

## Navid Saleh

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### EDUCATION

**PhD, Carnegie Mellon University**, Pittsburgh, PA (*May, 2007*)  
Major in Environmental Engineering and Science

**MS, Carnegie Mellon University**, Pittsburgh, PA (*August, 2004*)  
Major in Environmental Engineering and Science

**BS, Bangladesh University of Engineering and Technology**, Dhaka, Bangladesh (*August, 2001*)  
Civil Engineering

### APPOINTMENTS & POSITIONS

06/07-present

**Post-doctoral Research Associate**, Yale University, New Haven, CT.

*Supervisors:* Menachem Elimelech and Lisa D. Pfefferle

Aggregation and Deposition Behavior of Carbon Nanotubes in Aquatic Environments

06/03-05/07

**Graduate Research Assistant**, Carnegie Mellon University, Pittsburgh, PA.

*Advisors:* Gregory V. Lowry and Robert D. Tilton

Developing Engineered Reactive Nanoparticles for in situ delivery to subsurface DNAPL.

01/02 –12/02

**Lecturer**, Civil and Environmental Engineering, University of Asia Pacific, Dhaka, Bangladesh.

### PROFESSIONAL RESPONSIBILITIES

Teaching Assistant, Civil & Env. Eng., Carnegie Mellon University, Spring 2004, Spring 2005, Spring 2006, and Spring 2007.  
Fluid Mechanics, Physicochemical Processes of Organic Compounds in Aquatic Systems, Introduction to Civil and Environmental Engineering, Water Quality Engineering, Water Quality Engineering Lab.

Lecturer, Civil & Env. Eng., University of Asia Pacific, Jan-Dec 2002.

*Courses Instructed:* Introduction to Civil and Environmental Engineering, Computer Skills, Civil Engineering Drawing, Details of Construction, Structural Analysis and Design, Practical Surveying, Environmental Impact Assessment, Structural Analysis and Design Lab.

*Advising:* Undergraduate student advising for two semesters.

### AWARDS AND HONORS

*Best Poster Award*, Gordon Research Conference, Environmental Sciences: Water, 2008.

*Outstanding Teaching Assistant Award*, Carnegie Mellon University, Pittsburgh, PA, 2007.

*Quantitative Environmental Analysis (QEA), LLC Graduate Scholarship* 2006-2007.

*ACS Environmental Chemistry Graduate Student Award*, 2006.

*ACS 'Environmental Interfaces' Travel Grant Award* 2006.

*Sigma Xi Grant in Aid of Research Award* 2005-2006.

*Air & Waste Management Association (A&WMA) Award* 2005-2006.

*Research Assistantship*, Carnegie Mellon University, Pittsburgh, PA, July 2003-Present.

*Departmental Merit Scholarship*, Carnegie Mellon University, Pittsburgh, PA, Jan-Dec, 2003.

*Tau Beta Pi*, The National Engineering Honor Society.

*Sigma Xi*, The Scientific Research Society.

*Chi Epsilon*, The National Civil Engineering Honor Society.

*Pi Epsilon*, The National Environmental Science Honor Society.

Bibliographic Listings: *Who's Who in Engineering Education*, 2008-.

*National Merit Scholarship (Prime Minister's Award, Bangladesh) 1992.*

## CHAired POSITIONS (CONFERENCES)

Chair, Colloidal and Interfacial Phenomena in Aquatic Systems (09019), Environmental Division, American Institute of Chemical Engineers (AIChE) Annual Meeting, Philadelphia, PA, November 16-21, 2008.

## RESEARCH PROJECTS

*Aggregation and Deposition Behavior of Carbon Nanotubes in Aquatic Environments (June 2007-present)* *Yale University*

- Synthesis of Co-MCM-41 catalyst for CNT synthesis.
- Controlled synthesis of carbon nanotubes using carbon mono-oxide disproportionation reaction.
- Characterization of CNT using Raman Spectroscopy, Transmission Electron Microscopy (TEM), Fluorescent spectroscopy, Fourier Transformed Infra-red Spectroscopy (FTIR), electrophoretic mobility, titration.
- Aggregation kinetics of multi walled (MWNT) & single walled (SWNT) carbon nanotubes using dynamic light scattering (DLS).
- Deposition kinetics of CNTs using quartz crystal micro balance (QCM-D).
- Functionalization of SWNT and MWNT to enhance aqueous colloidal stability.
- Toxicological effects of CNTs on human cells and organisms.

*Arsenic removal using nano-scale iron particles (August 2007-present)* *International Collaboration with BUET, EAWAG, MIT*

- Characterization of metallic nanoparticles.
- Adsorption kinetics of As(III) and As(V) to different iron oxide nanoparticles.
- Use iron nanoparticles as an augment to filter media to study adsorption of arsenic during filtration.
- Use arsenic contaminated natural groundwater from sites in Bangladesh to study efficiency of arsenic.

*Transport and targeting of nano-iron for subsurface DNAPL remediation (2003-May 2007)* *Carnegie Mellon*

- Characterization of metallic nanoparticles.
- Modification of nano-particles using surfactants and block co-polymers for enhanced transport and targeting
- Conducting transport experiments in 1-D, 2-D columns and also micro-fluidic flow cells.
- Conducting ex-situ (emulsification) and insitu (column with NAPL saturated sand) targeting experiments.
- Optimization transport of nanoiron in porous matrix for varying geochemical & geophysical environment.
- Optimization of targeting of the DNAPL/water interface by modified nanoiron.

*Distribution of DNAPL and targeting the DNAPL/water interface (February, 2005)* *Idaho National Laboratory*

- Imaging NAPL distribution in porous matrix using X-ray Tomographic technique.
- Conducting 2-D flow cell experiments for digital imaging of targeting of nano-iron.

*Oxidative stress response of living cells to metal oxide and latex nanoparticles (May 2005-present)* *In conjunction with EPA*

- Characterization of metallic nanoparticles (Iron, surfactant modified iron and anatase)
- Measuring size, surface charge and colloidal stability.

## RESEARCH INTERESTS

Environmental nanotechnology; physicochemical processes; fate and transport of nanomaterials in the environment; groundwater remediation.

## DISSERTATION TITLE

An Assessment of Novel Polymeric Coatings to Enhance Transport and In-Situ Targeting of Nanoiron for Remediation of Non-aqueous Phase Liquids (NAPLs)

## PEER REVIEWED PUBLICATIONS

**Saleh, N.;** Pfefferle, L. D.; Elimelech, M. "Aggregation Kinetics of Multi-walled Carbon Nanotubes in Aquatic Systems: Measurements and Environmental Implications". *Environ. Sci. Technol*, 2008. 42, 7963-7969.

Jaisi, P. D.; **Saleh, N.**; Blake, R. E.; Elimelech, M. "Transport of Single-Walled Carbon Nanotubes in Porous Media: Role of Physicochemical Filtration". *Environ. Sci. Technol.* **2008**, *42*, 8317-8323.

Veronesi, B.; Tajuba, J.; **Saleh, N.**; Ward, W.; Hester, S.; Carter, J.; Lowry, G. V. "Functionally Charged Polystyrene Particles Activate Immortalized Mouse Microglia (BV2): Cellular and Genomic Response". *Nanotoxicol.* **2008**. (*in press*).

**Saleh, N.**; Kim, H.-J.; Phenrat, T.; Matyjaszewski, K.; Tilton, R.D.; Lowry, G.V. "Ionic Strength and Composition affect the mobility of surface-modified NZVI in water-saturated sand columns". *Environ. Sci. Technol.* **2008**. *42*, 3349-3355.

Phenrat, T.; **Saleh, N.**; Sirk, K.; Kim, H.-J.; Tilton, R.D.; Lowry, G.V. "Stabilization of Aqueous Nanoscale Zerovalent Iron Dispersions by Anionic Polyelectrolytes: Adsorbed Anionic Polyelectrolyte Properties and their Effect on Aggregation and Sedimentation". *J. Nanopart. Res.* **2008**. *10*, 795-814.

**Saleh, N.**; Sirk, K.; Phenrat, T.; Dufour, B.; Matyjaszewski, K.; Tilton, R.D.; Lowry, G.V. "Surface Modifications Enhance Nanoiron Transport and DNAPL Targeting". *Environ. Eng. Sci.* **2007**. *24*, 45-57.

Phenrat, T.; **Saleh, N.**; Tilton, R.D.; Lowry, G.V. "Aggregation and Sedimentation of Aqueous Nanoscale Zerovalent Iron Dispersions". *Environ. Sci. Technol.* **2007**. *41*, 284-290.

Long, T.; Tajuba, J.; Sama, P.; **Saleh, N.**; Swartz, C.; Parker, J.; Lowry, G. V.; Veronesi, B. "Nanosize Titanium Dioxide Stimulates Reactive Oxygen Species in Brain Microglia and Damages Neurons, In Vitro". *Environ. Health Persp.* **2007**. *115*, 1637-1637.

Long, T.C.; **Saleh, N.**; Tilton, R. D.; Lowry, G.V.; Veronesi, B. "Non-Photoactivated Titanium Dioxide Nanoparticles Produce Reactive Oxygen Species in Immortalized Mouse Microglia (BV2)". *Environ. Sci. Technol.* **2006**. *40*, 4346-4352.

**Saleh, N.**; Phenrat, T.; Sirk, K.; Dufour, B.; Ok, J.; Sarbu, T.; Matyjaszewski, K.; Tilton, R.D.; Lowry, G.V. "Adsorbed Triblock Copolymers Deliver Reactive Iron Nanoparticles to the Oil/water Interface". *Nano Letters*. **2005**. *5*, 2489-2494.

**Saleh, N.**; Sarbu, T.; Sirk, K.; Lowry, G.V.; Matyjaszewski, K.; Tilton, R.D. "Oil-in-Water Emulsions Stabilized by Highly Charged Polyelectrolyte-Grafted Silica Nanoparticles". *Langmuir*. **2005**. *21*, 9873-9878.

### ***Publications in Preparation***

**Saleh, N.**; Pfefferle, L. D.; Elimelech, M. "Effects of Biomacromolecules on Aggregation Kinetics of Single-Walled Carbon Nanotubes in Aquatic Systems". *Environ. Sci. Technol.* (*expected submission: November 2008*).

**Saleh, N.**; Pfefferle, L. D.; Elimelech, M. "Biomacromolecules Significantly Impact the Aggregation Kinetics of Multi-walled Carbon Nanotubes". *ACS Nano* (*expected submission: December 2008*).

**Saleh, N.**; Dufour, B.; Matyjaszewski, K.; Tilton, R.D.; Lowry, G.V. "Effect of pH, Approach Velocity and Collector Size and Type of the System on Nanoiron Transport". *Environ. Sci. Technol.* (*expected submission: Dec 2008*).

### **REVIEWER FOR SCHOLARLY JOURNALS**

Environmental Science and Technology (ES&T)  
Carbon

### **CONFERENCE PROCEEDINGS**

**Saleh, N.**; Pfefferle, L.; Elimelech, M. "Aggregation Kinetics of Carbon Nanotubes in the Presence of Biomacromolecules" AIChE Annual Meeting, Philadelphia, PA, November 16-21, 2008.

**Saleh, N.**; Pfefferle, L.; Elimelech, M. "Aggregation Kinetics of Multi-walled Carbon Nanotubes in Aquatic Systems" AIChE Annual Meeting, Philadelphia, PA, November 16-21, 2008.

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Resume

Jaisi, P. D.; **Saleh, N.**; Blake, R. E.; Elimelech, M. "Filtration Mechanisms of Single-walled Carbon Nanotubes in Porous Media" AIChE Annual Meeting, Philadelphia, PA, November 16-21, 2008.

Elimelech, M.; Chen, K. L.; **Saleh, N.**; Kang, S. "Aggregation Kinetics of Carbon-based Nanomaterials in Aquatic Systems: Measurements and Environmental Implications" Chemodynamics of Ecosystems Conference, Monte Verita, Ascona, Switzerland, October 26-31, 2008.

Jaisi, P. D.; **Saleh, N.**; Blake, R. E.; Elimelech, M. "Transport and Filtration of Carbon Nanotubes in Porous Media". Goldschmidt Conference, Vancouver, Canada, July 13-18, 2008.

**Saleh, N.**; Pfefferle, L.; Elimelech, M. "Aggregation Kinetics of Multi-walled Carbon Nanotubes in Aquatic Systems." The 235<sup>th</sup> ACS National Meeting, New Orleans, LA, April 6-10, 2008.

Sirk, K., **Saleh, N.**, Phenrat, T., Kim, H.-J., Lowry, G. V., Tilton, R. D. "Amphiphilic block copolymer surface modification of nanoscale zero valent iron (NZVI) for source zone DNAPL remediation" The 81st ACS Colloid & Surface Science Symposium, Newark, DE June 24-27, 2007.

Phenrat, T., Kim, H.-J., **Saleh, N.**, Sirk, K., Tilton, R. D., Lowry, G. V. "Polyelectrolyte-surfactant Complexes as Nanoscale Zerovalent Iron (NZVI) Surface Modifiers for In Situ NAPL Targeting" The 81st ACS Colloid & Surface Science Symposium, Newark, DE June 24-27, 2007.

**Saleh, N.**, Phenrat, T., Tilton, R. D., Lowry, G. V. "Porewater velocity and collector grain size affects the mobility of surface-modified nanoiron in water-saturated porous media." Division of Colloid and Surface Chemistry for the 233rd ACS National Meeting, Chicago, IL March 25-29, 2007.

Phenrat, T., **Saleh, N.**, Sirk, K., Kim, H.-J., Liu, Y., Tilton, R. D., Lowry, G. V. "Polyelectrolyte-Modified Nanoscale Zerovalent Iron: Characteristics of the Adsorbed Polyelectrolyte Layer and Dispersion Stability." Division of Colloid and Surface Chemistry for the 233rd ACS National Meeting, Chicago, IL March 25-29, 2007.

Lowry, G. V., Kim, H.J., Liu, Y., Phenrat, T., Matyjaszewski, K., **Saleh, N.**, Sirk, K., Tilton, R. D. "Functionalized Fe<sup>0</sup> nanoparticles for targeted in situ degradation of entrapped DNAPL." Division of Industrial Engineering & Chemistry for the 233rd ACS National Meeting, Chicago, IL March 25-29, 2007.

Phenrat, T., Liu, Y., Kim, H.-J., **Saleh, N.**, Sirk, K., Tilton, R. D., Lowry, G. V. "Effect of adsorbed polyelectrolytes on TCE dechlorination and product distribution by Fe<sup>0</sup>/Fe-oxide nanoparticles." In the Proceedings of the Division of Environmental Chemistry for the 233rd ACS National Meeting, Chicago, IL March 25-29, 2007.

Lowry, G.V., **Saleh, N.**, Phenrat, T., Kim, H.-J., Sirk, K., Tilton, R. D., Illangasekare, T. "Effects of Polymeric Surface Coatings on NZVI Mobility in Saturated Porous Media and Reactivity with TCE." Partners in Environmental Technology Technical Symposium & Workshop, Washington, D.C. November 28-30, 2006.

Lowry, G. V., **Saleh, N.**, Phenrat, T., Liu, Y., Kim, H., Sirk, K., Matyjaszewski, K., Tilton, R. "Delivering Polymer-modified Fe<sup>0</sup> Nanoparticles to Subsurface Chlorinated Organic Solvent DNAPL." US EPA Nanotechnology and the Environment: Applications and Implications Progress Review Workshop III, Washington D.C., November 8-9, 2006.

Long, T., Sama, P., Tajuba, J., **Saleh, N.**, Parker, J., Swartz, C., Lowry, G. V., and Veronesi, B. "Nanosize Titania stimulates reactive oxygen species in brain microglia and damages neurons." The 12th International Conference on Advanced Oxidation Technologies for Treatment of Water Air and Soil (AOTs-12), Pittsburgh, PA September 25-28, 2006.

**Saleh, N.**, Sirk, K., Liu, Y., Phenrat, T., Dufour, B., Matyjaszewski, K., Tilton, R. D., Lowry, G. V., "Surface modifications enhance colloidal iron transport and deliver them to the NAPL/water interface", 232<sup>nd</sup> ACS National Meeting, San Francisco, CA, September 10-14, 2006.

**Saleh, N.**, Kim, H. J., Phenrat, T., Sirk, K., Dufour, B., Matyjaszewski, K., Tilton, R. D., Lowry, G. V. "Long-range transport of polymer-modified nanoiron in saturated porous sand and real aquifer media", 80<sup>th</sup> ACS COLLOID AND SURFACE SCIENCE SYMPOSIUM, Boulder, CO. June 18-21, 2006.

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Resume

Lowry, G. V., **Saleh, N.**, Tilton, R. D., Long, T. C., Veronesi, B. "Brain microglia (BV2) response to non-photoactivated TiO<sub>2</sub> nanoparticles: Implications for nanoparticle neurotoxicity", 80<sup>th</sup> ACS COLLOID AND SURFACE SCIENCE SYMPOSIUM, Boulder, CO. June 18-21, 2006.

Sirk, K., **Saleh, N.**, Kim, H. J., Phenrat, T., Sarbu, T., Dufour, B., Ok, J., Matyjaszewski, K., Lowry, G. V., Tilton, R. D. "Nanoiron surface modification by amphiphilic triblock copolymers for enhanced stability, transportability and accumulation at the NAPL/water interface", 80<sup>th</sup> ACS COLLOID AND SURFACE SCIENCE SYMPOSIUM, Boulder, CO. June 18-21, 2006.

Lowry, G.V., **Saleh, N.**, Liu, Y., Phenrat, T., Sirk, K., Dufour, B., Sarbu, T., Matyjaszewski, K., Tilton, R.D., "Nanoiron Treatment of DNAPL Source Zones: Efficient Delivery and DNAPL Targeting", The Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA. May 22-25, 2006.

Lowry, G. V., **Saleh, N.**, Sirk, K., Phenrat, T., Dufour, B., Matyjaszewski, K., Tilton, R. D., "Effect of Groundwater Geochemistry on Nanoiron Transport in Saturated Porous Media", 231<sup>st</sup> ACS National Meeting, Atlanta, GA, March 26-30, 2006.

Lowry, G. V., Liu, Y., **Saleh, N.**, Phenrat, T., Sirk, K., Dufour, B., Matyjaszewski, K., Tilton, R. D., "Triblock Copolymer Coatings Enhances Nanoiron Transport and Localizes Nanoiron at the DNAPL/water Interface", 231<sup>st</sup> ACS National Meeting, Atlanta, GA, March 26-30, 2006.

Tilton, R. D., Lowry, G. V., Matyjaszewski, K., **Saleh, N.**, Sirk, K., Liu, Y., Sarbu, T., Dufour, B., Ok, J., Phenrat, T., Kim, H.-J. "Triblock Copolymers as Nanoparticulate Iron Targeted Delivery Vehicles for Source-Zone Remediation of Contaminated Aquifers", 231<sup>st</sup> ACS National Meeting, Atlanta, GA, March 26-30, 2006.

Long, T., **Saleh, N.**, Phenrat, T., Swartz, C., Parker, J., Lowry, G.V., Veronesi, B., "Metal oxide nanoparticles produce oxidative stress in CNS microglia and neurons", Society of Toxicology Annual Meeting, San Diego, CA. March 5-9, 2006.

Lowry, G.V., Phenrat, T., **Saleh, N.**, Liu, Y., Sirk, K., Tilton, R.D., "Creating Stable Nanoiron Suspensions for Efficient Subsurface Delivery to DNAPL Source Zones", SERDP Partners in Environmental Technology Technical Symposium & Workshop, Washington, D.C. November 28-30, 2005.

Sirk, K., **Saleh, N.**, Sarbu, T., Matyjaszewski, K., Lowry, G. V., Tilton, R.D. "Development of Triblock Copolymers as Dispersants and Interfacial Delivery Vehicles for Reactive Nanoparticulate Iron", 2005 American Institute of Chemical Engineers Annual Meeting, Cincinnati, OH. October 30-November 4, 2005.

**Saleh, N.**, Sirk, K., Sarbu, T., Tilton, R.D., Matyjaszewski, K., Lowry, G. V., "Transport and DNAPL Targeting of Polyelectrolyte- and Surfactant-modified Nanoiron", 230<sup>th</sup> ACS Meeting and Exposition. Washington, DC. August 28-September 1, 2005.

Lowry, G.V., **Saleh, N.**, Liu, Y., Tilton, R.D., Sirk, K., Majetich, S.A., Matyjaszewski, K., Sarbu, T. "Delivering Engineered Iron Nanoparticles to Subsurface DNAPL", 2005 AEESP Biennial Research and Education Conference, Potsdam, NY. July 23-27, 2005.

**Saleh, N.**, Sirk, K., Sarbu, T., Lowry, G. V., Tilton, R.D., Matyjaszewski, K., Redden, G., "Targeted Delivery of Nanoiron to the NAPL-water Interface", 79<sup>th</sup> ACS COLLOID AND SURFACE SCIENCE SYMPOSIUM, Potsdam, NY. July 12-15, 2005.

Sirk, K., **Saleh, N.**, Liu, Y., Sarbu, T., Almusallam, A.S., Lowry, G., Matyjaszewski, K., Majetich, S., Sholl, D., Tilton, R., "Development of Polymer-Modified Nanoparticles for Targeted Delivery of Remediation Agents to DNAPL/Water Interfaces", AIChE 2004 National Meeting, November 7-12, 2004, Austin, TX.

Lowry, G., Liu, Y., Tilton, R., Sholl, D., Sirk, K., **Saleh, N.**, Sarbu, T., Majetich, S., Matyjaszewski, K., "Developing Functional Fe<sub>0</sub>-based Nanoparticles for In Situ Degradation of DNAPL Chlorinated Organic Solvents", Presented at the U.S. EPA 2004 Nanotechnology Science to Achieve Results (STAR) Progress Review Workshop - Nanotechnology and the Environment II. August 18-20, 2004.

Tilton, R., Sirk, K., **Saleh, N.**, Lowry, G., "Development of Polymer-Decorated Nanoparticles for Targeted Delivery of Remediation Agents to the Trichloroethylene/Water Interface", 78<sup>th</sup> ACS COLLOID AND SURFACE SCIENCE SYMPOSIUM, New Haven, CT. June 20-23, 2004.

**INVITED LECTURES**

**Saleh, N.**, Lowry, G.V., "Developing Metallic Nanoparticles for In Situ Remediation of Subsurface DNAPL", Chatham College, Pittsburgh, PA, October, 2004.

#### **PROFESSIONAL AFFILIATIONS**

American Chemical Society (ACS)  
National Groundwater Association (NGWA)  
International Association of Colloids and Interface Scientists (IACIS)  
American Geophysical Union (AGU)  
American Water Resources Association (AWRA)  
American Society of Civil Engineers (ASCE)  
Environmental and Engineering Geophysical Society (EEGS)  
Environmental & Water Resources Institute of the ASCE  
Institute of Civil Engineers, UK (ICE)  
National Association of Graduate-Professional Students (NAGPS)  
Pittsburgh Geological Society (PGS)  
American Society of Civil Engineers, Pittsburgh Section (ASCE-Pittsburgh)  
The Institution of Engineers, Bangladesh (IEB)  
American Association of Bangladeshi Engineers and Architects

#### **OUTREACH**

Sigma Xi Undergraduate Research Symposium Judge, May 2006  
'Pittsburgh Regional Science and Engineering Fair' Judge, March 2006  
'Pennsylvania Junior Academy of Science' Judge, January 2006  
K-12 Science Educator, 'Allegheny Intermediate Unit' (AIU), Pittsburgh, PA, January 2006