

Yield determination by respirometry - The possible influence of storage under aerobic conditions in activated sludge

Klaus Dircks, Peter F Pind, Hans Mosbæk and Mogens Henze*

Department of Environmental Science and Engineering, Building 115, Technical University of Denmark, DK-2800 Lyngby, Denmark.

Abstract

In this study we found that the oxygen uptake rate (OUR) response from activated sludge to the addition of a single organic substrate can be divided into two phases. The first phase reflects the primary metabolism of the added substrate, while the second presumably originates from metabolism of stored polymers like polyhydroxyalkanoate (PHA) and/or glycogen produced during the metabolism of the exogenous substrate. This shift is due to the depletion of exogenous substrate. The obtained yield on acetate of 0.71 g COD/g COD correlates very well with experimental results in literature where addition of excess acetate to a pure culture led to extensive formation of polyhydroxybutyrate (PHB). Furthermore the highest obtained yield on glucose of 0.91 g COD/g COD is very close to the theoretical yield for formation of glycogen from glucose (0.96 g COD/g COD). This indicates that the response of activated sludge to a substrate addition is to store the substrate instead of an immediate growth response.

Introduction

The use of oxygen uptake rate (OUR) measurements for control purposes and as an experimental tool is rapidly increasing (Brouwer et al. 1994; Spanjers and Vanrolleghem, 1995; Smolders et al. 1997). By using it we can get more information on the biological wastewater treatment processes and the wastewater (Henze, 1992). The direct registration of the oxygen consumption rate in a biological process allows us to get a first insight into the metabolism of the micro-organisms. The consumption rate of the electron donor has for many years been the primary objective of these measurements, but a more detailed analysis of the data obtained allows us to extract more information from the OUR measurements. The coupling between oxygen and substrate consumption can be used to calculate the amount of substrate consumed. A key question in this calculation of the substrate consumption is the conversion factor, normally called the yield coefficient. If the yield coefficient used in the calculation is incorrect, then the calculated substrate consumption is false. Since many OUR experiments expose the biomass to significant substrate dynamics, the metabolic response need not be the traditional growth and oxidation only. There is thus a need for a more detailed analysis of OUR curves and the associated yields in order to learn more details of the fate of the substrate in the metabolic process. This paper analyses the yield of activated sludge from full-scale treatment plants being subjected to OUR experiments with pure substrates.

Respirometric measurements

Empirically an OUR curve for a batch culture, to which an amount of substrate is added, can look like the one shown in Fig. 1.

When interpreting the OUR curve it is essential to know the respiration due to the biomass itself, called the endogenous respiration. This respiration is normally assumed to be caused by maintenance of the biomass. The concept is then to subtract this

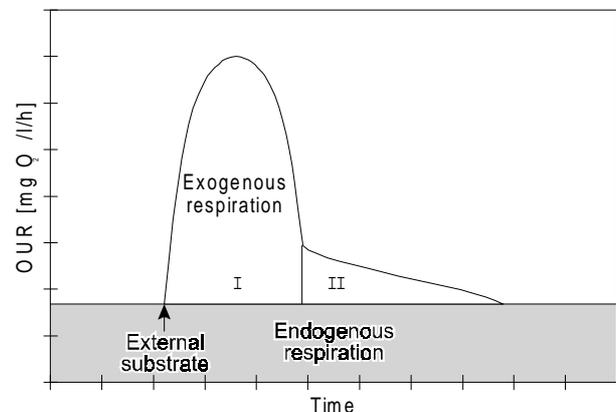


Figure 1

Example of a respirogram, where a pulse of organic substrate is added. If certain experimental conditions are met, the peak Phase (I) and the tail Phase (II) will be seen.

respiration from the measured respiration in order to determine the true yield coefficient. In this work the endogenous respiration used in all experiments is the original start respiration, the one measured in the sludge sample just before substrate is added.

It is obvious that the operation and design of the wastewater treatment plant (WWTP), including the composition of incoming wastewater and sludge age from where the activated sludge sample is taken, must play an important role for the experimental results obtained. This is demonstrated in Fig. 2 where the change in the endogenous respiration over time in the activated sludge used in an experiment is shown. The figure shows that the time before a relatively constant level of respiration is reached is very different for the two types of sludges investigated.

If the endogenous respiration is known then the exogenous respiration, which is due to added substrate, can be calculated. The amount of added substrate expressed as COD, which has been oxidised, is then equal to the white area in Fig. 1. In Fig. 1 the first part of the curve the peak (Phase I) has a similar shape to what has been reported in Kong et al., 1996. The OUR curve can then,

* To whom all correspondence should be addressed.

+45 4525 1477; fax +45 4593 2850; e-mail mh@imt.dtu.dk

Received 20 February 1998; accepted in revised form 17 June 1998.