

inventive method for the use of the present device generally comprises (1) provide a biological sample containing a component labeled with a magnetic label; (2) introducing the biological sample to a microfluidic device comprising a magnetic microchannel under a condition whereby the labeled components are retained in the magnetic microchannel, while those that not labeled flow through. If the target analytes are retained in the channel, they can be washed at least once while retained in the channel. After the optional washing step, the target analytes can either be directly detected in the channel, or eluted from the microchannel for further processing and/or detection.

**[0293]** Target analytes, or other magnetic or magnetically-labeled particles, are retained in the channel as they are drawn to an area of high magnetic field strength within the channel. In a preferred embodiment, an area of high magnetic field strength is provided by magnetic beads within a wall of the channel. In yet another embodiment, an area of high magnetic field strength is provided by gradient inducing features within the channel, as described above. Thus, magnetic or magnetically-labeled particles may be retained in a channel despite surrounding fluid flow, as the magnetic or magnetically-labeled particles are attracted to areas of high magnetic field strength. Similarly, magnetic or magnetically-labeled particles may be separated within the channel according to their magnetic response.

**[0294]** In a preferred embodiment, the components in the sample are labeled in a labeling chamber integral to the inventive device, as outlined above. In another embodiment, they can be labeled in a separate device prior to the processing by the present device. Alternatively, the biological sample contains components that are intrinsically magnetic, i.e., possessing magnetic property without being attached to a magnetic label.

**[0295]** In a preferred embodiment, the biological sample is introduced into the magnetic microchannel through the sample inlet port. The amount of sample to be introduced each time depends on the concentration of the magnetic or magnetically labeled component in the biological sample. To achieve a maximum capturing efficiency, it is preferred that the total amount of the labeled components that is introduced into the magnetic microchannel does not exceed the amount that will saturate all sections of the channel comprising magnetic beads or gradient inducing features.

**[0296]** The sample can be introduced into the channel as a continuous flow through the channel. The flow rate of the sample can be slow, for example less than 1 mm/sec average velocity, for a greater capturing efficiency. Alternatively, the sample outlet port and the disposal port can be closed temporarily during the loading of the sample. Upon loading of the sample, the flow can also stopped temporarily to allow the magnetic or magnetically labeled component to be captured. After the capturing step, the uncaptured components are then disposed or collected as desired.

**[0297]** In a preferred embodiment, usually when the target analytes are retained in the magnetic microchannel, the channels are washed at least once, by running a sufficient volume of washing buffers through the magnetic microchannel. Various buffer can be used as a washing buffer, as long as they don't disrupt the binding between the target analytes and the binding ligand on the magnetic particle. For instance, phosphate buffered saline (PBS) can be conve-

niently used. The buffer can either be introduced into the microchannel through the sample inlet port, or through a separate fluidic inlet port. The resultant wash solution can then be disposed through the sample outlet port, or more preferably, the disposal port.

**[0298]** The washing buffer can be introduced into the channel in separate batches, each batch having a volume of or more than the chamber volume. Alternatively, the buffer can run through the channel as a continuous flow. When a continuous flow of washing buffer is running through the magnetic channel, one wash is achieved by running one chamber volume of the washing buffer through the channel. Similarly, more washes is achieved by running more than one chamber volume of the washing buffer through the channel.

**[0299]** In a preferred embodiment, the target analytes are eluted from the magnetic microchannel. The elution can be achieved in a variety of ways. For example, the target analytes can be eluted along with the magnetic labels by introducing magnetic ferrofluids into the channel or by reversing the polarity of the electromagnets that provide the magnetic field in the channel. Alternatively, the target analytes can be eluted by a releasing reaction, as outlined above.

**[0300]** In a preferred embodiment, the elution of the target analyte is achieved by supplying the magnetic microchannel with magnetic ferrofluid, i.e., a fluid containing a suspension or dispersion of particles with higher magnetization than those which are retained. The ferrofluid will effectively displace the retained materials in the magnetic microchannel or alter the characteristics of the overall magnetic environment in the magnetic microchannel, and thus result in the flow of the retained particles through the sample outlet port.

**[0301]** In a preferred embodiment when the magnetic microchannel comprise external electromagnets (in the case of embedded channel, coated channel, filled channel, and channel comprising a gradient inducing feature), elution of the target analyte can be achieved by reversing the polarity of the electromagnets. The change of the magnetic environment will then result in the release of the labeled material from the channel.

**[0302]** In a preferred embodiment, elution of the target analyte is achieved by releasing the target analytes from the magnetic labels, under a condition that disrupts the binding between the target analyte and the binding ligand on the magnetic particle, as fully described above.

**[0303]** In a preferred embodiment, the target analytes retained in the magnetic channel are further subjected to chemical reactions inside the channel, as has been described above for the reaction module. The products of such reactions can then be released from the channel and detected. If the reaction products are still attached to the magnetic labels, and are thus retained in the magnetic microchannel, they can either be eluted from the channel by the methods described above, or detected directly within the magnetic microchannel.

**[0304]** In a preferred embodiment, the target analytes or reaction products resulting from the target analytes are directly detected while they are retained in the magnetic microchannel. Preferably, the target analyte or the reaction product to be detected contain detection labels. The detection labels include, but is not limited to, fluorescent, chemi-