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Miniaturization of analytical techniques—lab on a chip

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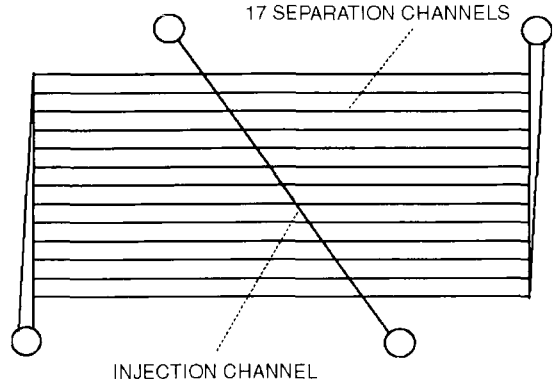
"What does not need to be big, will be small", a word by an engineer at a recent conference on chips technology. This sentence is particularly true for chemistry, where the standard entity is of nanometer size, a molecule, and for biology, where it is of micrometer size, a living cell. Nature has designed a variety of systems that are very small, and extremely competitive, like viruses.

In many areas of chemistry and biology there is no need for being big. Analytical sciences are concerned with obtaining information, e.g., the base sequence in a strain of DNA or the concentration of an impurity in a drug sample. In drug discovery, combinatorial chemistry and high throughput screening revolutionised the research labs, and there is no need for large quantities. Finally, microbiologists would appreciate to be able to manipulate single cells, follow its metabolisms and observe its behaviour.

Microfabrication technology emerged from microelectronics into areas like mechanics and now chemistry and biology. The engineering of micron and submicron sized features on the surface of silicon, glass and polymers opens a whole new world. Micromotors smaller than a human hair have been fabricated and they work fine. The coming century might provide us with credit cards or passports based on DNA fingerprints, with medical doctors that will tell us the results of clinical tests while we are still in the same consultation and with who knows what wonderful analytical instrumentation for our pharmaceutical investigations!

As an example for the potential of such chip microstructures I would like to show electrophoresis on chip. For high-throughput separation of compounds by capillary electrophoresis, a glass microstructure containing 1 injection channel, and 17 parallel channels has been developed. The device is tested for multiple injections of one sample and is controlled by only 4 electrodes. Theoretically, up to 17 samples in serial order can be injected into the 17 channels.



The device consists of mainly 50 x 10 μm capillaries. The parallel channels are located at distances of 500 μm. The introduction channel is placed at an angle to obtain identical distances between the electrodes at the ends of the parallel channels.

Preliminary results for injections only give throughputs of 1 Hz [86,000 injections per day]. Taking a typical separation time of 1 minute into account, a more realistic value might be 0.2 to 0.3 Hz. However, the interfacing of such high speeds with appropriate sample containers, e.g., micro well plates, is not engineered yet!

Reference for a general overview:

Manz, A., Becker, H. (1998) Micro system technology in chemistry and life sciences, Topics in Current Chemistry, Vol. 194, Springer Berlin