Title: A miniature membrane reactor for evaluation of process design options on the enzymatic degradation of pectin

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Abstract: The objective of this paper is to assess if a membrane microbioreactor system could potentially be used to diagnose consequences of different process design and reactor operation options relevant for larger-scale enzymatic degradation of pectin reactions. The membrane microbioreactor prototype was fabricated from poly(methylmethacrylate) (PMMA) and poly(dimethylsiloxane) (PDMS) with a working volume of ~190 µL. The prototype also contained the necessary sensors and actuators, i.e., pressure transducer, mixing via magnetic stirrer bar and a temperature controller. The functionality of the prototype was demonstrated by performing a continuous enzymatic degradation of pectin experiment for a range of reactor conditions: different membrane molecular weight cutoff (MWCO) values, enzyme-to-substrate ratios (E/S), and substrate feeding rates (F) were assessed. Based on the experimental data, it was found that the apparent reaction rate increased from 0.11 µmol/h to 0.13 µmol/h when the E/S ratio was doubled from 0.2% (g/g) to 0.4% (g/g). In contrast, when the substrate feeding rate was reduced from 200 µL/h to 100 µL/h (i.e., longer residence time), a higher yield was achieved (producing a pectin fragment concentration of 0.82 mM in the permeate) and the apparent reaction rate increased by ~50% (i.e., from 0.11 µmol/h to 0.17 µmol/h). Clearly, this signifies that the substrate feeding rate is a critical variable that influences the conversion rate and the process yield. The data also showed that the process design affected the membrane rejection profile. The results obtained thus underlined the suitability of a miniature membrane reactor system for evaluating different process design options that are relevant for larger-scale reactions of enzymatic pectin degradation.