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Elucidating enzyme-based cleaning of protein soils (gelatine and egg yolk) using a scanning fluid dynamic gauge

Patrick W. Gordon[a], *Anju D.M. Brooker*[b], *Y.M. John Chew*[c], *Nathalie Letzelter*[b], *David W. York*[b], *D. Ian Wilson*[a,*]

[a] *Department of Chemical Engineering and Biotechnology, University of Cambridge, New Museums Site, Pembroke Street, Cambridge, CB2 3RA, UK*

[b] *Procter & Gamble Technical Centres Ltd., Whitley Road, Longbenton, Newcastle-upon-Tyne, NE12 9TS, UK*

[c] *Department of Chemical Engineering, University of Bath, Claverton Down, Bath, BA2 7AY, UK*

ABSTRACT

The enzyme-based cleaning of two model protein soils was investigated using a scanning fluid dynamic gauge (sFDG). The sFDG device allows data to be collected from more than one sample or location during a single experiment and therefore makes a range of comparative studies feasible. The sFDG was modified to allow the forces imposed on the surface to be controlled during a test. Gelatine films on stainless steel swelled in the presence of alkali at 20 °C but were not removed. Enzymes from a commercial dishwasher product interrupted swelling when the mean water volume fraction of the film reached ~0.9 and promoted removal. The enzyme effectiveness decreased over time. Egg yolk deposits (spray dried on mica) were studied in a protease/buffer solution at 40 °C. The deposits swelled on contact with alkali, and removal started after ~40 min. Some flow over the deposit was required to achieve complete cleaning, but the time taken to clean exhibited a weak dependence on the shear stress imposed by the flow for shear stresses above 10 Pa. The cleaning behaviour was strongly influenced by the nature of the deposit. Baking the deposit at 150 °C reduced the rate and extent of swelling as well as the rate of removal, and could result in the formation of a residual film that exhibited yield stress characteristics.

Keywords: Cleaning; Fluid dynamic gauging; Fouling; Protein; Swelling

1. Introduction

The growth or removal of soft-solid layers on process surfaces immersed in liquids is of interest to many industrial sectors, where the layer may be a biofilm, a polymer coating, or a fouling layer. These materials can pose measurement challenges as they are often heterogeneous, deform on contact, and collapse when removed from the liquid environment. Tuladhar et al. (2000) reviewed the techniques available to study such materials and noted that many required knowledge of the layer material's properties and so did not yield a direct measurement. Those techniques which do allow direct measurement often carry limitations, such as laser sheets (Mendret et al., 2007) where the liquid must be transparent, or magnetic resonance imaging (MRI, Creber et al., 2010) where the system must be free from materials that interfere with the magnetic field. Both require specialist apparatus and expert operators. Tuladhar (2001) developed fluid dynamic gauging (FDG) as an alternative, relatively cheap, non-contact measurement technique which can be used to track the thickness of such layers *in situ* and in real time.

Fig. 1(a) illustrates the key concepts behind the FDG technique. Flow behaviour is exploited to locate the layer surface: it is a non-contact technique, requiring that the surface is locally flat and stiff over the time and scale of the measurement. A small conical nozzle of throat diameter d_t is positioned close to the surface. A pressure difference, imposed between the bulk liquid and the nozzle discharge, draws liquid into this nozzle. Fig. 1(b) shows that the flow rate through the nozzle, m_f, is very sensitive to the clearance between the nozzle and the surface,

* *Corresponding author.* Tel.: +44 01223 334791; fax: +44 01223 334796.
E-mail address: diw11@cheng.cam.ac.uk (D.I. Wilson).

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