Effect of rheology on k_La and mixing time in 42&340L stirred reactors

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Abstract

Introduction

Ethanol production from cellulosic biomass requires enzymes which are produced in aerated bioreactors by submerged culture of the filamentus fungus *T.Reesei* (Marten et al., 1995; Reczey et al., 1996). The fermentation broth has a time-dependant rheology, characterized by a strong non-Newtonian shear thinning behaviour (Olsvik et al., 1994). The knowledge of mixing and transfer phenomena is a main issue for the scale-up of appropriate bioreactors. At the early steps of process development, only a small amount of broth is available. Model fluids of similar rheologies can be used to investigate bioreactor hydrodynamics. Homogenous polymer solutions such as CMC (Kawase et al., 1988; Yagi et al., 1975) are often used to simulate flow behaviour of filamentous fungi broths. According to some authors (Benchapattarapong et al., 2005; Olsvik et al., 1994), this choice is not satisfactory, because the microstructure of the media is not respected and it leads to underestimate both k_La and mixing time. Authors then suggest to use suspensions of cellulose fibres in a 0.1% CMC solution. Concerning *T.Reesei* broth, its rheology, during the growth step, is much more shear-thinning than CMC solutions or fibre suspensions, and fits much better with xanthan solutions. However, despite a large number of papers dealing with homogenous polymer solutions, the effect of the rheology on k_La is still not clearly known. For non-Newtonian fluids, literature mainly reports correlations based on apparent viscosity, i.e. viscosity corresponding to the mean shear rate in the reactor following a Metzner-Otto approach (Garcia-Ochoa et al., 2009). Independently of the filamentous structure contribution, it appears crucial to dissociate the rheological contribution (i.e. shear thinning behaviour) from the effect of apparent viscosity. This is the objective of this study, wherein behaviours of CMC and xanthane solutions of equivalent apparent viscosity are compared at two different reactor scales.

Experiments

42 and 340L volumes stirred vessels (H/T ratio of 1 and 2) of standard geometry are used to study mass transfer and mixing time inside 0 to 0.5% CMC and xanthan gum solutions, in a wide range of power consumptions (500 to 4500 W/m^3), gas velocities (3.9 and 7.9 mm/s) and impeller shapes: Rushton and/or Pitch Blades. k_La are calculated by the dynamic oxygen electrode method assuming a perfectly stirred model for the liquid

phase and plug flow for the gas. A particular care is dedicated to the power input measurement, determined by an optical-electronic device. Mixing times are measured by thermometric and image processing methods.

Results & Perspectives

Some mass transfer results obtained in the smaller vessel are reported in figure 1. For a given media, k_La mainly depends on the power input. The effect of the media is very important. In particular k_La in 0.5% CMC solutions are much more important than in 0.5% xanthan solutions, although both media have similar apparent viscosities at the mean shear rate in the vessel. In addition to apparent viscosity, the rheological behaviour in the range of shear rate present in the reactor impacts the mass transfer. As a conclusion, polymer solutions have to be used with caution to study the scale-up of bioreactors. In consideration of which this could be relevant to evaluate effects of rheology evolution between *T.Reesei* growth and enzyme production steps. Complex media including xanthan solution and cellulose fibres will be investigated in order to dissociate the impact of rheology and that of filamentous structure on hydrodynamics and oxygen transfer.

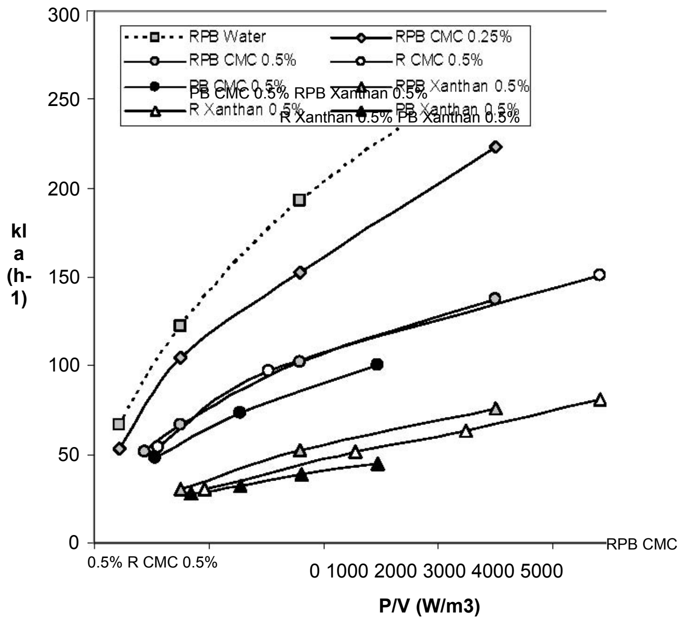

Figure 1 : k_La in water, 0.5% Xanthan and 0.25%-0.5% CMC solutions

V=20L, H/D = 1&2, V_{sg}=3.9mm/s.

R: Rushton, PB: Pitch Blades, RPB: Rushton+Pitch Bade

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