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EDUCATION

2004	CARNEGIE MELLON UNIVERSITY PhD in Chemical Engineering	PITTSBURGH, PA
1997	LONDON SCHOOL OF ECONOMICS M.Sc. in Operational Research	LONDON, UK
1996	NATIONAL TECHNICAL UNIVERSITY OF ATHENS Diploma in Chemical Engineering	ATHENS, GREECE

PROFESSIONAL EXPERIENCE

08/04 – date	UNIVERSITY OF WISCONSIN DEPARTMENT OF CHEMICAL AND BIOLOGICAL ENGINEERING	MADISON, WI
	Paul E. Elfers Professor	1/2017 –
	Executive Officer	11/2015 – 7/2018
	Vilas Distinguished Achievement Professor	06/2015 –
	Professor	09/2014 –
	Associate Professor	09/2010 – 08/2014
	Assistant Professor	08/2004 – 08/2010
	GREAT LAKES BIOENERGY RESEARCH CENTER	
	Aim 1 Leader	2017 –
	Management Team Member	2017 –

SELECT AWARDS AND HONORS

Paul E. Elfers Professor	2017 – date
<i>Production and Operations Management Society Applied Research Challenge Award</i>	2016
2016 <i>Covestro Lecture</i> , Department of Chemical Engineering, Carnegie Mellon University	2016
2014 Best Paper Award, <i>Computes and Chemical Engineering</i>	2015
Vilas Distinguished Achievement Professor	2015
2013 Outstanding Young Researcher Award – CAST Division of AIChE	2013
2012 Best Paper Award, <i>Computes and Chemical Engineering</i>	2013
Vilas Associate, University of Wisconsin – Madison	2013-2015
2008 W. David Smith Jr. Graduate Student Paper Award – CAST Division of AIChE	2008
National Science Foundation CAREER Award	2006-2011
Inaugural Olaf A. Hougen Fellowship	2004-2007
Alexander S. Onassis Public Benefit Foundation Graduate Fellowship	1999-2001
Fulbright Graduate Fellowship (declined)	1999

TEACHING

- Senior level *Process Design*.
- Senior level *Process Dynamics and Control*.
- Core graduate course: *Intermediate Problems in Chemical Engineering*.
- Graduate elective course: *Advanced Chemical Process Synthesis and Optimization*.

SELECT PROFESSIONAL ACTIVITIES

1. PROFESSIONAL COMMITTEES:

- *Computing and Systems Technology (CAST)* division of the *American Institute of Chemical Engineers*, 2017 2nd Vice Chair; 2018 1st Vice Chair.
- CACHE Product and Process Design Task Force, Member, 2015 – date
- Optimization Theme, Wisconsin Institute for Discovery, Advisory Board Member, 2014 – date
- CAST division of American Institute of Chemical Engineers (AIChE), Director (2011 – 2014).
- Sustainable Manufacturing Advances in Research and Technology (SMART) Coordination Network, Steering Committee, Member.

2. JOURNAL SERVICE:

- *Computers and Chemical Engineering*, Editorial Advisory Board, 2017 – date.
- *AIChE Journal*, Consulting Editors Board, 2017 – date.
- *Energy Technology*, International Advisory Board member, 2017 – date.
- *BioEnergy Research*, Guest Editor.

3. CONFERENCE ORGANIZATION:

- *Foundations of Computer-aided Process Operations 2017*: Chair.
- *Pan American Advanced Studies: Process Modeling and Optimization for Energy and Sustainability*, 2011: Chair.
- *AIChE 2009 Annual Meeting*: Area 10C Program Coordinator.

4. PROPOSAL REVIEWER:

US National Science Foundation; American Chemical Society – Petroleum Research Fund; National Sciences and Engineering Research Council of Canada; Hellenic Ministry of Education; Dutch Technology Foundation STW; Swiss National Science Foundation; North Central Sun Grant Center; The Royal Society, UK.

RESEARCH MENTORING

Former PhD Students: Charles Sung (2009), Matthew Colvin (2010), Arul Sundaramoorthy (2011), Carlos Henao (2012), Kaushik Subramanian (2012), Patricia Nason (2013), Sara Velez (2014), Murat Sen (2014), Andres Merchan (2016), Yachao Dong (2017), Michael Risbeck (2018).

Current PhD Students: Dhruv Gupta, Tony Wu, Ho Jae Lee, Lingxun Kong, Xinyue Peng, Yifu Chen, Ranjeet Kumar, Venkatachalam Avadiappan, Yaqing Wu, Joonjae Ryu.

Former Postdoctoral Scholars: Pradeep Prasad (2005-06), Jiyong Kim (2009-13), Jeehoon Han (2012-14); Srinivas Rangarajan (2013-16), Jeff Herron (2013-2015), Kirti Yenkie (2015-17), Bruno Calfa (2015-17), Wangyun Won (2015-17), Gautham M. Ramapriya (2016 – 2018).

Current postdoctoral Scholars: Rex Ng, Kefeng Huang, Peyman Fasahati.

PUBLICATIONS

JOURNAL PAPERS

- [1] Dong Y, Jerome N, Maravelias CT. Reoptimization Framework and Policy Analysis for Maritime Inventory Routing under Uncertainty. *Optimization and Engineering*, accepted, **2018**. (DOI: 10.1007/s11081-018-9383-8).
- [2] Lee H, Maravelias CT. Combining the Advantages of Discrete- and Continuous-Time Scheduling Models: Part 1: Framework and Mathematical Formulations. *Computers & Chemical Engineering*, accepted, **2018**. (DOI: 10.1016/j.compchemeng.2017.12.003).
- [3] Wu W, Long MR, Zhang X, Reed JL, Maravelias CT. A Framework for the Identification of Promising Bio-based Chemicals. *Biotechnology and Bioengineering*, 2328-2340, 115, **2018**.

- [4] Ramapriya GM, Won W, Maravelias CT. A Superstructure-based Approach to Process Synthesis for Complex Reactor Networks. *Chemical Engineering Research and Design*, 589-608, 137, **2018**.
- [5] Wang L, Xia M, Wang H, Huang K, Qian C, Maravelias CT, Ozin GA. Greening Ammonia: Toward the Solar Ammonia Refinery, *Joule*, 2, 1055-1074, **2018**.
- [6] Rawlings JB, Patel NR, Risbeck MJ, Maravelias CT, Wenzel MJ, Turney RD. Economic MPC and Real-time Decision Making with Application to Large-Scale HVAC Energy Systems. *Computers & Chemical Engineering*, 114, 89-98, **2018**.
- [7] Kong L, Maravelias CT. An Optimization-based Approach for Simultaneous Chemical Process and Heat Exchanges Network Synthesis. *Industrial & Engineering Chemistry Research*, 57, 6330-6343, **2018**.
- [8] Ng RTL, Patchin S, Wu W, Sheth N, Maravelias CT. An optimization-based Web Application for Synthesis and Analysis of Biomass-to-fuels Strategies. *Biofuels, Bioproducts & Biorefining*, 12 (2), 170-176, **2018**.
- [9] Martagan T, Krishnamurthy A, Leland P, Maravelias CT. Performance Guarantees and Optimal Purification Decisions for Engineered Proteins. *Operations Research*, 6 (1), 18-41, **2018**.
- [10] Huang K, Miller JB, Huber GW, Dumesic JA, Maravelias CT. A General Framework for the Evaluation of Direct Nonoxidative Methane Conversion Strategies. *Joule*, 2, 349-365, **2018**.
- [11] Ng RTL, Kurniawan D, Wang H, Mariska B, Wu W, Maravelias CT. Integrated Framework for Designing Spatially Explicit Biofuel Supply Chains. *Applied Energy*, 116-131, 216, **2018**.
- [12] Huang K, Won W, Barnett KJ, Brentzel ZJ, Alonso DM, Huber GW, Dumesic JA, Maravelias CT. Improving Economics of Lignocellulosic Biofuels: An Integrated Strategy for Coproducing 1,5-Pentanediol and Ethanol. *Applied Energy*, 213, 585-594, **2018**.
- [13] Motagamwala AH, Won W, Maravelias CT, Sener C, Martin Alonso D, Maravelias CT, Dumesic JA. Towards Biomass-Derived Renewable Plastics: Production of 2,5-Furandicarboxylic Acid from Fructose, *Science Advances*, 4 (1), eaap9722, **2018**.
- [14] Rangarajan S, Maravelias CT, Mavrikakis M. Sequential Optimization-Based Framework for Robust Modeling and Design of Heterogeneous Catalytic Systems. *Journal of Physical Chemistry C*, 121, 25847-25863, **2017**.
- [15] Kong L, Wu W, Maravelias CT. Simultaneous Utility and Heat Exchanger Area Targeting for Integrated Process Synthesis and Heat Integration. *Industrial & Engineering Chemistry Research*, 56, 11847-11859, **2017**.
- [16] Gupta D, Maravelias CT. A General State-Space Formulation for Online Scheduling. *Processes*, 5(4), 69, **2017**.
- [17] Lee H, Maravelias CT. Discrete-time Mixed-integer Programming Models for Short-term Scheduling in Multipurpose Environments. *Computers and Chemical Engineering*, 107, 171-183, **2017**.
- [18] Ng RTL, Maravelias CT. Economic and Energetic Analysis of Biofuel Supply Chains. *Applied Energy*, 205, 1571-1582, **2017**.
- [19] He J, Huang K, Barnett KJ, Krishna S, Martin Alonso D, Brentzel Z, Burt SP, Walker TW, Banholzer W, Maravelias CT, Hermans I, Dumesic JA, Huber GW. New Catalytic Strategies for alpha-omega Diol Production from Lignocellulosic Biomass. *Faraday Discussions*, 202, 247-267, **2017**.
- [20] Lee H, Maravelias CT. Mixed-integer Programming Models for Simultaneous Batching and Scheduling in Multi-purpose Batch Plants. *Computers and Chemical Engineering*, 106, 621-644, **2017**.
- [21] He J, Liu M, Huang K, Walker TW, Maravelias CT, Dumesic JA, Huber GW. Production of Levoglucosenone and 5-hydroxymethylfurfural from Cellulose in Polar Aprotic Solvent-water Mixtures. *Green Chemistry*, 19, 3642-3653, **2017**.

- [22] Won W, Maravelias CT. Thermal Fractionation and Catalytic Upgrading of Lignocellulosic Biomass to Biofuels: Process Synthesis and Analysis. *Renewable Energy*, 114, 357-366, **2017**.
- [23] Won W, Motagamwala AH, Dumesic JA, Maravelias CT. A co-solvent hydrolysis strategy for the production of biofuels: Process synthesis and technoeconomic analysis, *Reaction Chemistry and Engineering*, 2, 397-405, **2017**.
- [24] Huang K, Brentzel ZJ, Barnett KJ, Dumesic JA, Huber GW, Maravelias CT. Conversion of Furfural to 1,5-Pentanediol: Process Synthesis and Analysis. *ACS Sustainable Chemistry & Engineering*, 5, 4699-4706, **2017**.
- [25] Peng X, Root TW, Maravelias CT. Storing Solar Energy with Chemistry: The Role of Thermochemical Storage in Concentrating Solar Power. *Green Chemistry*, 19, 2427-2438, **2017**.
- [26] Martin Alonso D, Hakim S, Zhou S, Won W, Hosseinaei O, Tao J, Garcia-Negron V, Motagamwala AH, Mellmer MA, Huang K, Houtman CJ, Labbé N, Harper DP, Maravelias CT, Runge T, Dumesic JA. Increasing the Revenue from Lignocellulosic Biomass: Maximizing Feedstock Utilization. *Science Advances*, 3 (5), e1603301, **2017**.
- [27] Yenkie KM, Wu W, Maravelias CT. Synthesis and analysis of separation networks for the recovery of intracellular chemicals generated from microbial-based conversions. *Biotechnology for Biofuels*, 10:119, **2017**.
- [28] Risbeck MJ, Maravelias CT, Rawlings JB, Turney RD. A Mixed-Integer Linear Programming Model for Real-Time Cost Optimization of Building Heating, Ventilation, and Air Conditioning Equipment, *Energy and Buildings*, 142, 220-235, **2017**.
- [29] Brentzel ZJ, Barnett KJ, Huang K, Maravelias CT, Dumesic JA, Huber GW. Commodity Chemicals from Biomass: Combining Ring-opening Tautomerization and Hydrogenation Reactions to Produce 1,5-Pentanediol from Furfural, *ChemSusChem*, 10, 1351-1355, **2017**.
- [30] Dong Y, Velez S, Maravelias CT. Changeover Formulations for Discrete-time Mixed-integer Programming Scheduling Models. *European Journal of Operational Research*, 260 (3), 949-963, **2017**.
- [31] Dong Y, Sundaramoorthy A, Pinto JM, Maravelias CT. Solution Methods for Vehicle-based Inventory Routing in the Chemicals Sector. *Computers and Chemical Engineering*, 101, 259-278, **2017**.
- [32] Kong L, Avadiappan V, Huang K, Maravelias CT. Simultaneous Chemical Process Synthesis and Heat Integration with Unclassified Hot/Cold Process Streams. *Computers and Chemical Engineering*, 101, 210-225, **2017**.
- [33] Herron JA, Vann T, Duong N, Resasco DE, Crossley S, Lobban LL, Maravelias CT. A Systems-level Roadmap for Biomass Thermal Fractionation and Catalytic Upgrading Strategies. *Energy Technology*, 5, 130-150, **2017**.
- [34] Wu W, Yenkie K, Maravelias CT. A Superstructure-based Framework for Bioseparation Network Synthesis. *Computers and Chemical Engineering*, 96, 1-17, **2017**.
- [35] Ng RTL, Maravelias CT. Design of Biofuel Supply Chains with Variable Regional Depot and Biorefinery Locations. *Renewable Energy*, 100, 90-102, **2017**.
- [36] Martagan T, Krishnamurthy A, Leland PA, Maravelias CT. Optimal Purification Decisions for Engineer-to-Order Proteins at Aldevron. *Production and Operations Management*, 25(12), 2003-2005, **2016**.
- [37] Gupta D, Maravelias CT, Wassick JM. From Rescheduling to Online Scheduling. *Chemical Engineering Research and Design*, 116, 83-97, **2016**.
- [38] Yenkie KM, Wu W, Clark RL, Pflieger BF, Root TW, Maravelias CT. A Roadmap for the Synthesis of Separation Networks for the Recovery of Bio-based Chemicals: Matching Biological and Process Feasibility, *Biotechnology Advances*, 34, 1362-1383, **2016**.

- [39] Motagamwala AH, Won W, Maravelias CT, Dumesic JA. An Engineered Solvent System for Sugar Production from Lignocellulosic Biomass Using Biomass Derived γ -valerolactone. *Green Chemistry*, 18, 5756-5763, **2016**.
- [40] Herron JA, Maravelias CT. Assessment of Solar-to-Fuels Strategies: Photocatalysis and Electro-catalytic Reduction. *Energy Technology*, 4, 1369-1391, **2016**.
- [41] Merchan AF, Lee H-J, Maravelias CT. Discrete-Time Mixed-integer Programming Models for Solution Methods for Production Scheduling in Multistage Facilities. *Computers & Chemical Engineering*, 94, 387-410, **2016**.
- [42] Gupta D, Maravelias CT. On Deterministic Rescheduling: Major Considerations, Paradoxes, and Remedies. *Computers and Chemical Engineering*, 94, 312-330, **2016**.
- [43] Wu W, Henao CA, Maravelias CT. A Superstructure Representation, Generation, and Modeling Framework for Chemical Process Synthesis. *AIChE J.*, 62 (9), 3199-3214, **2016**.
- [44] Kong L, Sen SM, Henao CA, Dumesic JA, Maravelias CT. A Superstructure-based Framework for Simultaneous Process Synthesis, Heat Integration, and Utility Plant Design. *Computers and Chemical Engineering*, 91, 68-84, **2016**.
- [45] Martagan T, Krishnamurthy A, Maravelias CT. Optimal Condition-Based Harvesting Policies for Biomanufacturing Operations with Failure Risks. *IIE Transactions*, 48(5), 440-461, **2016**.
- [46] Ng RTL, Maravelias CT. Design of Cellulosic Ethanol Supply Chains with Regional Depots. *Industrial and Engineering Chemistry Research*, 55, 3420-3432, **2016**.
- [47] Merchan AF, Maravelias CT. Preprocessing and Tightening Methods for Time-Indexed Mixed-integer Programming Models for Chemical Production Scheduling. *Computers & Chemical Engineering*, 84, 516-535, **2016**.
- [48] Velez S, Merchan AF, Maravelias CT. On the Solution of Large-Scale Mixed-integer Programming Scheduling Models. *Chemical Engineering Science*, 136, 139-157, **2015**.
- [49] Han J-H, Sen SM, Luterbacher JS, Martin Alonso D, Dumesic JA, Maravelias CT. Process Systems Engineering Studies for the Synthesis of Catalytic Biomass-to-Fuels Strategies. *Computers and Chemical Engineering*, 81, 57-69, **2015**.
- [50] Han J-H, Luterbacher JS, Martin Alonso D, Dumesic JA, Maravelias CT. A Lignocellulosic Ethanol Strategy via Nonenzymatic Sugar Production: Process Synthesis and Analysis. *Bioresource Technology*, 182, 258-266, **2015**.
- [51] Herron JA, Kim J, Upadhye AA, Huber GW, Maravelias CT. A Generalized Framework for the Assessment of Solar Fuels Technologies. *Energy and Environmental Science*, 8, 126-157, **2015**.
- [52] Velez S, Maravelias CT. Theoretical Framework for the Formulation of MIP Scheduling Models with Multiple and Nonuniform Discrete-time Grids. *Computers and Chemical Engineering*, 72, 233-254, **2015**.
- [53] Dong Y, Sundaramoorthy A, Pinto JM, Maravelias CT. A MIP Model for Inventory Routing in Industrial Gases Supply Chain. *Industrial & Engineering Chemistry Research*, 53(44), 17214-17225, **2014**.
- [54] Velez S, Maravelias CT. Advances in Mixed-integer Programming Methods for Chemical Production Scheduling. *Annual Review of Chemical and Biomolecular Engineering*, 5, 97-121, **2014**.
- [55] Merchan AF, Maravelias CT. Reformulations of Mixed-integer Programming Continuous-time Models for Chemical Production Scheduling. *Industrial & Engineering Chemistry Research*, 53(24), 10155-10165, **2014**.
- [56] Bond JQ, Upadhye AA, Olcay H, Tompsett GA, Jae J, Xing R, Alonso DM, Wang D, Zhang T, Kumar R, Foster A, Sen SM, Maravelias CT, Malina R, Barrett SRH, Lobo R, Wyman CE, Dumesic JA, Huber GW. Production of Renewable Jet Fuel Range Alkanes and Commodity Chemicals from Integrated Catalytic Processing of Biomass. *Energy and Environmental Science*, 7, 1500-1523, **2014**.

- [57] Nason T, Grabow L, Mavrikakis M, Biegler LT, Maravelias CT. Advanced Solution Methods for Microkinetic Models of Catalytic Reactions: a Methanol Synthesis Case Study. *AIChE J.*, 60(4), 1336-1346, **2014**.
- [58] Subramanian K, Rawlings JB, Maravelias CT. Economic Model Predictive Control for Inventory Management in Supply Chains. *Computers and Chemical Engineering*, 64, 71-80, **2014**.
- [59] Harjunkoski I, Maravelias CT, Bongers P, Castro P, Engell S, Grossmann IE, Hooker J, Mendez C, Sand G, Wassick J. Scope for Industrial Applications of Production Scheduling Models and Solution Methods. *Computers and Chemical Engineering*, 62, 161-193, **2014**.
- [60] Luterbacher JS, Rand JM, Martin Alonso D, Han J, Youngquist JT, Maravelias CT, Pflieger BF, Dumesic JA. Nonenzymatic Sugar Production from Biomass Using Biomass-derived γ -Valerolactone. *Science*, 343, 207, **2014**.
- [61] Han J-H, Sen SM, Alonso D, Dumesic JA, Maravelias CT. A Strategy for the Simultaneous Catalytic Conversion of Hemicellulose and Cellulose from Lignocellulosic Biomass to Liquid Transportation Fuels. *Green Chemistry*, 16, 653-661, **2014**.
- [62] Merchan AF, Velez S, Maravelias CT. Tightening Methods for Continuous-time Mixed-Integer Programming Models for Chemical Production Scheduling. *AIChE J.*, 59(12), 4461-4467, **2013**.
- [63] Caes BR, Van Oosbree TR, Lu F, Ralph J, Maravelias CT, Raines RT. Simulated Moving Bed Chromatography: Separation and Recovery of Sugars and Ionic Liquid from Biomass Hydrolysates. *ChemSusChem*, 6(11), 2083-2089, **2013**.
- [64] Kim J, Miller JA, Maravelias CT, Stechel EB. Comparative Analysis of Environmental Impact of S2P (Sunshine to Petrol) System for Transportation Fuel Production. *Applied Energy*, 111, 1089-1098, **2013**.
- [65] Velez S, Maravelias CT. A Branch-and-Bound Algorithm for the Solution of Chemical Production Scheduling MIP Models Using Parallel Computing. *Computers and Chemical Engineering*, 55, 28-39, **2013**.
- [66] Velez S, Maravelias CT. Multiple and Nonuniform Time Grids in Discrete-Time MIP Models for Chemical Production Scheduling. *Computers and Chemical Engineering*, 53, 70-85, **2013**.
- [67] Velez S, Maravelias CT. Reformulations and Branching Methods for Mixed-integer Programming Chemical Production Scheduling Models. *Industrial & Engineering Chemistry Research*, 52 (10), 3832-3841, **2013**.
- [68] Velez S, Maravelias CT. Mixed-integer Programming Model and Tightening Methods for Scheduling in General Chemical Production Environments. *Industrial and Engineering Chemistry Research*, 52 (9), 3407-3423, **2013**.
- [69] Kim J, Sen SM, Maravelias CT. An Optimization-Based Assessment Framework for Biomass-to-Fuels Conversion Strategies. *Energy and Environmental Science*, 6 (4), 1093-1104, **2013**.
- [70] Subramanian K, Rawlings JB, Maravelias CT, Flores-Cerrillo J, Megan, L. Integration of Control Theory and Scheduling Methods for Supply Chain Management. *Computers and Chemical Engineering*, 51, 4-20, **2013**.
- [71] Velez S, Sundaramoorthy A, Maravelias CT. Valid Inequalities Based on Demand Propagation for Chemical Production Scheduling MIP Models. *AIChE J.*, 59(3), 872-887, **2013**.
- [72] Sen SM, Alonso DM, Wettstein SG, Gurbuz EI, Henao CA, Dumesic JA, Maravelias CT. A Sulfuric Acid Management Strategy for the Production of Liquid Hydrocarbon Fuels via Catalytic Conversion of Biomass-derived Levulinic Acid. *Energy and Environmental Science*, 5(12), 9690-9697, **2012**.
- [73] Sen SM, Gurbuz EI, Wettstein SG, Alonso DM, Dumesic JA, Maravelias CT. Production of Butene Oligomers as Transportation Fuels using Butene for Esterification of Levulinic Acid from Lignocellulosic Biomass: Process Synthesis and Technoeconomic Evaluation. *Green Chemistry*, 14 (12), 3289-3294, **2012**.

- [74] Subramanian K, Maravelias CT, Rawlings JB. A State-space Model for Chemical Production Scheduling. *Computers and Chemical Engineering*, 47, 97-110, **2012**.
- [75] Kim J, Miller JA, Johnson T, Stechel E, Maravelias CT. Fuel Production from CO₂ Using Solar-Thermal Energy: System Level Analysis. *Energy and Environmental Science*, 5 (9), 8417 - 8429, **2012**.
- [76] Sen SM, Binder JB, Raines RT, Maravelias CT. Conversion of Biomass to Sugars via Ionic Liquid Hydrolysis: Process Synthesis and Economic Evaluation. *Biofuels, Bioproducts & Biorefining*, 6(4), 444-452, **2012**.
- [77] Maravelias CT. A General Framework and Modeling Approach Classification for Chemical Production Scheduling. *AIChE J.*, 58 (6), 1812-1828, **2012**.
- [78] Maravelias CT. On the Combinatorial Structure of Discrete-time MIP Formulations for Chemical Production Scheduling. *Computers and Chemical Engineering*, 38, 204-212, **2012**.
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- [81] Kim J, Henao CA, Johnson TA, Dedrick DE, Miller JA, Stechel EB, Maravelias CT. Methanol Production from CO₂ Using Solar-Thermal Energy: Process Development and Techno-Economic Analysis. *Energy and Environmental Science*, 4, 3122-3132, **2011**.
- [82] Colvin M, Maravelias CT. R&D Pipeline Planning: Task Interdependencies and Risk Management. *European Journal of Operational Research*, 215, 616-628, **2011**.
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- [84] Sundaramoorthy A, Maravelias CT. Computational Study of Scheduling Approaches for Batch Process Networks. *Industrial and Engineering Chemistry Research*, 50(9), 5023-5040, **2011**.
- [85] Henao CA, Maravelias CT. Process Superstructure Optimization Using Surrogate Models. *AIChE J.*, 57(5), 1216-1232, **2011**.
- [86] Kopanos G, Puigjaner L, Maravelias CT. Production Planning and Scheduling of Parallel Continuous Processes with Product Family Considerations. *Industrial and Engineering Chemistry Research*, 50, 1369-1378, **2011**.
- [87] Sundaramoorthy A, Maravelias CT. A General Framework for Process Scheduling. *AIChE J.*, 57(3), 695-710, **2011**.
- [88] Colvin M, Maravelias CT. Modeling Methods and a Branch and Cut Algorithm for Pharmaceutical Clinical Trial Planning Using Stochastic Programming. *European Journal of Operational Research*, 203, 205-215, **2010**.
- [89] Maravelias CT, Sung C. Integration of Production Planning and Scheduling: Overview, Challenges and Opportunities. *Computers and Chemical Engineering*, 33 (12), 1919-1930, **2009**.
- [90] Maravelias CT, Papalamprou K. Polyhedral Results for Discrete-time MIP Formulations for Scheduling and Production Planning. *Computers and Chemical Engineering*, 33(11), 1890-1904, **2009**.
- [91] Sung C, Maravelias CT. A Projection-Based Method for Production Planning of Multiproduct Facilities. *AIChE J.*, 55 (10), 2614-2630, **2009**.
- [92] Gimenez DM, Henning G, Maravelias CT. A Novel Network-based Continuous-time Representation for Process Scheduling: Part II. Integrated Framework. *Computers and Chemical Engineering*. 33(10), 1644-1660, **2009**.
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- [94] Ferris MC, Maravelias CT, Sundaramoorthy A. Simultaneous Batching and Scheduling Using Dynamic Decomposition on a Grid. *INFORMS Journal on Computing*, 21 (3), 398-410, **2009**.
- [95] Sundaramoorthy A, Maravelias CT, Prasad P. Scheduling of Multi-stage Batch Processes under Utility Constraints. *Industrial and Engineering Chemistry Research*, 48 (13), 6050-6058, **2009**.
- [96] Colvin M, Maravelias CT. Scheduling of Testing Tasks and Resource Planning in New Product Development Using Stochastic Programming. *Computers and Chemical Engineering*, 33 (5), 964-976, **2009**.
- [97] Colvin M, Maravelias CT. A Stochastic Programming Approach for Clinical Trial Planning in New Drug Development. *Computers and Chemical Engineering*, 32(11), 2626-2642, **2008**.
- [98] Sundaramoorthy A, Maravelias CT. Modeling of Storage Constraints in Batching and Scheduling of Multi-stage Processes. *Industrial and Engineering Chemistry Research*, 47 (17), 6648-6660, **2008**
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- [100] Sundaramoorthy A, Maravelias CT. Simultaneous Batching and Scheduling in Multi-stage Multi-product Processes. *Industrial and Engineering Chemistry Research*, 47 (5), 1546-1555, **2008**.
- [101] Sung C, Maravelias CT. A Mixed-Integer Programming Formulation for the General Capacitated Lot-sizing Problem. *Computers and Chemical Engineering*, 32(1), 244-259, **2008**.
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- [103] Prasad P, Maravelias CT, Kelly J. Optimization of Aluminum Smelter Casthouse Operations. *Industrial and Engineering Chemistry Research*, 45 (22), 7603-7617, **2006**.
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- [107] Maravelias CT, Grossmann IE. A Hybrid MIP/CP Decomposition Approach for the Short Term Scheduling of Multipurpose Plants. *Computers and Chemical Engineering*, 28, 1921-1949, **2004**.
- [108] Maravelias CT, Grossmann IE. Optimal Resource Investment and Scheduling of Tests for New Product Development. *Computers and Chemical Engineering*, 28 (6-7), 1021-1038, **2004**.
- [109] Maravelias CT, Grossmann IE. Using MILP and CP for the Scheduling of Batch Chemical Processes. *Lecture Notes on Computer Science*, 3011, 1-20, **2004**.
- [110] Maravelias CT, Grossmann IE. Minimization of Makespan with Discrete-Time State Task Network Formulation. *Industrial and Engineering Chemistry Research*, 42 (24), 6252-6257, **2003**.
- [111] Maravelias CT, Grossmann IE. New Continuous-Time State Task Network Formulation for the Scheduling of Multipurpose Batch Plants. *Industrial and Engineering Chemistry Research*, 42 (13), 3056 – 3074, **2003**.
- [112] Maravelias CT, Grossmann IE. Simultaneous Planning for New Product Development and Batch Manufacturing Facilities. *Industrial and Engineering Chemistry Research*, 40 (26), 6147-6164, **2001**.

BOOK CHAPTERS

- [1] Wu, W-Z.; Kurniawan, D.; Zhu, W.; Maravelias, C.T. Composite-Curve-Based Biomass Procurement Planning Approach. *Advances in Energy Systems Engineering* (Editors: Kopanos, G.M.; Liu, P.; Georgiadis, M.C.), 749-770. Innovation Activities in Low Carbon Energy Technologies Series, Springer, 749-770, **2017** (ISBN: 978-3-319-42803-1).

- [2] Colvin, M.; Maravelias, C.T. Pharmaceutical R&D Pipeline Planning. *Handbook on Project Management and Scheduling, Vol. 2* (Editors: Schwindt, C.; Zimmermann, J.), 1267-1287, Springer, **2015**.
- [3] Aggoun, A.; Maravelias, C.T.; Vazacopoulos, A. Mixed Integer Programming/Constrained Programming. Hybrid Methods. In *Encyclopedia of Optimization* (Editors: Floudas, C.A.; Pardalos, P.M.), 2nd ed., Springer, 2270-2276, **2008** (DOI: 10.1007/978-0-387-74759-0)
- [4] Sung, C.; Maravelias, C.T. Production Planning in Process Systems Engineering. *Process Systems Engineering. Vol. 4: Supply Chain Optimization* (Editors: Georgiadis, M. C.; Papageorgiou, L. C.), WILEY-VCH, Winheim, **2007**.
- [5] Maravelias, C.T.; Grossmann, I.E. Logic Inference and a Decomposition Algorithm for the Resource-Constrained Scheduling of Testing Tasks in Development of New Pharmaceuticals and Agrochemicals. *Handbook on Modeling for Discrete Optimization* (Editors: Appa, G.; Pitsoulis, L.; Williams, H.P.), Springer's International Series in Operations Research and Management Science, **2006**.

REPORTS

- [1] Mavrikakis, M.; Maravelias, C. T.; Stewart, C. A.; Miller, J. E.; Kemp, R. A. *LDRD Final Report on "Fundamentals of Synthetic Conversion of CO₂ to Simple Hydrocarbon Fuels"* (LDRD 113486).

PATENTS

- [1] Maravelias, C.T.; Zenner, S.; Sundaramoorthy, A. Computerized Systems for Chemical Production Scheduling. US 9,146,550 B2, September 29, **2015**.

40 PAPERS IN CONFERENCE PROCEEDINGS (PEER REVIEWED)

WORKSHOP PRESENTATIONS

- [1] Maravelias, C.T. From Rescheduling to Online Scheduling: Major Considerations, Paradoxes, and Remedies, *LCCC Process Control Workshop*, Lund, Sweden, September 28-30, **2016**.
- [2] Maravelias, C.T. Integration of Production Planning and Scheduling: An Assessment of Bottlenecks Related to Production Plan Execution. *International Seminar on Production Planning and Scheduling*, Petrobras, Rio de Janeiro, Brazil, October 9-11, **2012**.
- [3] Rawlings, J.B.; Stewart, B.T.; Subramanian, K.; Maravelias, C.T. Cooperation-based optimization of industrial supply chains. *Workshop on Distributed Model Predictive Control and Supply Chains*, Lund University, Lund, Sweden, May 19-21, **2010**.
- [4] Maravelias, C.T. Mixed-integer programming methods for supply chain optimization. Pan American Advanced Studies Institute 2011: Process modeling and optimization for energy and sustainability. Angra dos Reis, RJ, Brazil, July 19-29, **2011**.

PLENARY, KEYNOTE AND INVITED CONFERENCE PRESENTATIONS

- [1] Lee HJ, Maravelias CT. (Invited) Combining the Advantages of Discrete- and Continuous-time MIP Scheduling Models. *INFORMS Annual Meeting*, Phoenix, AZ, November 4-7, **2018**.
- [2] Chen Y, Maravelias CT. (Invited) Preprocessing Algorithms and Tightening Constraints for Multiperiod Blend Scheduling Problems. *INFORMS Annual Meeting*, Phoenix, AZ, November 4-7, **2018**.
- [3] Maravelias, C.T.; Rawlings, J.B. (Keynote) Optimization Methods for Real-time Decision Making in Large-scale Energy Systems. *Process Systems Engineering 2018*, San Diego, CA, July 1-5, **2018**.
- [4] Maravelias, C.T. (Invited). Discussions on Scheduling, (Re)optimization, Feedback, and Closed-loop Performance. *AIChE Annual Meeting*, In Honor of Jim Rawlings' 60th Birthday, Minneapolis, MN, October 29 – November 3, **2017**.

- [5] Maravelias, C.T.; Herron, J.A. (Invited). A Systems-Level View of Solar Fuels. *9th Sino-US Joint Conference on Chemical Engineering*, Beijing, China, October 15-19, 2017.
- [6] Maravelias, C.T. (Invited). A Systems-Level View of Solar Fuels. *Connaught Global Challenge Symposium: CO2 Chemistry Solutions to Climate Change*, University of Toronto, Toronto, ON, Canada, May 9 – 10, **2017**.
- [7] Maravelias, C.T. (Plenary). Process Systems Engineering for Biofuels and Biochemicals. *Great Lakes Bioenergy Research Center 2016 Annual Scientific Meeting*, Lake Geneva, WI, May 17-19, **2016**.
- [8] Risbeck, M.J.; Maravelias, C.T.; Rawlings, J.B.; Turney, R.D. (CAST Plenary Session). Mixed-Integer Model Predictive Control for Online Scheduling of HVAC Equipment in Commercial Buildings. *AIChE Annual Meeting*, Salt Lake City, UT, November 8-13, **2015**.
- [9] Herron, J. A.; Maravelias, C.T. (Invited). A Generalized Framework for the Assessment of Solar Fuels Technologies. In Honor of the 2014 Wilhelm Award Winner. *AIChE Annual Meeting*, Salt Lake City, UT, November 8-13, **2015**.
- [10] Maravelias, C.T. (Keynote). Process Systems Engineering for Biomass-to-Fuels/Chemicals Strategies. *3rd International Tailor-Made Fuels from Biomass Conference*, Aachen, Germany, June 23-25, **2015**.
- [11] Maravelias, C.T. (Keynote). Chemical Production Scheduling: From Models to Online Solution Methods. *12th Process Systems Engineering and 25th European Symposium in Computer-Aided Process Engineering Joint Event*. Copenhagen, Denmark, May 31 – June 4, **2015**.
- [12] Maravelias, C.T. (Invited). Recent Advances in Chemical Production Scheduling. In Honor of Ignacio Grossmann's 65th Birthday. *AIChE Annual Meeting*, Atlanta, GA, November 16-21, **2014**.
- [13] Maravelias, C.T. (Invited). On the Solution of Large Scale Chemical Production Scheduling Problems. Larry Evans's 80th birthday: How computing has changed chemical engineering. *AIChE Annual Meeting*, Atlanta, GA, November 16-21, **2014**.
- [14] Maravelias, C.T. (Keynote). Process Systems Engineering for Renewable Energy: Lessons Learned, Challenges, and Opportunities. *8th International Conference on Foundations of Computer-Aided Process Design*, Suncadia Resort, Cle Elum, WA, July 13-17, **2014**.
- [15] Velez, S.; Maravelias, C.T. (Invited). Solution Methods for MIP Production Planning and Scheduling Models. *11th International Conference on Computational Management Science*, Lisbon, Portugal, 29-31 May, **2014**.
- [16] Colvin, M.; Maravelias, C.T. (Invited). Stochastic Programming Models and Algorithms for Pharmaceutical R&D Planning. *13th International Conference on Stochastic Programming*, Bergamo, Italy, 8-12 July, **2013**.
- [17] Maravelias, C.T.; Rawlings, J.B.; Subramanian, K. (Invited). A State-space Model for Chemical Production Scheduling. *26th European Conference on Operations Research*, Rome, Italy, 1-4 July, **2013**.
- [18] Velez, S.; Maravelias, C.T. (Invited). Valid Inequalities Based on Demand Propagation for Chemical Production Scheduling MIP Models. *26th European Conference on Operations Research*, Rome, Italy, 1-4 July, **2013**.
- [19] Colvin, M.; Maravelias, C.T. (Invited). Pharmaceutical R&D Planning. *MathBio4: SCALE Symposium*, Wisconsin Institutes for Discovery, Madison, WI, October 18-19, **2012**.
- [20] Subramanian, K.; Rawlings, J.B.; Maravelias, C.T.; Flores-Cerrillo, J.; Megan, L. (Keynote) Integration of Control Theory and Scheduling Methods for Supply Chain Management. *Foundations of Computer-aided Process Operations & Chemical Process Control*, Savannah, GA, January 8 – 11, **2012**.
- [21] Zenner, S.; Maravelias, C.T. (CAST Plenary Session). Classification of chemical production scheduling problems and approaches, and a general solution framework. *AIChE Annual Meeting*, Minneapolis, MN, October 16-21, **2011**.

- [22] Maravelias, C.T. (Keynote). Integration of Production Planning and Scheduling. In Proceedings: *10th International Symposium on Process Systems Engineering*, Salvador, Brazil, August 16-20, **2009**.
- [23] Maravelias, C.T.; Sung, C. (Keynote). Integration of production planning and scheduling: Review, Challenges and Opportunities. In Proceedings: *Foundations of Computer-aided Process Operations* (Eds: Ierapetritou, M.; Bassett, M.; Pistikopoulos, S.), 13-22, Boston, MA, June 29 – July 2, **2008**.
- [24] Colvin, M.; Maravelias, C.T. (Invited). New Product Development Planning Using Stochastic Programming. *2009 INFORMS Annual Meeting*, San Diego, CA, October 11-14, **2009**.
- [25] Prasad, P.; Maravelias, C.T. (Invited) Task Selection, Assignment and sequencing in Multistage Batch Processes. *INFORMS Annual Meeting*, Pittsburgh, PA, November 5-8, **2006**.
- [26] Maravelias, C.T. (Invited). Resource Planning for R&D Portfolio Optimization. *Institute of Industrial Engineers Annual Conference and Exposition*, Orlando, FL, May 20-24, **2006**.

INVITED SEMINARS & PRESENTATIONS

- [1] *Production Scheduling and Supply Chain Operations: Models, Solution Methods, Paradoxes, and Open Questions*, Amazon, Seattle, WA, February 27, **2018**.
- [2] *Chemical Production Scheduling and Supply Chain Optimization*, ASPEN Technology Inc, Houston, TX, October 24, **2017**.
- [3] *Process Systems Engineering for Renewable Energy*, School of Engineering, University of Edinburgh, Edinburgh, UK, September 29, **2017**.
- [4] *From Scheduling to Online Scheduling: Models, Solution Methods, Paradoxes, and Open Questions*, Center for Management Sciences, Technical University of Lisbon, Lisbon, Portugal, September 27, **2017**.
- [5] *Process Systems Engineering for Renewable Energy*, Department of Chemical and Biochemical Engineering, Technical University of Denmark, Lyngby, Denmark, September 25, **2017**.
- [6] *Optimization Methods for Catalyst Design, Chemical Process Synthesis and Operations*. ExxonMobil Research & Engineering Company, Annandale, NJ, August 4, **2017**.
- [7] *Process Systems Engineering for Solar Fuels*, Department of Mechanical Engineering, University of Minnesota, Minneapolis, MN, February 8, **2017**.
- [8] *Process Systems Engineering for Renewable Energy*, Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, MA, December 2, **2016**.
- [9] *Process Systems Engineering for Solar Fuels*, Argonne-Northwestern Solar Energy Research Center, Northwestern University, Evanston, IL, November 3, **2016**.
- [10] *Process Systems Engineering for Renewable Energy*, Chemical and Biochemical Engineering, Rutgers University, Piscataway, NJ, October 20, **2016**.
- [11] *Process Systems Engineering for Renewable Energy*, The Bayer Lecture on Process Systems Engineering, Department of Chemical Engineering, Carnegie Mellon University, September 8, **2016**.
- [12] *From Scheduling to Online Scheduling: Models, Solution Methods, Paradoxes, and Open Questions*, Process Systems Engineering Seminar Series, Department of Chemical Engineering, Carnegie Mellon University, September 7, **2016**.
- [13] *Process Systems Engineering for Renewable Energy*, Department of Chemical and Biological Engineering, Tufts University, January 25, **2016**.
- [14] *Process Systems Engineering for Renewable Energy*, Department of Chemical and Biological Engineering, Princeton University, December 2, **2015**.
- [15] *Process Systems Engineering for Solar Fuels*, Institute of Energy Technology, Eidgenössische Technische Hochschule (ETH) Zurich, Switzerland, June 22, **2015**.
- [16] *Process Systems Engineering for Renewable Energy*, Institute for Chemical and Bio Engineering, Eidgenössische Technische Hochschule (ETH) Zurich, Switzerland, June 10, **2015**.

- [17] *Process Systems Engineering for Renewable Energy*, Mechanical Engineering, École Polytechnique Fédérale de Lausanne, Switzerland, June 9, **2015**.
- [18] *Advances in Chemical Production Scheduling*. AIChE CAST Division Webinar, January 27, **2015**.
- [19] *Process Systems Engineering for Renewable Energy*. The Bren School of Environmental Science & Management, University of California – Santa Barbara, January 20, **2015**.
- [20] *Chemical Production Scheduling: From Models to Online Solution Methods*. Center for Control, Dynamical-Systems, and Computation, University of California – Santa Barbara, May 23, **2014**.
- [21] *Process Systems Engineering for Renewable Energy*. Department of Chemical Engineering and Materials Science. University of Minnesota, Minneapolis, MN, March 27, **2014**.
- [22] *Chemical Production Scheduling: Notation, Problem Classes, Modeling Approaches, and Solution Methods*. Carnegie Mellon University, Enterprise-wide Optimization Seminar Series (webinar), February 27, **2014**.
- [23] *Process Systems Engineering for Renewable Energy*. Department of Chemical and Petroleum Engineering, University of Pittsburgh, Pittsburgh, PA, February 7, **2014**.
- [24] *Process Systems Engineering for Renewable Energy*. School of Chemical, Biological & Materials Engineering, University of Oklahoma, Norman, OK, December 5, **2013**.
- [25] *Advances in Mixed-integer Programming Methods for Chemical Production Scheduling*. Department of Automatic Control, Lund University, Lund, Sweden, October 11, **2013**.
- [26] *Chemical Production Scheduling: Overview and Future Directions*. 25th Anniversary McMaster Advanced Control Consortium Meeting and Workshop, McMaster University, Hamilton, Ontario, Canada, May 15, **2013**.
- [27] *Integration of Chemical Production Planning and Scheduling: An assessment of bottlenecks Related to Production Plan Execution*. Petrobras International Seminar on Production Planning and Scheduling, Rio de Janeiro, Brazil, October 11, **2012**.
- [28] *Integration of Chemical Production Planning and Scheduling*. TU Dortmund, Dortmund, Germany, June 28, **2012**.
- [29] *Chemical Production Scheduling: Notation, Problem Classes, Modeling Approaches, Theory, and Solution Methods*. Center for Process Systems Engineering, Imperial College, London, UK, June 25, **2012**.
- [30] *Modeling and Solution Methods for Stochastic Programming Problems under Endogenous Observation of Uncertainty*. Department of Computing, Imperial College, London, UK, June 21, **2012**.
- [31] *Integration of Simulation and Optimization Methods for Chemical Process Synthesis*. Wisconsin Institute for Discovery - Doing Optimization at Wisconsin Seminar Series, University of Wisconsin, Madison, WI, October 3, **2011**.
- [32] *Production Planning and Scheduling in the Chemical Industries*. Department of Mathematical Physical and Computational Sciences, Faculty of Engineering, Aristotle University, Thessaloniki, Greece, May 27, **2011**.
- [33] *Integration of Production Planning and Scheduling* Department of Chemical Engineering, Texas A&M University, College Station, TX, March 8, **2011**.
- [34] *Sunshine to Petrol - Reimagining Transportation Fuels: Systems-level Studies*. Sandia National Laboratories, Albuquerque, NM, February 23, **2011**.
- [35] *Integration of Production Planning and Scheduling*. Department of Chemical and Biological Engineering, Princeton University, 16 February, **2011**.
- [36] *Optimization Methods for Chemical Process Design and Operations*. ExxonMobil Research & Engineering Company, Annandale, NJ, January 31, **2011**.
- [37] *Mixed-integer Programming Methods in Process Systems Engineering*, ABB, Corporate Research Center, Ladenburg, Germany, June 16, **2010**.

- [38] *Integration of Production Planning and Scheduling*. Department of Chemical and Biological Engineering, Illinois Institute of Technology, Chicago, IL, January 13, **2010**.
- [39] *Integration of Production Planning and Scheduling in the Chemical Industry*. Department of Chemical Engineering, Carnegie Mellon University, Pittsburgh, PA, September 24, **2009**.
- [40] *Integration of Production Planning and Scheduling in the Chemical Industry*. Department of Chemical Engineering, University of Delaware, Newark, DE, September 18, **2009**.
- [41] *Modeling and Solution Methods for Production Planning and Scheduling*, Cervecería Cuauhtemoc Moctezuma, Monterrey, Mexico, August 31, **2009**.
- [42] *Integration of Production Planning and Scheduling in the Chemical Industry*. The Operations Research Society – Mathematical Programming Group, London, UK, May 27, **2009**.
- [43] *Modeling and Solution Methods for a Class of Stochastic Programming Problems under Endogenous Observation of Uncertainty*. Automatic Control Laboratory, Eidgenössische Technische Hochschule (ETH), Zurich, Switzerland, May 20, **2009**.
- [44] *Modeling and Solution Methods for Stochastic Programming Problems under Endogenous Uncertainty*. Center for Computational Engineering Science, RWTH Aachen University, Aachen, Germany, May 18, **2009**.
- [45] *Integration of Production Planning and Scheduling*. School of Chemical and Biomolecular Engineering, Georgia Tech, Atlanta, GA, April 15, **2009**.
- [46] *Integration of Production Planning and Scheduling in the Chemical Industry*. Department of Chemical Engineering, McMaster University, Hamilton, Ontario, Canada, March 26, **2009**.
- [47] *Integration of Production Planning and Scheduling*. Department of Chemical and Biomolecular Engineering, University of California – Los Angeles, January 23, **2009**.
- [48] *Supply Chain Management*, Praxair, Buffalo, NY, October 23, **2008**.
- [49] *Integration of Production Planning and Scheduling*. Department of Chemical Engineering and Chemical Technology, Imperial College, London, UK, May 30, **2008**.
- [50] *Management of the Pharmaceutical Research and Development Pipeline Using Stochastic Programming*. Department of Chemical Engineering, University College London, London, UK, May 29, **2008**.
- [51] *Integration of Production Planning and Scheduling*. Department of Chemical Engineering, Universitat Polytecnica de Catalunya, Barcelona, Spain, May 27, **2008**.
- [52] *Production Planning in the Chemical Industry*. Department of Chemical Engineering, University of Iowa, Iowa City, IA, November 29, **2007**.
- [53] *A Stochastic Programming Approach to Pharmaceutical Research and Development Planning*. Department of Industrial and Systems Engineering, University of Wisconsin – Madison, Madison, WI, October 12, **2007**.
- [54] *Production Planning in the Chemical Industry*. Department of Chemical Engineering, Universidad Nacional del Sur, Bahia Blanca, Argentina, March 30, **2007**.
- [55] *Modeling and Optimization of the Pharmaceutical Supply Chain*. Centocor, St. Louis, MO, January 7, **2007**.
- [56] *Supply Chain Optimization in the Chemical Industry*. Department of Chemical Engineering, University of Rhode Island, Kingston, RI, March 9, **2006**.
- [57] *Scheduling in the Chemical Industry*. Committee on Optimization and its Applications – Fall 2004 Seminar Series, University of Wisconsin – Madison, WI, November 2, **2004**.
- [58] *Optimization Methods for the Scheduling of Batch Processes*. Department of Chemical and Biological Engineering, University of Wisconsin – Madison, WI, March 9, **2004**.
- [59] *Optimization Methods for the Scheduling of Batch Processes*. Department of Chemical Engineering, Texas A&M University, College Station, TX, Spring **2004**.