

Unconventional Calorimetry Using Segmented-Flow Technique

Solid Samples in Flow-Through & Dispersion Free Reaction Calorimetry

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The adaptation of the segmented-flow technology (SFT) to chip calorimetry extends its application range considerably, in particular for the study of (micro-)biological materials. Primarily, the SFT was developed to handle samples of picoliters or nanoliters in microfluidic systems. Samples dissolved or suspended in aqueous droplets are forced through the fluidic channels by a water-immiscible carrier liquid. Due to the interface tension, plug flow characteristic is achieved which is the precondition for an increased throughput. Moreover, the formation of spatially limited plugs enables the defined transport of solid or aggregated samples through the measuring device. As an effect of the viscous entrainment of the carrier liquid and the capillary pressure inside the droplets, a thin lubricant film is present between the droplets and the walls. The thin film protects the walls against contamination by the sample (e. g. biofilm formation) and prevents cross-talking.

In the presented work, we demonstrate the capability of a segmented flow chip calorimeter to analyze drug effects on cancer tissues in real-time. Samples of 1 mm³ of colorectal cancer tissue were treated with 5-Fluorouracil or staurosporine and subsequently analyzed by segmented flow chip calorimetry. The observed dynamics of the drug effects is characterized by defined inflection points in the heat rate curves.

The investigation of the effect of adrenalin and noradrenalin on the metabolism of daphnia demonstrated the excellent real-time capabilities of the used segmented flow chip calorimeter. The small thermal time constant of the calorimeter of only 25 s enabled the detection of drug caused changes in the motility of the daphnia in a frequency band-width of 0.02 Hz.

The growth of biofilms at the specifically prepared surface of small aluminum cylinders which were transported in segments containing nutrient medium was studied. The influence of the properties of the nutrient medium on the growth rate could be analyzed.

The controlled fusion of segments inside the measuring chamber offers opportunities for the design of new procedures for high-throughput reaction calorimetry. In case of an appropriate parameterization of the segmented flow regarding segment size and carrier flow rate, separate segments containing the reactants can be sequentially transported to the measuring chamber and merged therein at a defined position. First application examples will be presented.