

Thus, there is a need in the art to improve the process of purifying biological samples without the need for expensive and highly specialized equipment.

SUMMARY

5 Examples of the present technology uses electric fields and/or gels, such as polyether compounds, to separate bioanalytes from a biological sample contained on a substrate. According to a first example of the technology, a method for separating bioanalytes comprises: providing a first well and a second well that are connected to each other via a micro channel. A
10 fluid, such as a buffer, is provided in the first well into which the biological sample is placed. Magnetic beads, for example, magnetic particles based on polyvinyl alcohol (M-PVA Magnetic Beads) are then introduced into the first well. The surfaces of the M-PVA Magnetic Beads can be functionalized with many different groups and modified with individually tunable loadings. In one
15 example, the M-PVA Magnetic Beads can be tuned to isolate nucleic acids in the biological sample, which may comprise blood.

 The M-PVA Magnetic Beads isolate nucleic acids in the biological sample and draw the target molecules to the M-PVA Magnetic Beads. An electric field is then applied to the first well that interacts with negatively
20 charged contaminants in the buffer. A magnet, external to the first well, is then brought in proximity to the first well. The magnet functions to attract the M-PVA Magnetic Beads such that, when the magnet is externally moved toward the microchannel, the M-PVA Magnetic Beads along with the target molecules attracted thereto, are pulled toward and into the microchannel. However, most
25 of the negatively charged contaminants are maintained in the first well due to their interaction with the electric field. The magnet continues along its path in the microchannel toward the second well pulling the M-PVA Magnetic Beads and target molecules into the second well. The microchannel also contains a buffer and the movement of the M-PVA Magnetic Beads through the buffer in

in the first well, the second well and the microchannel. The method further comprises the steps of placing the biological sample into the first well, introducing magnetic beads into the first well and drawing target molecules within the biological sample to the magnetic beads. The method still further

5 comprises the steps of applying an electric field to the first well, the electric field interacting with the contaminants, introducing a magnet generating a magnetic field into the vicinity of the first well, the magnet field interacting with the magnetic beads and moving the magnet toward the microchannel, the magnetic beads being drawn along with the movement of the magnet such that the

10 magnetic beads and the target molecules are drawn into the microchannel. The method is provided such that the electric field acts on the contaminants so as to maintain the contaminants in the first well as the magnetic beads and target molecules move into the microchannel. Finally, the method comprises the step of moving the magnet toward the second well, the magnetic beads and target

15 molecules being drawn along with the movement of the magnet such that the magnetic beads and target molecules are drawn into the second well. In one aspect, the present disclosure refers to a method for removing one or more contaminants from a biological sample, the method comprising: providing a first well and a second well connected to each other via a microchannel; placing the

20 biological sample into the first well; introducing magnetic beads into the first well to attract target molecules within the biological sample; applying an electric field across the microchannel, the electric field adapted to interact with at least some of the one or more contaminants; introducing a magnet generating a magnetic field into the vicinity of the first well, the magnetic field interacting with

25 the magnetic beads; and moving the magnetic beads into and through the microchannel and to the second well by moving the magnet; wherein, while moving the magnetic beads into and through the microchannel and to the second well by moving the magnet, the electric field acts on at least some of the one or more contaminants to maintain at least some of the one or more

contaminants in the microchannel as the magnetic beads and attracted target molecules move through the microchannel and to the second well.

In another example, a system for removing contaminants from a biological sample is provided comprising a first well adapted to contain a fluid and receive the biological sample, a second well adapted to contain a fluid and a microchannel extending between the first well and the second well. The system is provided such that magnetic beads are adapted to be introduced into the first well, the magnetic beads tuned to attract target molecules in the biological sample. The system further comprises a source of electrical power and two probes coupled to the source of electrical power, the two probes adapted to apply an electric field to the first well. The system is provided such that when electrical power is applied to the two probes, the two probes are adapted to generate an electric field there between with the contaminants interacting with the electric field. The system still further comprises a magnet adapted to be moved into the vicinity of the first well, the magnet is adapted to generate a magnetic field to interact with the magnetic beads. The system is

further provided such that the magnet is provided to be moved toward the microchannel so that the magnetic beads are drawn along with the movement of the magnet and into the microchannel. Additionally, the electric field is adapted to interact with the contaminants such that the contaminants are maintained in the first well and the magnet is adapted to move toward the second well such that the magnetic beads and target molecules are drawn into the second well. In another aspect, the present disclosure refers to a system for removing one or more contaminants from a biological sample, the system comprising: magnetic beads that are tuned to attract target molecules from the biological sample; a first well adapted to contain the biological sample and the magnetic beads; a second well adapted to contain the biological sample and the magnetic beads; a microchannel extending between the first well and the second well; a magnet adapted to be moved into the vicinity of the first well, the magnet adapted to generate a magnetic field to interact with the magnetic beads, the magnet further capable of moving the magnetic beads from the first well to the second well via the microchannel; a source of electrical power and two probes coupled thereto, the two probes adapted to apply an electric field across the microchannel when the source provides electrical power, such that when the magnetic beads are moved by the magnet from the first well to the second well via the microchannel, the electric field interacts with at least some of the one or more contaminants to maintain at least some of the one or more contaminants in the microchannel as the magnetic beads and attracted target molecules move from the first well to the second well.

The M-PVA Magnetic Beads isolate nucleic acids in the biological sample and draw the target molecules to the M-PVA Magnetic Beads. A magnet, external to the first well, is then brought in proximity to the first well. The magnet functions to attract the M-PVA Magnetic Beads such that, when the magnet is moved toward the microchannel, the M-PVA Magnetic Beads along with the target molecules attracted thereto, are pulled toward and into the microchannel. The microchannel is filled with a polyether compound, such as,

polyethylene glycol (PEG) also known as polyethylene oxide or polyoxyethylene depending on its molecular weight. The contaminants are negatively charged particles. When the negatively charged contaminants are drawn into the PEG, the PEG functions to block progression of those negatively charged species
5 through the microchannel.

The magnet continues along its path in the microchannel toward the second well pulling the M-PVA Magnetic Beads and target molecules into the second well. By the time the M-PVA Magnetic Beads reach the second well, the target molecules are essentially free of contaminants, which have been
10 shed in the PEG.

At this point, the M-PVA Magnetic Beads can be withdrawn from the second well with the target molecules still attached and placed into a chamber where the M-PVA Magnetic Beads can be de-tuned to shed the target molecules and then be removed. The result is a very clean biological sample
15 that is essentially free of contaminants. There is no need for expense or specialized equipment, such as is needed for centrifugation, chemical

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for removing one or more contaminants from a biological sample, the method comprising:

providing a first well and a second well connected to each other via a microchannel;

placing the biological sample into the first well;

introducing magnetic beads into the first well to attract target molecules within the biological sample;

applying an electric field across the microchannel, the electric field adapted to interact with at least some of the one or more contaminants;

introducing a magnet generating a magnetic field into the vicinity of the first well, the magnetic field interacting with the magnetic beads; and

moving the magnetic beads into and through the microchannel and to the second well by moving the magnet;

wherein, while moving the magnetic beads into and through the microchannel and to the second well by moving the magnet, the electric field acts on at least some of the one or more contaminants to maintain at least some of the one or more contaminants in the microchannel as the magnetic beads and attracted target molecules move through the microchannel and to the second well.

2. The method of claim 1, further comprising:

withdrawing the magnetic beads from the second well;

inserting the magnetic beads into a container including a fluid; releasing the target molecules from the

magnetic beads; and removing the magnetic beads from the container.

3. The method of claim 1, further comprising:

providing a third well and a second microchannel, the third well connected to the second well via the second microchannel;

moving the magnetic beads and target molecules through the second microchannel and to the third well using the magnet.

4. The method of any one of claims 1 to 3, further comprising:

providing a buffer within the microchannel, the buffer to separate at least some of the one or more contaminants from the target molecules in the microchannel.

5. The method of any one of claims 1 to 4, further comprising:

providing a fluid in the first well, the second well, and the microchannel; and

creating a volume differential of the fluid between the second well and the first well such that a flow of the fluid is created in the microchannel from the second well toward the first well.

6. The method of any one of claims 1 to 5, further

comprising: stirring the biological sample in the first well.

7. The method of any one of claims 1 to 6, further

comprising: heating the biological sample in the first well.

8. The method of any one of claims 1 to 7, wherein applying an electric field across the microchannel includes disposing a first probe in the first well and a second probe in the second well, the first probe and the second probe having opposite polarities.

9. The method of any one of claims 1 to 8, further comprising providing a third well in communication with the microchannel and a fourth well in communication with the microchannel, wherein applying an electric field across the microchannel includes disposing a first probe in the third well and a second probe in the fourth well, the first probe and the second probe having opposite polarities.

10. A system for removing one or more contaminants from a biological sample, the system comprising:

magnetic beads that are tuned to attract target molecules from the biological sample;

a first well adapted to contain the biological sample and the magnetic beads;

a second well adapted to contain the biological sample and the magnetic beads;

a microchannel extending between the first well and the second well;

a magnet adapted to be moved into the vicinity of the first well, the magnet adapted to generate a magnetic field to interact with the magnetic beads, the magnet further capable of moving the magnetic beads from the first well to the second well via the microchannel;

a source of electrical power and two probes coupled thereto, the two probes adapted to apply an electric field across the microchannel when the

source provides electrical power, such that

when the magnetic beads are moved by the magnet from the first well to the second well via the microchannel, the electric field interacts with at least some of the one or more contaminants to maintain at least some of the one or more contaminants in the microchannel as the magnetic beads and attracted target molecules move from the first well to the second well.

11. The system of claim 10, further comprising:

a third well; and

a second microchannel, said third well connected to the second well via the second microchannel;

wherein the magnet is adapted to move along the second microchannel from the second well to the third well to move the magnetic beads and target molecules from the second well to the third well.

12. The system of claim 10 or 11 further comprising:

a fluid in the first well, the second well, and the microchannel; and

a volume differential of the fluid between the second well and the first well, the volume differential adapted to provide a flow of the fluid in the microchannel from the second well toward the first well.

13. The system of any one of claims 10 to 12, further comprising a magnetic stirrer adapted to stir the contents of said first well.

14. The system of any one of claims 10 to 13, further comprising a heater adapted to heat said first well.

15. The system of any one of claims 10 to 14, wherein a first one of the two probes is disposed in the first well and a second one of the two probes is disposed in the second well, the first probe and the second probe having

opposite polarities.

16. The system of any one of claims 10 to 15, further comprising a third well in communication with the microchannel and a fourth well in communication with the microchannel, wherein a first one of the two probes is disposed in the third well and a second one of the two probes is disposed in the fourth well, the first probe and the second probe having opposite polarities.