CHARACTERIZATION OF MEMBRANES FOR ENZYME RETENTION

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Soluble enzymes can be used in ultrafiltration membrane reactors to achieve continuous operation at enforced flow (convective) mode. The main difference between normal ultrafiltration for concentration processes and the use for reaction engineering purposes is that—in the later case—the enzyme has to stay for extended periods of time with little loss of protein. For this special case the integral loss governs the performance—as shown in Figure 1 for 4 different rejection coefficients (R). Even a very high retention (99%) yields a loss of enzyme of 40% after 50 times the mean residence time. When the mean residence time lies within a period of one hour, a retention of 99% would lead to a "half life" of activity of about 2.5 days, not taking into account the normal deactivation.

The retention characteristic of a capillary membrane module has been characterized taking into account the hydrodynamic conditions in the capillaries. The retention has been calculated for the values obtained after establishment of equilibrium—which often exceeds 20 mean residence times. In (Figure 2) the retention characteristic of a capillary membrane module BPR 10 00 15 (Berghof) is given as function of the Reynolds' number in the capillaries with varied cross-membrane flow rates (V).

The resulting curves can be interpreted taking into consideration two different effects decreasing the retention.

First of all a concentration polarization layer should enhance the loss of protein—this effect is the highest at low Reynolds' numbers. On the other hand high Reynolds' numbers cause
an increase in pressure drop along the capillaries, leading to a non-uniform cross-membrane flow. This seems to lead to an increased polarization in the beginning of the capillaries and therefore to a decrease of the rejection coefficient. The optimal Re-number lies below the turbulent flow region.

Another aspect is very interesting for technical applications: normal commercially available enzymes are crude preparations and the impurities will have a cooperative effect on the retention of the active protein fraction. In Figure 3 the effluent concentra-

![Graph showing retention as function of the operation time.](image1)

**Fig. 1.** The overall retention as function of the operation time.

![Graph showing retention as function of inner capillary Reynolds' number and varied cross-membrane flow rates.](image2)

**Fig. 2.** Retention as function of inner capillary Reynolds' number and varied cross-membrane flow rates (\( V \)).