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Darren L. Oatley-Radcliffe, Steffan R. Williams, Thomas J. Ainscough, Christopher Lee, Daniel J. Johnson, Paul M. Williams

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Experimental determination of the hydrodynamic forces within nanofiltration membranes and evaluation of the current theoretical descriptions

Darren L. Oatley-Radcliffe*, Steffan R. Williams, Thomas J. Ainscough, Christopher Lee, Daniel J. Johnson, Paul M. Williams

Centre for Water Advanced Technologies and Environmental Research (CWATER), College of Engineering, Swansea University, Singleton Park, Swansea SA2 8PP, UK.

* to whom correspondence should be addressed

Tel: + 44 (0)1792 606 668

Email address: d.l.oatley@swansea.ac.uk

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Abstract

In this study a series of different molecular weight PEG solutions have been characterised for particle size and the results have been used, in conjunction with several other techniques, to determine the pore size of the Nadir UH004 membrane. The resulting information, in conjunction with experimentally determined rejection profiles for the PEG solutions, has then been used to back calculate the hindrance factors for nanofiltration rejection theory. These experimentally derived values obtained for the hindrance factors were found to be in close agreement with the widely accepted theoretical predictions derived from hydrodynamic theory for micro and ultrafiltration. To our knowledge, this is the first experimental validation of these hindrance factors for nanofiltration and suggests that the correlations found throughout the literature are accurate enough for the calculation of hindrance factors describing the hydrodynamic drag forces experienced by a solute inside a nanopore.

1.0 Introduction

Membrane based processes for the separation and concentration of valuable compounds have received significant attention in the past three decades and the future remains promising with significant growth expected. The driving factors for growth in membrane technologies are attributed to the ease of operation and scale up, low operational cost, low energy requirement and high selectivity factors [1]. Nanofiltration (NF) is a pressure driven membrane separation technique situated between ultrafiltration and reverse osmosis. NF membranes are typically polymeric, asymmetric and consist of a low resistance support layer with a functionally active porous top layer [2, 3]. The nominal molecular weight cut-off of an NF membrane is in the range 100-1000 Da, indicating that the NF membrane active layer has an approximate pore size of 1 nm.

NF is an extremely complex process and is dependent on the micro-hydrodynamic and interfacial events occurring at the membrane surface and within the membrane nanopores. The nano-scale phenomena involved in neutral and charged solute separations by NF are extremely complex and, as such, are likely to be a rigorous test of any macroscopic description of ion transport and partitioning. The optimisation of NF membrane equipment along with an expansion in potential applications would be greatly facilitated if simple, accurate and quantitative methods for predicting process

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