ANAEROBIC DIGESTION OF CARBOHYDRATE AND PROTEIN-BASED WASTEWATERS IN FLUIDIZED BED BIOREACTORS

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***Abstract*— The present work is focused on evaluating the anaerobic digestion of complex substrates (proteins and carbohydrates) in anaerobic fluidized bed reactors (AFBRs). In a previous paper, an AFBR model was adjusted using only the experimental data obtained during the acclimatization stage (glucose and acetate-based feeding) of two mesophilic bioreactors. Here, the sensitivity of that model to represent the digestion processes of proteins such as gelatin and albumin, and sucrose as a carbohydrate, is analyzed. Some kinetic expressions and parameters for the enzymatic hydrolysis processes need to be modified to represent the real behavior of bioreactors. Under the analyzed operating conditions, a hydraulic retention time higher than 1 day is suggested to ensure good system efficiency.**

***Keywords*— Anaerobic processes, biofilms, complex substrates, dynamic modeling, fluidized bed bioreactor, wastewater treatment.**

I. INTRODUCTION

Most full-scale anaerobic reactors have been designed for treating wastewaters from the sugar, starch and brewery industries, where carbohydrates are the main pollutants (Fang and Yu, 2002). However, many industrial and agricultural wastewaters contain also a significant fraction of proteins, which are the main compounds responsible for the residual chemical oxygen demand (COD) in the effluent of anaerobic reactors processing domestic sewage.

Few studies have been carried out on how the use of multiple and complex substrates affects the degradation processes in a mixed anaerobic community developed inside a fluidized bed reactor (Borja *et al.*, 2004; Tsuneda *et al.*, 2002). At industrial scale, there is generally a pre-acidification tank where the complex organic matter is degraded into organic acids. Since the acidogenic reaction is usually rapid, this acidification tank is relatively small (hydraulic retention time HRT of 4 to 6 hours), which usually corresponds to an existing buffer tank.

Fluidized bed is one of the most widely used high-rate systems for the treatment of dissolved organic matter. This reactor type retains high attached biomass concentration on an inert support material, presents smaller pressure drop than fixed bed systems, shows no bed-clogging problems, demands small reactor volume and determines low external mass transport resistance when compared to other reactor configurations. However, some practical aspects need to be addressed. Due to the slow growth rate of the anaerobic consortium compared to the aerobic growth, anaerobic systems require long periods for starting up and recovering an efficient operation regimen after a sudden change of the organic load due to a perturbation of either the inlet flow rate or contaminant concentration. When the disturbance is on the inlet flow rate, the system hydrodynamics is significantly affected; whereas when a disturbance on the influent organic concentration occurs, the biological process rates govern the transient behavior of the system. However, the biological process rates affect the system hydrodynamics since variations on the biofilm concentration modifies the density of the support particles and, consequently, their fluidization characteristics. Therefore, an anaerobic fluidized bed reactor (AFBR) model is intended through its four major modeling tasks: (1) the anaerobic digestion model, (2) the biofilm model, (3) the bioparticle model, and finally (4) the hydrodynamic model.

In a previous paper (Fuentes *et al.*, 2007), the specific biofilm detachment rate coefficient (k_E) was estimated by adjustment of an AFBR model based on the anaerobic digestion model proposed by Angelidaki *et al.* (1999) (Fig. 1). The experimental data obtained from two mesophilic (36±1ºC) lab-scale AFBRs during the acclimatization stage (glucose and acetate-based feeding) were used. That paper was oriented to bioreactor modeling focused on hydrodynamics and parameter estimation. Afterwards, the experimental work was continued using the same experimental setup but adding complex substrates, such as proteins and carbohydrates, to bioreactor feeding. The present work is mainly focused on evaluating the model sensitivity for representing the experimental behavior when complex substrates are digested in AFB reactors.

Proteins such as gelatin and albumin, and sucrose as a carbohydrate, are used. Gelatin and albumin are often present in wastewaters. The former is present in animal connective tissue and is the main constituent of slaughterhouse and meat-processing wastewaters; and the latter is the main proteic component in raw palm oil and some food processing wastes, which have an important polluting effect (Fang and Yu, 2002; Yu and Fang, 2003).

In this context, the paper is organized as follows: in Section 2, main hypotheses and mathematical equations are presented. Characteristics of bioreactors and inert support materials, and the experimental protocol are