the World Health Organization 86:480-487 (2008); Makani et al., "Mortality in sickle cell anemia in Africa: a prospective cohort study in Tanzania" *PloS one* 6:e14699 (2011); and McGann et al., "A prospective newborn screening and treatment program for sickle cell anemia in Luanda, Angola. *American journal of hematology* 88:984-989 (2013). In all 50 states of America, and the District of Columbia, hemoglobin screening of newborns is mandated in order to diagnose SCD early, so that, monitoring and treatment can be started immediately. In: National Institutes of Health. The Management of Sickle Cell Disease 4th Ed., *NIH Publication No. 02-2117* NIH National Heart, Lung and Blood Institute (2002).

[0006] Early diagnosis through newborn screening, followed by simple interventions, has dramatically reduced the SCD related mortality in the US. However, these strategies have not been widely available in Africa and other third world countries, due to limited resources. What is needed is a point-of-care biochip-based hemoglobin screening method.

SUMMARY

[0007] Embodiments described herein relate to an electrophoresis biochip and system for detecting hemoglobin disorders, such as sickle cell disease (SCD). The biochip includes a housing, first and second buffer ports, a sample loading port, and first and second electrodes. The housing also includes a microchannel that extends from a first end to a second end of the housing. The microchannel contains cellulose acetate paper that is at least partially saturated with an alkaline buffer solution. The first buffer port and the second buffer 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 are capable of receiving the alkaline buffer solution that at least partially saturates the cellulose acetate paper. The sample loading port can receive a blood sample and extends through the first end of the housing to the microchannel and cellulose acetate paper. The first electrode and the second electrode can generate an electric field across the cellulose acetate paper effective to promote migration of hemoglobin variants in the blood sample along the cellulose acetate paper. The first electrode and second electrode can extend, respectively, through the first buffer port and the second port to the cellulose acetate paper.

[0007a] Disclosed is an electrophoresis chip, comprising:

a housing that includes a microchannel that extends through a portion of the housing, the microchannel containing an electrophoresis sieving medium;

means for introducing a sample to the microchannel and sieving medium;

a first electrode and a second electrode for generating an electric field along a length of the sieving medium, wherein the generated electric field induces migration and separation of components of the sample introduced into the opening, a portion of the housing being optically transparent for visualizing the migrated and separated sample.

[0007b] Also disclosed is an electrophoresis biochip for use in detecting hemoglobin variants, comprising:

a housing that includes a microchannel that extends through a portion of the housing, the microchannel containing a sieving medium;

means for introducing a blood sample to the microchannel and sieving medium;

a first electrode and a second electrode for generating an electric field along a length of the sieving medium, wherein the generated electric field induces migration and separation of hemoglobin variants in a blood sample introduced into the opening, a portion of the housing being optically transparent for visualizing the migrated and separated hemoglobin variants.

[0007c] In one aspect, there is provided an electrophoresis chip, 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 at least partially saturated with an alkaline buffer solution;

a sample loading port for introducing a sample to the microchannel and cellulose acetate paper;

buffer ports capable of receiving the alkaline buffer solution that at least partially saturates the cellulose acetate paper

a first electrode and a second electrode for generating an electric field along a length of the cellulose acetate paper, wherein the generated electric field induces migration and separation of components of the sample introduced into the sample loading port along the length of the cellulose acetate paper, a portion of the housing being optically transparent for visualizing the migrated and separated sample along the length of the cellulose acetate paper

[0007d] In another aspect, there is provided an electrophoresis biochip for use in detecting hemoglobin variants, comprising:

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

a sample loading port for introducing a blood sample to the microchannel and cellulose acetate paper;

buffer ports capable of receiving the alkaline buffer solution that at least partially saturates the cellulose acetate paper

a first electrode and a second electrode for generating an electric field along a length of the cellulose acetate paper, wherein the generated electric field induces migration and separation of hemoglobin variants in a blood sample introduced into the sample loading port along the length of the cellulose acetate paper, a portion of the housing being optically transparent for visualizing the migrated and separated hemoglobin variants along the length of the cellulose acetate paper

[0008] In some embodiments, the housing can include a viewing area for visualizing the cellulose acetate paper and hemoglobin variant migration. The electrophoresis biochip

CLAIMS

1. An electrophoresis chip, 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 at least partially saturated with an alkaline buffer solution;

a sample loading port for introducing a sample to the microchannel and cellulose acetate paper;

buffer ports capable of receiving the alkaline buffer solution that at least partially saturates the cellulose acetate paper

a first electrode and a second electrode for generating an electric field along a length of the cellulose acetate paper, wherein the generated electric field induces migration and separation of components of the sample introduced into the sample loading port along the length of the cellulose acetate paper, a portion of the housing being optically transparent for visualizing the migrated and separated sample along the length of the cellulose acetate paper.

2. The electrophoresis chip of claim 1, wherein the electrophoresis chip is part of a system comprising a portable, computer interfaceable imaging system for visualizing and quantifying sample migration along the length of the cellulose acetate paper.

3. The electrophoresis chip of claim 2, wherein the portable, computer interfaceable imaging system includes a camera that is used to image sample migration along the length of the cellulose acetate paper and a software application that recognizes pixel intensity of sample migration and quantifies sample migration along the length of the cellulose acetate paper.

4. The electrophoresis chip of claim 3, the housing including an optically clear area for visualizing the cellulose acetate paper and sample migration.

5. The electrophoresis chip of claim 4, wherein the housing comprises a top cap and a bottom cap, wherein at least one of the top cap or bottom cap includes optically transparent

glass or plastic.

6. The electrophoresis chip of claim 5, wherein the sample is a blood sample and the first electrode and second electrode generate an electric field effective to promote migration and separation of hemoglobin variants in the blood sample.

7. The electrophoresis biochip of claim 6, wherein the camera images hemoglobin variant migration and the software application that recognizes and quantifies the hemoglobin band types and/or density along the length of the cellulose acetate paper to aid screening decision or diagnosis.

8. The electrophoresis chip of claim 1, wherein the voltage applied by first electrode and the second electrode is in the range of about 1V to about 400 V.

9. The electrophoresis chip of claim 1, wherein the sample introduced into the cellulose acetate paper is less than 10 microliters.

10. The electrophoresis chip of claim 1, wherein the housing comprises a top cap, a bottom cap, and a cavity interposed between the top cap and the bottom cap, the cavity defining the microchannel in the housing.

11. An electrophoresis biochip for use in detecting hemoglobin variants, comprising:

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

a sample loading port for introducing a blood sample to the microchannel and cellulose acetate paper;

buffer ports capable of receiving the alkaline buffer solution that at least partially saturates the cellulose acetate paper

a first electrode and a second electrode for generating an electric field along a

length of the cellulose acetate paper, wherein the generated electric field induces migration and separation of hemoglobin variants in a blood sample introduced into the sample loading port along the length of the cellulose acetate paper, a portion of the housing being optically transparent for visualizing the migrated and separated hemoglobin variants along the length of the cellulose acetate paper.

12. The electrophoresis biochip of claim 11, wherein the electrophoresis chip is part of a system comprising a portable, computer interfaceable imaging system for visualizing and quantifying hemoglobin variant migration along the cellulose acetate paper.

13. The electrophoresis biochip of claim 12, wherein the portable, computer interfaceable imaging system includes a camera that images hemoglobin variant migration and a software application that recognizes and quantifies pixel intensity of the hemoglobin band types and/or density along the length of the cellulose acetate paper to make a screening decision or diagnosis.

14. The electrophoresis biochip of claim 13, the housing including an optically clear area for visualizing the cellulose acetate paper and hemoglobin variant migration.