

ROBERT E. SYNOVEC

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UNIVERSITY OF WASHINGTON, College of Arts and Sciences

Basic Data:

Department: Chemistry
Academic Rank: Professor
Birth Date: March 4, 1959

Date of last promotion: 2001

Educational Background:

<u>Institution</u>	<u>Degree</u>	<u>Dates</u>
Bethel College, St. Paul, MN	B.A., Chemistry (Summa Cum Laude)	1977-1981
Iowa State University, Ames, IA	Ph.D., Anal. Chem.	1981-1986
Ph.D. dissertation title: "Instrumental and Computational Techniques for Obtaining Analytical Data in High Performance Liquid Chromatography"		

Employment Record:

<u>Institution</u>	<u>Position</u>	<u>Dates</u>
1978-1981	Teaching Assistant, Chemistry and Mathematics, Bethel College, St. Paul, MN.	
1981-1982	Teaching Assistant, Iowa State University, Ames, IA.	
1982-1986	Research Assistant, Iowa State University, Ames, IA.	
1986-1992	Assistant Professor of Chemistry, University of Washington, Seattle, WA.	
1992-2001	Associate Professor of Chemistry, University of Washington, Seattle, WA.	
2007-2011	Faculty Director, Center for Process Analytical Chemistry (CPAC), UW	
2001-present	Professor of Chemistry, University of Washington, Seattle, WA	
2007-present	Associate Chair, Graduate Program, Department of Chemistry	

Other Experience and Professional Memberships and Honors:

1983 – present, American Chemical Society (ACS)
1984 Alpha Chi Sigma Graduate Research Award in Analytical Chemistry, ISU
1984 ACS Fellowship, ACS Division of Analytical Chemistry, ISU
1985 – 1986, Phillips Petroleum Fellowship in Analytical Chemistry, ISU
1986 Excellence in Graduate Research Award, Iowa State University (ISU)
1999 DuPont Educational Aid Grant, DuPont
1999 Visiting Faculty, Royal Golden Jubilee PhD Program, Chiang Mai University, Chiang Mai, Thailand
2000 Amersham Pharmacia Professor in Residence, Molecular Dynamics, Sunnyvale, CA
1992 – present, Assistant Editor for *TALANTA*
2003 – present, Editorial Board for *J. Chromatography A*

ROBERT E. SYNOVEC

2004 – present, Editorial Board for *Current Analytical Chemistry*

2009 – L. S. Palmer Award, Minnesota Chromatography Forum, Minneapolis, MN

2010 – present, member of the GC × GC Symposium permanent scientific committee

2013 – GC × GC Scientific Achievement Award, 10th GC × GC Int. Symp., Palm Springs, CA

Brief Biographical Summary:

Robert E. Synovec is a Professor of Chemistry at the University of Washington (UW) in Seattle WA. He obtained his Ph.D. in 1986 from Iowa State University under the direction of Edward S. Yeung, and then joined the Faculty at UW. He currently serves as **Associate Chair** in charge of the **Graduate Program**. Synovec currently has a very active research group (see group web site at <http://depts.washington.edu/synlab/>) and has graduated **34** Ph.D., and **3** Thesis Masters and **5** Non-Thesis Masters students, the first in 1991. He has also supervised **43** undergraduate students and **10** post docs in research. His group pioneers the development of novel analytical instrumentation and methodology based upon chemical separation science (primarily using GC and LC), with further integration with chemometric data analysis. The group is keenly interested in investigating the basic principles of separation science, detection, and data analysis at both a fundamental and problem solving level. Synovec has **215** publications (including several invited manuscripts, book chapters, and reviews), and **over 500** research presentations that include over **200** invited lectures and invited presentations to date. Synovec has been an assistant editor of TALANTA since 1992, working with Professor Emeritus Gary Christian, Editor in Chief for TALANTA. Synovec has been appointed to the editorial board for *J. Chromatography A*, serving since January 2003. He Co-Chaired the International Symposium on Capillary Chromatography (ISCC) with Frank Svec in Portland, OR, May 2009 and again in San Diego, CA, May 2011. He also co-chaired the ISCC meeting this May 2013, in Palm Springs, CA. Synovec was named in 2010 as a member of the GC × GC International Symposium permanent scientific committee. In May 2009, he received the L. S. Palmer Award from the Minnesota Chromatography Forum. In May 2013, Synovec was awarded the GC × GC Scientific Achievement Award at the 10th GC × GC International Symposium in Palm Springs, CA. This award has been instituted to recognize the pioneering contributions of key scientists in promoting GC × GC instrumentation, software, method development and/or applications. He routinely teaches the undergraduate course “Quantitative Analysis” and an advanced “Chemical Separation Techniques” course to graduate students. He has also taught “General Chemistry” and “Instrumental Analysis.”

Current Research Program Summary:

The Synovec group is working in the areas of traditional analytical chemistry, bioanalytical chemistry and process analytical chemistry, centered upon fundamental studies and applications of separation science. Primarily, the group works in the areas of gas chromatography (GC) and liquid chromatography (LC) instrumentation, sensors, analytical methodology, chemical measurement science and multivariate data analysis (chemometrics). The group seeks to find a better fundamental understanding of the right balance of chemical separation and mathematical separation required to optimally glean the desired chemical information from analytical separation data. We complement our interest in developing and applying novel instrumentation and chemometrics software with a deep interest in modeling the separation processes based upon theory. Our theoretical modeling has provided fundamental insight and guidance for instrumentation design improvements. Application of our separations technology in many exciting areas such as metabolomics, forensics, petroleum-based fuels, biofuels and environmental systems are being explored.

In the area of GC, the fields of two-dimensional GC and chemometric data analysis are being integrated. Comprehensive two-dimensional GC instrumentation with time-of flight mass spectrometry detection ($GC \times GC - TOFMS$) has been developed, improved upon, and applied, using two different modulation interfaces: valve-based and thermal-based. The $GC \times GC - TOFMS$ instrument provides an information-rich chemical fingerprint for complex samples, and the data is ideally suited for chemometric data analysis. For example, we are pioneering the development of higher order discovery-based software to find up- and down-regulated biomarker metabolites in metabolomics studies. Based upon the locations found in the two dimensional separation space that indicate potential biomarker locations, the $GC \times GC - TOFMS$ data at these key locations is further mined to identify and quantify the metabolites of interest. This is accomplished using the chemometric method PARAFAC, a third order data analysis algorithm. Using PARAFAC, analytes of interest are deconvoluted (i.e., mathematically resolved), identified, and quantified, in the presence of unknown interferences, from a single $GC \times GC - TOFMS$ data set, under conditions in which only partial chemical selectivity is needed along the three dimensions (the two GC dimensions and the MS dimension). Recently, we have automated the PARAFAC algorithm using a graphical user interface (GUI). This GUI, as well as other chemometric software we have developed, considerably strengthens our ability to provide valuable insight into complex samples analyzed by $GC \times GC - TOFMS$. This research has been currently extended with novel pattern recognition and discovery-based methods for rapid classification and screening applications, e.g., for bioanalytical metabolomics, forensics, petroleum-based fuels, biofuels, and environmental studies. For many of the projects, we also develop and apply novel LC-MS/MS methods to provide a broader understanding of the chemical systems being investigated. For example, in metabolomics studies the metabolites determined by the GC and LC platforms are complementary, with some metabolites determined by both platforms, but many metabolites more readily determined by one approach than the other. The group has also developed a comprehensive three-dimensional gas chromatography instrument ($GC \times GC \times GC$), which provides interesting opportunities to study selectivity advantages of 3D separations. Concurrently, work in the area of ultra-high speed GC has been pioneered, with separations on the time scale of a chemical sensor (e.g., separations under a few seconds). This work, in the general area of "GC-on-a-chip," has involved the study and use of novel single walled carbon nanotube stationary phases within the GC-chip channel structure combined with rapid resistive heating to do rapid temperature programming. For example, GC separations of ten chemical components have been separated in a fraction of one second, and temperature programming rates of 100 °C/ second are readily achieved.

Publications:

An * indicates an INVITED publication. Each entry is a peer reviewed manuscript unless noted otherwise. Principal author is underlined.

1. "Quantitative Analysis Without Analyte Identification by Refractive Index Detection," R.E. Synovec and E.S. Yeung, *Anal. Chem.*, 1983, **54**, 1599-1603.
2. "Quantitative Gel-Permeation Chromatography Without Standards," R.E. Synovec and E.S. Yeung, *J. Chromatogr.*, 1984, **283**, 183-190.
3. "Correlation of Elution Orders in Different Liquid Chromatographic Systems Without Analyte Identification," R.E. Synovec and E.S. Yeung, *Anal. Chem.*, 1984, **56**, 1452-1457.
- 4.* "Characterization of Crude Oils using Liquid Chromatography Without Standards," R.E. Synovec and E.S. Yeung, in *Characterization of Heavy Crude Oils and Petroleum Residues*, B. Tissot, Ed., Editions Technip, Paris, 1984, pp-268-272. **Invited, peer reviewed conference proceeding.**
5. "Quantitation of Components in Crude Oils using Liquid Chromatography Without Identification," R.E. Synovec and E.S. Yeung, *J. Chromatogr. Sci.*, 1985, **23**, 214-221.
6. "Improvement of the Limit of Detection in Chromatography by an Integration Method," R.E. Synovec and E.S. Yeung, *Anal. Chem.*, 1985, **57**, 2162-2167. (Patent Awarded)
7. "A Laser-Based Circular Dichroism Detector for Conventional and Microbore Liquid Chromatography," R.E. Synovec and E.S. Yeung, *Anal. Chem.*, 1985, **57**, 2606-2610.
8. "Comparison of an Integration Procedure to Fourier Transform and Data Averaging Procedures in Chromatographic Data Analysis," R.E. Synovec and E.S. Yeung, *Anal. Chem.*, 1986, **58**, 2093-2095.
9. "Fluorescence Detected Circular Dichroism as a Detection Principle in High Performance Liquid Chromatography," R.E. Synovec and E.S. Yeung, *J. Chromatogr.*, 1986, **368**, 85-93.
- 10.* "Detectors for Liquid Chromatography," E.S. Yeung and R.E. Synovec, *Anal. Chem.*, 1986, **58**, 1237A-1256A. **Invited, peer reviewed A-page article.**
- 11.* "Laser-Based Circular Dichroism Detection of Molecules in Flowing Systems using High-Frequency Polarization Modulation," R.E. Synovec and E.S. Yeung, *AIP Conf. Proc.*, 1987, **160** (Adv. Laser Sci.-2), 615-617. **Invited, peer reviewed conference proceeding.**
12. "Effect of Ultrasonic Agitation in High Performance Size Exclusion Chromatography," R.E. Synovec and E.S. Yeung, *J. Chromatogr.*, 1987, **388**, 105-112.
13. "Refractive Index Effects in Cylindrical Detector Cell Designs for Microbore High Performance Liquid Chromatography," R.E. Synovec, *Anal. Chem.*, 1987, **59**, 2877-2884.

14. "High Speed and Super Speed Size-Exclusion Chromatography of Polymers for Process Analysis," C.N. Renn and R.E. Synovec, *Anal. Chem.*, 1988, **60**, 200-204.
15. "Dual Beam Absorbance Measurements by Position Sensitive Detection," C. N. Renn and R. E. Synovec, *Anal. Chem.*, 1988, **60**, 1188-1193.
16. "Improved Detection in Super-Speed Size-Exclusion Chromatography by Reducing On-Column Dilution and Detector Noise," C. N. Renn and R. E. Synovec, *Anal. Chem.*, 1988, **60**, 1829-1832.
17. "Refractive Index Gradient Detection of Femtomole Quantities of Polymers by Microbore Size-Exclusion Chromatography," D. O. Hancock and R. E. Synovec, *Anal. Chem.*, 1988, **60**, 1915-1920.
18. "Rapid Characterization of Linear and Star-Branched Polymers by Concentration Gradient Detection," D. O. Hancock and R. E. Synovec, *Anal. Chem.*, 1988, **60**, 2812-2818.
19. "Early Detection of C-130 Aircraft Engine Malfunction by Principal Component Analysis of the Wear Metals in C-130 Engine Oil," D. O. Hancock and R. E. Synovec, *Appl. Spectrosc.*, 1989, **43**, 202-208.
20. "Microbore LC and Refractive Index Gradient Detection of Low Nanogram and Low PPM Quantities of Carbohydrates," D. O. Hancock and R. E. Synovec, *J. Chromatogr.*, 1989, **464**, 83-91.
21. "Examination of the Automated Solute-Independent Calibration Technique," C. N. Renn and R. E. Synovec, *Anal. Chem.*, 1989, **61**, 1915-1921.
22. "Pointing Stability Limited, Dual Beam Absorbance Measurements by Position Sensitive Detection," C. N. Renn and R. E. Synovec, *Appl. Spectrosc.*, 1989, **43**, 1393-1398.
- 23.* "New Directions in Process Liquid Chromatography," R.E. Synovec, L.K. Moore, C.N. Renn and D.O. Hancock, *Am. Lab.*, 1989, October, 82-87. **Invited, non-peer reviewed article.**
- 24.* "Novel Approaches in Detector Instrumentation for Process Liquid Chromatography," R.E. Synovec, *AIP Conf. Proc.*, 1989, **191**, 716-721. **Invited, peer reviewed conference proceeding.**
- 25.* Review of "Instrumental Methods of Analysis," 7th ed., by H.H. Willard, L.L. Merritt, Jr., J.A. Dean, F.A. Settle, *Anal. Chem.*, 1989, **61**, 417A-418A. **Invited review**
- 26.* Review of "Preparative-Scale Chromatography," Chromatographic Science Series, Vol. 46, Eli Gruska, ed., *JACS*, 1989, **111**, 8768-8769. **Invited review**

- 27.* Review of "On-Line Process Analyzers," by Gary D. Nichols, *Anal. Chem.*, 1989, **61**, 1376A-1377A. **Invited review**
- 28.* "Fiber Optic Absorbance and Fluorescence Measurements in High Temperature Liquid Chromatography," R.E. Synovec, C.N. Renn, and L.K. Moore, *Proc. SPIE-Int. Soc., Opt. Eng.*, 1990, **1172**, 49-59. **Invited, peer reviewed conference proceeding.**
29. "Single Optical Fiber, Position-Sensitive Detector Based Multi-Wavelength Absorbance Spectrophotometer," C.N. Renn and R.E. Synovec, *Anal. Chem.*, 1990, **62**, 558-564.
30. "Ratio of Sequential Chromatograms for Quantitative Analysis and Peak Deconvolution: Application to Standard Addition Method and Process Monitoring," R.E. Synovec, E.L. Johnson, T.J. Bahowick, and A.W. Sulya, *Anal. Chem.*, 1990, **62**, 1597-1603.
31. "Ion Chromatographic Determination of Oxalate in Plasma: Correlation Study with an Enzymatic Method," K.J. Skogerboe, T. Felix-Slinn, and R.E. Synovec, *Anal. Chim. Acta*, 1990, **237**, 299-304.
32. "Flow Dependence and Sensitivity of the Refractive Index Gradient Measurement with the Z-Configuration Flow Cell at Low Reynolds Number," D.O. Hancock, C.N. Renn, and R.E. Synovec, *Anal. Chem.*, 1990, **62**, 2441-2447.
- 33.* "Liquid Chromatography: Equipment and Instrumentation," R.E. Synovec, E.L. Johnson, L.K. Moore and C.N. Renn, *Anal. Chem.*, 1990, **62**, 357R-370R. **Invited fundamental review.**
34. "Refractive Index Gradient Detection of Biopolymers Separated by High Temperature Liquid Chromatography," R.E. Synovec and C.N. Renn, *J. Chromatogr.*, 1991, **536**, 289-301.
- 35.* "Molecular Weight Sensing of Polyethylene Glycols by Flow Injection Analysis and Refractive Index Gradient Detection," V. Murugaiyah and R.E. Synovec, *Anal. Chim. Acta*, 1991, **246**, 241-249. **Invited, peer reviewed manuscript for young analytical chemists.**
36. "Thermal Gradient Microbore Liquid Chromatography and Dual-Wavelength Absorbance Detection," C.N. Renn and R.E. Synovec, *Anal. Chem.*, 1991, **63**, 568-574.
- 37.* "Sensitive Laser-Based Measurements of Hydrodynamically Generated Concentration Gradients," R.E. Synovec and V. Murugaiyah, *SOQUE Lasers '90 Conf. Proc.: Lasers in Chemistry*, 1991, **13**, 763-771. **Invited, peer reviewed conference proceeding.**
- 38.* "A Novel Approach for the Refractive Index Gradient Measurement in Microliter Volumes Using Fiber Optic Technology," R.E. Synovec and C.N. Renn, *Proc. SPIE-Int. Soc. Opt. Eng.*, 1991, **1435**, 128-139. **Invited, peer reviewed conference proceeding.**

- 39.* "Gradient Microbore Liquid Chromatography with Dual-Wavelength Absorbance Detection: Tunable Analyzers for Remote Chemical Monitoring," R.E. Synovec, L.K. Moore and A.W. Sulya, *Proc. SPIE-Int. Soc. Opt. Eng.*, 1991, **1434**, 147-158. **Invited, peer reviewed conference proceeding.**
40. "The Effect of Temperature on Separation Efficiency for High-Speed Size Exclusion Chromatography," C.N. Renn and R.E. Synovec, *Anal. Chem.*, 1992, **64**, 479-484.
41. "Sequential Chromatogram Ratio Technique: Evaluation of the Effects of Retention Time Precision, Adsorption Isotherm Linearity, and Detector Linearity on Qualitative and Quantitative Analysis," T.J. Bahowick and R.E. Synovec, *Anal. Chem.*, 1992, **64**, 489-496.
- 42.* "Trace Analysis of Organics in Ground Water by On-Column Preconcentration and Thermal Gradient Microbore Liquid Chromatography with Dual Wavelength Absorbance Detection," L. K. Moore and R.E. Synovec, *ACS Symposium Series*, 1992, 508 (Pollution Prevention in Industrial Processes), Chapter 20, 243-257. **Invited, peer reviewed book chapter.**
43. "Radial Measurement of Hydrodynamically Generated Concentration Profiles for Molecular Weight Determination," V. Murugaiah and R.E. Synovec, *Anal. Chem.*, 1992, **64**, 2130-2137.
- 44.* "Liquid Chromatography: Equipment and Instrumentation," T.J. Bahowick, V. Murugaiah, A.W. Sulya, D.B. Taylor, R.E. Synovec, R.J. Berman, C.N. Renn and E.L. Johnson, *Anal. Chem.*, 1992, **64**, 255R - 270R. **Invited fundamental review.**
45. "Uncoupling the Effects of Convection and Diffusion on Refractive Index Gradient Detection in High Temperature Liquid Chromatography" L.R. Lima III and R.E. Synovec, *Anal. Chem.*, 1993, **65**, 128-134.
46. "Chromatographic Determination of Copper Speciation in Jet Fuel," D.B. Taylor and R.E. Synovec, *Talanta*, 1993, **40**, 495-501.
47. "High Speed Chromatographic Analysis of High Fructose Corn Syrup for Process Monitoring," D.R. Dunphy and R.E. Synovec, *Talanta*, 1993, **40**, 775-780.
- 48.* "Molecular Weight Determination of Polymers by Flow Injection Analysis and Refractive Index Gradient Detection," V. Murugaiah, L.R. Lima, III and R.E. Synovec, *Proceedings of the ACS, Division of Polymeric Materials: Science and Engineering*, 1993, **69**, 410-411. **Invited, peer reviewed conference proceeding.**
49. "Axial Thermal Gradient Microbore Liquid Chromatography by Flow Programming," L.K. Moore and R.E. Synovec, *Anal. Chem.*, 1993, **65**, 2663-2670.
50. "Liquid Chromatographic Determination of Copper Speciation in Jet Fuel Resulting from Dissolved Copper," D.B. Taylor and R.E. Synovec, *J. Chromatogr. A*, 1994, **659**, 133-141.

51. "Analysis of Unresolved Chromatographic Peaks by the Absorbance Ratio and Sequential Chromatogram Ratio Techniques Coupled with Peak Suppression," T.J. Bahowick, D.R. Dunphy and R.E. Synovec, *J. Chromatogr. A*, 1994, **663**, 135-150.
52. "Isocratic Mixed Mode Liquid Chromatographic Separation of Phospholipids with Octadecylsilane-Silica Stationary Phases," L.R. Lima, III and R.E. Synovec, *Talanta*, 1994, **41**, 581-588.
53. "Dynamic Surface Tension Detection by Optically Probing a Repeating Drop Rate," L.R. Lima, III, D.R. Dunphy and R.E. Synovec, *Anal. Chem.*, 1994, **66**, 1209-1216.
- 54.* "Liquid Chromatography: Equipment and Instrumentation," C.A. Bruckner, M.D. Foster, L.R. Lima, III, R.E. Synovec, R.J. Berman, C.N. Renn and E.L. Johnson, *Anal. Chem.*, 1994, **66**, 1R-16R. **Invited fundamental review.**
- 55.* "Chemical Sensing of In-Situ Extracted Organics by Direct Detection of Mode-Filtered Light," R.E. Synovec, C.A. Bruckner, L.W. Burgess and M.D. Foster, *Proc. SPIE-Int. Soc. Opt. Eng.*, 1994, **2293**, 167-177. **Invited, peer reviewed conference proceeding.**
- 56.* "Molecular Weight Determination of Polymers by Flow Injection Analysis and Refractive Index Gradient Detection," V. Murugaiah, L.R. Lima, III and R.E. Synovec, *ACS Symposium Series*, 1994, **581** (Hyphenated Techniques in Polymer Characterization), Chapter 3, 25-43. **Invited, peer reviewed book chapter.**
- 57.* Review of "Process Gas Chromatography Fundamentals and Applications" by R. Annino and R. Villalobos, *Anal. Chem.*, 1994, **66**, 302A-303A. **Invited review**
58. "Laser-Based Dynamic Surface Tension Detection for Liquid Chromatography by Probing a Repeating Drop Radius," L.R. Lima, III and R.E. Synovec, *J. Chromatogr. A*, 1995, **691**, 195-204.
59. "Fiber Optic-Based Mode-Filtered Light Detection for Small Volume Chemical Analysis," R.E. Synovec, A.W. Sulya, L.W. Burgess, M.D. Foster and C.A. Bruckner, *Anal. Chem.*, 1995, **67**, 473-481.
60. "Correlation of Quantitative Analysis Precision to Retention Time Precision and Chromatographic Resolution for Rapid, Short-Column Analysis," T.J. Bahowick and R.E. Synovec, *Anal. Chem.*, 1995, **67**, 631-640.
- 61.* "The Influence of Organic Compounds on Cloud Droplet Growth," M. L. Shulman, M. C. Jacobson, T. E. Young, R. E. Synovec and R. J. Charlson, *Proceedings of the ACS*, Division of Environmental Chemistry, 1995, **35**, 163-165. **Invited, peer reviewed conference proceeding.**
62. "Liquid Chromatographic Sensing in Water on a Thin-Clad Optical Fiber by Mode-Filtered Light Detection," M.D. Foster and R. E. Synovec, *Anal. Chem.*, 1996, **68**, 1456-1463.

63. "Enhanced Surfactant Determination by Ion-Pair Formation using Flow Injection Analysis and Dynamic Surface Tension Detection," T. E. Young and R. E. Synovec, *Talanta*, 1996, **43**, 889-899.
64. "Gas Chromatographic Sensing on an Optical Fiber by Mode-Filtered Light Detection," C. A. Bruckner and R. E. Synovec, *Talanta*, 1996, **43**, 901-907.
65. "Dissolution Behavior and Surface Tension Effects of Organic Compounds in Nucleating Cloud Droplets," M. L. Schulman, M. C. Jacobson, R. J. Charlson, R. E. Synovec and T. E. Young, *Geophysical Research Letters*, 1996, **23**, 277-280.
66. "Reversed Phase Liquid Chromatography of Organic Hydrocarbons with Water as the Mobile Phase," M. D. Foster and R. E. Synovec, *Anal. Chem.*, 1996, **68**, 2838-2844.
67. "High-Speed Liquid Chromatography of Phenylethanolamines for the Kinetic Analysis of [¹¹C]-meta-Hydroxyephedrine and Metabolites in Plasma," J. M. Link, R. E. Synovec, K. A. Krohn, J.H. Caldwell, *J. Chromatogr. B*, 1997, **693**, 31-41.
- 68.* "Parallel-Column Gas Chromatography Coupled with Mass Spectrometry and Chemometrics," R. E. Synovec, B. J. Prazen and B. R. Kowalski, *Proc. 19th Int. Symp. Cap. Chromatogr and Electrophoresis*, 1997, pp. 366-367. **Invited conference proceeding.**
- 69.* "High-Speed Short Column Capillary Gas Chromatography with Chemometrics," R. E. Synovec, C. A. Bruckner and B. J. Prazen, *Proc. 19th Int. Symp. Cap. Chromatogr. and Electrophoresis*, 1997, pp. 148-149. **Invited conference proceeding.**
70. "Dynamic Surface Tension and Adhesion Detection for the Rapid Analysis of Surfactants in Flowing Aqueous Liquids," N. A. Olson, R. E. Synovec, W. B. Bond, D. M. Alloway and K. J. Skogerboe, *Anal. Chem.*, 1997, **69**, 3496-3505.
71. "Simultaneous Flame Ionization and Absorbance Detection of Volatile and Non-Volatile Compounds by Reversed Phase Liquid Chromatography with a Water Mobile Phase," C. A. Bruckner, S. T. Ecker and R. E. Synovec, *Anal. Chem.*, 1997, **69**, 3465-3470.
72. "Standardization of Second Order Chromatographic/Spectroscopic Data for Optimum Chemical Analysis," B. J. Prazen, R. E. Synovec and B. R. Kowalski, *Anal. Chem.*, 1998, **70**, 218-225.
73. "Bonded Stationary Phases for Reversed Phase Liquid Chromatography with a Water Mobile Phase: Application to Subcritical Water Extraction," T. E. Young, S. T. Ecker, R. E. Synovec, N. T. Hawley, J. Lomber and C. M. Wai, *Talanta*, 1998, **45**, 1189-1199.
74. "Hydrophobic Interaction Chromatography Coupled with Dynamic Surface Tension Detection for the Determination of Surface Active Species in Protein Formulations," N. A. Olson, K. J. Skogerboe and R. E. Synovec, *J. Chromatogr. A*, 1998, **806**, 239-250.

75. "Bridging the Gap between Process Gas Chromatography and Chemometrics," R. E. Synovec, C. A. Bruckner and B. J. Prazen, *At Process*, 1998, Vol. III, No. 3,4, 132-138.
76. "Comprehensive Two-Dimensional High Speed Gas Chromatography (GC × GC) with Chemometric Analysis," C. A. Bruckner, B. J. Prazen and R. E. Synovec, *Anal. Chem.*, 1998, **70**, 2796-2804.
77. "Second Order Chemometric Standardization for High Speed Hyphenated Gas Chromatography: Analysis of GC/MS and Comprehensive GC × GC Data," B. J. Prazen, C. A. Bruckner, R. E. Synovec and B. R. Kowalski, *J. Microcolumn Separations*, 1999, **11**, 97-107.
78. "Enhanced Chemical Analysis Using Parallel Column Gas Chromatography with Single Detector Time-of-Flight Mass Spectrometry and Chemometric Analysis," B. J. Prazen, C. A. Bruckner, R. E. Synovec, and B. R. Kowalski, *Anal. Chem.*, 1999, **71**, 1093-1099.
79. "Whole-Column Radioactivity Detection: Simultaneous Separation and Enhanced Detectability," J. M. Link and R. E. Synovec, *Anal. Chem.*, 1999, **71**, 2700-2707.
- 80.* "Comparison of the Binding Constant of Decanesulfonate with β-Cyclodextrin as Determined by Liquid Chromatography with a Water Mobile Phase and Flow Injection Analysis Coupled with Dynamic Surface Tension Detection," T. E. Young, K. E. Miller and R. E. Synovec, *Microchemical Journal*, 1999, **62**, 70-82. **Special issue honoring P. K. Dasgupta, peer reviewed.**
- 81.* "Advances in High-Speed Multidimensional Gas Chromatography Coupled with Chemometric Analysis," R. E. Synovec, C. G. Fraga, W. W. C. Quigley and K. J. Johnson, *Proc. 21st Int. Symp. Cap. Chromatogr. and Electrophoresis*, 1999, p.20. **Invited conference proceeding.**
- 82.* "Capillary-Based Hyphenated Chemical Analyzers using Liquid Chromatography with a Water Mobile Phase," R. E. Synovec, P. G. Vahey, W. W. C. Quigley, C. G. Fraga, B. J. Marquardt and L. W. Burgess, *Proc. 21st Int. Symp. Cap. Chromatogr. and Electrophoresis*, 1999, p. 216. **Invited conference proceeding.**
83. "The Relative Importance of Background and Signal in Quantifying Chromatographic Radioanalytes: Post-Column Versus Whole Column Radiation Detection," J. M. Link and R. E. Synovec, *J. Labelled Cpd. Radiopharm.*, 1999, **42**, (Suppl. 1), S883-S885.
84. "Reversed Phase Liquid Chromatography with UV Absorbance and Flame Ionization Detection Using a Water Mobile Phase and a Cyano Propyl Stationary Phase: Analysis of Alcohols and Chlorinated Hydrocarbons," W. W. C. Quigley, S. T. Ecker, P. G. Vahey and R. E. Synovec, *Talanta*, 1999, **50**, 569-576.
85. "Novel Calibration of a Dynamic Surface Tension Detector: Flow Injection Analysis of Kinetically-Hindered Surface Active Analytes," K. E. Miller, K. J. Skogerboe and R. E. Synovec, *Talanta*, 1999, **50**, 1045-1056.

86. "A Novel Raman Waveguide Detector for Liquid Chromatography," B. J. Marquardt, P. G. Vahey, R. E. Synovec and L. W. Burgess, *Anal. Chem.*, 1999, **71**, 4808-4814.
87. "Comprehensive LC x GC for Enhanced Headspace Analysis," W. W. C. Quigley, C. G. Fraga and R. E. Synovec, *J. Microcolumn Separations*, 2000, **12**, 160-166.
- 88.* "Enhancing the Limit of Detection for Comprehensive Two-Dimensional Gas Chromatography (GC x GC) Data Using Bilinear Chemometric Analysis," C. G. Fraga, B. J. Prazen and R. E. Synovec, *J. High Resolut. Chromatogr.*, 2000, **23**, 215-224. **Special issue honoring John Phillips, peer reviewed.**
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