Practical Tips for Writing Effective Papers

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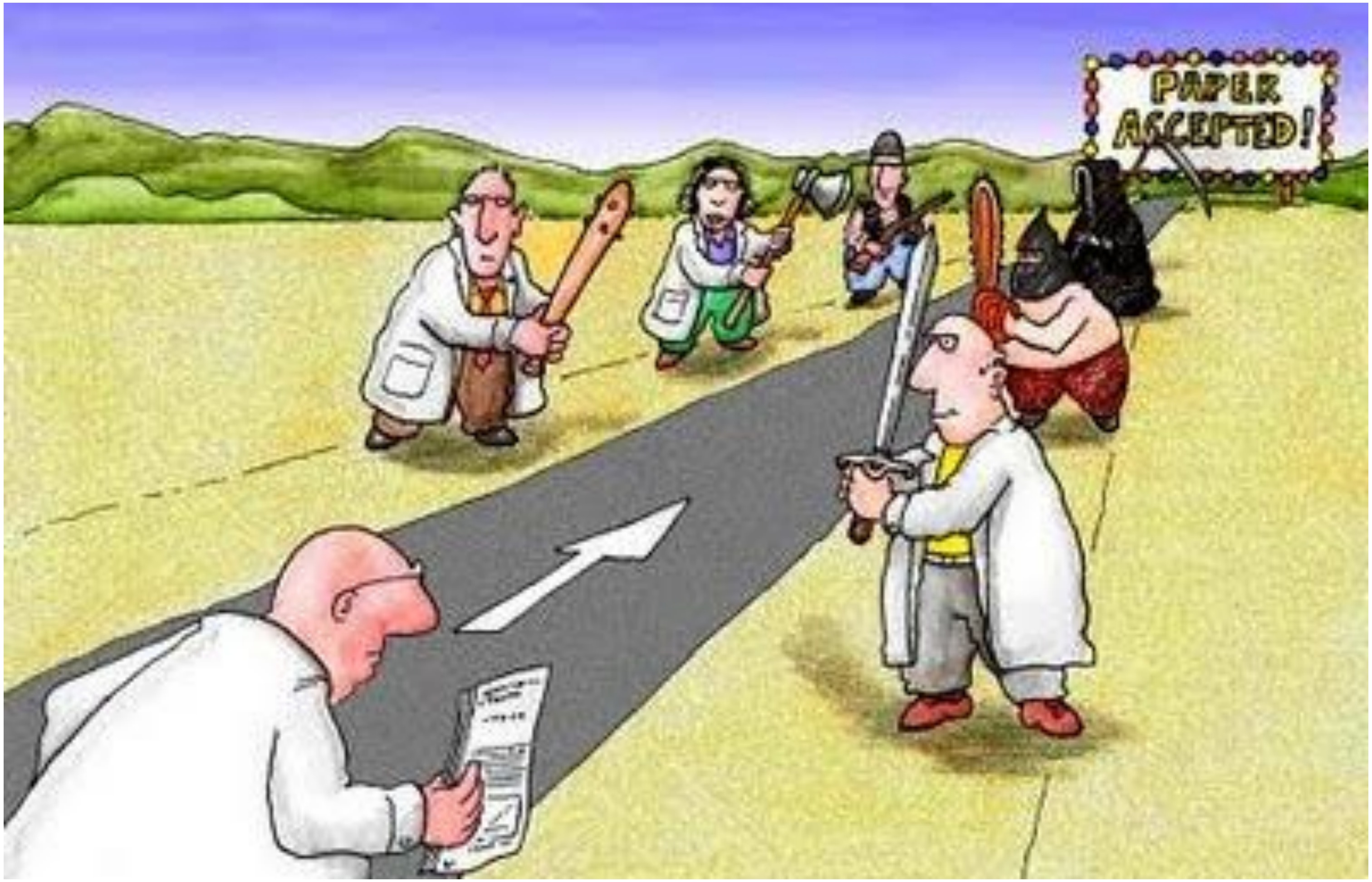
Publishing a paper can be a long journey….



http://oncirculation.com/2013/05/22/write-that-journal-article-in-7-days/

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Highly Recommended to Read

ADVANCED MATERIALS

Whitesides' Group: Writing a Paper**

By *George M. Whitesides**

Adv. Mater. **2004**, *16*, No. 15, August 4 DOI: 10.1002/adma.200400767

G.M. Whitesides, Harvard University, is one the world most cited chemists and author of over 1,200 journal publications

Tips from Whitesides….**Outline**!

A paper is an organized description of hypotheses, data and conclusions, intended to instruct the reader. Papers are a central part of research. If your research does not generate papers, it might just as well not have been done. "Interesting and unpublished" is equivalent to "non-existent".

A paper is not just an archival device for storing a completed research program; it is also a structure for *planning* your research in progress. If you clearly understand the purpose and form of a paper, it can be immensely useful to you in *organizing* and conducting your research. A good outline for the paper is also a good plan for the research program. You should write and rewrite these plans/outlines throughout the course of the research.

I emphasize the central place of an outline in writing papers, preparing seminars, and planning research. I especially believe that for you, and for me, it is most *efficient* to write papers from outlines. An *outline* is a written plan of the organization of a paper, *including* the data on which it rests. You should, in fact, think of an outline as a carefully organized and presented set of data, with attendant objectives, hypotheses, and conclusions, rather than an outline of text.

All writing that I do—papers, reports, proposals (and, of course, slides for seminars)—I do from outlines. I urge you to learn how to use them as well.

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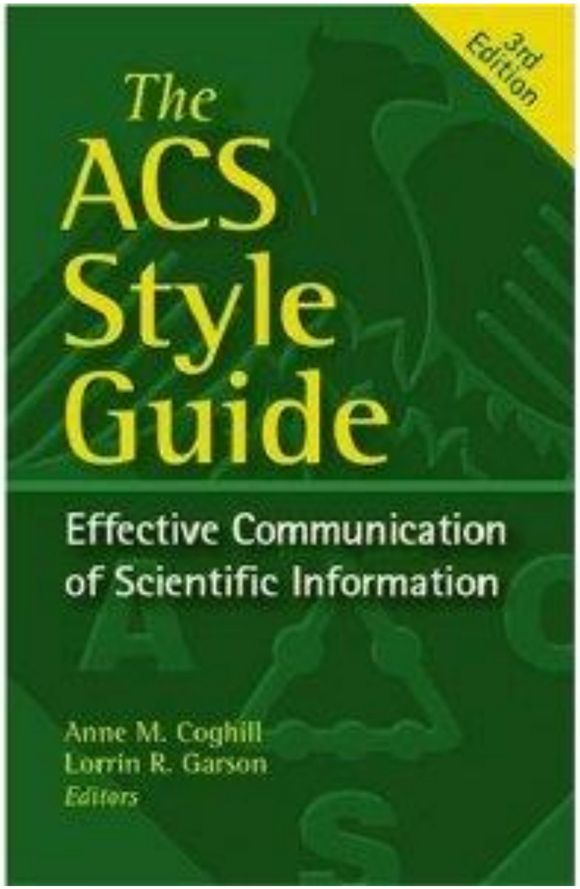
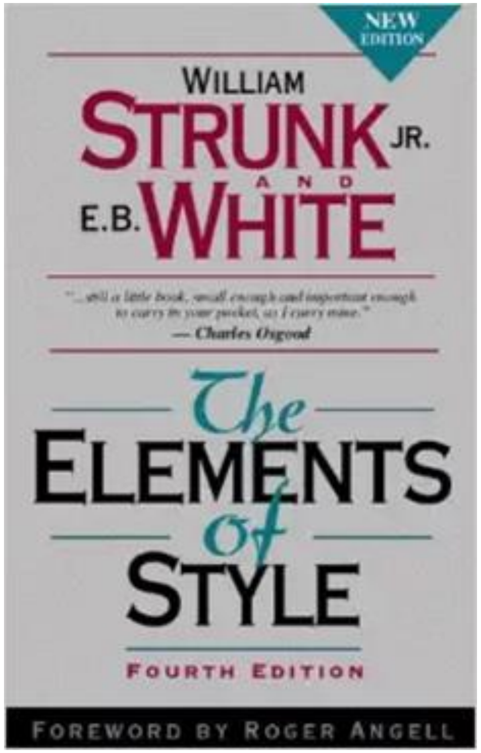
Recommended Books for Effective Writing

Series: American Chemical Society Publication Series
ISBN-13: 9780841239999. 2006





The Elements of Style, Fourth Edition,1999
by William Strunk Jr. and E. B. White

More Recommended Readings

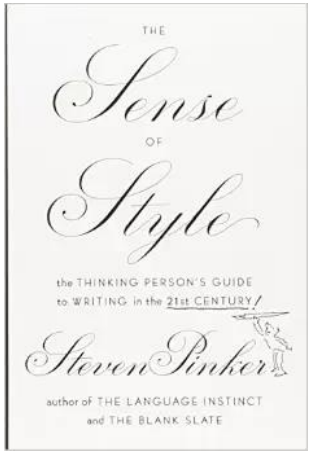
- The Chronicle of Higher Education: Why Academics Stink at Writing

  http://chronicle.com/article/Why-Academics-Writing-Stinks/148989/

- Bad Writing Contest

  http://denisdutton.com/bad_writing.htm/

- The Sense of Style: The Thinking Person's Guide to Writing in the 21st Century, by Steven Pinker, 2014



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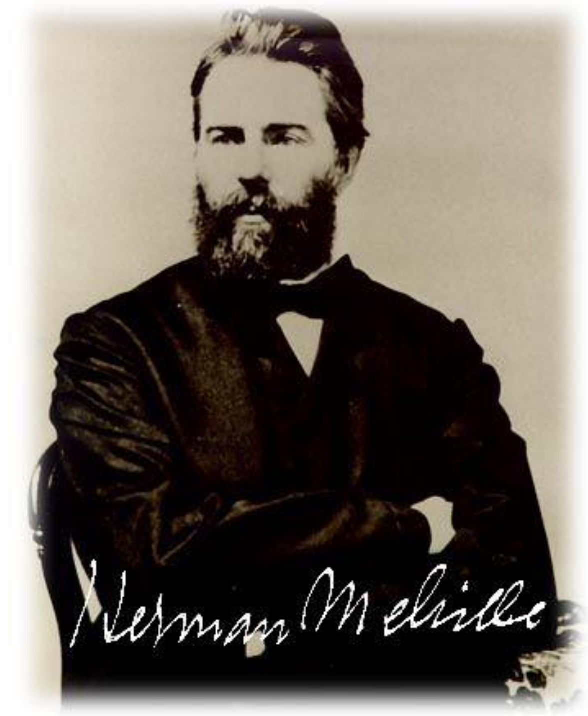
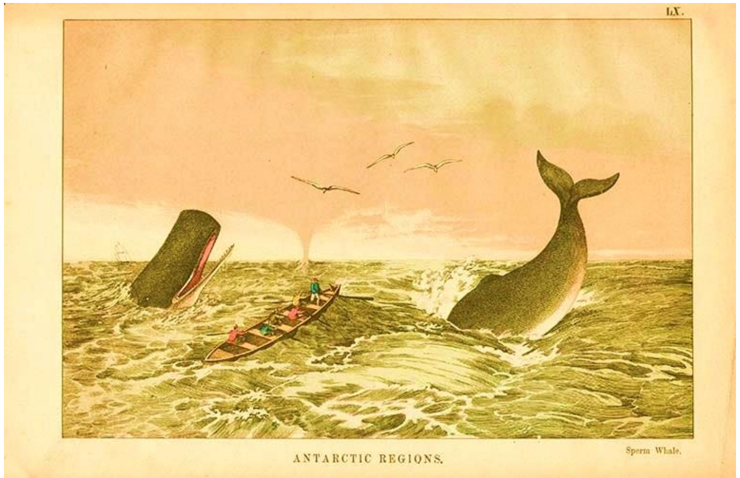
General Steps

- “*To produce a mighty book, you must choose a mighty theme*” (Herman Melville).
  - Topic is important — new, hot topics are easier to publish, but strive for rigor and relevance (R^2)



- *No great and enduring volume can ever be written on the flea*... (Herman Melville).
  - Good writing takes tremendous efforts



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General Steps

- Decide about a suitable journal and rough title of the paper
- Likely journals in our environmental engineering/science field are *ES&T, ES&T Letters, Water Research*, and other specialized journals; can aim higher – e.g., *Energy & Environmental Science* (*EES*), *Science, Nature, PNAS*....
- Criteria for journal: Right audience; high impact factor (not an obscure journal, like JW Gibbs)
- Start drafting the outline of the paper as you continue to collect data; it will help you to better plan the experiments

Outline as a Planning Tool

- Think about what data you plan to collect and how to present the data most effectively (insightful figures, detailed tables, etc.)
- Sketch the future figures (can be done even by hand) with the expected data; this will help you to design the experiments
- Get ideas about figures and style from good published papers that you read (of well respected and impactful authors that you appreciate)

General: Paper Structure for Drafting the Outline

- Papers usually have the following sections:
  - Abstract (with TOC Art/graphic abstract)
  - Highlights (some journals; mostly Elsevier journals)
  - Introduction
  - Theory or Modeling (for papers with modeling, if model is new)
  - Materials and Methods
  - Results and Discussion (some split to “Results” and “Discussion” as separate sections)
  - Conclusion (ES&T doesn’t have this section)
- Plan on ~4-8 figures and a few tables (if any) presenting important data
- Most journals have online **Supporting Information** for other data (usually less important or “boring” data)

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Outline — General

- Decide about the journal and adopt its style for sections, subsections, etc.
- Most journals allow sections and subsections. Some (like Elsevier journals) allow sub-subsections (e.g., 2.xx, 2.1.xx, 2.1.1.xx)
- Think about a logical way to present the data so you can tell the "story" of your research in a way that is easy to follow and understand
- It is like a flowchart for a computer code — ideas should flow logically and in the right order
- *Creative* research, but *effective* writing — *Story* NOT a *mystery*

The Outline

- Have the headings (titles) of all sections and subsections (and sub-subsections) in order
- Indicate what figures, tables, and equations will be included in each of the sections or subsections
- Provide final form of figures (if you have data) and sketch of what you hope will be the data while you are still collecting data or planning experiments
- Provide equations and *detailed* figure and table captions

Outline: Start with Title Page

Photo-Grafting Graphene Oxide to Inert Membrane Materials to Enhance Antibacterial Activity

Submitted to

Environmental Science & Technology Letters

Masashi Kaneda[1, 2], Xinglin Lu[*, 1], Wei Cheng[1, 3], Xuechen Zhou[1], Roy Bernstein[4], Wei Zhang[4], Katsuki Kimura[2], and Menachem Elimelech[*, 1]

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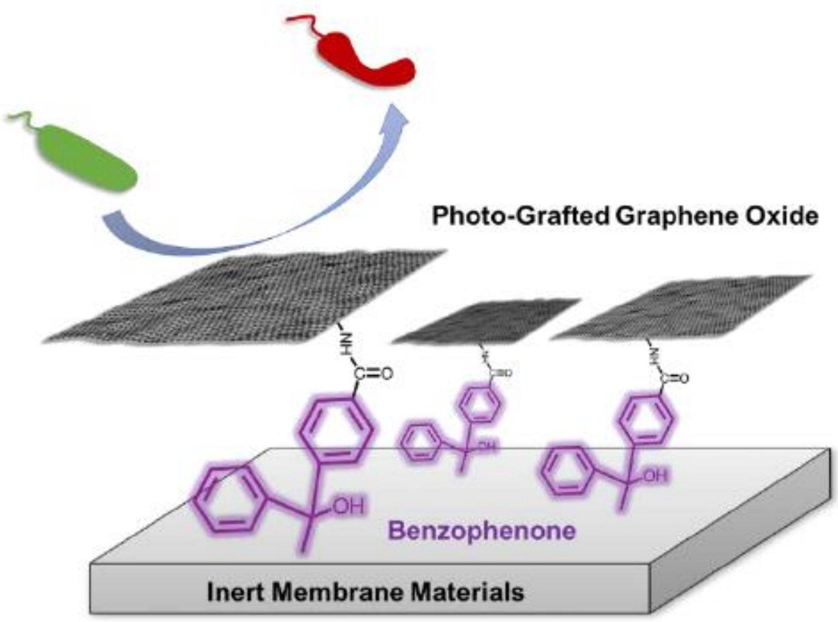
Outline: Rest of the Paper

Abstract

TOC Art



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Outline: Include the Last Paragraph of the Introduction

INTRODUCTION

In this study, we demonstrate, for the first time, a facile technique using 4-benzoylbenzoic acid as an anchor to graft GO nanosheets to inert membrane materials, including PVDF and polysulfone. The functionalized membranes are extensively characterized to confirm the successful grafting of GO and to assess its effect on the membrane's intrinsic transport properties. The grafted GO nanosheets impart strong antibacterial activity to the inert membranes, as evidenced by the decreased viability of bacterial cells in contact with the membrane surface. Our results highlight the potential application of benzophenone chemistry in surface modification of inert materials for a variety of environmental applications.

MATERIALS AND METHODS

Synthesis of Benzophenone-Functionalized Graphene Oxide (GO).

FIGURE 1

Surface Modification of Inert Membranes.

Characterization of Modified Membranes.

Antibacterial Activity of Modified Membranes.

RESULTS AND DISCUSSION

GO Nanosheets Are Irreversibly Grafted to Inert Membrane Materials.

FIGURE 2

FIGURE 3

Minimal Impact of Surface Functionalization on both Membrane Transport and Surface Properties.

GO-Functionalized Membranes Exhibit Enhanced Antibacterial Activity.

FIGURE 4

Outline: Figures with Figure Captions

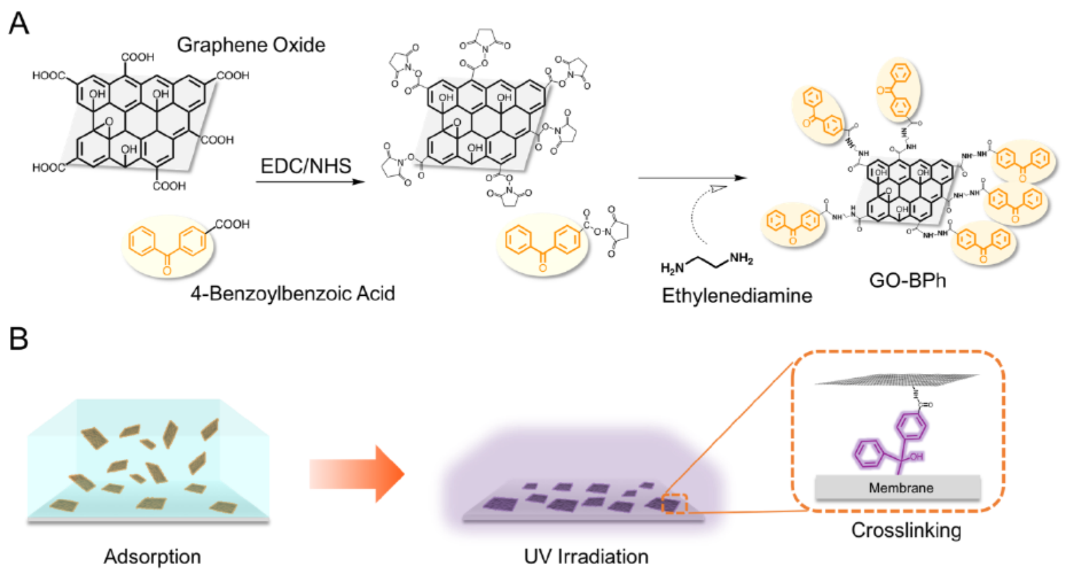

Figure 1. Schematic diagram of the surface modification procedure using benzophenone chemistry. (A) Reaction procedure to synthesize benzophenone-functionalized GO nanosheets. GO nanosheets are functionalized with 4-benzoylbenzoic acid (benzophenone) using 1-ethyl-3-[3-(dimethylamino) propyl] carbodiimide hydrochloride (EDC)- and *N*-hydroxysuccinimide (NHS)-mediated activation of carboxyl groups. Native carboxyl groups of GO nanosheets and 4-benzoylbenzoic acid are first converted into amine-reactive esters by EDC and NHS. Ethylenediamine (ED) is then covalently bonded through the formation of amide bonds to link the benzophenone molecule to GO nanosheets. (B) Benzophenone-functionalized GO nanosheets are first adsorbed on the membrane surface through hydrophobic interactions. Benzophenone groups are then covalently linked to the substrate membranes via photo-induced grafting and crosslinking under UV irradiation.

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Outline: Figures with Figure Captions

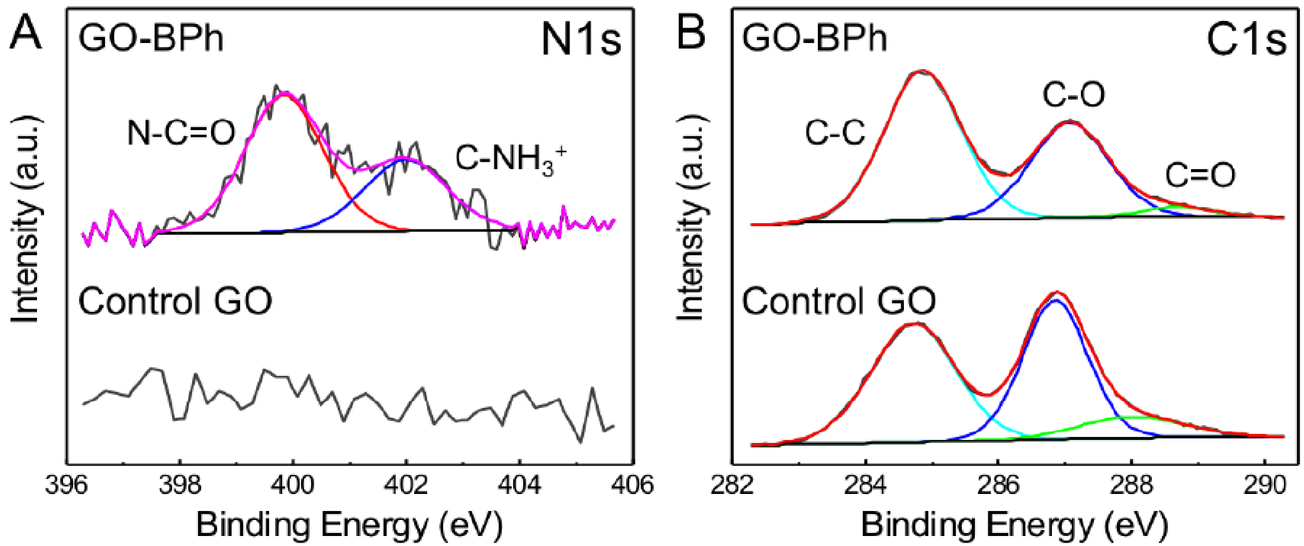

Figure 2. N1s XPS spectra of (A) control GO and benzophenone-functionalized GO (GO-BPh). C1s XPS spectra of (B) control GO and GO-BPh composite.

Outline: Figures with Figure Captions

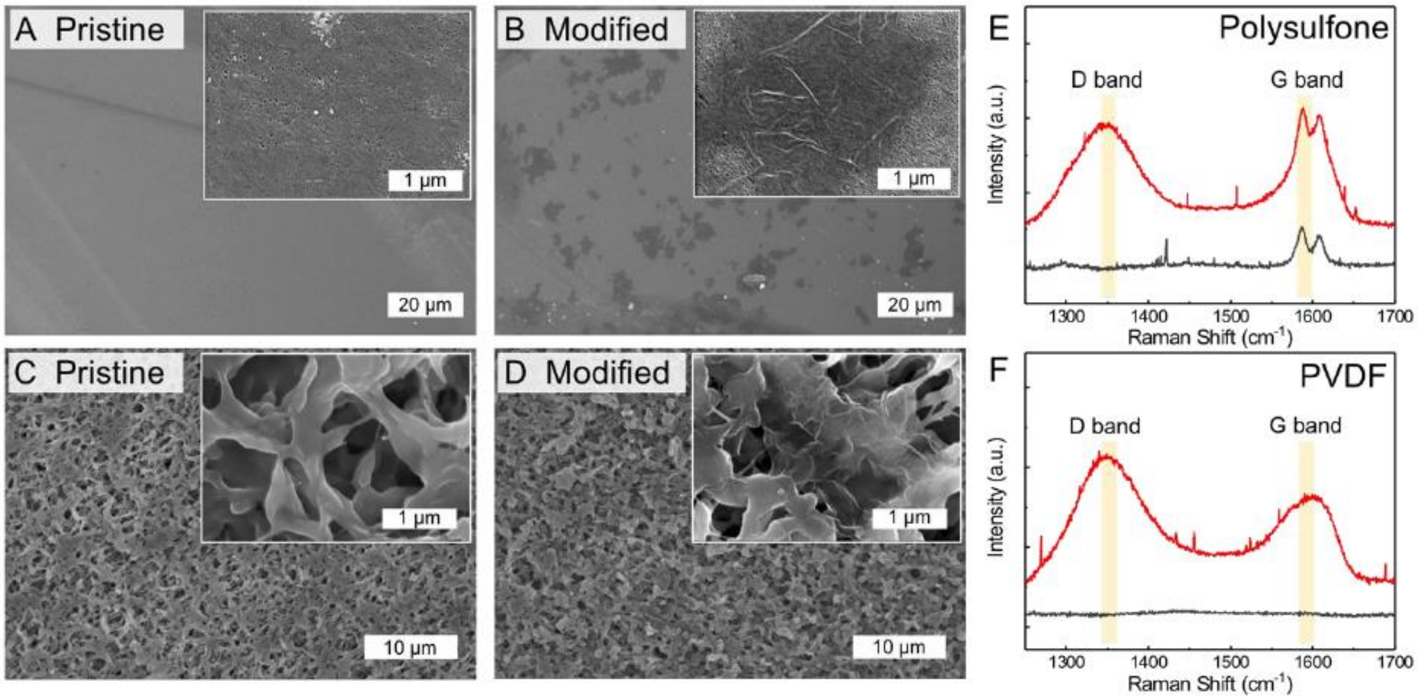

Figure 3. Representative SEM micrographs of (A) pristine polysulfone, (B) GO-functionalized polysulfone, (C) pristine PVDF, and (D) GO-functionalized PVDF membranes. Raman spectra of (E) pristine polysulfone (gray) and GO-functionalized polysulfone membranes (red), and (F) pristine PVDF (gray) and GO-functionalized PVDF membranes (red).

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Outline: Figures with Figure Captions

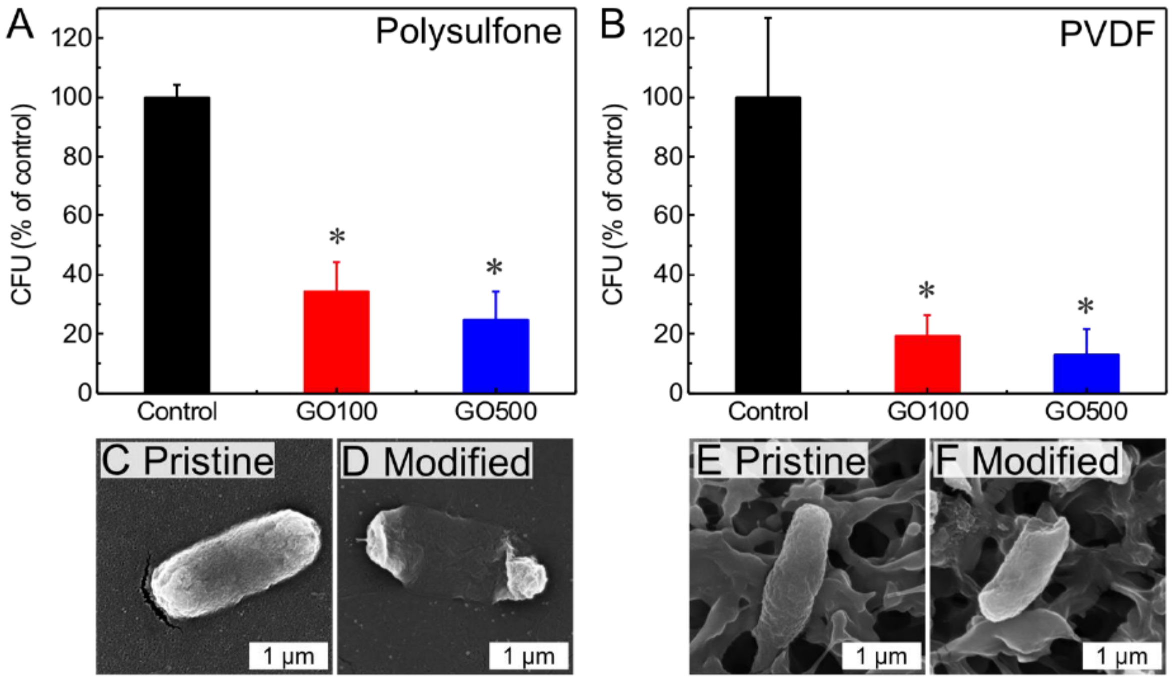

Figure 4. Antibacterial activity of GO-functionalized membranes. Relative number of viable *E. coli* cells after three hours of contact with (A) GO-functionalized polysulfone membranes and (B) GO-functionalized PVDF membranes. Values marked with an asterisk (*) are significantly different from the value of the control sample (n = 3; Student's t-test, P < 0.05). Representative SEM micrographs of *E. coli* cells fixed on (C) pristine polysulfone, (D) GO-functionalized polysulfone, (E) pristine PVDF, and (F) GO-functionalized PVDF membranes.

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Outline: Supporting Information

Supporting Information

Photo-Grafting Graphene Oxide to Inert Membrane Materials to Enhance Antibacterial Activity

Environmental Science & Technology Letters

Masashi Kaneda[1, 2], Xinglin Lu[*, 1], Wei Cheng[1, 3], Xuechen Zhou[1], Roy Bernstein[4], Wei Zhang[4], Katsuki Kimura[2], and Menachem Elimelech[*, 1]

[1]Department of Chemical and Environmental Engineering, Yale University, New Haven, CT 06520-8286, United States

[2]Division of Environmental Engineering, Hokkaido University, N13W8, Kita-ku, Sapporo 060-8628, Japan

[3]State Key Laboratory of Urban Water Resource and Environment, School of Environment, Harbin Institute of Technology, Harbin 150090, China

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Outline: Supporting Information – More on Materials and Methods

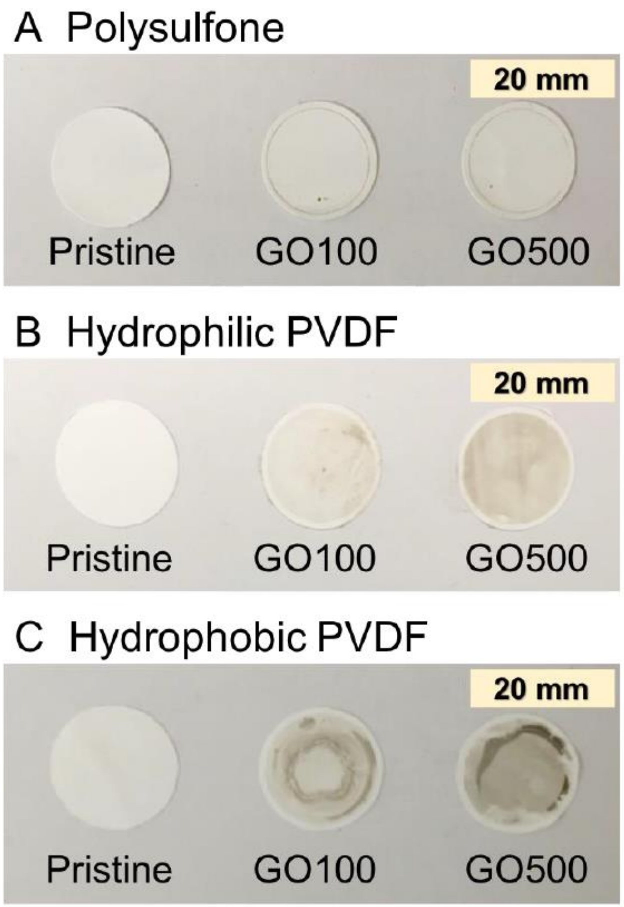
MATERIALS AND METHODS

Materials and Chemicals.

Synthesis of Benzophenone-functionalized GO Nanosheets (GO-BPh).

Membrane Surface Functionalization with GO-BPh Composite.

Outline: Supporting Information – More Figures and Tables



S2. Representative photographs of (A) GO-functionalized polysulfone, (B) GO-nalized hydrophilic PVDF, and (C) GO-functionalized hydrophobic PVDF membranes.

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Outline: Supporting Information – More Figures and Tables

Table S1. XPS elemental composition of control and benzophenone-functionalized GO (GO-BPh). Nitrogen content detected in the control GO was too small to be deconvoluted as shown in Figure S2A.

Samples	C %	N %	O %
GO	68.6	n/a	30.9
GO-BPh	71.5	1.8	26.7

Table S2. XPS elemental composition change of polysulfone and hydrophilic PVDF membranes after GO functionalization.

Samples	S %	C %	O %	F %	O/S	O/F
Pristine polysulfone	3.1	82.7	14.2		4.6	
GO functionalized polysulfone	1.8	79.1	19.0		10.6	
Pristine PVDF		61.4	20.2	18.4		1.0
GO functionalized PVDF		62.9	24.4	12.7		1.9

Outline: Review Article (Title Page)

Invited Review Article

The role of nanotechnology in tackling global water challenges

Nature Sustainability

Meagan S. Mauter, Ines Zucker, Francois Perreault, Jay R. Werber, Jae-Hong Kim and Menachem Elimelech*

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Outline: Review Article (Main Paper)

Abstract.

Introduction

This paper critically reviews the use of nanomaterials to address global water challenges through the lens of sustainability. We relate ENM properties to their application in disinfecting, decontaminating, and desalinating water and highlight safe and effective strategies for deploying nanomaterials in water treatment processes. We conclude by proposing sustainability frameworks for evaluating the net benefits of nanotechnology-enabled water treatment processes, including risk frameworks and social acceptance frameworks.

Pathogen inactivation for providing safe water

Figure 1

Decontamination for providing clean water

Figure 2

Desalination and reuse for augmenting water supply

Figure 3

Environmental and health implications

Figure 4

Sustainability and societal acceptance

Figure 5

Conclusion and outlook

References

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Outline: Review Article (Figures)

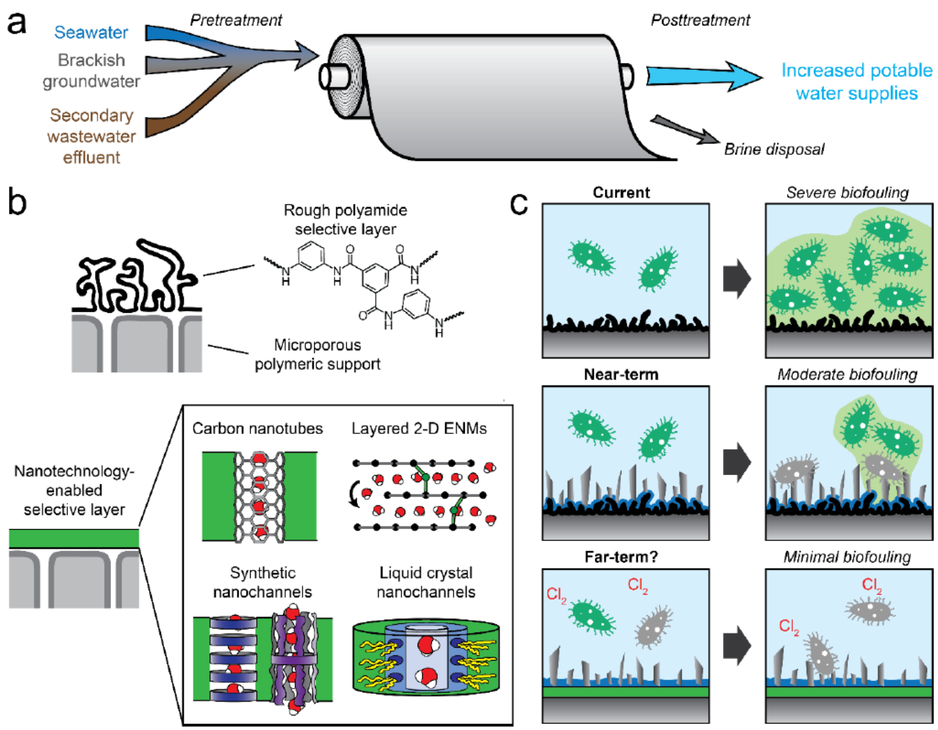

Figure 3. Nanotechnology-enabled reverse osmosis (RO) for desalination and water reuse to efficiently expand potable water supplies. (a) General RO process for turning unconventional water sources (seawater, brackish water, and municipal wastewater) into potable water. Desalination membranes are used in high-membrane-area spiral-wound modules. (b) Current polymeric and potential nanotechnology-enabled desalination membranes. (c) Use of nanotechnology to combat biofouling in RO. Current rough polymeric membranes often suffer severe biofouling, which can be partially mitigated in the near-term using anti-adhesive coatings (dark blue) and surface-attached ENMs that enable contact-mediated bacterial inactivation (gray). Ideally, novel oxidation-resistant selective layers will allow usage of chlorine, in addition to biocidal and anti-adhesive coatings, to eliminate biofouling.

Outline: Review Article (Figures)

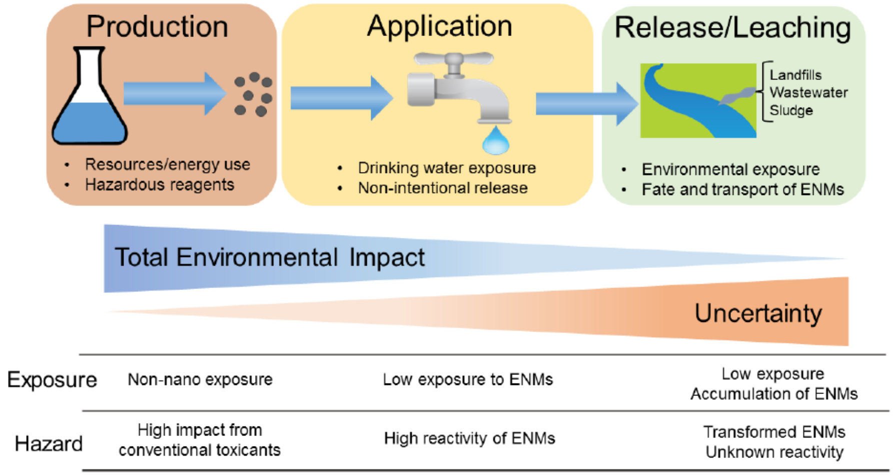

Figure 4. Environmental implications of nanotechnology in water treatment throughout their life cycle. The overall environmental impact of ENMs occurs early during the production stage through the use of non-renewable resources and hazardous reagents in the synthesis of ENMs[41,109]. Even though production stage impacts are not "nano" in nature, they represent the main contributor to the total environmental impact of ENMs. The development of manufacturing methods leading to energy efficiency and waste reduction will have a significant impact on the overall sustainability of ENMs[125]. Nano-specific impacts due to the direct exposure to ENMs can occur from occupational exposure to ENMs during manufacturing, or through the release of ENMs in drinking water or the environment. The risk for ENMs exposure tends to decrease through this life cycle as only a small quantity is typically used for nano-enabled processes, and only a negligible fraction of this quantity will likely be released to the environment. While ENMs are initially designed to be highly reactive, their transformation during the different stages of the life cycle will alter their surface chemistry and reactivity. Challenges in predicting how these changes in surface chemistry affect the fate and toxicity of ENMs in complex environments lead to increasing level of uncertainty during the latter stages of the life cycle of ENMs.

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Title

- Attractive titles, but not too “commercial”, “PR” style
- Should reflect the contents of the paper
- Concise but still informative
- Avoid jargon, symbols, commercial names
- Avoid papers with titles followed by “Part 1: xxx” (with future papers having “Part 2: yy” etc.)

Example of "Good" Titles

Correlation Equation for Predicting Single-Collector Efficiency in Physicochemical Filtration in Saturated Porous Media

NATHALIE TUFENKJI AND MENACHEM ELIMELECH*
Department of Chemical Engineering, Environmental Engineering Program, P.O. Box 208286, Yale University, New Haven, Connecticut 06520-8286

Aggregation Kinetics of Multiwalled Carbon Nanotubes in Aquatic Systems: Measurements and Environmental Implications

NAVID B. SALEH, LISA D. PFEFFERLE, AND MENACHEM ELIMELECH*
Department of Chemical Engineering, Yale University, New Haven, Connecticut 06520-8286

Antibacterial Effects of Carbon Nanotubes: Size Does Matter!

Seoktae Kang, Moshe Herzberg,[†] Debora F. Rodrigues, and Menachem Elimelech*

Department of Chemical Engineering, Yale University, P.O. Box 208286, New Haven, Connecticut 06520-8286

Received March 26, 2008. Revised Manuscript Received May 6, 2008

Example of "Good" Titles

Energy & Environmental Science

ROYAL SOCIETY OF CHEMISTRY

REVIEW

View Article Online
View Journal | View Issue

CrossMark
click for updates

Cite this: *Energy Environ. Sci.*, 2016, **9**, 31

Pressure-retarded osmosis for power generation from salinity gradients: is it viable?

Anthony P. Straub, Akshay Deshmukh and Menachem Elimelech*

Environmental Science & Technology LETTERS

Review

pubs.acs.org/journal/estlcu

The Critical Need for Increased Selectivity, Not Increased Water Permeability, for Desalination Membranes

Jay R. Werber,† Akshay Deshmukh,† and Menachem Elimelech*,†,‡

†Department of Chemical and Environmental Engineering, Yale University, New Haven, Connecticut 06520-8286, United States
‡Nanosystems Engineering Research Center for Nanotechnology-Enabled Water Treatment (NEWT), Yale University, New Haven, Connecticut 06520-8286, United States

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Example of Not So Good Titles (Yes…my papers ☹)

Journal of Colloid and Interface Science **229,** 554–567 (2000)
doi:10.1006/jcis.2000.7062, available online at http://www.idealibrary.com on IDEAL®

Coupled Influence of Colloidal and Hydrodynamic Interactions on the RSA Dynamic Blocking Function for Particle Deposition onto Packed Spherical Collectors

Chun-Han Ko, Subir Bhattacharjee, and Menachem Elimelech[1]

Department of Chemical Engineering, P.O. Box 208286, Yale University, New Haven, Connecticut 06520-8286

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Available online at www.sciencedirect.com
ScienceDirect

Journal of Membrane Science 296 (2007) 42–50

journal of MEMBRANE SCIENCE

www.elsevier.com/locate/memsci

Protein antifouling mechanisms of PAN UF membranes incorporating PAN-*g*-PEO additive

Seoktae Kang[a], Ayse Asatekin[b], Anne M. Mayes[c], Menachem Elimelech[a,*]

Example of Not So Good Titles

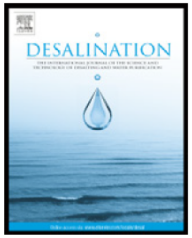
Desalination 350 (2014) 61–68

Contents lists available at ScienceDirect

ELSEVIER

Desalination

journal homepage: www.elsevier.com/locate/desal



Using indigenous microalga species to reduce HCO_3^-, NH_3N, NO_3N, total P, Ca^{2+}, SO_4^{2-}, and Cl^- from a high conductivity concentrate

CrossMark

Abstract

- Concise, yet informative (some journals have word count limit)
- Length – about 0.5 to 0.75 page (single space)
- Unless it is a new area of research, no need for general/overview opening sentences
- Not too general and vague
- Some specific/quantitative details (but not too much)
- Avoid acronyms, equations, references
- Avoid heavy jargon
- Think about some busy researchers who read only the abstract…..

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Abstract (Paper)

A new equation for predicting the single-collector contact efficiency (η_0) in physicochemical particle filtration in saturated porous media is presented. The correlation equation is developed assuming that the overall single-collector efficiency can be calculated as the sum of the contributions of the individual transport mechanisms—Brownian diffusion, interception, and gravitational sedimentation. To obtain the correlation equation, the dimensionless parameters governing particle deposition are regressed against the theoretical value of the single-collector efficiency over a broad range of parameter values. Rigorous numerical solution of the convective−diffusion equation with hydrodynamic interactions and universal van der Waals attractive forces fully incorporated provided the theoretical single-collector efficiencies. The resulting equation overcomes the limitations of current approaches and shows remarkable agreement with exact theoretical predictions of the single-collector efficiency over a wide range of conditions commonly encountered in natural and engineered aquatic systems. Furthermore, experimental data are in much closer agreement with predictions based on the new correlation equation compared to other available expressions.

Correlation Equation for Predicting Single-Collector Efficiency in Physicochemical Filtration in Saturated Porous Media

NATHALIE TUFENKJI AND MENACHEM ELIMELECH*

Department of Chemical Engineering, Environmental Engineering Program, P.O. Box 208286, Yale University, New Haven, Connecticut 06520-8286

Environ. Sci. Technol. **2004**, *38*, 529−536

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Abstract (Paper

nature energy

ARTICLES

PUBLISHED: 27 JUNE 2016 | ARTICLE NUMBER: 16090 | DOI: 10.1038/NENERGY.2016.90

Harvesting low-grade heat energy using thermo-osmotic vapour transport through nanoporous membranes

Anthony P. Straub[1], Ngai Yin Yip[2], Shihong Lin[3], Jongho Lee[1] and Menachem Elimelech[1*]

Low-grade heat from sources below 100 °C offers a vast quantity of energy. The ability to extract this energy, however, is limited with existing technologies as they are not well-suited to harvest energy from sources with variable heat output or with a small temperature difference between the source and the environment. Here, we present a process for extracting energy from low-grade heat sources utilizing hydrophobic, nanoporous membranes that trap air within their pores when submerged in a liquid. By driving a thermo-osmotic vapour flux across the membrane from a hot reservoir to a pressurized cold reservoir, heat energy can be converted to mechanical work. We demonstrate operation of air-trapping membranes under hydraulic pressures up to 13 bar, show that power densities as high as $3.53 \pm 0.29\ \mathrm{W\,m^{-2}}$ are achievable with a 60 °C heat source and a 20 °C heat sink, and estimate the efficiency of a full-scale system. The results demonstrate a promising process to harvest energy from low-temperature differences (<40 °C) and fluctuating heat sources.

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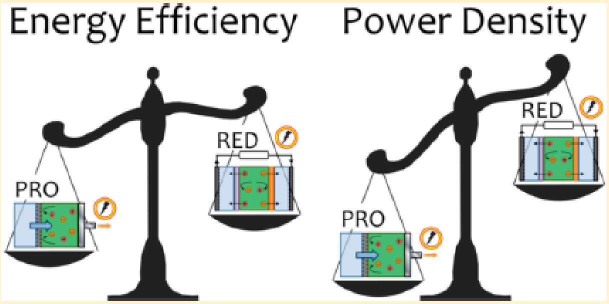
Abstract (Paper): Use Effective TOC Art (Graphic Abstract)

Comparison of Energy Efficiency and Power Density in Pressure Retarded Osmosis and Reverse Electrodialysis

Ngai Yin Yip and Menachem Elimelech*

Department of Chemical and Environmental Engineering, Yale University, New Haven, Connecticut 06520-8286, United States

Supporting Information



ABSTRACT: Pressure retarded osmosis (PRO) and reverse electrodialysis (RED) are emerging membrane-based technologies that can convert chemical energy in salinity gradients to useful work. The two processes have intrinsically different working principles: controlled mixing in PRO is achieved by water permeation across salt-rejecting membranes, whereas RED is driven by ion flux across charged membranes. This study compares the energy efficiency and power density performance of PRO and RED with simulated technologically available membranes for natural, anthropogenic, and engineered salinity gradients (seawater—river water, desalination brine—wastewater, and synthetic hypersaline solutions, respectively). The analysis shows that PRO can achieve both greater efficiencies (54—56%) and higher power densities (2.4—38 W/m^2) than RED (18—38% and 0.77—1.2 W/m^2). The superior efficiency is attributed to the ability of PRO membranes to more effectively utilize the salinity difference to drive water permeation and better suppress the detrimental leakage of salts. On the other hand, the low conductivity of currently available ion exchange membranes impedes RED ion flux and, thus, constrains the power density. Both technologies exhibit a trade-off between efficiency and power density: employing more permeable but less selective membranes can enhance the power density, but undesired entropy production due to uncontrolled mixing increases and some efficiency is sacrificed. When the concentration difference is increased (i.e., natural → anthropogenic → engineered salinity gradients), PRO osmotic pressure difference rises proportionally but not so for RED Nernst potential, which has logarithmic dependence on the solution concentration. Because of this inherently different characteristic, RED is unable to take advantage of larger salinity gradients, whereas PRO power density is considerably enhanced. Additionally, high solution concentrations suppress the Donnan exclusion effect of the charged RED membranes, severely reducing the permselectivity and diminishing the energy conversion efficiency. This study indicates that PRO is more suitable to extract energy from a range of salinity gradients, while significant advancements in ion exchange membranes are likely necessary for RED to be competitive with PRO.

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Abstract (Letter, Feature/Perspective Article) –Shorter than Paper

Antibacterial Effects of Carbon Nanotubes: Size Does Matter!

Seoktae Kang, Moshe Herzberg,[†] Debora F. Rodrigues, and Menachem Elimelech*

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We provide the first evidence that the size (diameter) of carbon nanotubes (CNTs) is a key factor governing their antibacterial effects and that the likely main CNT-cytotoxicity mechanism is cell membrane damage by direct contact with CNTs. Experiments with well-characterized single-walled carbon nanotubes (SWNTs) and multiwalled carbon nanotubes (MWNTs) demonstrate that SWNTs are much more toxic to bacteria than MWNTs. Gene expression data show that in the presence of both MWNTs and SWNTs, *Escherichia coli* expresses high levels of stress-related gene products, with the quantity and magnitude of expression being much higher in the presence of SWNTs.

Critical Review

Environmental Applications of Carbon-Based Nanomaterials

MEAGAN S. MAUTER AND MENACHEM ELIMELECH*

The unique and tunable properties of carbon-based nanomaterials enable new technologies for identifying and addressing environmental challenges. This review critically assesses the contributions of carbon-based nanomaterials to a broad range of environmental applications: sorbents, high-flux membranes, depth filters, antimicrobial agents, environmental sensors, renewable energy technologies, and pollution prevention strategies. In linking technological advance back to the physical, chemical, and electronic properties of carbonaceous nanomaterials, this article also outlines future opportunities for nanomaterial application in environmental systems.

Abstract (Letter, Feature/Perspective Article) –Shorter than Paper

The Critical Need for Increased Selectivity, Not Increased Water Permeability, for Desalination Membranes

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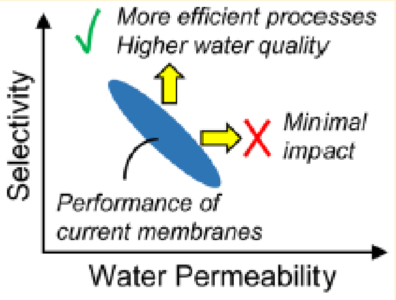
Supporting Information

ABSTRACT: Desalination membranes are essential for the treatment of unconventional water sources, such as seawater and wastewater, to alleviate water scarcity. Promising research efforts on novel membrane materials may yield significant performance gains over state-of-the-art thin-film composite (TFC) membranes, which are constrained by the permeability−selectivity trade-off. However, little guidance currently exists on the practical impact of such performance gains, namely enhanced water permeability or enhanced water−solute selectivity. In this critical review, we first discuss the performance of current TFC membranes. We then highlight and provide context for recent module-scale modeling studies that have found limited impact of increased water permeability on the efficiency of desalination processes. Next we cover several important examples of water treatment processes in which inadequate membrane selectivity hinders process efficacy. We conclude with a brief discussion of how the need for enhanced selectivity may influence the design strategies of future membranes.



Highlights (some journals)

- Typically 3-5 highlights; each highlight is limited to ~85 characters (with spaces)
- Typically, one highlight on what you have done; the others on the main findings
- Example:
  - RO is significantly more energy efficient than CDI for brackish water desalination
  - Novel simplified CDI circuit model can predict key aspects of energetic performance
  - Development of CDI electrode materials will marginally improve energy efficiency
  - CDI cannot compete with RO on the basis of both energy consumption and capital cost

Highlights (some journals)

- Examples:

- SiNPs or zwitterionic polymer brushes were grafted on TFC membrane surfaces.
- SiNP coating cannot prevent calcium-ion induced organic fouling mechanism.
- Electrostatic attraction aggravates organic fouling of SiNP-modified membrane.
- Zwitterionic polymer coating imparts excellent organic fouling resistance.

- We present a fouling-resistant thin-film composite forward osmosis membrane
- An amine-rich polyamide active layer facilitates surface functionalization with PEG
- Improved organic fouling resistance at high (250 mg/L) alginate feed concentrations

Introduction

- At least 3-4 paragraphs (short paragraphs, each ~ 1/3 page or less, but no less than 3 sentences)
- First paragraph – overview about the general, broad importance
- Second paragraph (optional) – more overview about the specific focus of your paper
- Middle paragraphs – critical review of past work
- One before last – based on the above critical review, why your paper is needed and how it will add to the body of knowledge
- Last paragraph – state the objectives and scope of the paper, with possibly a general finding and/or importance

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Last Paragraph of Introduction

- State the objective(s) and scope of the paper — Don’t repeat the abstract!
- Avoid specific details on the experiments and detailed results
- After stating the objective, highlight in general terms what you have done and the general/broad findings

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General Tips for Writing the Main Body of Paper

- Use short paragraphs (typically ~ 3-6 sentences)
- Minimize the use of long sentences
- Simple is better!
- Elegant and eloquent, but not Shakespearean
- Avoid redundancy
- Can use “we”, “our”; but <u>NOT “I”, “my”</u>
- When you are not sure about style (e.g., equations), look at previously published papers in that journal

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Conclusion Section

- “Conclusion” or “Concluding Remarks” — not “Conclusions”
- Do not repeat the abstract
- Summarize the key findings
- Indicate the broader impact
- Avoid references and equations
- ES&T and some other journals do not have a Conclusion section
- For ES&T can use “Implications”

Figures

- Thoughtful presentation of data
- Avoid simple figures with only one data set
- Use multiple graphs if possible
- Large fonts and symbols
- Clear and easy to read legends
- Units for y and x axes; e.g. “Residence Time (min)”
- Capitalize first letter of each word in title (US style)
- Moderately thick lines
- Provide very detailed figure captions with all necessary experimental conditions
- Use colors when needed (dark colors): black, blue, red, green, etc.

Examples of Good Figures

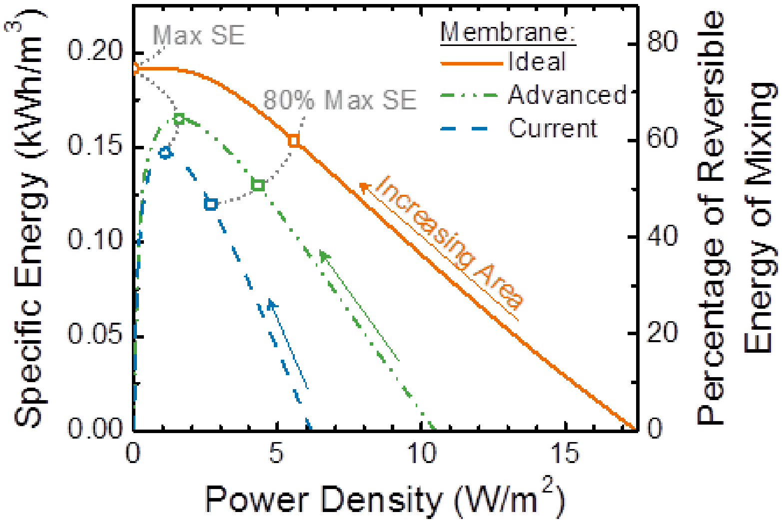

Figure 5. Specific energy vs power density for three different types of counter-current modules: an ideal module with no reverse salt flux or concentration polarization (solid red line), a module using advanced membranes (dashed and dotted green line), and a module using currently available commercial membranes (dashed blue line). The ideal membrane has a water permeability coefficient, A, of 3 L m^{-2} h^{-1} bar^{-1} and $B = 0$. For the advanced membrane, $A = 3$ L m^{-2} h^{-1} bar^{-1}, $B = 0.36$ L m^{-2} h^{-1} (determined from the permeability-selectivity trade-off, eq 5), and $S = 100$ μm. The commercial membrane properties are representative of a thin-film composite membrane from Hydration Technology Innovations ($A = 2.49$ L m^{-2} h^{-1} bar^{-1}, $B = 0.39$ L m^{-2} h^{-1}, and $S = 564$ μm). In both cases with concentration polarization, a mass transfer coefficient of $k = 138.6$ L m^{-2} h^{-1} is used. The feed solution is river water (0.015 M NaCl) and the draw solution is seawater (0.6 M NaCl). Curves are obtained by increasing the membrane area with fixed operating conditions of $\phi = 0.5$ and $\Delta P = 14.5$ bar. For each membrane, the maximum specific energy (hollow circle) and 80% of the maximum specific energy (hollow square) are indicated. The coupon-scale power density for each membrane occurs at the horizontal axis (power density) intercept.

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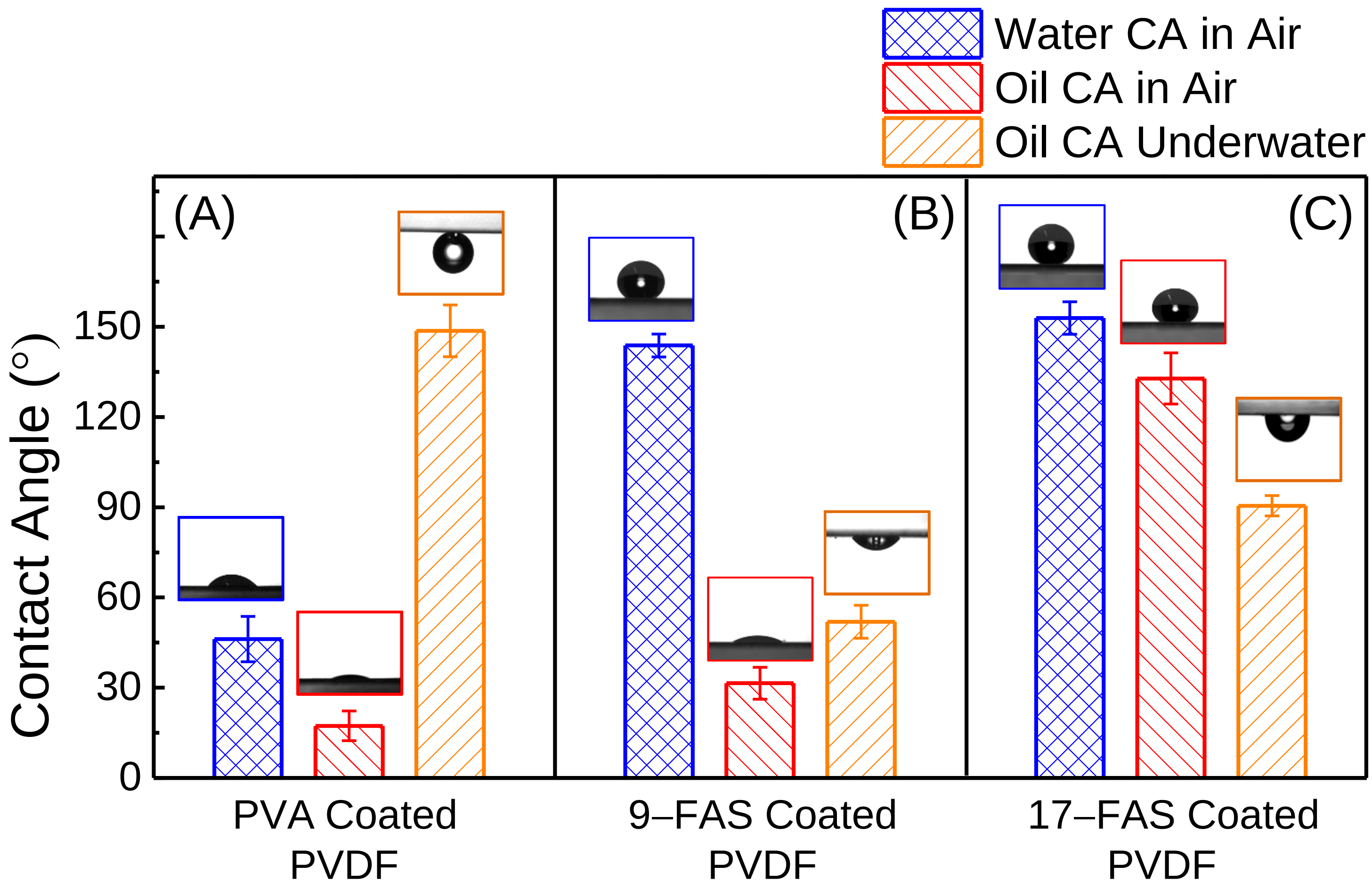
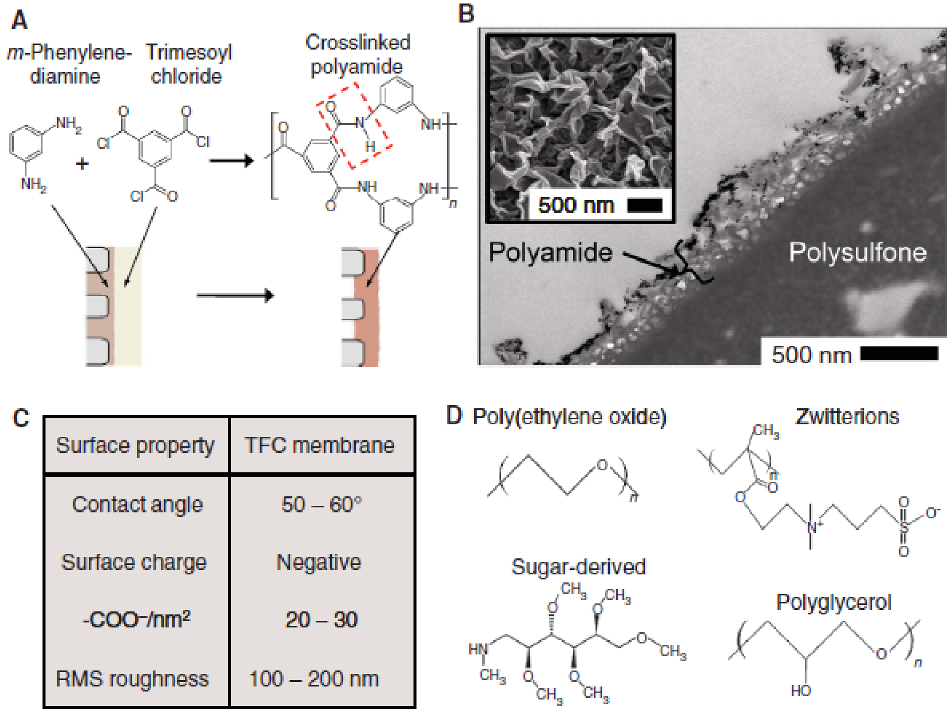
Examples of Good Figures



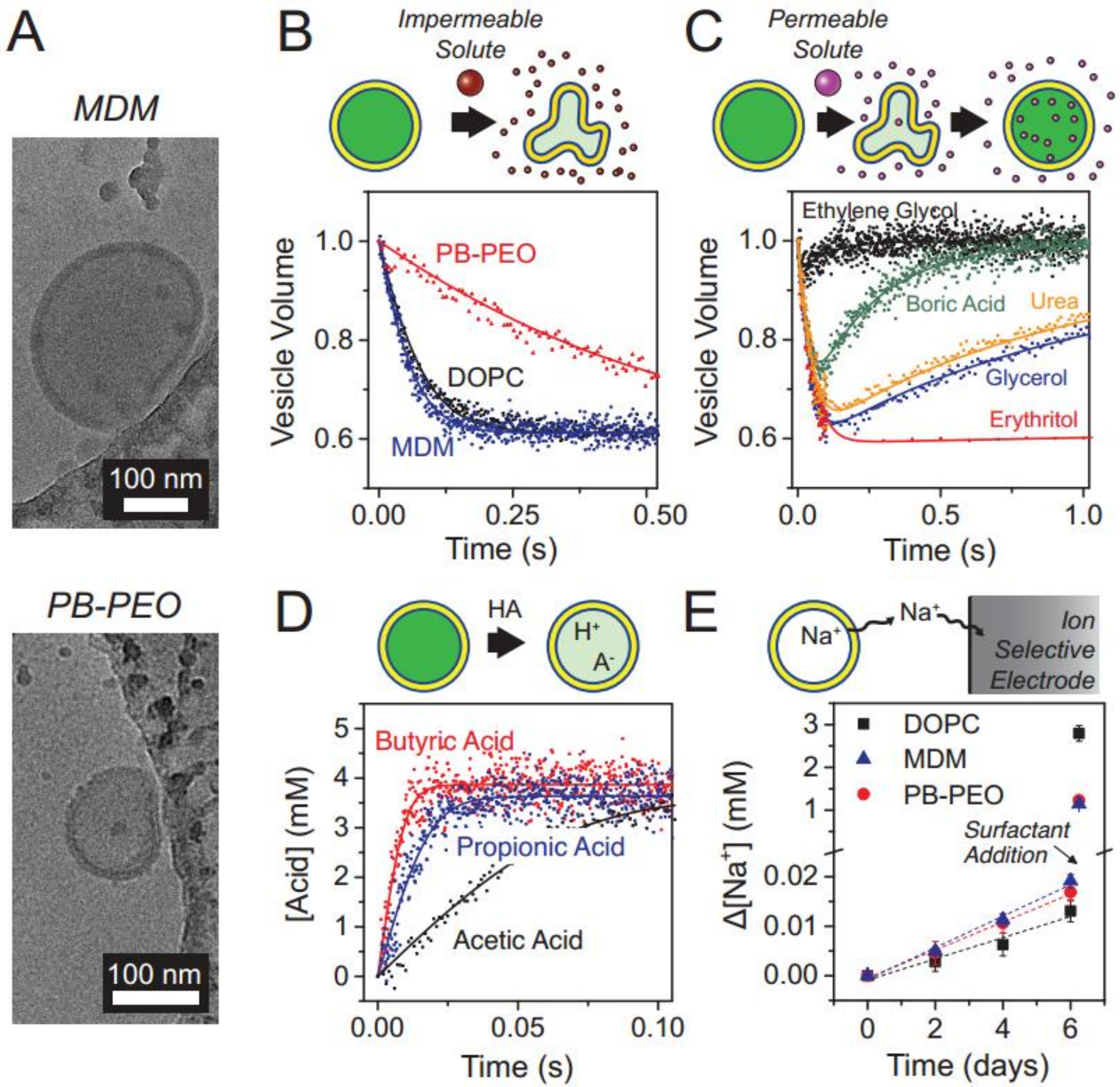
Examples of Good Figures



Surface property	TFC membrane
Contact angle	50 – 60°
Surface charge	Negative
-COO⁻/nm²	20 – 30
RMS roughness	100 – 200 nm

Fig. 3. (**A**) A schematic of the interfacial polymerization used to form thin-film composite (TFC) membranes. The monomers *m*-phenylenediamine and trimesoyl chloride react to form a highly cross-linked polyamide layer, which allows for the selective transport of water over salt. Ultrathin films are fabricated by dissolving the *m*-phenylenediamine in water and trimesoyl chloride in a water-immiscible organic solvent, such as hexane. A porous support is soaked in the aqueous solution and then contacted with the organic solution. The resulting polyamide formation is confined to the region near the interface of the two solutions. One drawback of the polyamide chemistry is the amide linkage (highlighted in dashed box), which is susceptible to attack by chlorine and other oxidizing agents. (**B**) Micrographs displaying the structure of the TFC membranes (*48*). A transmission electron micrograph of the membrane cross-section shows the extremely thin polyamide layer on top of a porous polysulfone support. The dark regions on top of the polyamide layer are gold nanoparticles used to obtain sufficient contrast between the polyamide and polysulfone layers during imaging. (Inset) A scanning electron micrograph of the polyamide top surface showing the rough ridge and valley structure typical of these films. (**C**) Surface properties of TFC membranes (*49*, *50*). Fouling-resistant membranes would be smooth and possess surface chemical properties postulated by (*30*); TFC membranes do not meet all of these constraints, consistent with their high fouling propensity. (**D**) Chemistries that have demonstrated the ability to resist protein or organic macromolecule adhesion: poly(ethylene oxide) (*31*), zwitterions such as poly(sulfobetaine) (*33*), sugar-derived molecules (*30*), and polyglycerol (*34*).

Examples of Good Figures



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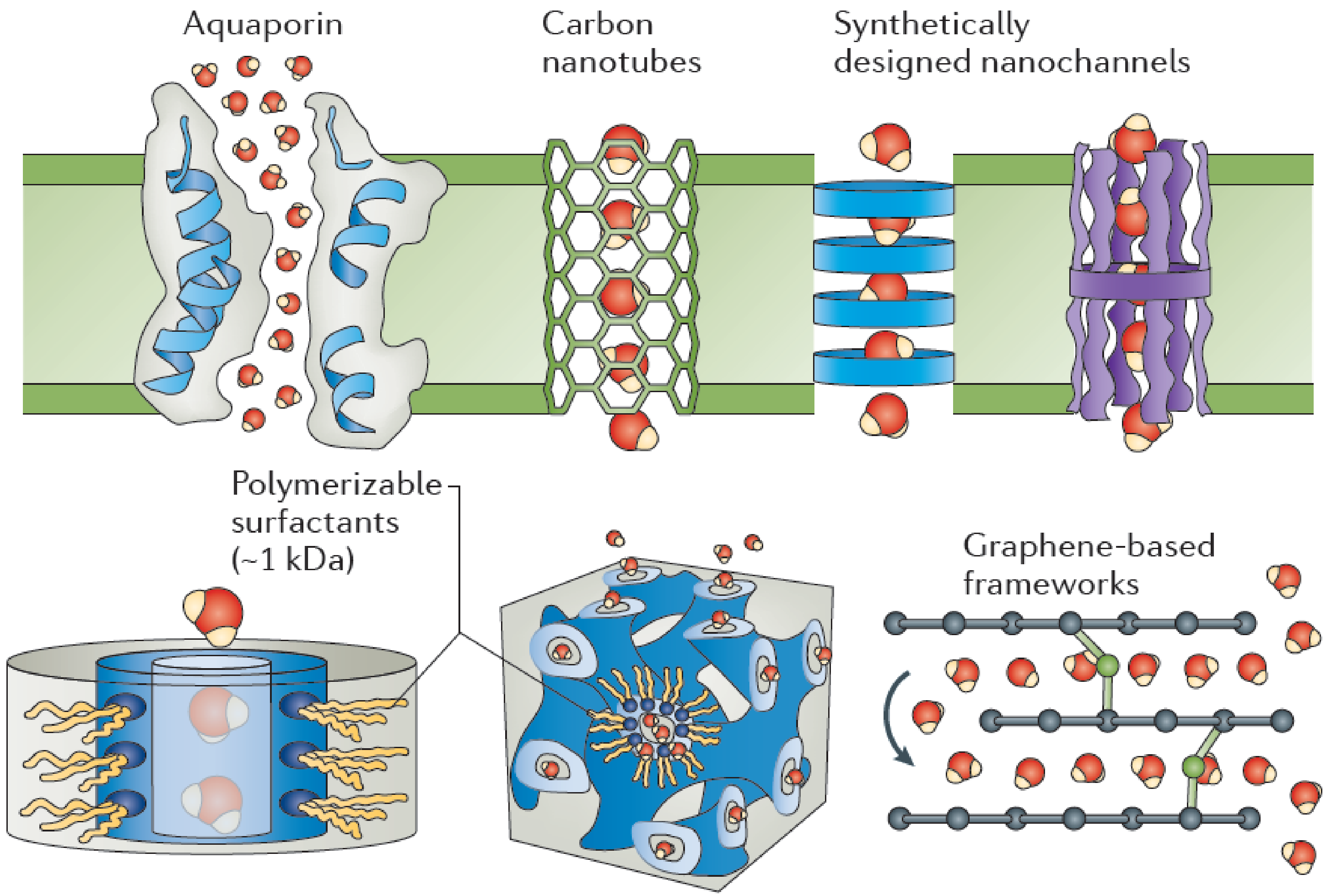
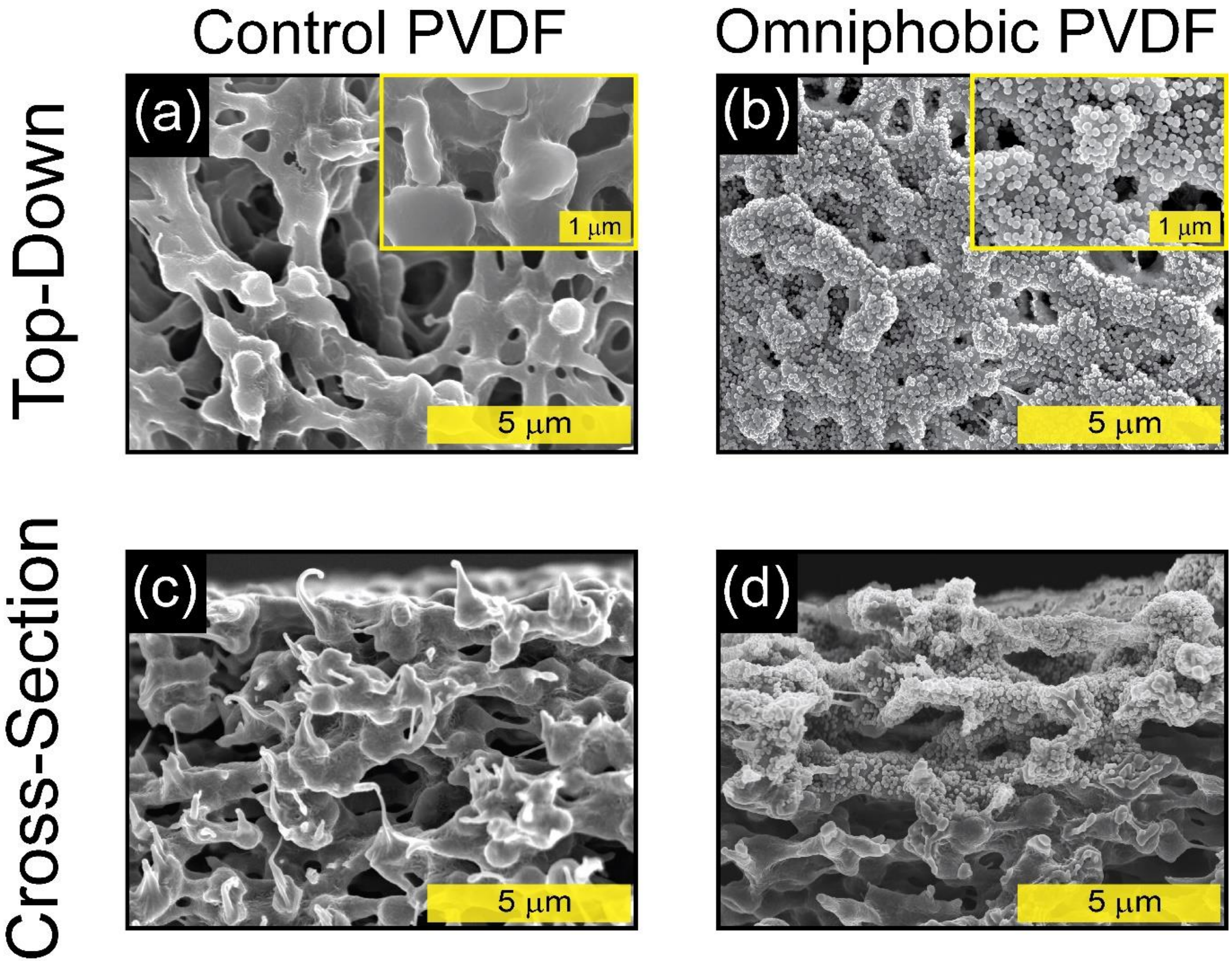
Examples of Good Figures



Werber, et al., *Nature Reviews Materials*, 1 (2016) 1-15.

Examples of Good Figures



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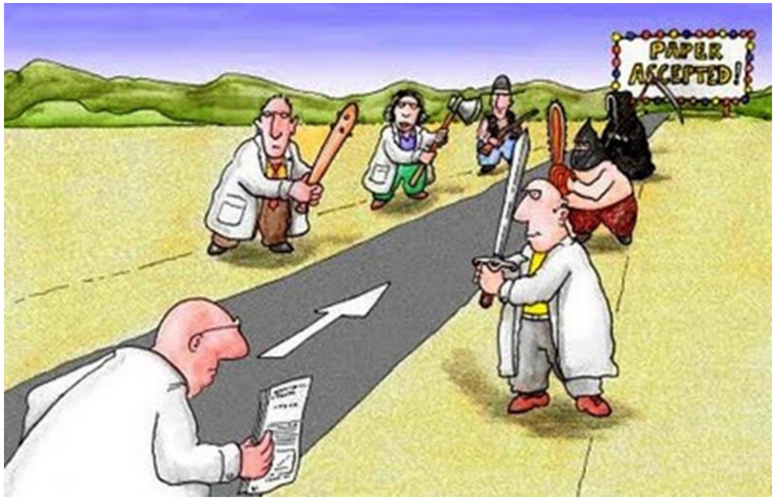
Recap

- Good writing takes tremendous efforts
- Always start with an outline!
- Creative research, but effective writing — a story not a mystery
- Strive for rigor and relevance (R^2)



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