Available online at www.sciencedirect.com
ScienceDirect
Desalination 218 (2008) 238–247
DESALINATION
www.elsevier.com/locate/desal

Development and characterisation of a vacuum flash evaporator for concentrating a heat sensitive aqueous peptide stream

R.J. Macdonald*, P.G. Middlewood, R.L. MacManus

Canesis Network Limited, PO Box 4749, Christchurch, 8000, New Zealand
Tel. +64 (3) 321-8800; Fax +64 (3) 321-8811; email: becky.macdonald@agresearch.co.nz, Paul.middlewood@agresearch.co.nz, Rachael.macmanus@agresearch.co.nz

Received 6 November 2006; accepted 8 February 2007

Abstract

Canesis Network Limited, in conjunction with Keratec Limited, has developed a patented process for the chemical extraction of soluble keratin proteins from wool. This extraction process results in the generation of several protein-rich streams, including a dilute aqueous based peptide stream. This peptide stream requires concentration, and evaporation has been found to be a convenient method for achieving this. The peptide-containing stream is sensitive to heat damage. The existing evaporator has been found to be far from ideal for the application, with the harsh evaporation conditions resulting in damage to the peptides and undesirable darkening of the peptide solution. To overcome this, and increase product throughput, a new evaporator has been designed and built for this application. This study discusses the design and construction of this new, purpose built, flash type evaporator to evaporate the peptide stream in a vacuum. The study also details investigations undertaken to assess the performance of the evaporator and characterise the evaporation peptide stream. The overall outcome of this study has shown that the peptide stream can be successfully concentrated by evaporation using a flash evaporator operating under vacuum. Damage to the peptide stream can be minimised by controlling the evaporation conditions. Optimal operating conditions for processing the peptide stream have been identified. Investigations into the heat damage of keratin peptides and the effects of heat damage on the peptide offer an exciting opportunity for future research work.

Keywords: Peptide; Keratin; Protein; Wool; Biopolymer; Evaporation; Flash evaporation; Low pressure evaporation; Pilot scale; Scale up; Low temperature evaporation

*Corresponding author.

Presented in the Separation Sessions at Chemeca 2006, the 34th Australasian Chemical and Process Engineering Conference, Auckland, New Zealand, 17– 20 September 2006. Organised by the University of Auckland and the Society of Chemical Engineers New Zealand (SCENZ).

0011-9164/08/$– See front matter
doi:10.1016/j.desal.2007.02.019

1. Introduction

Canesis Network Limited (CNL) in conjunction with Keratec Ltd., have been researching the extraction of keratin protein from wool. An extraction process has been developed that extracts these bio-derived proteins from wool, retaining their high functionality and with minimum damage to the keratin protein molecules [1]. Purified biopolymer-rich streams from this process are dilute and require concentration to produce a commercially valuable product stream [2].

Evaporation is commonly used by various processing industries as a method of concentrating aqueous liquid streams by vaporising the water component [3]. However, the evaporation process can be harsh, with the process streams being concentrated exposed to elevated temperatures as part of the vaporisation process. This can result in damage to heat sensitive molecules [3]. Experience has shown that the keratin protein biopolymers extracted from wool are heat sensitive and can be damaged when exposed to elevated temperatures. Such heat damage is irreversible and reduces the commercial value of the extracted proteins [2].

2. Background

Early work investigating the use of evaporation to concentrate the keratin protein solutions was carried out using a second hand scraped film evaporator. This equipment was selected simply because it was readily available and of a suitable capacity. This offered an opportunity to assess the suitability of evaporation for this application whilst minimising both time and capital expenditure. However, the equipment was not ideal for processing the aqueous keratin streams, which are low viscosity, low concentration and susceptible to heat damage, as these evaporators are more typically used where the evaporating fluid has a high viscosity and a high solids content at the outlet (such as confectionary products) [3].

The early work using the scraped film evaporator established that evaporation was a suitable method for concentrating the keratin proteins. The outcome of the initial work was so successful that this technology was transferred over to the small pilot scale production facility being developed by Keratec to manufacture keratin polymers on a small scale. The scraped film evaporator was incorporated into the production line to allow commercial samples of the aqueous keratin protein solutions to be manufactured [3].

Pilot scale manufacturing quickly identified that the keratin proteins were sensitive to heat damage and that extreme care was required when processing these streams through the scraped film evaporator. Tight controls on the operating conditions for the evaporator were required, as even slight fluctuations from the optimal process conditions would adversely impact on the product quality [4].

While the scraped film evaporator operates at atmospheric pressure, which limits the scope for varying (and optimising) the processing conditions, optimal conditions for evaporation were identified, within the limitations of the equipment. Saturated steam was available for heating at typically 4 bar. However, this could vary depending on what upstream demands were being placed on the steam line. At times the steam supply pressure could fluctuate from 7 to 8 bar down to close to 1 bar over just a few minutes. This would severely impact on the performance of the evaporator with rapidly fluctuating steam pressure resulting in widely varying evaporation rates [4].

The scraped film evaporator was normally operated in a single pass mode, with process liquor passing from an inlet tank, through the evaporator to an outlet tank. Usually two to three separate passes were required to achieve sufficient concentration. The evaporator could be configured to operate in a recirculating mode, where the outlet fed back into the inlet tank, although this mode of operation was only used occasionally due to other operating and quality constraints [2].

The key indicator used to identify heat damage was product appearance. Heat damaged pro-