DR ANJALI JAIN
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OBJECTIVE

To achieve a bright career in progressive and rewarding environment where I can actively devote my ability and professional interests to satisfy my urge of excellence.

AREAS OF INTEREST

Alternative Fuels (Bioethanol), Membrane Separation

EDUCATION

Banasthali Vidyapith — **Ph. D.** in **Chemical Engg.** (**2018**)
entitled
"Bioethanol Production in Membrane Bioreactor"
under the Supervision of
Prof. S. P. Chaurasia (MNIT, Jaipur) and
Prof A. K. Dalai (University of Saskatchewan, Canada)

Malaviya National Institute of Technology, Jaipur — **M.Tech. (Chemical Engg.)**
(2008-2010) — CGPA 8.87 on a scale of 10

Dr. B. R. Ambedkar University (Agra University), — **B.E. (Biotechnology)**
Institute of Engineering and Technology — Aggregate: 76.06%
(2004-2008)

Kendriya Vidyalaya, R.D.S.O., Lucknow — **CBSE XII**
(2003) — 74.4%

Kendriya Vidyalaya, R.D.S.O., Lucknow — **CBSE X**
(2001) — 84.4%

EXPERIENCE SUMMARY

1. Worked as **Visiting Research Scholar** in **Department of Chemical and Biological Engineering**, College of Engineering in University of Saskatchewan, **Saskatoon, Canada** from August 2014 to March 2016.
2. Worked as **Assistant Professor, Department of Chemical Engineering** in **Banasthali Vidyapith, Rajasthan, India** from July 2011 to May 2014.
3. Worked as **Quality Control Manager** in **Sharp Menthol Global Ltd.** from August, 2010

to June, 2011.

COURSES TAUGHT

Analytical Techniques, Environmental Pollution Control, Chemical Process Calculations, Food Processsing and Engineering

RESEARCH PAPERS PUBLISHED IN JOURNALS

1. A. Jain, A. K. Dalai, and S. P. Chaurasia, "Estimation of Permeance and Activation Energy for Separation of Ethanol from Ethanol/Water Binary Mixture by Pervaporation with PDMS Membrane", International Journal of Research and Scientific Innovation-IJRSI Vol.4, Issue 7, (2017); 113-119.
2. A. Jain, R. Dhabhai, A. K. Dalai, and S. P. Chaurasia, "Kinetics Of Bioethanol Production Using Saccharomyces Cerevisiae", International Journal of Applied and Natural Sciences (UANS), ISSN(P): 2319-4014; ISSN(E): 2319-4022 , Vol. 5, Issue 5, (Aug - Sep 2016); 87-96.
3. A. Jain and S. P. Chaurasia, "Bioethanol Production in Membrane Bioreactor (MBR) System: A Review", International Journal of Environmental Research and Development, ISSN 2249-3131 Volume 4, Number 4 (2014); 387-394.
4. R. Dhabhai , A. Jain and S. P. Chaurasia, "Production Of Fermentable Sugars By Dilute Acid Pretreatment And Enzymatic Saccharification of Three Different Lignocellulosic Materials" International Journal of ChemTech Research CODEN(USA): IJCRGG, ISSN : 0974-4290 Vol.4, No.4 (Oct-Dec 2012), pp 1497-1502.

BOOK CHAPTERS PUBLISHED

1. A. Jain, R. Dhabhai, A. K. Dalai, S. P. Chaurasia, Book Chapter No. 15 "Bioethanol Production in a Pervaporation Membrane Bioreactor" in Book entitled "Membrane Technology: Sustainable Solutions in Water, Health, Energy and Environmental Sectors", by S. Sridhar (Ed.), by CRC Press, Taylor And Francis Group, ISBN-13:978-1138095427, October, 2018.
2. A. Jain, S. Upadhyaya, A. K. Dalai, and S. P. Chaurasia, Book Chapter No. 3 "Pervaporation for ethanol-water separation and effect of fermentation inhibitors" Accepted to be published by John Wiley & Sons in Book entitled "Advances in Pervaporation, Vapor Permeation and Membrane Distillation for Industrial Scale Separations and Water/Wastewater Treatment", ISBN: 978-1-119-41822-1, November 2018.

RESEARCH PAPERS PRESENTED/PUBLISHED IN CONFERENCES

1. A. Jain, S.P. Chaurasia, A. K. Dalai, "Coupling of fermentation with pervaporation: A Membrane Bioreactor System", 67th Canadian Chemical Engineering Conference, CSChE 2017, Edmonton (AB), Canada, October 22-25, 2017.
2. S. P. Chaurasia, A. Jain, A. K. Dalai, "Bioethanol production using pervaporation Membrane Bioreactor", 66th Canadian Chemical Engineering Conference, CSChE 2016, Québec City, QC, Canada, October 16-19, 2016.

3. A. Jain, S.P. Chaurasia, A. K. Dalai, "Performance of a poly-(dimethylsiloxane) membrane for removal of ethanol from aqueous solution/fermentation broth", 65th Canadian Chemical Engineering Conference, CSChE2015, Calgary, Alberta, October 4-7, 2015.
4. A. Jain, A. K. Dalai and S. P. Chaurasia, "Influence of glucose, ammonium sulphate and glycerol on pervaporation performance of a polydimethylsiloxane membrane for the selective removal of ethanol", CHEMCON 2015, the 68th Annual Session of the Indian Institute of Chemical Engineers, the Indian Institute of Technology (IIT) Guwahati, Assam, December 27-30, 2015.
5. A. Jain and S. P. Chaurasia, "Bioethanol Production in Membrane Bioreactor (MBR) System: A Review", International Conference on "Agriculture, Food Engineering and Environmental Sciences- Sustainable Approaches*"* (AFEESSA- 2014) at Jawaharlal Nehru University, New Delhi, 29th & 30th March, 2014.
6. A. Jain, R. Dhabhai, N. Bajpai and S. P. Chaurasia,"Kinetic study on enzymatic saccharification of sorghum straw" International Journal of Applied Engineering Research, Vol 8 No. 7, 2013, ISSN 0973-4562, pp20-23.
7. S. Shankar, A. Singh, A. Jain, M. Agarwal and S. P. Chaurasia, " Application of Lipases for Green Synthesis of Different Compounds'', International Journal of Environmental Engineering and Management, ISSN 2231-1319 Volume 3, Number 3 (2012), pp391-394.
8. A. Jain, N. Bajpai, P. Mishra and S.P. Chaurasia, "Effect of Solvent on Saccharification of Sweet Sorghum with Cellulase from A. niger", International Conference on Renewable energy, (Jan 17-21, 2011), Centre for Non conventional Energy Resources, University of Rajasthan, Jaipur, India, BP-20.
9. A. Jain, N. Bajpai and S.P. Chaurasia, "Saccharification of Sorghum with Cellulase from Trichoderma viridae in presence of Solvent", Conference on Advances in Chemical Engineering 2011(AChem E2011) at Thapar University, Patiala, India, 27-28th Feb,2011, Abstract Ref. No. 113.
10. A. Jain, and S. P. Chaurasia, "Effect of Solvent on Enzymatic Saccharification of Sweet Sorghum", Paper selected for 60th Canadian Chemical Engineering Conference, 2010 at Sasketchwan University, Saskatoon, Canada.
11. A. Jain, R. Dhabhai, and S. P. Chaurasia, "Lignocellulose to Bioethanol", PODDAR 2ND National symposium on "Emerging Trend and Opportunities in Basic and Applied Sciences", 2010.
12. A. Jain, K. Bhandari and S. P. Chaurasia, "Rhizopus oryzae Lipase Catalysed Esterification of Oleic Acid with Butanol in a Biphasic System", International Conference on Oils, Fats, Fuels and Surfactants (64th Annual Conference of Oil Technologist Association of India), New Delhi, India, Dec.2009,pp 68.
13. R. Dhabhai, A. Jain, M. Krishania, and S. P. Chaurasia "Effect of Delignification of Lignocellulosic Substrates on Saccharification with Trichoderma Reesei Cellulase", International Conference on Oils, Fats, Fuels and Surfactants (64th Annual Conference of Oil Technologist Association of India), New Delhi, India, Dec.2009, pp 100.
14. K. Bhandari, A. Jain, A. Gupta and S. P. Chaurasia, "Enzymatic Esterification of Oleic Acid with Lauryl Alcohol", International Conference CHEMCON, Vishakhapatnam, India, Dec.2009, pp. 25.

WORKSHOP/CONFERENCES ATTENDED

1. Short term course on **"Membrane Processes for Water Purification and Reject Management"**, September 20-24, 2017 at Department of Chemical Engineering, **Malaviya National Institute of Technology**, Jaipur.
2. Stakeholder's Workshop on **"Community Water Purification Plants In Quality Affected Habitations Of Rajasthan: Issues, Challenges And Way Forward"**, July 27, 2017, organized by Dept. of Civil Engineering And Chemical Engineering, **Malaviya National Institute of Technology**, Jaipur.
3. **65th Canadian Chemical Engineering Conference**, CSChE2015, October 4-7, 2015 at **Calgary**, Alberta, Canada.
4. A Certificate course on **Laboratory Safety** was attended on September 18, 2014, conducted by **Workplace Safety and Environmental Protection**, University of Saskatchewan, Saskatoon, Canada.
5. A certificate course on **Bio-Safety** was attended on September 3, 2014, conducted by **Workplace Safety and Environmental Protection**, University of Saskatchewan, Saskatoon, Canada.
6. International Conference on **"Agriculture, Food Engineering and Environmental Sciences- Sustainable Approaches"** (AFEESSA- 2014), March 29-30, 2014 at **Jawaharlal Nehru University**, New Delhi.
7. International Conference on **"Various Facets Of Energy Technologies And Its Management For Sustainable Development"** (ET & MSD – 2013) Organized by "Krishi Sanskriti", March 16-17, 2013 at **Jawaharlal Nehru University**, New Delhi.
8. Seminar on **"India Innovation Growth Programme 2013"** organized by **FICCI**, February 8, 2013 at Jaipur.
9. National Conference on **"Emerging Trends in Engineering, Technologies & Sciences for Sustainable Development"** (ETETSSD – 2012) Organized by "Krishi Sanskriti", June 5-6, 2012 at **Jawaharlal Nehru University**, New Delhi.
10. Seminar on **"Intellectual Property and Innovation Management in Knowledge ERA"** Organized by: National Research Development Corporation (NRDC), New Delhi, January 28, 2012 at Banasthali University, Rajasthan.
11. Workshop on "**OLI PRO - II**" July 3-5, 2011 at Banasthali University, Rajasthan.
12. PODDAR 2nd National symposium, 2010, on **"Emerging Trend and Opportunities in Basic and Applied Sciences"** at Jaipur.
13. International Conference on **"Oils, Fats, Fuels and Surfactants" (64th Annual Conference of Oil Technologist Association of India)**, Dec 2009 at New Delhi, India.

POSITIONS HELD/ACHIEVEMENTS

- IIChE Student Chapter Coordinator at Banasthali University during 2011-2014.
- Faculty Coordinator for Chemical Engineering Dept. Technical Fest & Student (Innovative Chemical Engineeers) Club during 2011- 2014.
- Faculty Coordinator for Training & Placement of Chemical Engg. students during 2011-2014.
- **GATE Qualified (2008), 98.35 percentile and ALL INDIA RANK -219.**
- Received scholarship by MHRD during M. Tech.
- **2nd Rank** in **M. Tech.** (2010) at MNIT Jaipur.

- **Life Associate Member (Membership No. 43466) of Indian Institute of Chemical Engineers (IIChE),** India.
- **Life Member (Membership No. LM 465) of Indian Desalination Association** (InDA), India.
- Student Coordinator for M. Tech. Chemical Engineering Branch Placement during session 2009-2010.
- Awarded with certificate of appreciation for being a proactive member of BIOGEN-Biotech society during 2006.
- Secured Third position in Poster Drawing Competition on the topic "Wildlife Conservation" as a part of school activity during 2002.
- Awarded with Certificate of Appreciation in "All India Camel Colour Contest" held during year 2001.
- Awarded with certificate of Appreciation in "Youth Parliament" during 2000.
- Secured First position in Inter House "Hindi Drama Competition" during 2000.
- Secured Second position in Inter House "Group Dance Competition" during 1999.

PROJECTS & TRAININGS

Malaviya National Institute of Technology (July 2009-July 2010)
Dissertation Project: Enzymatic Saccharification of Sweet Sorghum
Minor Project: Studies on lipase catalysed esterification

Institute of Engineering and Technology, Khandari Campus (Jan-Jun 2008)
Major BE Project: Homology Modeling and Model Validation of Glycoprotein 160 of HIV-1

Bioinformatics Centre, Biotech Park, Lucknow (1July-31 July 2007)
Bioinformatics Tools and their Applications

Indian Institute of Sugarcane Research, Lucknow (26 June-25 July 2006)
Biochemical changes during storage of sugarcane

Cream Bell, Universal dairy product Pvt., Ltd (Jan-Feb 2007)
Various production techniques and quality control operations

REFEREES

Prof. S. P. Chaurasia, Prof. & Dean, International Affairs, Former Head, Chemical Engg. Dept, MNIT Jaipur, India, spchaurasia@mnit.ac.in , +91-141 2713339, +91 9414446464

Prof A. K. Dalai, Prof. & Canada Research Chair in Bioenergy**,** Chemical & Biological Engg. Dept. University of Saskatchewan, Saskatoon, Canada, akd983@mail.usask.ca, +1 306 222 3825

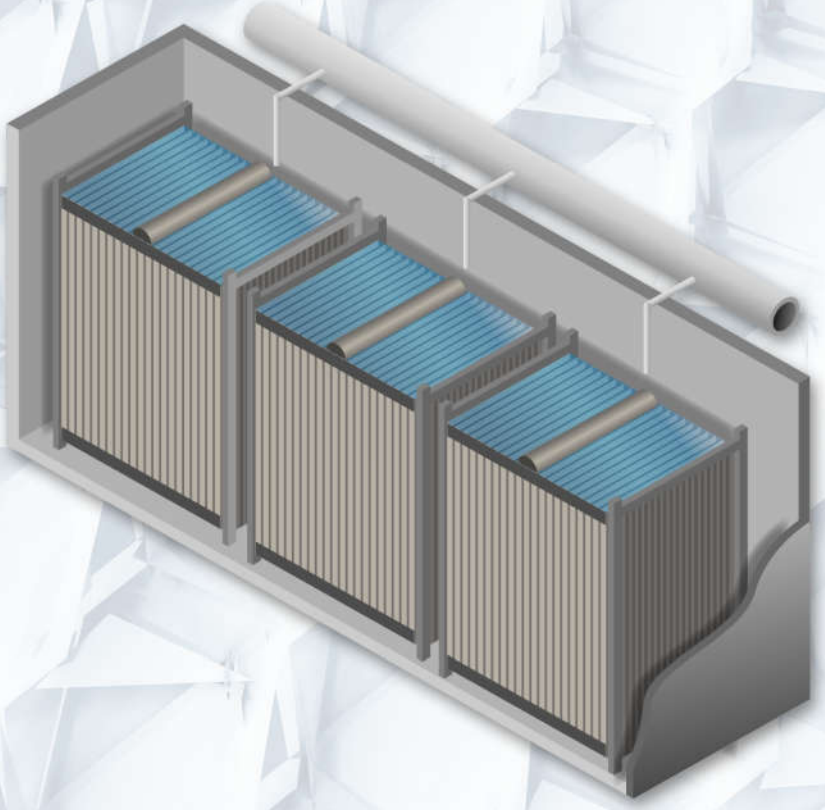
DECLARATION

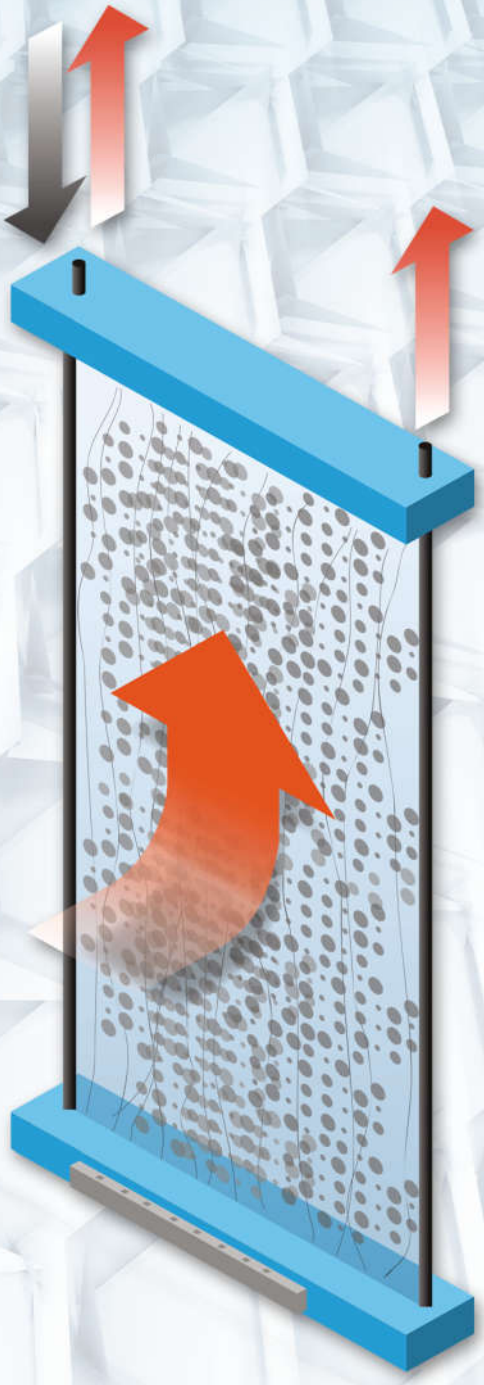
I consider myself familiar with Biotechnology & Chemical Engineering aspects. I am also confident of my ability to work in a team. I hereby declare that all the above information is true to the best of my knowledge.

(ANJALI JAIN)

Membrane Technology

Sustainable Solutions in Water, Health, Energy, and Environmental Sectors





Edited by
Sundergopal Sridhar

CRC Press
Taylor & Francis Group

Section III Health

Section IV Membrane Process Design

Section V Energy

Membrane Processes

Pervaporation, Vapor Permeation and Membrane Distillation for Industrial Scale Separations

Edited by
Sundergopal Sridhar
Siddhartha Moulik

WILEY

Estimation of Permeance and Activation Energy for Separation of Ethanol from Ethanol/Water Binary Mixture by Pervaporation with PDMS Membrane

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[1]*Department of Chemical Engineering, Banasthali University, Rajasthan India*
[2]*Catalysis and Chemical Engineering Laboratories, Department of Chemical and Biological Engineering, University of Saskatchewan, Saskatoon, SK S7N 5A9, Canada*
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***Abstract*- In this study pervaporation experiments were conducted to study the permeation behavior of binary ethanol-water mixture using polydimethyl siloxane membrane. The effects of feed flow rate, feed composition, and feed temperature were examined on permeation flux and separation factor. On increasing ethanol concentration in the feed, permeation flux was enhanced and separation factor was reduced; whereas permeation flux and separation factor both were increased on increasing the feed temperature and feed flow rate.**

The solution-diffusion model (combination of Henry's law of sorption and Fick's law of diffusion) is used to predict the solution-diffusion-desorption steps with a driving force term and a permeation term. The activity coefficient of ethanol and water in the binary mixture was calculated with UNIQUAC model. The activation energy of ethanol permeation was calculated by Arrhenius relationship. Permeance of ethanol varied from 10.96 to 11.62 g/m^2.h.bar, on increasing the ethanol concentration from 5-20 vol%. The activation energy for ethanol permeation was found to vary from 5.77 to 4.13 kJ/mol when the ethanol concentration in the feed was increased from 5% to 20 vol%.

Keywords: **PDMS membrane, Pervaporation, Solution- Diffusion model, Activation energy, UNIQUAC (UNIversal-QUAsi-Chemical)**

I. INTRODUCTION

Ethanol is an alternative green fuel that has received much attention over the last few decades [1]. Ethanol production from fermentation and the effects of its various by-products have been widely investigated [2]. Compared with traditional distillation, membrane separation technology has emerged as an attractive method for the separation of ethanol-water mixtures [3]. For example, pervaporation (PV) separates ethanol-water mixtures efficiently at low operational costs, as it is operated at low feed temperatures and pressures; moreover no additional chemicals are necessary for separation [4], [5].

Pervaporation is a membrane process, in which a phase change takes place across the membrane. The liquid mixture is brought in contact with one side of the membrane and the permeate is removed as a low pressure vapor on the other side. The driving force for mass transport over the membrane is the chemical potential gradient created by applying a vacuum pump on the permeate side to lower the partial pressure of the feed liquid and thus lowering the chemical potential of the permeate stream on the downstream side [6].

One of the most applied polymeric membranes for ethanol-water separation is polydimethylsiloxane (PDMS) [2]. PDMS exhibits high selectivity and permeability towards ethanol because of its flexible structure and therefore, is preferred for the removal of ethanol from water [7]. It is well known that the pervaporation performance is not only dependent on the properties of membranes, but also the process conditions such as feed concentration, temperature, permeate pressure and feed flow rate [8]. Though a number of researchers have studied the effect of operation conditions on pervaporation performance in terms of flux and separation factor; correlating separation performance with temperature and intrinsic separation characteristics of commercial PDMS membrane remain to be an underexploited area of research [9]. Verhoef et al. (2008) demonstrated the importance of taking the combined effects of activity coefficient and saturation vapour pressure into consideration while analysing the temperature effect on a hydrophobic nanofiltration membrane (SolSep 3360) performance for separation of ethanol from ethanol-water mixture [10]. The operating parameters affect the apparent membrane performance of membranes in pervaporation. Without using the permeance as a membrane performance parameter, these effects may be simply overlooked from the flux plots. Permeance is recommended when comparing the separation performance of the membranes, since it allows distinguishing the effect of the nature of the membrane and the operating conditions [11].

The mechanism of mass transfer of permeate across non-porous polymeric membrane include two stages: sorption of liquid, and its diffusion through the free volume of the polymeric material [8]. Many models have been proposed to predict the mass transfer process, such as solution diffusion

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KINETICS OF BIOETHANOL PRODUCTION USING SACCHAROMYCES CEREVISIAE STRAIN Y-35

ANJALI JAIN[1], RAVI DHABHAI[2], AJAY K. DALAI[3] & SATYENDRA P. CHAURASIA[4]

[1]Department of Chemical Engineering, Banasthali University, Rajasthan, India

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ABSTRACT

In the present work, an attempt was made to explore the potential of *S. cerevisiae* Y-35 for fermentation of glucose to produce ethanol in batch culture. Effects of parameters, such as initial inoculum loading in the range of 5-40 gL^{-1} dry cell weight (DCW) and glucose concentration (in the range of 5-26% by weight) were investigated. Maximum ethanol yield and volumetric productivity were obtained at inoculum loading of 20 gL^{-1} DCW and increased marginally at 40 gL^{-1} DCW. With increased initial sugar concentration, volumetric productivity was increased and the maximum productivity of 10.46 $gL^{-1}.h^{-1}$ was obtained with 13% sugar concentration at 4 h, corresponding to 94% of the maximum theoretical possible conversion. At high sugar concentrations, high productivity was obtained up to 10 h, corresponding to 6.9 and 5.9 $gL^{-1}h^{-1}$ at 20% and 26% initial glucose concentrations, respectively. The high productivities obtained with the yeast, even at 20-26% sugar concentrations, implies the robustness of the yeast strain and potential for its industrial use. Furthermore, in order to understand the kinetic behavior, the experimental data was fitted into a kinetic model based on modified Monod equation to predict the inhibitory effects of ethanol and glucose on fermentation performance. A MATLAB® program was employed to estimate the kinetic parameters in the model. High R^2 and low RMSE values supported good agreements between experimental data and model predictions.

KEYWORDS: Bioethanol, Dry Cell Weight, Fermentation, Kinetics, Monod Equation, *Saccharomyces Cerevisiae* Y-35

INTRODUCTION

In the last few decades, fossil fuel reserves are fast depleting due to the increased usage of transportation fuel, which is also raising environmental concerns due to the increased particulate and greenhouse gases emissions. This has led to intensive research for green alternative fuels such as bioethanol and biodiesel. It has been estimated that U.S. could produce 284 billion liters of cellulosic ethanol per year by 2030, more than half of today's U.S. gasoline demand (RFA, 2015). The most economical and widely used method for the production of ethanol involves fermentation of sugars by yeast, *Saccharomyces cerevisiae*. It is the choice organism for sucrose and starch based ethanol industries. In order to efficiently produce ethanol, specific growth rate, sugar consumption rate, volumetric productivity, ethanol yield, and ethanol tolerance must be on higher side for a microorganism (Zabed et al., 2014). However, the selection of a particular industrial strain is usually based on historical grounds, rather than scientific and hence suboptimal for their purposes (Steensels et al., 2014). Industrial processes rarely use the best performing strain. Therefore, there is still a lot of scope to

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http://www.ripublication.com/ijerd.htm

Bioethanol Production in Membrane Bioreactor (MBR) System: A Review

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[2]Department of Chemical Engineering, Malaviya National Institute of Technology Jaipur–302017, India

Abstract

World is facing not only atmospheric pollution but also climate changes as consequences of the use of petroleum fuels and progressive depletion of non-renewable energy resources. Therefore, biofuels as ethanol derived from biomass through fermentation are becoming more significant. The concentration of ethanol in the fermentation broth can range from 1 to 15 wt% depending upon the source of biomass and hydrolysis process. The water content of ethanol in broth must be reduced from 85 to 99 wt% to less than 1.3 wt% water to produce fuel grade ethanol. Distillation is the traditional technology for the recovery of ethanol from these dilute biomass fermentation broth which needs a high amount of energy. As an alternative, pervaporation is a membrane separation method that can be coupled with fermentation to remove ethanol from the fermentation broth continuously. Combining fermentation with pervaporation in addition to water and energy savings, will also reduce product inhibition by keeping the ethanol concentration in the broth low and simplify downstream processing as the ethanol recovered will be more concentrated. Overall, this review paper demonstrates that membrane bioreactor can serve as a highly selective, cost and energy saving technology in the bioethanol industry.

Keywords: Bioethanol, MBR, Pervaporation, Fermentation.

1. Introduction

The global production of bioethanol showed an upward trend over the last 25 years with a sharp increase from 2000. Worldwide annual production capacity in 2005 and 2006 were about 45 and 49 billion litres, respectively and total output in 2015 is forecast to reach over 115 billion litres. Brazil was for a time the largest bioethanol