



# Membrane science and membrane engineering in the past years and tomorrow

# Enrico Drioli

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History 1

In the late fifties - early sixties, Membrane Science had a very small visibility and no large scale industrial applications were present.

However its potentialities were already attracting an increasing attention.

In 1966, the first organized event on Membrane Science and Application was organized as a **NATO Advanced Study Institute** by Prof. H. Gregor (USA) and Prof. A.M. Liquori (Italy) on Membrane Transport Phenomena at Villa Cimbrone in Ravello.



Consiglio Nazionale delle Ricerc



History 2

Membrane Societies at the late seventies - early 80's:

# 1978 Foundation of



# The Membrane Society of Japan

President: Masayuki Nakagaki Vice Presidents: Terukatsu Miyauchi, Toshitsugu Oda

# 1982 Foundation of



# **European Membrane Society and Technology** President: Enrico Drioli Vice Presidents: Heiner Strathmann, Jean Neel, Gun Trägårdh,

Gunnar Jonsson

# Strategic actions:

- Internationalization
- Advanced Researches
- Development of Membrane Operations
- High education



# A breakthrough!



# The first International Conference



Europe -Japan Congress on Membranes and Membrane Processes, *Stresa, June 18-22, 1984* 





The **large number of participants**, of about **400**, from **26** countries including USA, Australia, China and Brazil, the **quality** of the Plenary Lectures and Scientific Communications made the Stresa Conference a **significant international success**.

As a result, the decision to organize the Japan - Europe Congress on Membranes and Membrane Processes in Tokyo, in 1987.



Prof. Elias Klein, USA participant at the Conference, promoted, in



**1985** the foundation of

North American Membrane

# Society - NAMS

President: Elias Klein Vice Presidents: Sun-Tak Hwang, Douglas Lloyd





From the Europe -Japan Congress on Membranes and Membrane Processes, Italy, June 18-22, 1984

То

# "ICOM - International Congress on Membranes and Membrane Processes"

*Tokyo* 1987









International Congress on Membranes and Membrane Processes (ICOM '87): Tokyo, Japan, June 8-12, 1987

Chairmen, Organizing Committee: **Prof. Dr. Masayuki Nakagaki**, President, **Membrane Society of Japan**;

Prof. Dr. Enrico Drioli, *President*, European Society of Membrane, Science and Technology

Secretary-General: Prof. Dr. Shoji Kimura, Institute of Industrial Science, University of Tokyo

700 participants400 papers28 countries



ICOM conferences

ITM - CNR	
Istituto per la Tecnologia delle Membrane	

Year	Location	Organizer	Chair	Statistics
ICOM '87 June 8-12 1987	Tokio, <i>Japan</i>	The Membrane Society of Japan, EMS	Masayuki Nakagaki Enrico Drioli	<ul><li>700 participants</li><li>400 papers</li><li>28 countries</li></ul>
ICOM '90 August 20-24 1990	Chicago, USA	NAMS	Norman N. Li	500 Presentat.
ICOM '93 August 30 - September 3, 1993	Heidelberg, <i>Germany</i>	EMS The Membrane Society of Japan, NAMS, and The University of Heidelberg	R. Rautenbach J.J. Vier R.N. Lichtenthaler	509 Presentat. Large n. of partic. from Easter Europe;
ICOM '96 August 18-23 1996	Yokohama, <i>Japan</i>	The Membrane Society of Japan, EMS, NAMS	Naofumi Kimura Takeo Shimizu	500 Presentat. 600 Partipants
ICOM '99 June 12-18 1999	Toronto, <i>Canada</i>	NAMS	Doug Lloyd Jim Davis	<ul><li>562 Presentat.</li><li>629 Participants</li></ul>
ICOM 2002 July 7-12, 2002	Toulouse, <i>France</i>	Université Paul Sabatier	John Howell, Roger Ben Aïm Pierre Aimar Corinne Cabassud	365 Presentat. 302 Partecipants Vol2 – Vol1



# ICOM conferences

Year	Location	Organizer	Chair	Statistics
ICOM 2005 August 21-26, 2005	Seoul, <i>Korea</i>	The Aseanian Membrane Society, The Membrane Society of Korea, NAMS, EMS	Tae Moon Tak Un Young Kim	<ul><li>793 Presentat.</li><li>&gt;700 Particip.</li><li>40 countries</li></ul>
ICOM 2008 July 12-18, 2008	Honolulu, <i>Hawaii,</i> USA	NAMS	Ingo Pinnau, Benny Freeman, Yoram Cohen	827 Presentat.
ICOM 2011 July 23-29, 2011	Amsterdam, The <i>Netherlands</i>	Membrane Technol ogy Group of Univ ersity of Twente	Kitty Nijmeijer Antoine Kemperman Matthias Wessling	1064 Presentat. 1051 Particip. (Asia 22% America 13% Europe 65%)
ICOM 2014 July 20-25, 2014	Suzhou, <i>China</i>	The Aseanian Membrane Society, EMS, NAMS	Congjie Gao Juin-Yih Lai Wanqin Jin Xiaolin Wang	1300 delegates of 514 oral presentations and 662 posters
ICOM 2017 29 July – 4 August 2017	San Francisco, CA USA	NAMS		
ICOM 2020				

ITM - CNR







Membrane Society



First Summer School of the European Society on Membranes Science and Technology

Cadarache, France

OF MEMBRANE SCIENCE AND TECHNOLOGY

ITM - CNR

Istituto per la Tecnologia delle Membrane

## SUMMER **SCHOOL**

in cooperation with :

the COMMISSARIAT A L'ENERGIE ATOMIQUE the ELECTRICITE DE FRANCE membrane club

CADARACHE - FRANCE

3-7 September 1984



the golden Adriatic Coast, surrounded by the vineyards and

thermal springs of the "Wellness Valley".

Bart VAN DER BRUGGEN (EMS)

lle Ricerche

EMS

European Membrane Society



# Major Membrane Societies today

#	Name	President	Link
1	Membrane Society of Japan	Toshinori Tsuru	maku-jp.org/ index_e.html
2	European MS	Bart van der Bruggen	www.emsoc.eu/ems/site/home/i ndex.php
3	NAMS	Dibakar Bhattacharyya	www.membranes.org
4	Korean Membrane Society	Hong Sik BYUN	www.membrane.or.kr
5	Membrane Industry Association of China	Liu Xianqin	www.membranes.com.cn
6	Chinese Membrane Society	It was proposed in 2015 , and Chinese Government	d is waiting to be approved by
7	Aseanian Membrane Society	Hideto Matsuyama	http://www.ams10.org
8	Russian Membrane Society	Andrei Yaroslavtsev	www.memtech.ru/index.php/en
9	Membrane Society of Australasia	Aaron Thornton	www.membrane-australasia.org
10	Indian Membrane Society	M. H. Mehta	indianmembranesociety.com
11	South Central Membrane Association	Alain Richard	www.scmembrane.org
12	American Membrane Technology Association	Mehul V. Patel	www.amtaorg.com
13	African Membrane Society	Abdoulaye Doucouré (board of directors)	http://www.sam-ptf.com/
14	Membrane Society in Singapore	WANG Rong	http://www.memsis.org/
15	Sociedad Mexicana de Ciencia y Tecnología de Membranas		http://www.smcytm.org.mx

# The Membrane Society of Japan





日本膜学会 The Membrane Society of Japan

Home日本膜学会についてNews学会誌「膜」年会と膜シンポジウム国際膜学会議等<td

日本膜学会 学会員 メールアドレス登録フォーム

はじめに



### 問い合わせ先

### 日本膜学会事務局

〒113-0033 東京都文京区本郷5-26-5 扇屋ビル702

TEL&FAX: 03-3815-2818

E-mail: membrane@ mua.biglobe.ne.jp 日本膜学会(The Membrane Society of Japan)は、様々な領域の膜 科学研究,すなわち人工膜,境界膜(リポソームなど),生体膜に 関する研究を推進し、もって人類の幸福と社会の進歩に貢献するこ とを目的に1978年に設立された学会です。また、これら異分野の研 究者が一堂に会して知識・情報を交換し、その融合を図ることで、 新たな膜科学の研究領域を開拓することも学会設立当初からの理 念・目標です。そのため、学会の構成員は工学、薬学、医学、理学 を背景とする大学・研究所関係者、膜を扱う産業界関係者など多岐 にわたっています。「本学会に入会すれば膜の全てがわかる」を モットーに様々な学術活動を活発に展開していますので、膜に興味



をお持ちの方は,是非入会頂き,我が国の膜学の発展に向けてご活躍いただければと願っています.

News







### MEMBRANE

### Vol. 40 No. 4 (2015)



Maku

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### The Membrane Society of Japan

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Istituto per la Tecnologia delle Membrane

### Goal

To promote co-operation between European Scientists and Engineers involved in research and development in the field of synthetic and artificial membranes and membrane processes



European Membrane Society



Organization of periodic workshops and study groups on various aspect of membrane science Publication of a quarterly news letter describing developments and activities of different membrane groups

Stimulation of exchange visits of membrane scientists and technologists in different countries Provision of guidelines to national and international agencies to promote the most efficient use of resources

Organization of Summer Schools for the education of young researchers with different backgrounds. The first edition in 1984 ....

To the 2016 EMS Summer School on Membranes and Membrane Processes Design near Bologna, Italy

# ITM - CNR The North American Membrane Society

NAMS is the only professional society in North America that promotes all aspects of membrane science and technology. This ranges from fundamental studies of membrane materials science to process application and development.



NORTH AMERICAN MEMBRANE SOCIETY

Mission *community by fostering the development and* 

membrane

Awards

fostering the fostering the development and dissemination of knowledge in membrane science and technology

to serve the synthetic

by promoting the collaborative efforts of researchers, technologists and end-users

Awards

•to encourage and support outstanding individuals at the start of their professional careers, and

• to recognize those that have made significant contributions to the advancement of membrane technology

NAMS promotes further development and understanding of membranes and membrane processes through:

- Organization of national and international meetings
- Presentation of short courses and workshops
- Support for student travel to NAMS Annual Meeting
- Publication of the Membrane Quarterly

Education

•provides a forum for the presentation of new ideas, problems, and projects related to the incorporation of membrane science and technology in both undergraduate and graduate education

Consiglio Nazionale delle Ricerch

# Membrane Society of Australasia

stituto per la Tecnologia delle Membran









# Indian Membrane Society



[Read More]



MEMBERS DIRECTORY

GALLERY

membranesand membrane separation processes.

### **Our Activities**

- Organization of National and International Meetings.
- Presentation of Short Courses and Workshops.
- Promotion of Graduate Student Research. .
- Publication of The Membrane Newsletter.



### **IMS Membership**

Individuals, Institutes, Industries who are engaged in research, development, engineering, technology, consultancy or any other aspect of membranes or otherwise interested in membrane technology or related fields may obtain membership of IMS. [ Read More ]



# African Membrane Society

The African Membrane Society is the result of discussions initiated in August 2010 in Bamako at a workshop of the Mali Symposium on Applied Sciences. AMS was officially created in August 2014.







# African Membrane Society

African Membrane Society Water \* Environment, Process, Energy Sfax, Tunisia, May 3-5, 2016 - Membrane Water Treatment in Small Urban and Village Centers African Membrane Society

### Meeting scope

- Identify key advanced research in the field of membrane and filtration technologies for the treatment of water.
- Present innovative projects in Africa that favor efficient water management.
- Stimulate economic growth by developing sustainable water and energy resources and technologies





### Sfax 2016: International mobilization

The culturally diverse African Membrane Society (AMS) has mobilized all its members so that the 5 geographic zones of Africa can be represented during its congress.

Nearly 20 countries are expected including representatives from Europe, India, North America and many decision -makers from the industry.

Consiglio Nazionale delle Ricerche



-10.2015 / Aachen

EMBRANE 20

# Major Other International Conferences 1

# Aseanian Membrane Society Conference (AMS)

Euromembrane

World Filtration Congress

International Membrane Science and Technology Conference (IMSTEC)

North American Membrane Society (NAMS) Meeting

International Conference on Inorganic Membranes (ICIM)

International Water Association Events

International Conference on Catalysis in Membrane Reactors (ICCMR13)

**WFC 12** 



NAMS 2016 Bellevue, Washington



NAMS 2015 Boston



12th WORLD FILTRATION CONGRESS

April 11-15, 2016 · Taipei / Congress April 12-14, 2016 · Taipei / Exhibition

14th International Conference on Inorganic Membranes (2016) 🛗 5-8 December 💡 Adelaide Convention Centre





2014

ston

NAMS 2013 Boise

ADELAIDE CONVENTION CENTRE, HEART OF SOUTH AUSTRALIA'S SCIENCE AND TECHNOLOGY HUB

# World Water Congress & Exhibition

9 - 14 October 2016 • Brisbane • Queensland • Australia







NAMS 2012

New Orleans

# TM - CNR C S

# Major Other International Conferences 2

per la Tecnologia delle Membra

Gordon Conferences USA

**Engineering Conferences International** 

European Congress of Chemical Engineering (ECCE)

World Congress of Chemical Engineering (WECCE)

Aachener Membrane Colloquium

Ravello Conferences (from 1966 every 11 years)

Etc....

# 16th Aachener Membran Kolloquium

# 2<sup>nd</sup>/3<sup>rd</sup> November 2016, Aachen

Gordon Research, Conferences cience



10<sup>th</sup> European Congress of Chemical Engineering 3<sup>rd</sup> European Congress of Applied Biotechnology 5<sup>th</sup> European Process Intensification Conference

ECCE 10+ECAB 3+EPIC5

September 27<sup>th</sup> October 1<sup>st</sup>, 2015 - Nice, France



# Some National Conferences...



Seminars
Guideline for speakers
Location map

### Seminars

The monthly periodic Seminar "Membranes and Membrane Technologies" is organized by **Russian Membrane Society** (Membrane Section within Mendeleev Russian Chemical Society). The goal of the Seminar is providing of the platform for fruitful discussions and exchanging of information and ideas between membrane society representatives (incl. coming events announcements) on the regular basis. In the first part of the Seminar, the invited person gives the presentation (up to 30 minutes) with the deeper focus in the specific membrane area followed by discussion.





NATCOM 2016





# Major International Journals on

Membrane Science and Engineering - 1

	Journal	Editor(s)	Publisher
Journal of MEMBRANE SCIENCE	Journal of Membrane Science	Ed in - Chief: A.L. Zydney Founded by Harry Lonsdale in 1976	Elsevier
The second secon	Membrane Technology	S. Atkinson	Elsevier
membranes	Membranes	Edin-Chief: Spas D. Kolev	MDPI AG, Basel, Switzerland
Journal of Expension Technology	Journal of Membrane and Separation Technology (Japan)	Ed.itor-in-Chief: Masakazu Yoshikawa	Lifescience Glob
A REFERENCE OF THE REFE	Journal of Membrane Science & Technology	Hao Fong, Abdul Latif Ahmad, Ruth Prassl	OMICS Publishing Group



# Major International Journals on

Membrane Science and Engineering - 2

	Journal	Editor(s)	Publisher
MEMBRANE BIOLOGY	The Journal of Membrane Biology	Ed in - Chief: Wolfgang E. Trommer (TU Kaiserslautern)	Springer
	Membrane (MAKU)	Ed in - Chief: Toshinori Tsuru (Hiroshima University)	Membrane Society of Japan
BIOMEMBFANES	Biochimica et Biophysica Acta (BBA) – Biomembranes	Ed.: Yechiel Shai, Hans Vogel	Elsevier
	Biochemistry (Moscow) Supplement Series A: Membrane and Cell Biology	Ed in - Chief: Stanislav S. Kolesnikov	Springer





# Major International Journals on

Membrane Science and Engineering - 3

	Journal	Editor(s)	Publisher
THE EXCLOSE	Journal of Membrane Science and Technology (China) (A Bimonthly publication of the Membrane Industry Association of China)	Ed: Liu Xianqiu	Editorial Department of Membrane Science and Technology
Journal of Management of Array and Arr	Journal of Membrane Science and Research (JMSR) (Iran)	Ed in - Chief: Ali Kargari	Membrane Processes Research Center (MPRC)
Molecular Molecular Ebiology	Molecular Membrane Biology	Ed in - Chief: Anthony I Magee	Taylor & Francis





# Newsletters, Bullettins,...

Institute on Membrane Technology Harbin Institute of Technology School of Manicipal and Environment

### EU – CHINA Membrane Newsletter



Seminars of RMS Conferen

Volume 55, Issue 10 / December 2015

On initial stage, English version is distributed as a part of Journal of "Pe

Structural and physicochemical properties of titanium dioxide thin films obtained by reactive magnetron sputtering, on the surface of track-etched

nembranes D. V. Artoshina, A. Rossouw, V. K. Semina, A. N. Nechaev & P. Yu. Apel

Evaluating the effectiveness of ion exchangers for the electrodeionization

Simulation of external mass transfer in hollow-fiber membrane contactors V. A. Kirsch, V. I. Roldugin, S. D. Bazhenov & T. V. Pilsko

Study of accessible free volume and transport properties of TEPS-co-TMSP

IR spectroscopic and thermogravimetric study of state of water in MGA-95

coporymer A. A. Kossov, A. A. Yushkin, V. S. Khotimskiy & A. V. Volkov

R spectroscopic and thermogravimetric study of state of water cellulose acetate membrane S. J. Lazarev, Yu. M. Golovin, D. S. Lazarev & V. M. Polikarpov

D. V. Golubenko, J. Křivčík & A. B. Yaroslavtsev

L Download

**IEMBRANES** 

About Journal

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Vol 55, Num 10 / Dec 2015

Vol 55, Num 5 / Jul 2015

Vol 55, Num 4 / Jun 2015

Vol 54, Num 8 / Dec 2014

Vol 54, Num 7 / Dec 2014

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Vol 53, Num 7 / Dec 2013

Vol 52, Num 8 / Dec 2012

Vol 52, Num 7 / Dec 2012

Vol 51, Num 8 / Dec 2011

Vol 51, Num 7 / Dec 2011

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AND MEMBRANE TECHNOLOGIES



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### FROM THE DIRECTOR

Water, energy and food are essential for the development and security of any society. The three sectors are closely linked, and the Water-Forroy-Food News describes the complex and nterdependent nature of our global resources. The three sectors have traditionally been looked at independently, but due to sing demands there is a need to consider the nexus approach ent predictions show that there will be an increasing demand Recent predictions show that there will be an increasing demand a find frash water energy and food seased by spoulations prunch and mobility, urbanication and increasing numbers of mega inspaces how diverse change. A text challenge in the future will be ensuing water, food and energy security, particularly in arist and water-scare regions.

Spring 2016

and varies over regions. It applications are seen as a region by the second and region by the second reg

WDRC News | Series 2011 🖉 🔮 Russian Membrane Society

### he water, every and food news underlines the strategic research apenda of the WDRC Akey aspec is the water-food news in arid and The water-boot neuron and and water-score regions. The Third's many states of the state-tool neuron and and water-score regions. The Third's many states are states a

http://www.gebologroutuw.agy improved water mans and regions, and is act this through use of renewable energy. Some of the mu includer novel advanced heatment recharactogies for



The newsletter of the European Membrane Society Special Issue - No. 87 September 2012 EMS 30th Anniversary



MEMBRANE Vol. 40 No. 4 (2018)



enaingh important in adding value to dy-products from various dairy production emailingh important for adding value to dy-products from version dairy production etwarm. Mondroses filtration is a good eccomple of a simple and efficient technology and to robe a growing must depend inne with standard fate

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-12)\*

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exert of appleating, including sock-economic and resonantial insues. Visit the web http://www.desline.com/congress/Rome2016/hor tion (MI) and ultrafil mution (LTF) is an efforttive means of recov ing by-products such a seart whey from the choose industry into food ingroßenn, whi can be used in for formulations, Inc. market mends sowards. uni (RO, PO, NF, UF, MP

manter trends towards conveningmin of Greek yaghten driven maidel by health heads resulted in generation of "acid why", which has emerged as a hard to process dary hy-product. Stor-age and disposed of acid when is subject to strict environmental regula-tions and can add significant one to the industry. The highly acide ma-terion and can add significant one to the industry. The highly acide mations and can and significant ions to the meaning. The rightly acceler that the of a clief whyer, onders is a challenging hypersolate to dail why. These removing large quantities of LA and Ca appears as a vult stop pri-der to forther processing of this network. Thus, membrane filtration, espe-art of hotele processing of this network. Thus, membrane filtration, espe-andly NH has memory and an antical appears to reaves the Industry composents. Now working in show collaboration with the Ameridian large industry. Visiona University OV, meanchest me at developing a data of the start of range of trials in evaluating how the elements of acid whey can be sim range of trails in evaluating how the dimension of add whey can be simi-larly processed and reased, with the use of membersof limitation, power tably saving millions of dollars for the industry. VU researchers have statud that, "If we can separate particled lacone, which can be used in infant formula, then we are training an expensive and environmentally sensitive disposal issue into an environmentally friendly money catter? Parification through separation of components by the use of membrane fibration would improve the quality of the food ingredient wastly.

For more information, contact: Vietoria University Researchers: Todor Vasiljevic: (Todor Vasiljeviciji)vu.edu.au) & Iarani Chandrapala

2015 Membrane News Twente MST

a full professorship at Eindhoven University of Technology

### One might wonder what this means for MST, and on this

and on membrane applications related to clean water. On behalf of the MST and FMI staff members: Dr. Antoine energy and life sciences will remain a key forus area of the Kemperman Prof. Frik Roesink, Dr. Zandrie Borneman University of Twente. For this we a have strong support from the Board of the University, as will also be clear from the contribution to this newsletter of the Dean of our Faculty, Prof. Hans Hilgenkamp. This strong support is both for the



thus remain a key European knowledge center for membrane science and technology. We are currently working very hard Some group members during the Euromembrane 2015.



N n m s



 
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 L1111 (クラレ) (IFEエンジニアリング) (家レ) 和名 (クラレ) 株石 (JEXエンジニアリング) 様之 (東レ) 久塚 (重要技術総合研究所創業運動研究部門) 作用 (草板大学広道工学部) 者は (近月24-5ジニートラル・スネルドー実数 様長 (東レ) は第 (3) 大学ュージンスニートン 構成(国人) 差す(国人)学大学校工学研究院(東京部) 等当(国人)学大学校型工学研究院) 一度(同時大学大学校型工学研究院) 一度(同時大学大学校型工学研究院) 二度(二学校大学大学地型二学研究) 単七(デイモン・メンプレン・システムズ 一単七(デイモン・メンプレン・システムズ) メンプレン・シスナ 学校医学養学研究部 ■ (慶乐国王大学大学校工学研究校) お (奏量・気品産業技業第1個 完備優支品助付研究所) 以 (支援工業大学工学校) 単 (形化成ケイミカルズ) ● (お化成ケイミカルズ) 新弘(芝厚二葉大子 吉年(地化成ケミネ 重要(産業技術総合 和品(崩焼肥厚料?) 1936、協義問題有許大字系考理。 大(111大子大学大型(第27年間代定) 著者(第2中交大学化学工学者(第27) 定該(第2年間大学大学派(第3年) 反員(定都助定)問題大学大学成学者(第3年) 展示(第2年間大学大学校工学者) 展示(第2年書大学会漫像化学者(第5) 展示(第2年書大学会漫像化学者(第5) 展示(第2年書大学会漫像化学者(第5) 定者(定年日美術業大学大学和工具研 之者(定年日美術業大学本工具)

**國家委員会** 國家委員長::其新 新久 (法教大学大学和思想事体集学研究和)

(大川大学基礎教育院) (工業) 後山 赤人(株戸大学大学校工学研究室)

日本語学会 〒113-0020 東京街文京区本籍 5-265-702 Tel & Faz (IS-3815-2nus) 電子メールアドレス : mombrane@maabiglobs.ns.jp ムームページ : http://maks-jp.org/

laniguchi (Toray Indus

Processes. Of course, we wish our colleague all the best in it. In case you have additional questions or you would like to her new position and we are very thankful for all the great receive further information or publications, please feel free work that Kitty has done for our group over the years. Strong to contact us at MSTtnw@utwente.nl or +31 53 489 2950. ties will remain between MST and the new membrane group On behalf of all members of the Membrane Science and and we look forward to many fruitful collaborations between Technology group of the University of Twente, we would like and happy 2016! we can be very clear: research on (polymeric) membranes, Dr. Wiebe de Vos

academic part of the group as well as for the part dedicated

to the valorization of our research, the European Membrane Institute. Both groups will continue. With its strong infrastructure, the experience of our technicians and the expertise of our staff members, MST will

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Kynichi Sallo (China University) Kynichi Sallo (China University) Iliroyuki Sallo (Cuinachina University) Yazaya Sakagochi (KUIRARAY CO. LTD

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the groups.

(ICIM) is the premier international meeting intergenic membranes. ICIM is organized et

Orgo//www.internationalizations/

- The 10th Conference of Assanian Me

liquid separation, energy and a line-related and biosinspired

https://www.pec.org/peragtama.appa2a1=12117

av in the 7th Membrane Meeting, IZMM2016, which will be held from 20 to 23, August, 2016 in Dallari (China), IZMM2005 wil

any their 26-July 29, 2016, Nam. Int



Welcome

to wish you pleasant Christmas holidays and a prosperous



# **EUDIME - Erasmus Mundus Doctorate in Membrane** Engineering

Erasmus Mundus is a cooperation and mobility programme in the field of higher education, promoted by the Executive Agency for Education, Audiovisual & Culture (EACEA- European Union) that *aims* to enhance the quality of European higher education and to promote dialogue and understanding between people and cultures through cooperation with Third Countries.

EUDIME is designed to implement - at international level - excellence, innovation, mobility and multi-disciplinarity in investigation approaches related to membrane science and technology.

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http://eudime.unical.it/index.php

### UNIVERSITY OF CALABRIA



### ERASMUS MUNDUS DOCTORATE IN MEMBRANE ENGINEERING

acronym EUDIME – web-site: http://eudime.unical.it

Department of Chemical Engineering and Materials



<u>Erasmus Mundus</u> is a cooperation and mobility programme in the field of higher education, promoted by the Executive Agency for Education, Audiovisual & Culture (EACEA- European Union) that aims to enhance



the quality of European higher education and to promote dialogue and understanding between people and cultures through cooperation with Third Countries. In the framework of Action 1 ("implementing joint programmes at postgraduate level"),

the <u>Erasmus Mundus Doctorate in Membrane Engineering (EUDIME)</u> is one of the nine selected proposals among 151 applications submitted to EACEA on 2010. In addition, EUDIME is the first selected proposal in the field of <u>MEMBRANE ENGINEERING</u>.

**EUDIME** is designed to implement - at international level - excellence, innovation, mobility and multi-disciplinarity in investigation approaches related to membrane science and technology.



### MOBILITY

The programme, mainly laboratory-based, includes two mandatory <u>mobility periods</u> in two different Universities of the consortium, scheduled as relevant and instrumental to the fulfillment of the research activities of the doctoral candidate.

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Istituto per la Tecnologia delle Membrane

### NIVERSITÀ DELLA CALABRIA Università della Calabria (Italy) Coordinating Institution Université Montpellier 2 Sciences et Techniques (France) Université Paul Sabatier Université Paul Sabatier Toulouse (France) OULOUSE II Φ University of Twente (The University of Twente Netherlands) Institute of Chemical Technology Prague (Czech republic) Katholieke Universiteit Leuven (Belgium)

### PARTNERS

The consortium includes six leading partner institutions: University of Calabria (Italy), University of Twente (The Netherlands), Institute of Chemical Technology Prague (Czech Republic), University of Montpellier 2 and University Paul Sabatier-Toulouse (France), University of Leuven (Belgium). The EUDIME consortium also includes the following ten associate partners: University of Lisboa (Portugal), University of Zaragoza (Spain), RWTH Aachen (Germany), the European Membrane Society, the European Membrane House, and five industrial companies well-reputed in the field: SAPIO S.r.L. and GVS S.p.A. (Italy), Veolia Environment (France), Alfa Laval A/S (Denmark), and Mikropur s.r.o.(Czech Republic). Even longer is the list of industries, universities and institutions supporting this action.

Theme 1. Energy Cluster 1.1: Electrolyte membranes for fuel cells Cluster 1.2: Membranes for gas separation, catalytic reactors & biofuel productio
Theme 2. Water & Environment Cluster 2.1: Membrane systems for desalination and water purification Cluster 2.2: (Rio Catalytic) Membrane Reactors for westewater treatment
Theme 3. Health & Biotechnology Cluster 3.1: Biomedical membrane processes/ Active Pharmaceutics
Ingredients/Food formulation Theme 4. New Nanostractured membrane materials Cluster 4.1: Nanofabrication / inorganic-hybrid membranes/molecular-sca

### **RESEARCH THEMES**

The Programme, which maximum duration is 4 years, offers a unique opportunity to doctoral candidates for career in academia or in industry as R&D membrane engineers. Research and training activities cover a large industrially-assessed of emerging and spectrum applications in the field of membrane engineering, such as: desalination and water treatment, gas separation at molecular level (CO<sub>2</sub> capture, O<sub>2</sub>/N<sub>2</sub>/H<sub>2</sub> purification etc.), (bio)catalytic membrane reactors (MBR, PEM fuel-cells, biofuel production etc.), membrane processes for agrofood applications, engineering/artificial tissue organs/biomedical devices etc.

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# Statistics & Countrywise distribution

Edition	# of	# of	Fellowships
	applicants	nationalities	awarded
Ι	110	35	9
II	99	24	9
III	90	28	9
IV	67	23	7
V	103	26	5







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# Countrywise distribution2









# **The EM3E Erasmus Mundus Master**

The **Master in Membrane Engineering EM3E** offers an advanced education programme related to membrane science and engineering at the interface between material science and chemical engineering and focused on specific applicative fields.

The EM3E Master is an Education Programme supported by the European Commission, the European Membrane Society (EMS), the European Membrane/House (EMH), and a large international network of industrial companies, research centres and universities.

http://eudime.unical.it/index.php/em3e-master





# As positive follow out:

# The Master in Membrane Science

At the University of Abou Bekr Belkaid -Tlemcen, Algeria Coordinator: Prof. Benamar DAHMANI in collaboration with the University of Calabria and Institute on Membrane Technology





AGREEMENT FOR EDUCATIONAL AND SCIENTIFIC COOPERATION BETWEEN UNIVERSITA' DELLA CALABRIA (ITALY) AND UNIVERSITE ABOU BEKR BELKAID – TLEMCEN, ALGERIA





### 3<sup>rd</sup> generation desalination

Membrane-Based Desalination: An Integrated Approach (acronym MEDINA)



Desalination: An Integrated Approach (MEDINA). Iwa Publishing, 2011.







Develop the system engineering technology thru design, building, and operation of various sizes of pilot plants



Scale-up: prototype -> pilot -> demo. Pilot

- Start small and scale-up gradually
- Through the process, develop the system engineering technology

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# Masdar Special Project on Renewable energy seawater desalination program

*Goal*: Identification and implementation of industrial scale and commercially viable desalination technologies to ensure sustainable water supply to the region

Objectives:

Stage 1: (2013-2016) Demonstration of energy efficient desalination technologies by using 4 pilot plants with total capacity of 1500 m<sup>3</sup>/day

Criteria for success

Reverse Osmosis Less than 3.6 kWh/m<sup>3</sup> of eletricity consumption Innovative membrane based processes Less than 3.1 kWh/m<sup>3</sup> of eletricity consumption

RO+MD	1000 m <sup>3</sup> /day	With partnership of Abenoga
RO	300 m <sup>3</sup> /day	With partnership of SIDEM/VEOLIA
RO+IE	100 m <sup>3</sup> /day	With partnership of SUEZ
FO	50 m <sup>3</sup> /day	With partnership of TREVI Syetems

Based in Ghantoot, Abu Dhabi, these plants will operate continuously for 18 months

Stage 2: Implementation and development of technologies, that meet the predefined criteria, at commercial scale





Investment

Investment

Enterprises

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A novel approach to promote the development of membrane science and technology: the first case of Membrane Science and Technology Industrial Park



# **Operational framework of the Membrane Science**



# **The Jiangsu Membrane Industrial Park**

### Technologies which will be developed in the Membrane Industrial Park







# China-EU Membrane Technology Industrial Park (Weihai)

Weihai Municipal Government establishes China-EU Membrane Technology Industrial Park (Weihai) in Weihai Torch Hi-tech Industrial Development Zone (national level), mainly including membrane technology center and membrane production base





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• Establish "Membrane Technology Center" in New Science and Technology Park Mansion in Hi-Tech Zone, with an office area of approximately 10,000 square meters.

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- The center is engaging in following membrane technology and products related activities:
  - 1) Applied Research and Development of Membrane Equipment and Technology
  - 2) Transformation of Achievements in Applied Membrane Technology
  - 3) Membrane-associated third-party testing technology
  - 4) Technical Exchanges and Personnel Training
  - 5) Membrane Technology Achievements Exhibition
  - 6) Intermediary Service Organizations







# **Some important aspects of Membrane Science**

- 1. Potentialities in redesigning of a modern Process Engineering based on Process Intensification
- 2. Strong multidisciplinary character from Chemical Engineering and Material Science Engineering to Biotechnology, Biology, Tissue Engineering, etc.
- 3. The largest spectrum of realized and potential application in practically all Industrial sectors and in Agriculture, Medicine, Space Technologies, etc.





# **Future Actions**



- 1. Global Membrane Network
- 2. Large scale multinational projects on strategic matters
- International Doctorate in Membrane Engineering (following the Erasmus Mundus Doctorate in Membrane Engineering, EUDIME)







# **Strategic topics**

- o Blue energy from salinity gradients
- o Membrane systems in the Space
- Hybrid organs as artificial brains
- New Mining Industry: mineral recovery from the sea
- o New 2D materials (Graphene and Graphene derivatives,
- phosphorenes, borenes,...) for new Membranes



# **Blue energy and energy resources distribution**

About 2 terawatt of blue energy is available globally from the river water falling into the sea. Waste water discharged into the sea can generate additional 18GW of energy.



BP: Statistical review 2011

Recalculated

According to some optimistic estimations, 80% of the worlds power consumption can be generated from the salinity gradient. It can reduce 40% emission of green house gases. J.W. Post, PhD thesis, Wageningen University, Wageningen The Netherlands (2009) ITM - CNR

# Membrane systems in the space

Current **water recycling** on the International Space Station uses membranes that weigh up to 150 kg each and need to be replaced regularly, so this new technology could be a smaller, lighter and less energy-hungry alternative. The output will now be analyzed to see if it can be used in space in the future.





ESA astronaut Andreas Mogensen's 10-day 'iriss' mission to the International Space Station includes the scientific experiment to purify some of the Station's waste water and test a 'biomimetic' membrane from Denmark. The membrane mimics nature to create clean drinking water using a nano-technology that requires no energy.

www.esa.int/Our\_Activities/Human\_Spaceflight/iriss/Highlights/Andre as\_in\_space Consiglio Nazionale delle Ricerche



# Hollow Fiber Membranes as Guidance Channels for Neurons



Lp= $0.0304 \text{ L/m}^2 \text{ h mbar}$  $\theta adv = 77.62 \pm 2.97^\circ$  $\theta rec = 62.35 \pm 4.73^\circ$ 

Lp= $0.215 \text{ L/m}^2 \text{ h mbar}$  $\theta adv = 67.49 \pm 3.93^\circ$  $\theta rec = 42.96 \pm 4.17^\circ$ 



S. Morelli, A.Piscioneri, S. Salerno, M. Rende, C. Campana, F. Tasselli, A. di Vito, G. Giusi, M. Canonaco, E. Drioli and L. De Bartolo. J Tissue Eng Regen Med 2012; 6: 299–313.



# Neuronal network construct in a membrane system

### β-TUB III

### **GAP 43**

MERGE



A. Piscioneri, S. Morelli, M. Mele, M. Canonaco, E. Bilotta, P. Pantano, E. Drioli, L. De Bartolo. <u>Acta Biomaterialia</u> 2015; 24: 297–308



# Micropatterned membranes for guidance of neuronal cells



S. Morelli, S. Salerno, A. Piscioneri, B.J. Papenburg, A. Di Vito, G. Giusi, M. Canonaco, D. Stamatialis, E. Drioli, L. De Bartolo, S. Morelli et al. *Biomaterials* 2010, 31: 7000-7011





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Source: BHIMANAPATI ET AL. ACS NANO, 9, 2015, 11509–11539

Non-graphene layered materials, including transition-metal dichalcogenides (TMDs), Mxenes, posphorene and others new properties and applications upon 2D confinement





Simulated "open" and "closed" states of the MoS<sub>2</sub>

The filter can be regulated by mechanical strain, yielding a highly tunable nanopore interface







# **<u>Thermal conductivity</u>: 2D Materials beyond graphene**

Material	<b>Thermal conductivity</b> @ T=300 K [W m <sup>-1</sup> K <sup>1</sup> ]	Reference
MONOLAYER graphene MONOLAYER SnSe	<b>0.46-0.68 (anisotropic)</b>	A. A. Balandin et al. Superior Thermal Conductivity of Single-Layer Graphene, <i>Nano Lett.</i> <b>2008</b> ,8, 902. L.D. Zhao et al. Ultralow thermal conductivity and high thermoelectric figure of merit in SnSe crystals. <i>Nature</i> <b>2014</b> , <i>508</i> , 373-377.
$Sb_2Te_3$ (similar to Bi2Se3)	0.23-0.5	<ul> <li>J. Chen et al. Sb<sub>2</sub>Te<sub>3</sub> Nanoparticles with Enhanced Seebeck Coefficient and Low Thermal Conductivity.</li> <li>Chem. Mater. 2010, 22, 3086-3092.</li> <li>M.K. Jana et al. lonothermal Synthesis of Few-Layer Nanostructures of Bi2Se3 and Related Materials.</li> </ul>
Bi <sub>2</sub> Se <sub>3</sub>	0.4 (few layers)	<i>Chem. Eur. J.</i> <b>2013,</b> <i>19</i> , 9110-9113. W. Li, et al. Thermal conductivity and phonon linewidths of monolayer MoS2 from first principles.
MoS <sub>2</sub> WSe <sub>2</sub>	108 (monolayer) 0.05 (monolayer) 1.5 (bulk)	<i>Appl. Phys. Lett.</i> <b>2013</b> , 103, 253103. C. Chiritescu at al. Ultralow Thermal Conductivity in Disordered, Layered WSe <sub>2</sub> Crystals. <i>Science</i> <b>2007</b> , <i>315</i> , 351-353.
Phosphorene	zigzag direction: 110 armchair direction: 36	A.Jain and A.J.H. McGaughey Strongly anisotropic in-plane thermal transport in single-layer black phosphorene. <i>Sci. Rep.</i> 2015, <i>5</i> , 8501.
Polymers PVDF Polytetrafluoroethylene Polypropylene Cellulose acetate	0.19 0.24-0.35 0.10-0.22 0.16-0.36	http://www.quadrantplastics.com/fileadmin/quadrant/documents/QEPP/EU/Product_Data_Sheets_PDF/Product_Data_Sheet_Symalit_PVDF_1020.pdf http://www.bearingworks.com/content_files/pdf/retainers/PTFE%20datasheet.pdf http://www.professionalplastics.com/professionalplastics/ThermalPropertiesofPlasticMaterials.pdf http://www.professionalplastics.com/professionalplastics/ThermalPropertiesofPlasticMaterials.pdf



# **Molecular Modelling Studies**

**Thermal conductivities of single- and multi-layer phosphorene**: a molecular dynamics study Ying-Yan Zhan et al. Nanoscale, 2016, 8,483–491



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layer phosphorene along zigzag and armchair directions.

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### **Organizing Committee**

### Symposium Organizer:

Ho Bum Park (Hanyang University, Korea)

Antonio Politano (University of Calabria, Italy)

Enrich Drioli (University of Calabria (Italy) & Hanyang University (Korea))

Francesco Canganella (Science and Technology Counsellor, Embassy of Italy)

