Magneto-capillary valve for integrated biological sample preparation using magnetic microcarriers

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A key challenge in point-of-care diagnostics is the integration of biological sample preparation. Magnetic microcarriers are very convenient for sample preparation, but it is difficult to miniaturize and integrate the required sequences of processes in a device technology. We report a novel microcarrier-based microtechnology in which magnetic particles are transported by magnetic forces through several stationary aqueous liquids separated by a capillary structure. The device consists of two microscope slides; the bottom one is completely hydrophobic, while the top substrate is patterned in hydrophilic and hydrophobic regions. In this way, fluid chambers and valve regions are defined. Since the transport of microcarriers between the liquids is based on a balance between magnetic and capillary forces, we have named it the magneto-capillary valve (MCV). In this presentation we will demonstrate that magnetic particles can be transported reproducibly between the aqueous liquids by magnetic forces. We will show that we can determine the magnetic forces applied on the magnetic particles and we will characterize the behavior of the valve in a model that balances magnetic forces, capillary forces and friction forces. Furthermore, we have investigated the valving efficiency of the MCV by monitoring the concentration of a fluorescent tracer in a purification procedure. For each crossing of particles over a MCV the dye concentration decreases by two orders of magnitude, which demonstrates very efficient purification. In addition, we have studied integrated nucleic-acid sample preparation and compared it to a standard manual procedure using Eppendorf tubes and a magnetic rack. The results demonstrate that the purification of DNA in MCV cartridges has a performance comparable to standard manual purification in tubes. We conclude that the MCV microtechnology opens new opportunities for integration and miniaturization of automated biological sample preparation and assays based on magnetic microcarriers.

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