THE FEASIBILITY OF PERVAPORATION IN THE PURIFICATION OF ETHANOL

A thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Process and Environmental Technology at Massey University.

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1998

All animals, except man, know that the principal business of life is to enjoy it.

S. Butler.

Abstract

This study investigated how pervaporation could be incorporated into hybrid schemes for purifying ethanol produced from whey of fusel oils and whether this could be achieved at a lower energy cost than distillation alone whilst maintaining product quality within specification. In order to achieve these objectives the project included: investigation of fundamental pervaporation mechanisms and the influence of operation parameters, simulation of the distillation train at the New Zealand Distillery Co. Ltd. (NZDCL) including pervaporation relationships developed during this study, and pinch analysis of the NZDCL.

Aqueous solutions of 5 to 20% w/w ethanol with approximately 1% w/w of a mixture of *n*-propanol, *i*-butanol, *n*-butanol, *i*-amyl alcohol and ethyl acetate were pervaporated through a disk apparatus fitted with either poly-ether-block-amide (PEBA) or poly(dimethyl siloxane) membranes. Similar solutions were sorbed into PEBA beads for the study of sorption.

A new, semi-empirical relationship between enrichment factor of alcohols during pervaporation and their molecular size and activity coefficient in the feed stream was proposed. It was observed that for organophilic membranes, sorption generally sets the enrichment factor while the influence of diffusion becomes relevant only when the distribution range of the size of the molecules involved is quite large. In consequence, it is recommended that the study of sorption and diffusion relationships between solvents and dense polymers be given priority as they are relevant for the fast development of this technology.

During pervaporation, the temperature of the feed affected mainly the process economics, as an increase in temperature resulted in an exponential increase in the total flux, without significantly changing the product composition.

The flux of the minor components studied was independent of the total flux through the membrane except for the *i*-amyl alcohol, which had its flux influenced by the total flux possibly due to its higher concentration.

For the removal of fusels from the fermentation broth with organophilic membranes, all three commercially available membranes investigated presented similar enrichment factors and, compared to evaporation, did not significantly improve the separation of fusels from ethanol. The membranes investigated differed amongst each other with respect to their total flux; the higher the flux through the membrane, the lower the membrane area required for a specific separation.

Hydrophilic membranes were used to remove the water fraction at an earlier stage of distillation. Simulation and experiments of the new process showed that it was possible to reduce design complexity and energy expenditure by approximately ten percent. This process could become economically feasible if membrane price dropped by over 60%.

Pinch analysis and simulation results of distillation were combined to investigate immediate opportunities to reduce energy usage at NZDCL. Changes in the heat exchanger network and in the distillation feed temperature could reduce production costs (steam usage) without compromising product quality and plant flexibility.

Acknowledgements

I would like to thank my supervisors *John Mawson* and *Don Cleland* for the opportunity to do this work and for their trust, guidance, and support throughout my studies, I thank *Stephen White* and *Prof. Ross Taylor* (Clarkson University, USA) for the constructive criticism and for sharing their knowledge in moments of need.

I would also like to thank *Moacir Kaminski*, professor at the Federal University of Paraná, Brazil, and *Edgar Liebold*, of BASF Ludwigshafen - AG, Germany, for their unconditional friendship, support, and help in the technical or personal aspects of this thesis.

This thesis could not have been completed without the dedication of all staff at the New Zealand Distillery Co. Ltd., that collected samples and helped me throughout the project by providing information freely and accurately; the technical staff at the Institute of Technology and Engineering at Massey University, that built and kept all experimental apparatus in running condition; and the Library staff.

Many a Wednesday or Thursday evening was spent in the company of *Stephanie* and *Camille*, who kept me sane, in touch with the world around, and motivated to bring this work to completion.

I thank my parents and sister, *Henrique, Heloisa* and *Eliane*, for their love and trust. Last but not least, I would like to thank *Stephen van Eyk* for sharing his wisdom through the ups and downs of the past four years, supporting me with his love, understanding, and endless faith.

This project was supported financially by the New Zealand Distillery Co. Ltd., the ECNZ, the BoP Electricity, and by Massey University. Pervaporation membranes were generously supplied by GFT/Deutche Carbone AG and GKSS Forschungszentrum, Germany. Membrane polymers were supplied by GKSS and Elf-Atochem (Pty) Australia.

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