Enzyme membrane reactor technology as a promising tool to increase enzyme efficiency

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Economic development of the enzyme market

Today, enzymatic biotransformations are already utilized in agricultural, food, pharmaceutical and chemical industry. The advantages of using enzymes include:

» High substrate selectivity (high product quality)
» Use of moderate process temperatures and pH values
» No toxic catalysts or solvents are needed

The global market for industrial enzymes valued $3.5 billion in 2011 and is expected to reach over $4.4 billion by 2015 [1]. Enzymes for food and beverage holding the dominant part with a market share of 38 % (figure 1 A). Carbohydrases (enzyme that catalyzes the breakdown of carbohydrates) and peptidases (enzyme that catalyzes the breakdown of proteins) represent the largest segments in the global market (figure 1 B).

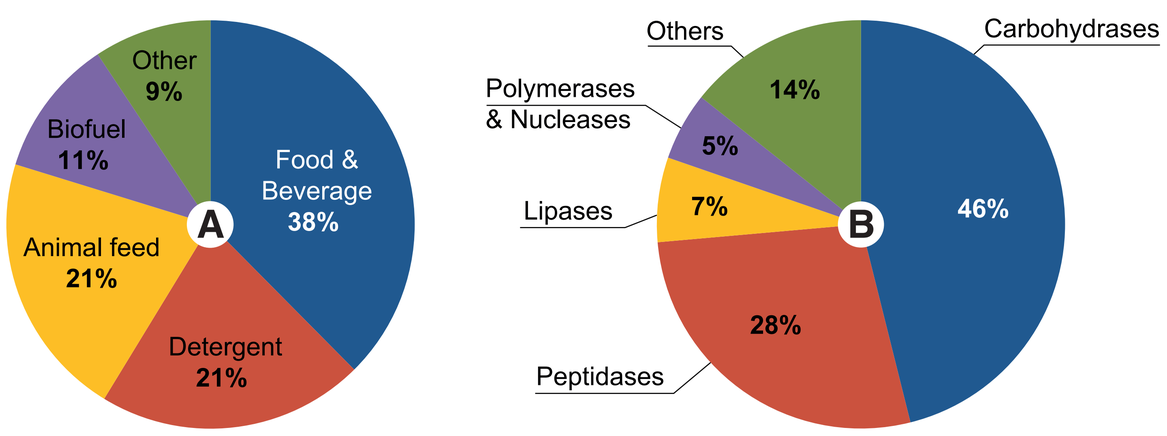

Figure 1: Global enzyme market revenue in 2013 shared by application (A) and by enzyme class (B) [1].

From 2001 to 2011 the global market represented an annual growth rate of 6.8 % and a continuing growth of 6.1 % is expected per year. Higher consumer demands in food quality leads to new enzyme applications in food processing. Therefore, enzymes in food and beverage applications are expected to reach a market revenue of over $1.3 billion by 2015 (figure 2), with the highest sales in the milk and dairy segment.

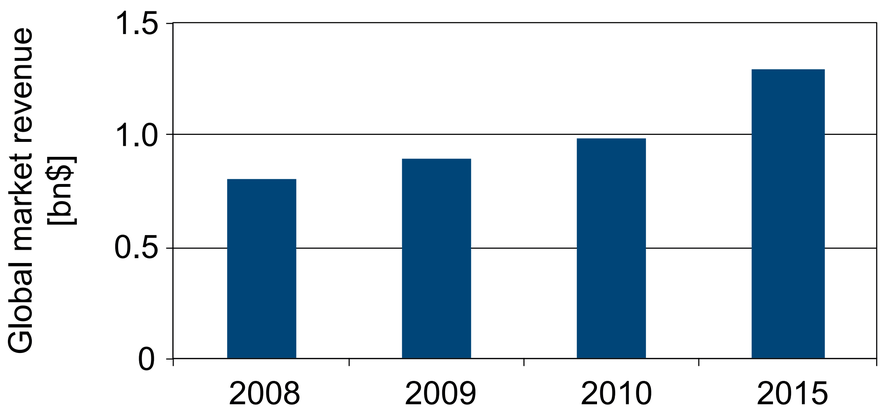

Figure 2: Global enzyme market revenue in the field of food and beverages from 2005-2015 [1].

» However, enzymes can make a big amount of the total production costs. To overcome this drawback, the enzyme membrane reactor technology is a promising tool to increase enzyme efficiency and thus, decrease production costs.

Enzyme membrane reactor technology

The enzyme membrane reactor (EMR) is, besides the classical batch process, an established mode for running continuous biocatalytic processes. These systems can range from mL scale to full-scale industrial units of several cubic meters volume and production capacities of hundreds of tons per year [2]. In an EMR (figure 3), the enzymes are dislocated in a reaction space, entrapped by a membrane and therefore can be reused. The membrane is used to retain large components (i.e. the enzyme and the substrate), while allowing small molecules to pass through [3] (i.e. the product).

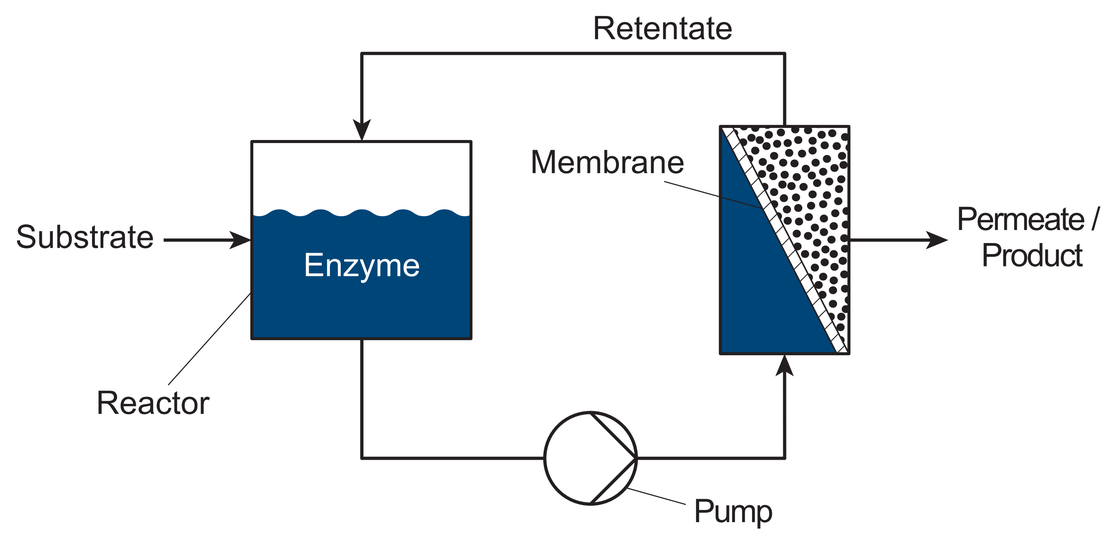

Figure 3: Basic setup of an enzyme membrane reactor (EMR) system.

Key features and advantages of an EMR system
» Selective mass transport through the membrane
» No activity loss upon immobilization
» Reuse of enzyme activity
» Constant space time yield (STY)

In the present study a stable continuous EMR protein hydrolysis process was designed and operated for 96 h. The STY (6.51 $g_{Product}$ h^{-1}) and productivity (figure 4) could be increased by 90 % and 540 %, respectively compared to a reference batch process.

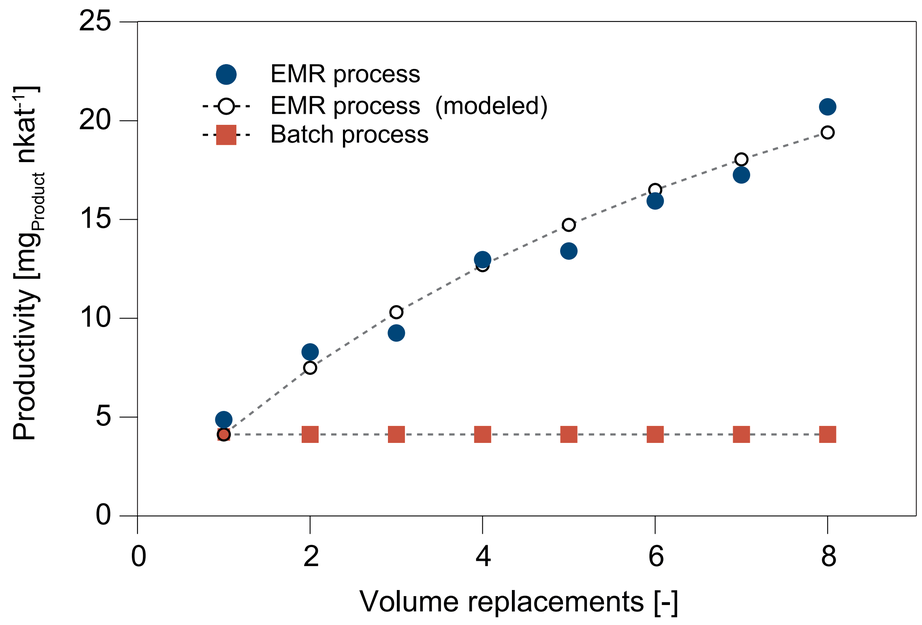

Figure 4: EMR productivity of a protein hydrolysis process compared to a reference batch process operated under comparable conditions.

Conclusion

» The enzyme efficiency could be increased by 540 % in the present EMR process compared to a reference batch process
» Space time yield was constant over the whole process time of 96 h and 90 % higher compared to the reference process

Literature:
[1] Grand View Research Inc. (2014). Enzymes Market Analysis By Product (Carbohydrase, Proteases, Lipases, Polymerases & Nucleases) And Segment Forecasts To 2020.
[2] Giorno, L. and Drioli, E. (2000). Biocatalytic membrane reactors: applications and perspectives. Trends in Biotechnology, 18(8):339-349.
[3] Bommarius, A. and Riebel, B. (2004). Biocatalysis: fundamentals and applications. Wiley-VCH.

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