ABSTRACT

A multiplex gas sampler for monitoring CO₂ and O₂ for column-type bioreactors used in solid-state fermentation was designed. The sampler mechanically couples up to 24 bioreactors to a central set of CO₂ and O₂ sensors. The user can set fermentation time, the number of bioreactors to be sampled by the sampling port, the sampling rate and the delay time between sampling (to guarantee the complete replacement of a gas sample). The user has the possibility to enable or disable sampling from bioreactor-ports. Due to its small size and weight, the gas sampler is portable. This device is also quite economical. This gas sampler was validated using two solid-state fermentation experiments. First, the CO₂ and O₂ measurements were confirmed to be highly reproducible. No significant differences were found for the fermentations of 19 experimental units (bioreactors) simultaneously run with Rhizopus sp. cultured at the same conditions. Second, the versatility of the gas sampler, operating simultaneously with several microorganisms cultured at different conditions, was demonstrated through the simultaneous monitoring of A. awamori and Rhizopus sp. solid-state fermentations, cultured at different temperatures and pH. By using the multiplex gas sampler, the above study was done in only one set of experiments rather than in five sets of experiments that would have been required by using other samplers, representing a great time saving.

Keywords: gas sampler, monitoring of respirometry, solid-state fermentation, enzyme production

Introduction

Solid-state fermentation (SSF) is defined as the microbial culture developing on solid substrate, in the absence (or near absence) of free water; although the substrate must possess enough moisture to support growth and metabolism of microorganisms (14). SSF has been extensively used for the production of enzymes such as pectinases (1, 16), cellulases (4, 5) and lipases (6, 9, 20). SSF has several advantages over liquid fermentation, enzyme production


to be implemented in SSF. Respirometry (O₂ consumption and CO₂ production) represents the most convenient way for on-line monitoring of the microbial growth in SSF (8, 12, 26), and control algorithms have been designed for biomass growth based on O₂ and CO₂ measurements (22). Furthermore, enzymatic activity and respirometry can be correlated, which enables to estimate a suitable time to stop the fermentation, which is generally just before the desired enzyme activity is degraded by proteases (3, 10, 23, 24).

Monitoring CO₂ and O₂ in column-type bioreactors used in SSF still has some drawbacks. Monitoring different columns requires several gas sensors which must be manually installed in each column. In addition, the quantification of O₂ and CO₂ is typically performed with an expensive gas chromatograph. To solve these drawbacks, some interesting approaches have been developed to monitor microbial respirometry in SSF. Saucedo-Castañeda et al. (21) developed an on-line automated monitoring and control system for CO₂ and O₂ in SSF. Their system, based on electro-valves and coupled to a gas chromatograph, could monitor simultaneously eight different fermenters. A gas sensor system based in a commercial 16-position flow-through valve was used in SSF bioreactors (17, 18). Spier et al. (25) designed a data acquisition system for monitoring phytase production in SSF. This system was used to determine O₂, CO₂, temperature, volumetric flow rate and relative humidity. However, it could only be installed in one column.