Potentials and limitations of miniaturized calorimeters for bioprocess monitoring.

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Abstract

In theory, heat production rates are very well suited for analysing and controlling bioprocesses on different scales from a few nanolitres up to many cubic metres. Any bioconversion is accompanied by a production (exothermic) or consumption (endothermic) of heat. The heat is tightly connected with the stoichiometry of the bioprocess via the law of Hess, and its rate is connected to the kinetics of the process. Heat signals provide real-time information of bioprocesses. The combination of heat measurements with respirometry is theoretically suited for the quantification of the coupling between catabolic and anabolic reactions. Heat measurements have also practical advantages. Unlike most other biochemical sensors, thermal transducers can be mounted in a protected way that prevents fouling, thereby minimizing response drifts. Finally, calorimetry works in optically opaque solutions and does not require labelling or reactants. It is surprising to see that despite all these advantages, calorimetry has rarely been applied to monitor and control bioprocesses with intact cells in the laboratory, industrial bioreactors or ecosystems. This review article analyses the reasons for this omission, discusses the additional information calorimetry can

provide in comparison with respirometry and presents miniaturization as a potential way to overcome some inherent weaknesses of conventional calorimetry. It will be discussed for which sample types and scientific question miniaturized calorimeter can be advantageously applied. A few examples from different fields of microbiological and biotechnological research will illustrate the potentials and limitations of chip calorimetry. Finally, the future of chip calorimetry is addressed in an outlook.

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