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Kenneth Reardon

*Colorado State University*, [kenneth.reardon@colostate.edu](mailto:kenneth.reardon@colostate.edu)

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## **SENSORS FOR CONTINUOUS MONITORING OF DISPOSABLE BIOREACTORS**

Kenneth F. Reardon, Department of Chemical and Biological Engineering, Colorado State University and  
OptiEnz Sensors, LLC  
Kenneth.Reardon@ColoState.Edu

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Continuous monitoring of biotechnological processes is important for control and optimization of quality and productivity. Typically, samples must be removed from the cultivation and analyzed in a laboratory to determine the concentrations of substrates and products. These time-delayed data cannot be used for real-time process control. The Process Analytical Technology initiative of the FDA supports the use of on-line measurement techniques for process development, production, and quality. Single-use systems are increasingly used in biotechnological applications, and face at least as many challenges as their stainless steel counterparts for process monitoring because the range of available sensors is limited to temperature, pH, and other parameters that do not directly reveal the progress of the cultivation. Furthermore, the requirements for sensors used in disposable reactors may be different than those for sensors for multi-use reactors. An overview of sensors will be presented, focusing on in-situ disposable sensors that contact the biological medium, and external sensors that contact the medium either optically (ex situ) or via a sterile (and disposable) sample removal system (on line). A specific example will then be presented: a new optical enzymatic sensor system for the continuous, direct, quantitative measurement of sugars and other organic molecules in aqueous media. This sensor system has three parts: a replaceable sensor tip, an opto-electronic hardware unit, and an optical fiber with a length appropriate for the application. The sensor tip includes a two-layer detection element – one layer containing a detection enzyme affixed to another fluorophore-containing layer. The change in fluorescence characteristics depends on the analyte concentration, and these sensors can be designed to provide quantitative output over different concentration ranges. These sensors can be sterilized with gamma irradiation. Performance metrics including the limit of detection have been determined glucose, lactose, and other analytes.