SENSORS FOR SINGLE-USE BIOREACTORS – A REVIEW OF PERSPECTIVES AND CHALLENGES

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In recent years, single-use bioreactors have been increasingly used in bioprocess development and production [1]. Online measuring principles that take into account the specific requirements of these cultivation systems are therefore needed [2]. In biotechnological cultivations, a reliable real-time measurement of parameters such as pH, dissolved oxygen and biomass concentration is crucial. Reusable sensors have been successfully applied to conventional bioreactors for many years, but these sensors are not well-suited to single-use bioreactors in many respects (e.g. geometry, lifetime in use and storage, or wetted materials used). From a manufacturer’s point of view, since these sensors an integral part of a bioreactor, they may be considered as part of a new business model which takes into account customer demand for ready-to-use, pre-calibrated and fully qualified sensors.

Although they are well-established in laboratory and process applications, potentiometric glass pH electrodes are hardly ever used in single-use bioreactors. In these cultivation systems, optical pH sensors have become standard, regardless of their limitations (e.g. measuring range, long-term stability) [3]. Optical sensors are also well-established for measuring dissolved oxygen in conventional as well as single-use bioreactors [4].

The advent of single-use bioreactors has opened up new perspectives in sensor technology. As they are not steam-sterilized, sensors may be based on heat-labile materials such as polymers, dyes, or enzymatic recognition elements. For example, voltammetric all-solid-state sensors can be used to measure pH in these cultivation systems. Such sensors combine simple electrochemical transduction with an electrolyte-free, robust sensor design, resulting in a shelf-life of several months [5].

As a further advantage of single-use bioreactors, the thin, transparent polymer films applied may facilitate non-invasive measurement principles. For instance, RFID (radiofrequency identification) transponders can be used as sensing elements mounted to single-use bioreactors. These passive devices are operated non-invasively and may serve as sensing platforms for pH, conductivity, and temperature [6]. In addition, sensors for biomass concentration that are specially adapted to single-use bioreactors are now commercially available. They are based on the measurement of polarization of viable cells in an alternating electric field in the radio-frequency range. This measurement technique is useful for monitoring the growth of cell suspensions as well as organ cultures. If the frequencies are increased to the GHz range, completely non-invasive measurements are feasible [7].

To establish sensors in single-use bioreactors, it is important to keep the following key criteria in mind:
(a) Sensors must be developed specifically to make sure they meet the requirements of single-use devices.
(b) Standardization of ports, protocols or software is a key issue.
(c) Traceable standards and methods are a prerequisite to ensuring comparability of novel and established sensing schemes.

References