Highly efficient DNA extraction with droplet-based microfluidics and magnetic microcarriers

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Fast, cheap and reliable DNA analysis tools are getting increasingly important for all kinds of diagnostics, including the detection of gene mutations, cancer diagnosis, and archeological or criminal identification. From the technological side the miniaturization of large-scale laboratory techniques onto the size of a chip offers interesting opportunities to develop DNA based diagnostic assays at the micro- and nanoscale.

In this research we have investigated the DNA extraction from a heterogeneous sample mixture with high efficiency using bio-functionalized magnetic microparticles in a droplet-based microfluidic system.

Droplets were formed in a water in oil system where the magnetic particles were suspended in the water phase and mixed with the sample (Fig.1A), which contained a heterogeneous mixture of DNA stands. Complementary DNA strands were immobilized on the magnetic particles, in order to bind the target DNA when the droplets pass through a mixing zone. The target strands were then separated from the non-specifically bound DNA strands using a magnetic splitter (Fig.1B). Through a T-junction the droplets split into two daughter drops while a magnet inserted close to the lower arm ensured that the target DNA was isolated into one daughter drop [1]. With this method Dittrich [1] presented a complete separation of warfarin using equal droplet split. Nevertheless to increase the extraction efficiency we had to concentrate the major part of the magnetic particles into a tiny daughter drop. Therefore the symmetric T-junction was modified, the narrow part of one arm was elongated which resulted an unequal droplet split. The splitting ratio depended on the asymmetry of the T-junction [2]. The DNA extraction efficiency was studied by using different size of particles and by changing the position of the magnet.

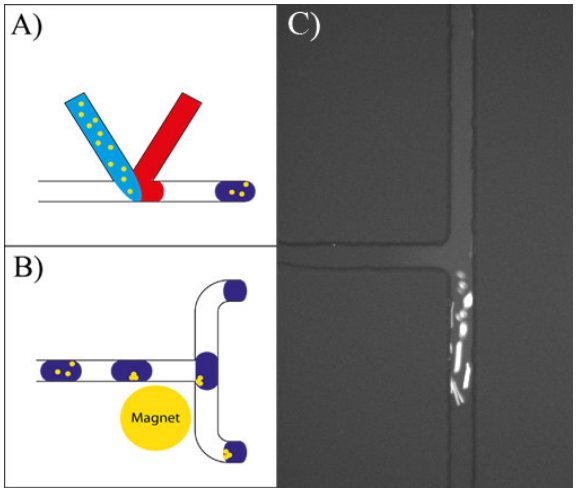

Fig.1. A Scheme of the droplet formation zone with magnetic particles and the sample mixture, **B** scheme of the magnetic splitter and the two daughter drops, **C** experimental image of the droplet containing magnetic particles inside the T-junction

[1] D. Lombardi, P.S. Dittrich, Anal. Bioanal. Chem. (2010), 399, 347-352
[2] J. Nie, R.T. Kennedy, Anal. Chem. (2010), 82, 7852-7856