Prof. Kumar Varoon Agrawal
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## Research Interest

Development of the next-generation, energy-efficient separation processes using two-dimensional nanoporous materials. More details at http://las.epfl.ch

## Education

Ph.D., Chemical Engineering, University of Minnesota, Minneapolis, MN, USA 2008-2013
Advisors: Prof. Michael Tsapatsis, Prof. Lorraine F. Francis
Thesis: Dispersible exfoliated zeolite nanosheets and their application in high performance zeolite membranes

B. Tech., Chemical Engineering, IIT Bombay, Mumbai, India 2001-2005

## Professional Experience

Assistant Professor, GAZNAT Chair for Advanced Separations July 2016- Present
École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

Postdoctoral Research Assistant June 2014 – June 2016
Department of Chemical Engineering, Massachusetts Institute of Technology (MIT), USA
Advisor: Prof. Michael S. Strano

Postdoctoral Research Assistant Nov 2013 - June 2014
Department of Chemical Engineering & Material Science, University of Minnesota, USA
Advisor: Prof. Michael Tsapatsis

Engineer Nov 2005 - May 2008
Global Hair Care R&D, Procter & Gamble, Kobe, Japan

## Publications

1. S. Huang, M. Dakhchoune, W. Luo, E. Oveisi, G. He, M. Rezaei, J. Zhao, A. Züttel, M. S. Strano, K. V. Agrawal, "Large-area single-layer graphene membranes by crack-free transfer for gas mixture separation". Submitted.

2. Dutta, S.; Rezaei, M.; Agrawal, K. V. Crystallization of Gas-Selective Nanoporous Graphene by Chemical Vapor Deposition: A Modeling Study by Kinetic Monte Carlo Simulation. Submitted.

3. G. He., M. Dakhchoune, J. Zhao, S. Huang, K. V. Agrawal, "Electrophoretic Nuclei Assembly for Crystallization of High Performance Membranes on Unmodified Supports", **Advanced Functional Materials**, 2018, just accepted.

4. D. O. Bellesario, A. T. Liu, D. Kozawa, R. Han, J. K. Harris, R. B. Zabala, Q. H. Wang, K. V. Agrawal, Y. Son, M. S. Strano, "Experimental Observation of Real Time Molecular Dynamics Using Electromigrated Tunnel Junctions", **The Journal of Physical Chemistry C**, 121, 22550–22558, 2017.

5. Z. Yuan, A. G. Rajan, L. W. Drahushuk, R. P. Mishra, K. V. Agrawal, M. S. Strano, D. Blankschtein, "Mechanism and Prediction of Gas Permeation through Sub-Nanometer Graphene Pores: Comparison of Theory and Simulation", **ACS Nano**, 11 (8), 7974–7987, 2017.

6. K. V. Agrawal*, Jesse Benck*, Zhe Yuan, Yannick Eatmon, Ananth Govind Rajan, Suneet Kale, Ximo S. Chu, Duo O. Li, Chuncheng Gong, Daniel Blankschtein, Jamie Warner, Qing Hua Wang, Michael S. Strano, "Fabrication, Pressure Testing and Nanopore Formation of Single Layer Graphene Membranes", **The Journal of Physical Chemistry C**, 121, 14312-14321, 2017.
   * These authors contributed equally.

7. M. H. Shete, M. Kumar, D. Kim, N. Rangnekar, B. Topuz, K.V. Agrawal, E. Karapetrova, B. Stottrup, S. Al-Thabaiti, S. Basahel, K. Narasimharao, J. D. Rimer, M. Tsapatsis, "Nanoscale Control of Homoepitaxial Growth on a Two-Dimensional Zeolite", **Angewandte Chemie International Edition**, 56, 2, 535, 2017.

8. K. V. Agrawal*, S. Shimizu*, L. W. Drahushuk, D. Kilcoyne, M. S. Strano, "Observation of Extreme Phase Transition Temperatures of Water Confined Inside Isolated Carbon Nanotube Nanopores", **Nature Nanotechnology**, 12, 267, 2017.
   * These authors contributed equally.

9. K. V. Agrawal, L. W. Drahushuk, D. Kilcoyne, M. S. Strano, "Observation and Analysis of the Coulter Effect Through Carbon Nanotube and Graphene Nanopores", **Philosophical Transactions of the Royal Society A**, 374, 20150357, 2016.

10. S. Shimizu, K. V. Agrawal, M. O'Mahony, L. W. Drahushuk, N. Manohar, A. S. Myerson, M. S. Strano, "Understanding and Analyzing Freezing-Point Transitions of Confined Fluids within Nanopores, **Langmuir**, 31, 10113, 2015.

11. K. V. Agrawal*, B. Topuz*, N. Sauer, T. C. T. Pham, N. Rangnekar, H. Zhang, K. Narasimharao, S. Basahel, L. F. Francis, C. W. Macosko, S. Al-Thabaiti, K. B. Yoon, M. Tsapatsis, "Oriented MFI Membranes by Gel-less Secondary Growth of Sub-100 nm MFI-nanosheet Seed Layers", **Advanced Materials**, 21, 3243, 2015.
    * These authors contributed equally.
    - Featured on the cover page.

12. N. Rangnekar, M. Shete, K. V. Agrawal, B. Topuz, P. Kumar, K. Narasimharao, I. Ismail, A. Alyoubi, S. Basahel, L. F. Francis, C. W. Macosko, K. A. Mkhoyan, B. Stottrup, S. Al-Thabaiti, M. Tsapatsis, "Langmuir-trough Deposition of Zeolite Nanosheets", **Angewandte Chemie International Edition,** 54, 6571, 2015.

13. P. Kumar, K. V. Agrawal, M. Tsapatsis, A. Mkhoyan, "Quantification of Thickness and Wrinkling of Exfoliated Two-dimensional Zeolite Nanosheets", **Nature Communications**, 6, 7128, 2015.

14. Kumar, P.; Varoon Agrawal, K.; Tsapatsis, M.; Andre Mkhoyan, K., "Analytical Method for Thickness and Wrinkling Measurements of 2-D Zeolites", **Microscopy and Microanalysis**, 2015, 21, 2367–2368.

15. P. Kumar, K. V. Agrawal, M. Tsapatsis, A. Mkhoyan, "Crystallographic Structure Determination of MFI-Zeolite Nanosheets", **Microscopy and Microanalysis**, 2014, 20 (S3), 390–391.

16. K. V. Agrawal, B. Topuz, M. Navarro, Z. Jiang, K. Nguenkam, B. Elyassi, L. F. Francis, M. Tsapatsis, "Solution-processable Exfoliated Zeolite Nanosheets Purified by Density Gradient Centrifugation", **AIChE Journal**, 59, 3458, 2013.

- Invited article in the special issue of AIChE J. Founders Tribute to Neal R. Amundson.

17. K. Varoon (Agrawal)*, X. Zhang*, B. Elyassi, D. D. Brewer, M. Gettel, S. Kumar, J. A. Lee, S. Maheshwari, A. Mittal, C. Y. Sung, M. Cococcioni, L. F. Francis, A. V. McCormick, K. A. Mkhoyan, M. Tsapatsis, "Dispersible Exfoliated Zeolite Nanosheets and Their Application as a Selective Membrane", **Science**, 334, 72, 2011.
    * These authors contributed equally.
    - Featured in runner-up in **breakthrough of the year, 2011** by the Science Magazine.

18. X. Zhang, D. Liu, D. Xu, S. Asahina, K. Cychosz, K. V. Agrawal, Y. Al Wahedi, A. Bhan, S. Al Hashimi, O. Terasaki, M. Thommes, M. Tsapatsis, "Synthesis of Self-Pillared Zeolite Nanosheets by Repetitive Branching", **Science,** 336, 1684, 2012.

19. H. Zhang, W. J. Suszynski, K. V. Agrawal, M. Tsapatsis, S. Al Hashimi, L. F. Francis, "Coating of Open Celled Foams, **Industrial & Engineering Chemistry Research**, 51, 9250, 2012.

20. J. A. Stoeger, M. Palomino, K. V. Agrawal, X. Zhang, G. N. Karanikolos, A. Corma, M. Tsapatsis, "Oriented CoSAPO-5 Membranes by Microwave-Enhanced Growth on $TiO_2$-Coated Porous Alumina", **Angewandte Chemie International Edition**, 51, 2470, 2012.

21. K. Kahali, K. Varoon (Agrawal), J. Bellare, "Preparation of Lacey Polymer Film as Efficient Specimen Supports for TEM and Cryo-Transmission Electron Microscpe (Cryo-TEM)", Proceedings of XXVII Annual Meeting of EMSI and Conference on Electron Microscopy and Allied Fields, April 1-3, 2004, p150-151.

## Patents

1. "Ultrahigh flux gas-selective nanoporous carbon membrane and manufacturing method thereof", K. V. Agrawal, M. Dakachoune, S. Huang, G. He, N. Dudani, Application PCT/EP2017/057684.

2. "Silica Support Structure for a Zeolite Membrane", M. Tsapatsis, K. V. Agrawal, L. F. Francis, U.S. Patent US20150376019 A1, 2015.

3. "Zeolite Nanosheet Membrane", M. Tsapatsis, K. V. Agrawal, U.S. Patent US 20150045206 A1, 2015.

4. "Method for Assessment of Friction Properties of Fibers or Substrates upon Mechanical Treatment", C. K. Yagnik, K. Varoon (Agrawal), U.S. Patent 20100049671, 2010.

5. "Method for Assessment of Electrostatic Properties of Fibers or Substrates", K. Varoon (Agrawal), U.S. Patent 20090195253, 2010.

## Invited Talks

1. Keynote Lecture on the Next Generation Membrane Technologies: GAZNAT 50th Anniversary, 2018
2. Latsis Symposium: 12th Int. Symposium Hydrogen & Energy 2018
3. Seminar, Indian Institute of Technology, Bombay, India 2018.
4. Seminar, Czech Academy of Sciences, Czech Republic, 2017.
5. Raman Microscopy Workshop, ETH Zurich, Switzerland, 2017.
6. Inorganic Chemistry Seminar, University of Bayreuth, Germany, 2017.
7. Chemical Engineering Seminar, Indian Institute of Science, Bangalore, India, 2016.
8. Chemical and Biological Engineering seminar, University of Wisconsin-Madison, Madison, USA, 2015.
9. Chemical & Biological Engineering seminar, Northwestern University, Evanston, USA, 2015.
10. Special Chemical Engineering Seminar, Purdue University, West Lafayette, USA, 2015.
11. Chemical & Biochemical Seminar, Rutgers University, New Jersey, USA, 2015.

12. Memento ISIC Seminar, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, 2014.
13. Seminar, Massachusetts Institute of Technology, Boston, USA 2014.
14. CEMS Advanced Doctoral Student Seminar, University of Minnesota, Minneapolis, USA, 2013.

## External Project Awards

- Cooperation and Development Center (CODEV) seed grant (2018)
- Swiss National Science Foundation Assistant Professor Energy grant (2017- 2020).
- GAZNAT carbon capture project (2017-2020).
- Swiss Competence Center of Energy Research – Efficiency in Industrial Processes (SCCER-EIP), Phase II (2017 – 2020).
- ETH-Board funding on exfoliation chemistry (2017-2020).
- ETH-Board funding on collaborative energy research (2016-2017).
- Academic host for Dr. Guangwei He, recipient of EPFL Fellows, co-sponsored by Marie Curie fellowship.

## Awards and Honors

1. Young Membrane Scientist Award, North American Membrane Society (NAMS), 2018
2. Best poster, Gordon Research Conference on Nanoporous Materials and Their Applications, 2015
3. AIChE Separations Division Graduate Student Research Award, 2013
4. Doctoral Dissertation Fellowship (2012-2013), University of Minnesota
5. Sigma Xi Award for best student poster presentation during DDF showcase
6. Best poster, Gordon Research Conference on Nanoporous Materials and Their Applications, 2011
7. CEMS Outstanding Teaching Assistant Award (2009-2010), University of Minnesota
8. Procter & Gamble R&D Vice President Power of You Gold Award
9. Institute Silver Medal for securing 1st rank in Department of Chemical Engineering at IIT Bombay
10. Manudhane Best Undergraduate Student Award for overall excellence at IIT Bombay
11. IIT Bombay Merit Scholarship (2003-2005)
12. Technical Citation, IIT Bombay, 2005
13. Organizational Citation, IIT Bombay, 2005

## Professional Activities

1. Area Chair (Inorganic Materials, Material Engineering and Sciences Division), AICHE Annual Meeting, Pittsburgh, USA, 2018
2. Session Chair, Graduate student award session (MESD), AICHE Annual Meeting, Pittsburg, USA 2018
3. Session Chair, 725 MOFs, COFs, and Porous Polymer Materials I: Synthesis, AICHE Annual Meeting, Minneapolis, USA, 2017
4. Session Chair, 725 MOFs, COFs, and Porous Polymer Materials II: Applications, AICHE Annual Meeting, Minneapolis, USA, 2017
5. Session Chair, Nanostructured Thin Films, AICHE Annual Meeting, San Francisco, USA, 2016
6. Session Co-Chair, Advances in the Synthesis and Application of Porous Materials I, AICHE Annual Meeting, San Francisco, USA, 2016
7. Session Chair, Advances in the Synthesis and Application of Porous Materials II, AIChE Annual Meeting, Salt Lake City, USA, 2015
8. Participant, Department of Energy's Advance Manufacturing Office Workshop on Membrane Technology, Chicago, USA, 2012
9. Participant, 12th Jülicher Werkstoffsymposium on "Gas Separation Membranes for Zero-emission Fossil Power Plants", Jülich, Germany, 2011

## Professional Affiliations

Swiss Chemical Society (SCS), Swiss Process & Chemical Engineers (SGVC), European Federation of Chemical Engineering (EFCE), American Institute of Chemical Engineers (AICHE), American Chemical Society (ACS),

Material Research Society (MRS), European Membrane Society (EMS), North American Membrane Society (NAMS)

## Teaching Experience

Lecturer, ChE 401: Fundamentals of Separation Processes, EPFL, Spring 2018
Lecturer, ChE 402: Advanced Diffusional Processes, EPFL, Fall 2018.
Project Coach, "ChE 413: Chemical Product Design", EPFL, Fall 2016 and 2017
Kaufman Teaching Certificate Program, MIT, 2016

Guest Lectures

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| Fall 2009 | 'Absorption, Adsorption and Extraction', CHEN 2001, University of Minnesota |
| Spring 2012 | 'Structure of Zeolites', CHEN 8501, University of Minnesota |
| Fall 2015 | 'Nanoporous Membranes: Zeolite and Graphene', 10.585, MIT |

Teaching Assistant, University of Minnesota

CHEN 2001: Material & Energy Balances
CHEN 3005: Transport Phenomenon: Momentum and Heat
CHEN 8501: Chemical Rate Process: Analysis of Chemical Reactors

## Reviewer of Journal Articles

Proceedings of National Academy of Sciences, Chemical Reviews, ACS Sensors, Journal of Membrane Science, Microporous and Mesoporous Materials, AICHE Journal, Chemical Engineering Science, Nanomaterials, Coatings, Membranes, Polymers, Materials