

CLAIMS

1. A cell (e.g., a population of cells) that expresses a CAR molecule that binds CD19 (a “CAR19-expressing cell”) in combination with one or more kinase inhibitors, for use in the treatment of a disease associated with expression of CD19, wherein the kinase inhibitor is chosen from a Bruton’s tyrosine kinase (BTK) inhibitor, a cyclin dependent kinase 4 (CDK4) inhibitor, an mTOR inhibitor, or a mitogen activated protein kinase interacting kinase (MNK) inhibitor.

2. Use of a cell (e.g., a population of cells) that expresses a CAR molecule that binds CD19 in combination with one or more kinase inhibitors, in the manufacture of a medicament for the treatment of a disease associated with expression of CD19, wherein the disease is cancer, and wherein the kinase inhibitor is chosen from a Bruton’s tyrosine kinase (BTK) inhibitor, a cyclin dependent kinase 4 (CDK4) inhibitor, an mTOR inhibitor, or a mitogen activated protein kinase interacting kinase (MNK) inhibitor.

3. The use of claim 1 or 2, wherein:

the kinase inhibitor and the CAR19-expressing cell are to be administered as a first line of therapy; or

the kinase inhibitor and the CAR19-expressing cell are to be administered in the following manner:

(i) the CAR19-expressing cell is to be administered subsequent to the cessation of the administration of the kinase inhibitor, or

(ii) the administration of the kinase inhibitor is to be begun prior to the administration of the CAR19-expressing cell, and the CAR19-expressing cell is to be administered in combination with continued administration of the kinase inhibitor.

4. The use of any of claims 1-3, wherein the disease associated with expression of CD19 is, or is identified as being, completely or partially responsive to the BTK inhibitor (e.g., ibrutinib), or completely or partially responsive to the CAR19-expressing cell.

5. The use of any of claims 1-4, wherein:

the BTK inhibitor is chosen from ibrutinib, GDC-0834, RN-486, CGI-560, CGI-1764, HM-71224, CC-292, ONO-4059, CNX-774, or LFM-A13;

the CDK4 inhibitor is chosen from: palbociclib, aloisine A, flavopiridol, 2-(2-chlorophenyl)-5,7-dihydroxy-8-[(3S,4R)-3-hydroxy-1-methyl-4-piperidinyl]-4-chromenone; crizotinib (PF-02341066, P276-00, RAF265, indisulam, roscovitine, dinaciclib, BMS 387032, MLN8054, AG-024322, AT7519, AZD5438, BMS908662; or ribociclib;

the mTOR inhibitor is chosen from: rapamycin, a rapamycin analog such as everolimus, temsirolimus, ridaforolimus, semapimod, AZD8055, PF04691502, SF1126, XL765, or OSI-027; or

the MNK inhibitor is chosen from: CGP052088, CGP57380, cercosporamide, ETC-1780445-2, or 4-amino-5-(4-fluoroanilino)-pyrazolo [3,4-d] pyrimidine.

6. The use of any of the preceding claims, wherein the kinase inhibitor is ibrutinib and the ibrutinib has a dose of about 250 mg, 300 mg, 350 mg, 400 mg, 420 mg, 440 mg, 460 mg, 480 mg, 500 mg, 520 mg, 540 mg, 560 mg, 580 mg, or 600 mg daily.

7. The use of any of the preceding claims, wherein the cell expresses a CAR molecule comprising an anti-CD19 binding domain, a transmembrane domain, and an intracellular signaling domain.

8. The use of claim 7, wherein the intracellular signaling domain comprises a costimulatory domain and a primary signaling domain.

9. The use of claim 7 or 8, wherein the CAR molecule comprises an anti-CD19 binding domain comprising a light chain complementary determining region 1 (LC CDR1), a light chain complementary determining region 2 (LC CDR2), a light chain complementary determining region 3 (LC CDR3), a heavy chain complementary determining region 1 (HC CDR1), a heavy chain complementary determining region 2 (HC CDR2), and a heavy chain complementary determining region 3 (HC CDR3) of an anti-CD19 binding domain.

10. The use of any of claims 7-9, wherein:

the anti-CD19 binding domain comprises a murine light chain variable region of Table 7, a murine heavy chain variable region of Table 7, or both;

the anti-CD19 binding domain comprises a LC CDR1 of SEQ ID NO: 5, a LC CDR2 of SEQ ID NO: 26, and a LC CDR3 of SEQ ID NO: 27;

the anti-CD19 binding domain comprises a HC CDR1 of SEQ ID NO: 19, a LC CDR2 of any of SEQ ID NOS: 20-23, and a HC CDR3 of SEQ ID NO: 24;

the anti-CD19 binding domain comprises a sequence of SEQ ID NO:59, or a sequence with 95-99% identity thereof;

the anti-CD19 binding domain is a humanized anti-CD19 binding domain;

the humanized anti-CD19 binding domain comprises a sequence chosen from: SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO: 4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11 and SEQ ID NO:12, or a sequence with 95-99% identity thereof; or

the humanized anti-CD19 binding domain is a scFv that comprises a light chain variable region attached to a heavy chain variable via a linker, e.g., wherein the linker comprises a sequence of SEQ ID NO: 53.

11. The use of any of the preceding claims, wherein the CAR molecule comprises a transmembrane domain of a protein chosen from: the alpha, beta or zeta chain of the T-cell receptor, CD28, CD3 epsilon, CD45, CD4, CD5, CD8, CD9, CD16, CD22, CD33, CD37, CD64, CD80, CD86, CD134, CD137 or CD154, wherein optionally:

the transmembrane domain comprises a sequence of SEQ ID NO: 15; or

the anti-CD19 binding domain is connected to the transmembrane domain by a hinge region, e.g., wherein the hinge region comprises a sequence of SEQ ID NO:14 or SEQ ID NO:45.

12. The use of any of the preceding claims, wherein the CAR molecule comprises a costimulatory domain, e.g., wherein the costimulatory domain comprises a functional signaling domain of a protein chosen from: OX40, CD2, CD27, CD28, CD30, ICAM-1, LFA-1 (CD11a/CD18) or 4-1BB (CD137), e.g., wherein the costimulatory domain comprises a sequence of SEQ ID NO: 16 or SEQ ID NO:51.

13. The use of any of the preceding claims, wherein the CAR molecule comprises an intracellular signaling domain, wherein:

the intracellular signaling domain comprises a functional signaling domain of 4-1BB, a functional signaling domain of CD3 zeta, or both, or wherein the intracellular signaling domain comprises a sequence of CD27, a functional signaling domain of CD3 zeta, or both; or

the intracellular signaling domain comprises a sequence of SEQ ID NO: 16, a sequence of SEQ ID NO:17, or both; wherein the intracellular signaling domain comprises a sequence of SEQ ID NO:16, a sequence of SEQ ID NO:43, or both; wherein the intracellular signaling domain comprises a sequence of SEQ ID NO: 51, a sequence of SEQ ID NO:17, or both; or wherein the intracellular signaling domain comprises a sequence of SEQ ID NO:51, a sequence of SEQ ID NO:43, or both.

14. The use of any of the preceding claims, wherein the CAR molecule further comprises a leader sequence, e.g., wherein the leader sequence comprises an amino acid sequence of SEQ ID NO: 13.

15. The use of any of the preceding claims, wherein CAR molecule comprises an amino acid sequence of SEQ ID NO:58, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:34, SEQ ID NO:35, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:38, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:41, or SEQ ID NO:42.

16. The use of any of the preceding claims, for use in combination with an agent which inhibits an immune inhibitory molecule chosen from: PD1, PD-L1, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4 or TGFR beta.

17. The use of any of the preceding claims, wherein the composition comprises $1-5 \times 10^8$ CAR-expressing cells.

18. The use of any of the preceding claims, wherein the disease associated with expression of CD19 is a cancer.

19. The use of any of the preceding claims, wherein the disease associated with expression of CD19 is a hematological cancer, e.g., a hematological cancer chosen from a leukemia or lymphoma.

20. The use of claim 18, wherein the cancer is chosen from: chronic lymphocytic leukemia (CLL), mantle cell lymphoma (MCL), multiple myeloma, acute lymphoid leukemia (ALL), Hodgkin lymphoma, B-cell acute lymphoid leukemia (BALL), T-cell acute lymphoid leukemia (TALL), small lymphocytic leukemia (SLL), B cell prolymphocytic leukemia, blastic plasmacytoid dendritic cell neoplasm, Burkitt's lymphoma, diffuse large B cell lymphoma (DLBCL), DLBCL associated with chronic inflammation, follicular lymphoma, pediatric follicular lymphoma, hairy cell leukemia, small cell- or a large cell-follicular lymphoma, malignant lymphoproliferative conditions, MALT lymphoma (extranodal marginal zone lymphoma of mucosa-associated lymphoid tissue), Marginal zone lymphoma, myelodysplasia and myelodysplastic syndrome, non-Hodgkin lymphoma, plasmablastic lymphoma, plasmacytoid dendritic cell neoplasm, Waldenstrom macroglobulinemia, splenic marginal zone lymphoma, splenic lymphoma/leukemia, splenic diffuse red pulp small B-cell lymphoma, hairy cell leukemia-variant, lymphoplasmacytic lymphoma, a heavy chain disease, plasma cell myeloma, solitary plasmocytoma of bone, extraosseous plasmocytoma, nodal marginal zone lymphoma, pediatric nodal marginal zone lymphoma, primary cutaneous follicle center lymphoma, lymphomatoid granulomatosis, primary mediastinal (thymic) large B-cell lymphoma, intravascular large B-cell lymphoma, ALK+ large B-cell lymphoma, large B-cell lymphoma arising in HHV8-associated multicentric Castleman disease, primary effusion lymphoma, B-cell lymphoma, or unclassifiable lymphoma.

21. The use of any of the preceding claims, for use in combination with a cytokine, wherein the cytokine is IL-7, IL-15, or IL-21.

22. The use of any of the preceding claims, wherein the CAR is a regulatable CAR (RCAR), wherein optionally the RCAR comprises:

an intracellular signaling member comprising an intracellular signaling domain and a first switch domain,

an antigen binding member comprising an antigen binding domain that binds CD19 and a second switch domain; and

a transmembrane domain.

23. The use of any of the preceding claims, wherein:

the disease associated with expression of CD19 has, or is identified as having, a BTK mutation;

the disease associated with expression of CD19 is a hematological cancer, and wherein resistance to the kinase inhibitor, the cell that expresses a CAR molecule, or both, is delayed or decreased; or

the disease associated with expression of CD19 is a hematological cancer, and wherein remission of the hematological cancer is prolonged or relapse of the hematological cancer is delayed.

24. The use of claim 1 or 2, wherein the CAR19-expressing cell is to be administered in combination a second kinase inhibitor, wherein:

the second kinase inhibitor is other than ibrutinib, when the disease associated with expression of CD19 is, or is identified as being, non-responsive or relapsed to ibrutinib; or

the second kinase inhibitor is chosen from one or more of GDC-0834, RN-486, CGI-560, CGI-1764, HM-71224, CC-292, ONO-4059, CNX-774, or LFM-A13, or a combination thereof.

25. The use of any of the preceding claims, wherein:

the disease associated with expression of CD19 is (or is identified as being) partially responsive to the kinase inhibitor, and the CAR19-expressing cell, alone or in combination with the BTK inhibitor, is to be administered during the period of partial response; or

the disease associated with expression of CD19 is (or is identified as being) non-responsive, progressive, or stable disease after treatment with ibrutinib, and the CAR19-expressing cell is to be administered, alone or in combination with a second BTK inhibitor, during the period of progressive or stable disease, wherein the second kinase inhibitor is other than ibrutinib.

26. The use of any of the preceding claims, wherein the kinase inhibitor is ibrutinib and the ibrutinib is formulated for the administration for 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or more cycles, e.g., wherein the cycle length is 21 or 28 days.

27. The use of any of the preceding claims, which comprises performing a lymphocyte infusion with at least one CD19 CAR-expressing cell.

28. The use of any of the preceding claims, wherein:

the cell and the kinase inhibitor are formulated for simultaneous administration; or
the cell and the kinase inhibitor are formulated for sequential delivery.

29. The use of any of the preceding claims, wherein the administration is to be performed after lymphodepletion, wherein the lymphodepletion is to comprise the administration of one or more of melphalan, cytoxan, cyclophosphamide, and fludarabine.

30. The use of any of the preceding claims, wherein the use is to further comprise the administration of a low, immune enhancing dose of an mTOR inhibitor, wherein the mTOR inhibitor is everolimus or rapamycin.

31. The use of any of the preceding claims, wherein the immune effector cells comprise T cells or NK cells, or wherein the population of cells includes T cells, NK cells, or both.

32. The use of any of the preceding claims, wherein the hematologic cancer is a relapsed or refractory hematologic malignancy.

33. The use of any of the preceding claims, wherein the anti-CD19 binding domain comprises a LC CDR1 of SEQ ID NO: 25, a LC CDR2 of SEQ ID NO: 26, a LC CDR3 of SEQ ID NO: 27, a HC CDR1 of SEQ ID NO: 19, a LC CDR2 of any of SEQ ID NOS: 20-23, and a HC CDR3 of SEQ ID NO: 24.

34. The use of any of the preceding claims, wherein the CAR19-expressing cell population is to be administered at least 1, at least 2, at least 3, at least 4, or at least 6 months after the administration of the kinase inhibitor has begun.

35. The use of any of the preceding claims, which results in a reduction in PD1-expressing T cells after the administration of the kinase inhibitor.

36. A population of immune effector cells that express a CAR polypeptide that comprises an anti-CD19 binding domain, a transmembrane domain, and an intracellular signaling domain, in combination with a Bruton's tyrosine kinase (BTK) inhibitor, for use in the treatment of a disease associated with expression of CD19 in a human subject having a leukemia or lymphoma.

37. Use of a population of immune effector cells that express a CAR polypeptide that comprises an anti-CD19 binding domain, a transmembrane domain, and an intracellular signaling domain, in combination with a Bruton's tyrosine kinase (BTK) inhibitor, in the manufacture of a medicament for the treatment of a disease associated with expression of CD19 in a human subject having a leukemia or lymphoma.

38. The use of claim 36 or 37, wherein the BTK inhibitor is ibrutinib.

39. The use of claim 36 or 37, wherein:
the CAR polypeptide has a sequence of SEQ ID NO: 58; or
the CAR polypeptide has a sequence of SEQ ID NO: 32.

40. The use of any of claims 36-39, wherein the leukemia or lymphoma is selected from BALL, ALL, DLBCL, B-cell lymphoma, Follicular Lymphoma, MCL, NHL, Hodgkin Lymphoma, CLL or SLL.

41. A method of making a CAR-expressing cell (e.g., a CAR-expressing immune effector cell) or population of cells, comprising:
contacting the cell or population of cells with a BTK inhibitor; and
introducing (e.g., transducing) a nucleic acid encoding a CAR molecule into the cell or population of cells under conditions such that the CAR molecule is expressed.

42. The method of claim 41, wherein:
the CAR molecule is a CAR molecule that binds CD19,
the cell is a T cell or NK cell, or wherein the population of cells includes T cells, NK cells, or both;

the method further comprises contacting the cell or population of cells with the BTK inhibitor for 10-20, 20-30, 30-40, 40-60, or 60-120 minutes and subsequently removing most or all of the BTK inhibitor from the cell or population of cells;

the BTK inhibitor is added after the cell or population of cells is harvested or before the cell or population of cells is stimulated;

the BTK inhibitor is chosen from: ibrutinib, GDC-0834, RN-486, CGI-560, CGI-1764, HM-71224, CC-292, ONO-4059, CNX-774, or LFM-A13;

the population of cells also comprises cancer cells;

the BTK inhibitor inhibits a BTK in the cancer cells; or

the method further comprises depleting T regulatory cells (e.g., CD25+ cells) from the population of cells.

43. A reaction mixture comprising a population of immune effector cells, a BTK inhibitor, and a CAR molecule or a nucleic acid encoding a CAR molecule, wherein:

one or more of the immune effector cells expresses the CAR molecule or comprises the nucleic acid encoding the CAR molecule;

the BTK inhibitor is chosen from ibrutinib, GDC-0834, RN-486, CGI-560, CGI-1764, HM-71224, CC-292, ONO-4059, CNX-774, or LFM-A13; or

the reaction mixture further comprises cancer cells.

44. A reaction mixture comprising a population of immune effector cells, and a CAR molecule or a nucleic acid encoding a CAR molecule, wherein the immune effector cells comprise covalently inactivated ITK, wherein:

the reaction mixture further comprises cancer cells; or

the cancer cells comprise covalently inactivated BTK.

45. A composition comprising a cell that expresses a CAR molecule that binds CD19 (a “CAR19-expressing cell”), and one or more kinase inhibitors, wherein the kinase inhibitor is chosen from a Bruton’s tyrosine kinase (BTK) inhibitor, a cyclin dependent kinase 4 (CDK4) inhibitor, an mTOR inhibitor, or a mitogen activated protein kinase interacting kinase (MNK) inhibitor.

46. The composition of claim 45, wherein the CAR19-expressing cell and the one or more kinase inhibitors are present in a single dose form, or as two or more dose forms.

47. The composition of claim 45 or 46 for use as a medicament.

48. The use of a composition of claim 45 or 46 in the manufacture of a medicament for use in the treatment of a disease associated with expression of CD19 wherein the disease is cancer.

49. The use, method or composition of any of the preceding claims, wherein the CAR19-expressing cell is a human immune effector cell (e.g., a human T cell or a human NK cell) or population of cells.

50. A method of engineering an immune effector cell (e.g., a T cell) to express a CAR, comprising:

contacting the immune effector cell ex vivo with an amount of an mTOR inhibitor that increases the number of PD1 negative immune effector cells (e.g., T cells) or increases the ratio of PD1 negative immune effector cells (e.g., T cells) to PD1 positive immune effector cells (e.g., T cells) and

introducing (e.g., transducing) a nucleic acid encoding a CAR molecule into the immune effector cell under conditions such that the CAR molecule is expressed.

51. The method of claim 50, wherein the mTOR inhibitor is an allosteric inhibitor (e.g., RAD001) or a catalytic inhibitor.

52. A population of cells that express a CAR molecule that binds CD19 and cytokine, e.g., IL-7, IL-15 and/or IL-21, for use in the treatment of a disease associated with the expression of CD19.

53. The use of a population of cells that express a CAR molecule that binds CD19 and cytokine, e.g., IL-7, IL-15 and/or IL-21, in the manufacture of a medicament for the treatment of a disease associated with the expression of CD19 wherein the disease is cancer.