

Having described the invention, the following is claimed:

1. An electrophoresis biochip for detecting hemoglobin disorders, comprising:
a housing that includes a microchannel that extends from a first end to a second end of the housing, the microchannel containing cellulose acetate paper that is at least partially saturated with an alkaline buffer solution;
a first buffer port and a second buffer that extend, respectively, through the first end and second of the housing to the microchannel and cellulose acetate paper, the first buffer port and the second buffer port being capable of receiving the alkaline buffer solution that at least partially saturates the cellulose acetate paper;
a sample loading port for receiving a blood sample, the sample loading port extending through the first end of the housing to the microchannel and cellulose acetate paper; and
a first electrode and a second electrode for generating an electric field across the cellulose acetate paper, the first electrode and second electrode extending, respectively, through the first buffer port and the second port to the cellulose acetate paper.
2. The electrophoresis biochip of claim 1, further comprising an imaging system for visualizing and quantifying hemoglobin variant migration along the cellulose acetate paper for blood samples introduced into the sample loading port.
3. The electrophoresis biochip of claim 1, the housing including a viewing area for visualizing the cellulose acetate paper and hemoglobin variant migration.
4. The electrophoresis biochip of claim 1, wherein the first electrode and the second electrode are connected to a power supply, the power supply generating an electric field of about 1V to about 400V.
5. The electrophoresis biochip of claim 4, wherein the voltage applied to the biochip by the electrodes does not exceed 250V.

6. The electrophoresis biochip of claim 1, wherein the blood sample introduced into the sample loading port is less than 10 microliters.

7. The electrophoresis biochip of claim 1, wherein the buffer solution comprises alkaline tris/Borate/EDTA buffer solution.

8. The electrophoresis biochip of claim 1, wherein the first electrode and the second electrode comprise graphite electrodes.

9. The electrophoresis biochip of claim 1, wherein the housing comprises a top cap, a bottom cap, and a channel spacer interposed between the top cap and the bottom cap, the channel spacer defining the channel in the housing.

10. The electrophoresis biochip of claim 1, wherein the top cap, bottom cap, and channel spacer comprise at least one of glass or plastic.

11. The electrophoresis biochip of claim 2, the imaging system comprising a mobile phone imaging system to visualize and quantify hemoglobin variant migration.

12. The electrophoresis biochip of claim 11, wherein the mobile phone imaging system includes a mobile telephone that is used to image hemoglobin variant migration and a software application that recognizes and quantifies the hemoglobin band types and thicknesses to make a diagnostic decision.

13. The electrophoresis biochip of claim 12, wherein the hemoglobin band types comprise hemoglobin types C/A, S, F, and A0.

14. The electrophoresis biochip of claim 11, diagnosing whether the subject has hemoglobin genotypes HbSS, HbSA, HbSC, or HbA2.

15. The electrophoresis biochip of claim 1, diagnosing whether the subject has sickle cell disease.

16. An electrophoresis biochip system for diagnosing sickle cell disease in a subject, comprising:

a housing that includes a microchannel that extends from a first end to a second end of the housing, the microchannel containing cellulose acetate paper that is at least partially saturated with an alkaline buffer solution;

a first buffer port and a second buffer that extend, respectively, through the first end and second of the housing to the microchannel and cellulose acetate paper, the first buffer port and the second buffer port being capable of receiving the alkaline buffer solution that at least partially saturates the cellulose acetate paper;

a sample loading port for receiving a blood sample, the sample loading port extending through the first end of the housing to the microchannel and cellulose acetate paper;

a first electrode and a second electrode for generating an electric field across the cellulose acetate paper, the first electrode and second electrode extending, respectively, through the first buffer port and the second port to the cellulose acetate paper; and

an imaging system for visualizing and quantifying hemoglobin variant migration along the cellulose acetate paper for blood samples introduced into the sample loading port and determining whether the subject has sickle cell disease.

17. The electrophoresis biochip system of claim 16, the housing including a viewing area for visualizing the cellulose acetate paper and hemoglobin variant migration.

18. The electrophoresis biochip system of claim 16, wherein the first electrode and the second electrode are connected to a power supply, the power supply generating an electric field of about 1V to about 400V.

19. The electrophoresis biochip system of claim 18, wherein the voltage applied to the biochip by the electrodes does not exceed 250V.

20. The electrophoresis biochip system of claim 16, wherein the blood sample introduced into the sample loading port is less than 10 microliters.
21. The electrophoresis biochip system of claim 16, wherein the buffer solution comprises alkaline tris/Borate/EDTA buffer solution.
22. The electrophoresis biochip system of claim 16, wherein the first electrode and the second electrode comprise graphite electrodes.
23. The electrophoresis biochip system of claim 16, wherein the housing comprises a top cap, a bottom cap, and a channel spacer interposed between the top cap and the bottom cap, the channel spacer defining the channel in the housing.
24. The electrophoresis biochip system of claim 16, wherein the top cap, bottom cap, and channel spacer comprise at least one of glass or plastic.
25. The electrophoresis biochip of claim 16, imaging system comprising a mobile phone imaging system to visualize and quantify hemoglobin variant migration.
26. The electrophoresis biochip of claim 16, wherein the mobile phone imaging system includes a mobile telephone that is used to image hemoglobin variant migration and a software application that recognizes and quantifies the hemoglobin band types and thicknesses to make a diagnostic decision.
27. The electrophoresis biochip of claim 16, wherein the hemoglobin band types comprise hemoglobin types C/A, S, F, and A0.

28. A method comprising:
- providing an electrophoresis biochip system that includes:
 - a housing that includes a microchannel that extends from a first end to a second end of the housing, the microchannel containing cellulose acetate paper that is at least partially saturated with an alkaline buffer solution;
 - a first buffer port and a second buffer that extend, respectively, through the first end and second of the housing to the microchannel and cellulose acetate paper, the first buffer port and the second buffer port being capable of receiving the alkaline buffer solution that at least partially saturates the cellulose acetate paper;
 - a sample loading port for receiving a blood sample, the sample loading port extending through the first end of the housing to the microchannel and cellulose acetate paper;
 - a first electrode and a second electrode for generating an electric field across the cellulose acetate paper, the first electrode and second electrode extending, respectively, through the first buffer port and the second port to the cellulose acetate paper; and
 - an imaging system for visualizing and quantifying hemoglobin variant migration along the cellulose acetate paper for blood samples introduced into the sample loading port.
 - introducing a blood sample from a subject into the sample loading port, the blood sample comprising at least one blood cell; and
 - imaging hemoglobin bands formed on the cellulose acetate paper with the imaging system to determine hemoglobin phenotype for said subject.
29. The method of claim 28, wherein the hemoglobin phenotype is selected from the group consisting of HbAA, HbSA, HbSS, HbSC, and HbA2.
30. The method of claim 29, wherein said HbAA hemoglobin phenotype diagnoses the subject as normal.
31. The method of claim 29, wherein said HbSA hemoglobin phenotype diagnoses the subject as having a sickle cell trait.

32. The method of claim 29, wherein said HbSS hemoglobin phenotype diagnoses the subject as having a sickle cell disease.

33. The method of claim 29, wherein said HbSC hemoglobin phenotype diagnoses the subject as having a hemoglobin SC disease.

34. The method of claim 29, wherein said HbA2 hemoglobin phenotype diagnoses the subject as having thalassemia.

35. The method of claim of 28, the housing including a viewing area for visualizing the cellulose acetate paper and hemoglobin variant migration.

36. The method of claim 28, wherein the first electrode and the second electrode are connected to a power supply, the power supply generating an electric field of about 1V to about 400V.

37. The method of claim 36, wherein the voltage applied to the biochip by the electrodes does not exceed 250V.

38. The method of claim 28, wherein the blood sample introduced into the sample loading port is less than 10 microliters.

39. The method of claim 28, wherein the buffer solution comprises alkaline tris/Borate/EDTA buffer solution.

40. The method of claim 28, wherein the first electrode and the second electrode comprise graphite electrodes.

41. The method of claim 28, the imaging system comprising mobile phone imaging system to visualize and quantify hemoglobin variant migration.

42. The method of claim 41, the mobile phone imaging system includes a mobile telephone that is used to image hemoglobin variant migration and a software application that recognizes and quantifies the hemoglobin band types and thicknesses to make a diagnostic decision.

43. The method of claim 28, wherein the hemoglobin band types comprise hemoglobin types C/A, S, F, and A0.

44. A microfluidic biochip device, comprising:
a housing that includes at least one microchannel that defines at least one cell adhesion region, the at least one cell adhesion region being coated with at least one bioaffinity ligand that adheres a cell of interest when a fluid containing cells is passed through the at least one microchannel and an imaging system that measures the quantity of cells adhered to the at least one bioaffinity ligand within the at least one microchannel when the fluid is passed through the channels, the bioaffinity ligands comprising at least one of fibronectin, laminin, selectin, von Willebrands' Factor, thrombomodulin or a C146 antibody.

45. The device of claim 44, wherein the imaging system comprises a lensless imaging system.

46. The device of claim 45, wherein the lensless imaging system comprising a charged coupled device sensor and a light emitting diode.

47. The device of claim 44, wherein the cells are blood cells obtained from the subject.

48. The device of claim 44, wherein the imaging system quantifies the adhered cells in each respective channel to monitor health of a subject from which the cells are obtained.

49. The device of claim 44, wherein the imaging system quantifies the adhered cells in each respective channel to monitor the progression of a disease of a subject from which the cells are obtained.

50. The device of claim 49, wherein the disease is sickle cell disease.

51. The device of claim 44, wherein the imaging system quantifies the adhered cells in each channel to measure the efficacy of a therapeutic treatment administered to a subject from which the cells are obtained.

52. The device of claim 44, the housing including a plurality of microchannels, each microchannel a separate cell adhesion region coated with at least one bioaffinity ligand.

53. The device of claim 52, at least two microchannels including different bioaffinity ligands.

54. The device of claim 52, at least three microchannels including different bioaffinity ligands.

55. The device of claim 52, the plurality of the microchannels including the same bioaffinity ligands.

56. The device of claim 52, at least one microchannel including at least two different bioaffinity ligands coated on the cell adhesion region of the microchannel.

57. The device of claim 52, wherein different bioffinity ligands are located at different positions within the cell adhesion region of at least one microchannel.

58. The device of claim 44, wherein the housing is a multilayer structure formed of a base layer, an intermediate layer, and a cover layer, the at least one microchannel being formed in the intermediate layer.

59. The device of claim 44, the housing including an inlet port and an outlet port in fluid communication respectively with a first end and a second end of each microchannel.

60. The device of claim 44, wherein the at least one microchannel is sized to accept microliter or milliliter volumes of blood or a solution containing cells to be adhered.

61. The device of claim 44, wherein at least one of the laminin, the selectin, the von Willebrands' Factor, the thrombomodulin and the C146 antibody are localized at different positions along the at least one microchannel.

62. A method, comprising:

providing a microfluidic biochip device, comprising a housing that includes at least one microchannel that defines at least one cell adhesion region, the at least one cell adhesion region being coated with at least one bioaffinity ligand that adheres a cell of interest when a fluid containing cells is passed through the at least one microchannel and an imaging system that measures the quantity of cells adhered to the at least one bioaffinity ligand within the at least one microchannel when the fluid is passed through the channels, the bioaffinity ligands comprising at least one of fibronectin, laminin, selectin, von Willebrands' Factor, thrombomodulin or a C146 antibody;

introducing a blood sample derived from a subject into the microchannel, wherein the blood sample comprises at least one blood cell; and

imaging the quantity of cells adhered to the at least one bioaffinity ligand within the at least one microchannel.

63. The method of claim 62, wherein the imaging system comprises a lensless imaging system.

64. The method of claim 63, wherein the lensless imaging system comprising a charged coupled device sensor and a light emitting diode.

65. The method of claim 62, wherein the quantity of adhered cells in each respective channel is indicative of the health of the subject from which the cells are obtained.

66. The method of claim 62, wherein the quantity of adhered cells in each respective channel is indicative of the progression of a disease of the subject from which the cells are obtained.

67. The method of claim 66, wherein the disease is sickle cell disease.

68. The method of claim 62, wherein the quantity of adhered cells in each respective channel is indicative of the efficacy of a therapeutic treatment administered to a subject from which the cells are obtained.