

or function of the claimed invention. Rather, these terms are merely intended to highlight alternative or additional features that may or may not be utilized in a particular embodiment of the present invention.

For the purposes of describing and defining the present invention it is noted that the term “substantially” is utilized herein to represent the inherent degree of uncertainty that may be attributed to any quantitative comparison, value, measurement, or other representation. The term “substantially” is also utilized herein to represent the degree by which a quantitative representation may vary from a stated reference without resulting in a change in the basic function of the subject matter at issue.

All documents cited are incorporated herein by reference; the citation of any document is not to be construed as an admission that it is prior art with respect to the present invention.

While particular embodiments of the present invention have been illustrated and described, it would be obvious to one skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

What is claimed is:

1. A method of performing gradient elution moving boundary electrophoresis (GEMBE) to separate of complex samples having charged particulates and oppositely charged analytes, the method comprising:

introducing a run buffer into a separation channel having an inlet end, an outlet end, and a length extending therebetween;

introducing the complex sample into a sample reservoir in fluid contact with the separation channel, wherein the complex sample was subject to no sample preparation or was subject to minimal sample preparation selected from the group consisting of dilution, suspension, and combinations thereof; and

separating the charged particulates and the oppositely charged analytes via GEMBE by:

applying an electric potential along the length of the separation channel to achieve electrophoretic migration of the oppositely charged analytes; and

varying with respect to time the bulk flow of the run buffer through the separation channel concurrent with application of the electric potential to achieve selective introduction of the oppositely charged analytes into the inlet end of the separation channel and differential migration of the oppositely charged analytes therethrough, wherein the bulk flow of the run buffer is varied in a direction substantially aligned with the electric potential, and wherein the bulk flow comprises a combination of electroosmotic flow and controlled, variable pressure-driven flow that is varied over time, such that:

the oppositely charged analytes are selectively introduced into the inlet end of the separation channel and are sequentially detected and quantified in the separation channel.

2. The method of claim 1, wherein the complex sample is at least one of soil, sediment, mud, dirt, milk, apple juice, estuarine sediment, coal fly ash, tomato leaves, peach leaves, citrus leaves, or calf serum.

3. The method of claim 1, wherein the charged particulates are negatively charged.

4. The method of claim 1, wherein the charged particulates are positively charged.

5. The method of claim 1, wherein the separation channel is a capillary tube or a microfluidic channel.

6. The method of claim 1, wherein a dynamic coating is applied to the separation channel.

7. The method of claim 1, wherein the variable, pressure-driven flow is decreased over time.

8. The method of claim 1, wherein the variable bulk flow is controlled by a regulated pressure control device.

9. The method of claim 8, wherein the regulated pressure control device creates a pressure differential across the inlet end and the outlet end of the separation channel.

10. The method of claim 9, wherein the pressure differential is from about $-60,000$ Pa to about $60,000$ Pa.

11. The method of claim 9, wherein the pressure differential varies with time at a rate of from about -1 Pa/s to about -1000 Pa/s.

12. The method of claim 9, wherein the pressure differential varies with time at a rate of from about -10 Pa/s to about -500 Pa/s.

13. The method of claim 1, wherein the complex sample was subject to no sample preparation prior to introduction into the sample reservoir.

14. The method of claim 1, wherein the complex sample was subject to the minimal sample preparation prior to introduction into the sample reservoir.

15. The method of claim 1, wherein the complex sample is in fluid contact with the separation channel continuously throughout the GEMBE.

16. The method of claim 1, wherein only oppositely charged analytes having electrophoretic velocities greater than a velocity of the bulk flow of the run buffer are selectively introduced into the inlet end of the separation channel.

17. The method of claim 1, wherein the pressure-driven flow is varied continuously with time.

18. A method of performing gradient elution moving boundary electrophoresis (GEMBE) to separate complex samples having charged particulates and oppositely charged analytes, the method comprising:

introducing a run buffer into a separation channel, wherein the separation channel has an inlet end, a sample reservoir at the inlet end, an outlet end, a length extending from the inlet end to the outlet end, and a buffer reservoir at the outlet end, and wherein the sample reservoir and the buffer reservoir are in fluid contact via the separation channel;

introducing the complex sample into the sample reservoir, wherein the complex sample is unfiltered; and

separating the charged particulates and the oppositely charged analytes via GEMBE by:

applying an electric potential along the length of the separation channel to achieve electrophoretic migration of the oppositely charged analytes; and

varying with respect to time the bulk flow of the run buffer through the separation channel concurrent with application of the electric potential to achieve selective introduction of the oppositely charged analytes into the inlet end of the separation channel and differential migration of the oppositely charged analytes therethrough, wherein the bulk flow of the run buffer is varied in a direction substantially aligned with the electric potential, and wherein the bulk flow comprises a combination of electroosmotic flow and con-