molecule; or,
- (iv) the fusion protein is conjugated to the cargo molecule by electrostatic interaction.

16. The complex according to claim 13, wherein the fusion protein is the fusion protein according to claim 11 or 12, and the cargo molecule comprises a domain capable of specifically binding to the specific binding sequence in the fusion protein.

17. The complex according to claim 16, wherein the specific binding sequence in the fusion protein comprises a leucine zipper peptide, and the cargo molecule comprises the complementary peptide of the leucine zipper, so that the leucine zipper peptide and the complementary peptide are able to form a heterodimer.

18. A composition, which comprises the fusion protein according to any one of claims 1 to 12, and a cargo molecule;

19. The composition according to claim 18, which comprises the fusion protein according to claim 11 or 12, and the cargo molecule comprises a domain capable of specifically binding to the specific binding sequence in the fusion protein.

20. The composition according to claim 19, wherein the specific binding sequence in the fusion protein comprises a leucine zipper peptide, and the cargo molecule comprises the complementary peptide of the leucine zipper, so that the leucine zipper peptide and the complementary peptide are able to form a heterodimer.

21. An isolated nucleic acid molecule, which comprises a nucleotide sequence encoding the fusion protein according to any one of claims 1 to 12, or a complex or composition comprising the fusion protein and a cargo molecule that is a peptide or protein.

22. A vector, which comprises the isolated nucleic acid molecule according to claim 21.

23. A host cell, which comprises the isolated nucleic acid molecule according to claim 21 or the vector according to claim 22.

24. A pharmaceutical composition, which comprises the fusion protein according to any one of claims 1 to 12, the complex according to any one of claims 13 to 17, the composition according to any one of claims 18 to 20, the isolated nucleic acid molecule according to claim 21, the vector according to claim 22 or the host cell according to claim 23, and a pharmaceutically acceptable carrier and/or excipient.

25. The pharmaceutical composition according to claim 24, wherein the pharmaceutical composition comprises the complex according to any one of claims 13 to 17, wherein the cargo molecule is a pharmaceutically active agent or a detectable label.

26. Use of the fusion protein according to any one of claims 1 to 12, or an isolated nucleic acid molecule, vector or host cell comprising a nucleotide sequence encoding the fusion protein, in the manufacture of a medicament.

27. Use of the complex according to any one of claims 13 to 17 or the composition according to any one of claims 18 to 20, in the manufacture of a medicament for treatment of a disease;

wherein the disease is a disease related to programmed cell necrosis, and the cargo molecule comprises protein phosphatase 1B; and wherein the disease related to programmed cell necrosis comprises liver injury, inflammatory disease, ischemia-reperfusion injury and/or neurodegenerative disease.

28. A kit, which comprises the fusion protein according to any one of claims 1 to 12, the complex according to any one of claims 13 to 17, the composition according to any one of claims 18 to 20, the isolated nucleic acid molecule according to claim 21, the vector according to claim 22, or the host cell according to claim 23;

and the kit further comprises an instruction for transfection and/or intracellular delivery.

29. Use of the fusion protein according to any one of claims 1 to 12, the complex according to any one of claims 13 to 17, the composition according to any one of claims 18 to 20, the isolated nucleic acid molecule according to claim 21, the vector according to claim 22, or the host cell according to claim 23, as a delivery agent.

30. A method for delivering a cargo molecule into a cell, which comprises contacting the cell with the complex according to any one of claims 13 to 17 *in vitro*, wherein the complex comprises the cargo molecule.