American Chemical Society

National Awards Nomination Packet

ACS Award in Chromatography:2017
for: Robert Kennedy

Received: 10/30/2015 *Cycle Year: 3*

"For the development of innovative techniques in miniaturization of chemical separations and microfluidics for highly sensitive analysis of biological compounds."

NOMINATOR:

Milos Novotny
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Bloomington, IN 47408-9502
UNITED STATES

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- Have you discussed this award nomination with the nominee? *Yes*

NOMINEE:

Robert Kennedy
University of Michigan
930 N University Ave
Ann Arbor, MI 48109-1055
UNITED STATES

Tel: (734)615-4363
Email: rtkenn@umich.eduXXX

ACS Current Member: Yes
Years of Service: 10
Date of birth: 01/01/1962
Present Position: Willard Professor of Chemistry and Chair and Professor of Pharmacology, University of Michigan
Industry: Academia

- Does the nominee employ and require good safety protocols and practices in his/her laboratory? *Yes*
- What is the nominee's present position? *Willard Professor of Chemistry and Chair and Professor of Pharmacology, University of Michigan*
- What professional discipline does the nominee work in? *Academia*

SUPPORTER 1

Jonathan Sweedler
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SUPPORTER 2

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INDIANA UNIVERSITY

DEPARTMENT OF CHEMISTRY

College of Arts and Sciences
Bloomington

October 30, 2015

Dear Committee Members:

I wish to re-nominate Robert T. Kennedy, Willard Professor of Chemistry and current Chemistry Department Chair, Professor of Pharmacology and Distinguished University Professor at University of Michigan, for the 2017 ACS Chromatography Award. This nomination has been prepared with great enthusiasm, as I believe that Professor Kennedy is an exceptionally qualified candidate for this recognition.

It has been a great pleasure to observe Bob Kennedy's rapid development into a leading separation scientist since the onset of his scientific career at the University of North Carolina, when he was a doctoral student in Jorgenson's group. More than 20 years ago, miniaturization of chromatography for the sake of studying small biological objects, which he did quite impressively even during the late 1980s, was to be followed by a most distinguished academic career to this date. Kennedy's current scholarly focus is still in the area of important bioanalytical measurements through the development of smaller, faster and more sensitive separation/detection methodologies. During the following decades, the impact of capillary and microfluidic separations on contemporary science has become phenomenal; Kennedy has been a protagonist in the use and further development of these remarkable separation tools for the sake of very unique biological and biochemical measurements.

Many scientists have been working in the area of biosensors for a long time. Bob Kennedy's early recognition that the analytical attributes of such measurements can be significantly enhanced through the prior application of fast LC and CE techniques was very important. With very broad biological and neurochemical perspectives, he has tackled some of the major technological hurdles in miniaturization and microfluidics in very original ways. Importantly, he has also been responsible for leading these techniques to advancing the areas of neuroscience, pharmaceutical analysis and metabolomics, among others. These efforts have been acknowledged by the recognitions and major lecture invitations even from the areas outside of analytical chemistry

Kennedy is a prolific scientist, having published 207 papers in chromatographic, bioanalytical and neuroscience journals. Many of the papers attest to the originality of instrumental design: fast CE-based affinity and immune assays, analytical uses of aptamers, *in vivo* measurements of metabolic profiles and multiple monitoring of neurotransmitters, are representative examples. He has renewed respect of many fellow scientists for the analytical power of microfluidic systems through demonstration of the real practical applications (peptide hormone monitoring from single cells and islets). He has also made several

technologically important contributions to LC/MS and CE-MS combinations. I am personally very impressed with the series of recent articles and presentations concerning the segmented-flow microfluidics, as these methodologies represent a very unique approach to solving important analytical problems.

Professor Kennedy has made important contributions to the field of separation science through his service as well. He has been involved with organizing several professional meetings and served on numerous organizing committees. While serving on the editorial boards of main analytical journals, Robert Kennedy has helped immensely the field of separation science to be recognized as a key approach in contemporary science. As his impressive CV reveals, Professor Kennedy has received numerous professional recognitions. He is a very effective educator as well. Several of his former graduate students and postdoctorals hold successful positions in academia and industry.

I summary, I am very pleased to initiate this nomination, which is endorsed enthusiastically by the seconding letters from Professor Jonathan Sweedler and Professor Edward S. Yeung. Robert Kennedy is a most deserving candidate for the ACS Chromatography Award.

Sincerely,
Milos V. Novotny (1986 Awardee)

Milos V. Novotny

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Biographical Sketch
Robert T. Kennedy

Robert T. Kennedy is the Willard Professor of Chemistry, Professor of Pharmacology and Distinguished University Professor at the University of Michigan. Professor Kennedy earned a B.S. in Chemistry at the University of Florida (1984) and a Ph.D. from the University of North Carolina (1988). He was a post-doctoral fellow at North Carolina from 1989-2001. He became professor of chemistry at the University of Florida in 2001 and served there for 11 years before moving to Michigan. Prof. Kennedy's research interests are analytical chemistry, especially separations, and its application to neuroscience, endocrinology, and biotechnology. A theme of his group has been development of high-speed, high-sensitivity separations for sensing, detection of non-covalent complexes, and screening. His group has developed instrumentation that couples sampling probes to capillary electrophoresis, capillary chromatography, LC-MS, mass spectrometry, and microfluidic assays for monitoring neurotransmitters *in vivo*. These methods have been used for studying changes in neurotransmitter concentrations associated with behavior and diseases. His group has also developed sensors and microfluidic electrophoresis devices for monitoring insulin secretion from pancreatic β-cells. These methods are coupled with LC-MS metabolomics to understand the biochemical mechanism of insulin secretion and perturbations associated with diabetes. His group is also researching use of rapid electrophoretic and mass spectrometric assays as novel approaches to high-throughput screening. He has published over 200 peer-reviewed papers on these topics. His h-index is 66 with 13,000 of citations (Google Scholar October 2015). His work has been recognized by several awards including two MERIT awards from the NIH, a Presidential Faculty Fellowship, a Sloan Foundation Fellowship, Beckman Young Investigator Award, ACS Findeis Award, McKnight Award for Technical Innovations in Neuroscience, EAS Separation Science Award, Golay Award for Achievements in Chromatography, and several teaching awards. He has graduated 50 PhD students and trained over 20 post-docs. He has been involved in helping to innovate novel training at the graduate level including co-founding and directing the Microfluidics in Biomedical Sciences Training Program (NIH-funded) and Chemistry Aligned with Life and Career at the University of Michigan (Calcium), which is a professional development program. He has held several service posts and is presently Associate Editor of *Analytical Chemistry*, Analytical Director of NIH supported Michigan Regional Comprehensive Metabolomics Research Core (MRC^2), chair of HPLC 2016, and Chair of the Chemistry Department at University of Michigan.

First use of microfluidic chip to monitor living cells. This chip integrated cell culture and electrophoresis:

1) Roper MG, Shackman JG, Dahlgren GM, & Kennedy RT **(2003)** "Microfluidic chip for continuous monitoring of hormone secretion from live cells using an electrophoresis-based immunoassay." *Analytical Chemistry* 75(18):4711-4717.

Example of enhancement to the chips, generates >5000 electrophoresis assays per hour with living cells on board:

2) Dishinger JF, Reid KR, & Kennedy RT **(2009)** "Quantitative monitoring of insulin secretion from single islets of langerhans in parallel on a microfluidic chip." Analytical Chemistry 81(8):3119-3127.

Discoveries using chip:

3) Ueki K, Okada T, Hu J, Liew CW, Assmann A, Dahlgren GM, Peters JL, Shackman JG, Zhang M, Artner I, Satin LS, Stein R, Holzenberger M, Kennedy RT, Kahn CR, & Kulkarni RN **(2006)** "Total insulin andIGF-I resistance in pancreatic beta cells causes overt diabetes." *Nature Genetics* 38(5):583-588.
4) Gerin I, Dolinsky VW, Shackman JG, Kennedy RT, Chiang SH, Burant CF, Steffensen KR, Gustafsson JA, & MacDougald OA (2005) "LXR beta is required for adipocyte growth, glucose homeostasis, and beta cell function." *Journal of Biological Chemistry* 280(24):23024-23031.

Novel technique for cell preparation for HPLC-MS for metabolomics:

5) Lorenz MA, Burant CF, & Kennedy RT **(2011)** "Reducing time and increasing sensitivity in sample preparation for adherent mammalian cell metabolomics." *Analytical Chemistry* 83(9):3406-3414.

Discovery using metabolomic technique:

6) Lorenz MA, El Azzouny MA, Kennedy RT, Burant CF. (**2013)** "Metabolome Response to Glucose in the β-Cell Line INS-1 832/13." *Journal of Biological Chemistry,* 288(15):10923-35.

Three of several papers describing "separations based sensor", i.e. coupling sampling probes to fast, high effeciency separations for chemical monitoring:

7) Lada MW, Vickroy TW, & Kennedy RT **(1997)** "High temporal resolution monitoring of glutamate and aspartate in vivo using microdialysis on-line with capillary electrophoresis with laser-induced fluorescence detection." *Analytical Chemistry* 69(22):4560-4565.
8) Bowser MT & Kennedy RT **(2001)** "In vivo monitoring of amine neurotransmitters using microdialysis with on-line capillary electrophoresis." *Electrophoresis* 22(17):3668-3676.
9) Sandlin ZD, Shou MS, Shackman JG, & Kennedy RT **(2005)** "Microfluidic electrophoresis chip coupled to microdialysis for in vivo monitoring of amino acid neurotransmitters." *Analytical Chemistry* 77(23):7702-7708.

Simple, and increasingly popular, technique that allows many polar neurochemicals to be detected by HPLC-MS with high sensitivity:

10) Song P, Mabrouk OS, Hershey ND, & Kennedy RT. (**2012**) "In vivo neurochemical monitoring using benzoyl chloride derivatization and liquid chromatography mass spectrometry" *Analytical Chemistry*, 84:412-419.

Discovery using this technique:

11) Duan L, Mabrouk OS, Liu T, Tian F, Xu G, Mathur A, Crooks CP, Kennedy RT, Wang MM, Ghanbari H, Borjigin J. **(2015)** “Surge of corticocortical and corticocardiac neurotransmissionsin dying animals” *Proceedings of the National Academy of Sciences USA*, 112: E2073-82.

One of several papers that describes how to achieve very high sensitivity LC-MS detection of peptides from low volume, complex samples:

12) Haskins, WE; Wang, ZQ; Watson, CJ; Kennedy RT (2001) “Capillary LC-MS^2 at the attomole level for monitoring and discovering endogenous peptides in microdialysis samples collected in vivo” *Analytical Chemistry* 73:5005-5014.

First detection of a peptide in vivo during behavior:

13) DiFeliceantonio AG, Mabrouk OS, Kennedy RT, & Berridge KC (**2012**) “Enkephalin surges in dorsal striatum as a signal to eat”, *Current Biology*, 22:1918-24.

Seminal papers on couple affinity to capillary or chip separations:

14) Schultz, NM, & Kennedy RT, **(1993)** “Rapid Immunoassays using Capillary Electrophoresis with Fluorescence Detection.” *Analytical Chemistry*, 65:3161-3165.
15) German I, Buchanan DD, & Kennedy RT **(1998)** "Aptamers as ligands in affinity probe capillary electrophoresis." *Analytical Chemistry* 70(21):4540-4545.
16) Deng Q, German I, Buchanan D, & Kennedy RT **(2001)** "Retention and separation of adenosine and analogues by affinity chromatography with an aptamer stationary phase." Analytical Chemistry 73(22):5415-5421.
17) Jin S, Anderson GJ, Kennedy RT. **(2013)** “Western blotting using microchip electrophoresis interfaced to a protein capture membrane” *Analytical Chemistry*, 85(12):6073-9.

First high sensitivity method for analyzing droplets by electrophoresis:

18) Roman GT, Wang M, Shultz KN, Jennings C, & Kennedy RT **(2008)** "Sampling and electrophoretic analysis of segmented flow streams using virtual walls in a microfluidic device." *Analytical Chemistry* 80(21):8231-8238.

First applications of droplet MS or electrophoresis to screening:

19) Guetschow ED, Steyer DJ, Kennedy RT. **(2014) “**Subsecond electrophoretic separations from droplet samples for screening of enzyme modulators”. *Analytical Chemistry* 86:10373-9.

Novel method to analyze high throughput separations data:

20) Shackman JG, Watson CJ, & Kennedy RT (2004) "High-throughput automated post-processing of separation data." *Journal of Chromatography A* 1040(2):273-282.

University of Illinois
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600 S. Mathews Ave. 63-5
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Jonathan V. Sweedler
October 28, 2015

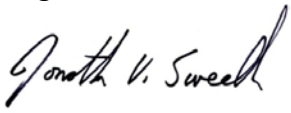
Dear Selection Committee:

I am excited to have the opportunity to second the nomination of Prof. Robert Kennedy for the ACS Award in Chromatography. Describing Bob's research accomplishments takes many superlatives as he has an extremely impressive track record in terms of research and innovation in separation sciences, electrochemistry, mass spectrometry and bioanalytical chemistry, and is one of the select few individuals who is shaping the entire field of analytical chemistry. His contributions do not stop there as these new tools are used to increase our understanding of cell-cell communication in the brain.

What has Bob Kennedy done? He has made substantial contributions to chromatography including new methods to quantitatively measure the microenvironments inside and around single cells using new sampling and capillary scale separations, ultrafast separations, and more recently, in metabolomics and peptidomics using chromatography coupled to mass spectrometry. As someone who has made a career of characterizing neuropeptides, my one word summary of his neuropeptide measurements is "fantastic!" He has developed several innovative Lab on a Chip devices for efficiently collecting cellular releasates and separating and assaying them. Recent efforts involve the development of separation and sampling systems to perform these analyses at high-throughput based on plug-based sampling approaches hyphenated to liquid chromatography and capillary electrophoresis; they allow the analysis of samples at very high throughputs. Many of these achievements have been copied by other groups (the highest form of flattery), including our group. His work is consistently among the most innovative and exciting presented at any conference he attends. His ten thousand plus citations to his work attest to its high impact.

The University of Illinois' Chemistry Department has tried to hire him twice – as an assistant professor, and as a tenured associate professor. Our loss has been the University of Michigan's gain. I can say with confidence that our entire department is extremely impressed with Kennedy and consider him one of the few individuals in the nation who are shaping the field of chemistry. In summary, Bob is certainly deserving of the ACS Award in Chromatography for his exceptional accomplishments in all aspects of separation science.

Regards,



Jonathan V. Sweedler, Ph.D.
James R Eiszner Family Chair in Chemistry; Director, School of Chemical Sciences
Editor-in-Chief, Analytical Chemistry

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October 26, 2015

Dear Awards Committee:

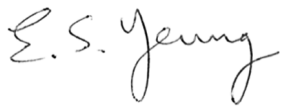
It is a pleasure for me to support the nomination of Professor Robert Kennedy for the ACS Award in Chromatography. I have known Kennedy since he was a graduate student at North Carolina, and am well familiar with his professional contributions.

There is no need to restate in detail his many scientific contributions to the field of chromatography. These are well documented in his CV and in the nomination letter, and have been recognized by many national and international awards. I would like to add a few personal observations. Kennedy's influence on science went well beyond his immediate circle of analytical chemistry. What distinguishes Kennedy's achievements from others is that he has developed new chromatographic methods specifically for biological research, such as for studying diabetes and neuronal events. The key is the selective detection of chemical signaling agents in small samples, at low concentrations, and with rapid time response. Examples of novel miniaturized methodologies demonstrated by Kennedy include capillary electrophoresis, capillary chromatography, microfluidics, and LC-MS. One major advance along these lines involved a microfluidic device to sample hormone secretion from live cells using an electrophoresis-based immunoassay. Another creative approach was the use of aptamers to modify migration in electrophoresis and to tune retention in liquid chromatography. His interdisciplinary contributions ultimately led to his appointment as Professor of Pharmacology in addition to his appointment in the chemistry department.

Kennedy also made significant impact to the field of chromatography through his service in key roles in the community. He is the current Associate Editor of Analytical Chemistry primarily responsible for the area of separation science. He has been elected as a member of the Permanent Scientific Committee of the premier annual meeting in the field – HPLC, and will also serve as the chair of the symposium in San Francisco in 2016. In these activities, Kennedy is helping to define chromatogrpahy within the context of today's scientific advances. In addition, Kennedy's mentoring of numerous students and postdoctorals in chromatographic research will further guarantee vitality of the field for years to come.

Professor Robert Kennedy is most worthy of the ACS Award in Chromatography. I support his nomination enthusiastically.

Sincerely,



Edward S. Yeung
Distinguished Professor Emeritus in
Liberal Arts and Sciences