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BORON IN NUCLEAR MEDICINE: NEW SYNTHETIC APPROACHES TO PET AND SPECT

Final Report

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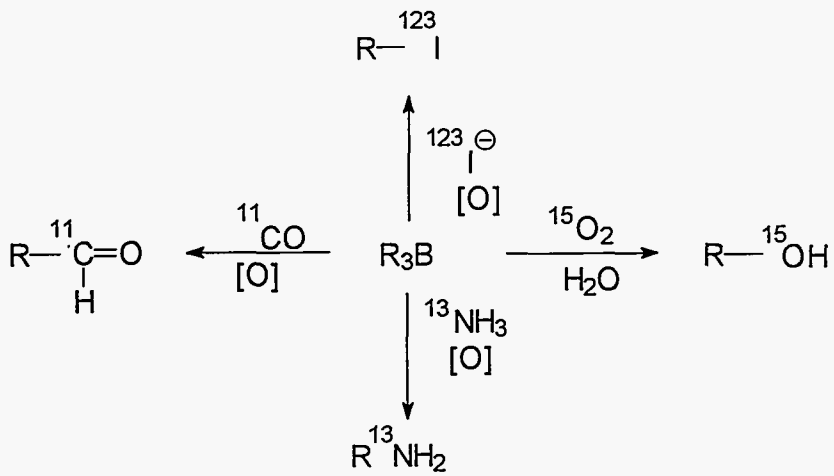
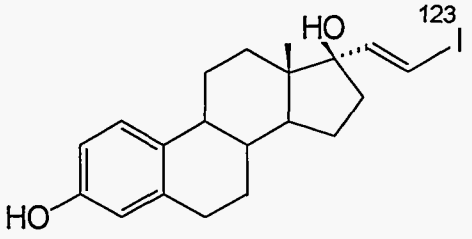
1. New Isotope Incorporation Reactions

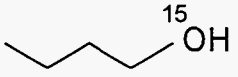
The major thrust of the D.O.E. program at The University of Tennessee is the development of new synthetic methodology for use in the rapid incorporation of short-lived isotopes. The program has been a productive one; one hundred and thirty five journal articles were published and one hundred and ninety one refereed abstracts appeared in print. In the initial stages of the program, efforts were directed at the use of functionalized organometallic reagents which would rapidly react with radiolabeled agents generated directly in the cyclotron or reactor targets. These included $^{18}F^-$, $^{15}O_2$, $^{13}NH_3$ and ^{11}CO for positron tomography, and $^{123}I^-$ for single photon tomography. The initial studies involved the use of simple organoborane precursors which led to the successful development of extensive, new isotope incorporation chemistry.[1,2] The early studies validated the



feasibility of using reactive intermediates, such as the organoboranes, and led others to investigate organometallic agents based on mercury, tin, and silicon.[3] In addition, the early boron studies led to the first syntheses of new agents which have since proven to be clinically important; these include (E)-17α-[^{123}I] iodovinylestradiol, **I**,[4,5] and [^{15}O]-butanol, **II**.[3]

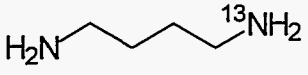


I

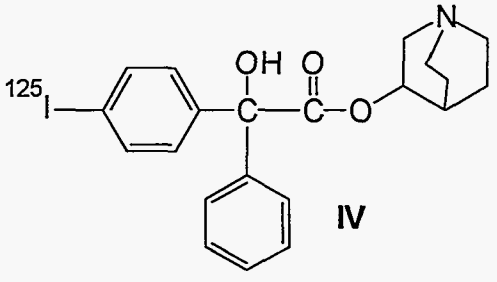


II

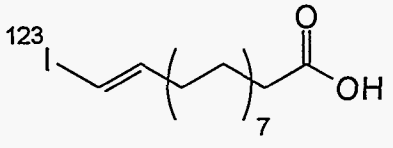
Other agents prepared via organoborane chemistry included [^{13}N]-putrescine, **III**,[3] [^{125}I]-QNB, **IV**,[6] and a wide variety of fatty acids such as **V**.[7]



III



IV



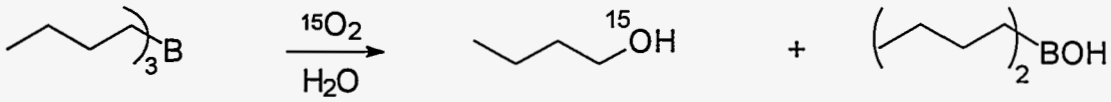
V

During the course of this research, it became apparent that the organometallic chemistry we, and others, had been developing would be even more useful in the clinical environment if the radiolabeled products could be readily separated from the undesired byproducts. We began to develop reactive organometallic reagents in which the metal

(often boron) was attached to a nonreactive organic or inorganic matrix such as polystyrene, silica or alumina.

(a) Oxygen-15

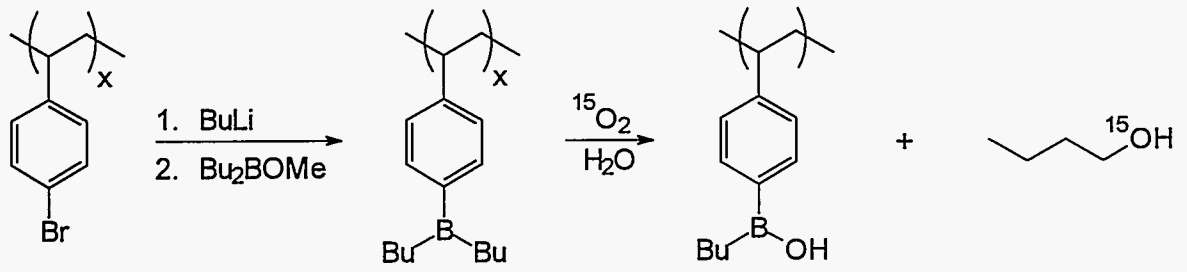
We developed the synthesis of oxygen-15 labeled butanol, **II**, early in this D.O.E. research effort.[8] [^{15}O]-Butanol has since been found to be a valuable blood flow agent



VI **II** **VII**

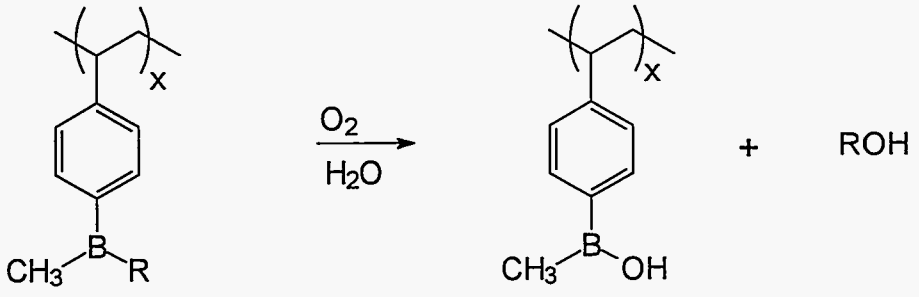
in humans.[9] The synthesis of **II** in the clinic is hampered by the concurrent formation of the borinic acid byproduct **VII** which arises because only one of the three butyl groups in the original tributylborane is generally utilized. To obviate this problem, we and others have used silica gel,[10] alumina,[11] and other solid surfaces[12] to trap the reaction byproducts.

We also developed a series of boronated organic and inorganic matrices in an effort to enhance the clinical utility of the oxygen-15 incorporation reaction. In the first approach, a dibutylboronated polystyrene, **IX**, was prepared as shown on the next page and its reactions with oxygen-15 gas were evaluated.[13]



VIII **IX** **X** **II**

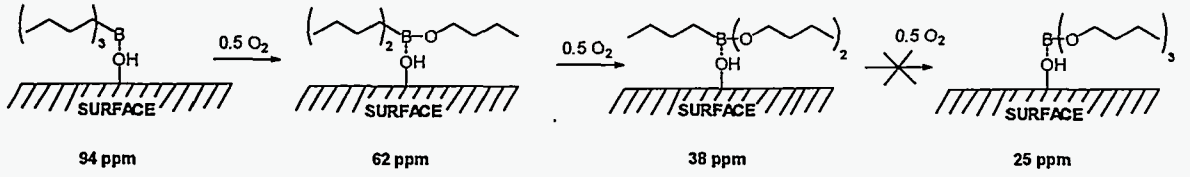
The yields of [^{15}O]-butanol using **IX** consistently exceeded 50% when corrected for decay, and the synthesis was complete in less than two minutes. We also prepared the methylboronated polystyrene derivative **XI** to take advantage of the fact that methyl groups have been shown to be less reactive than larger alkyl moieties.[14] The yields of alcohol **XIII** approached 80%![15] The application of this chemistry to the synthesis of oxygen-15 labeled butanol is currently being evaluated.



XI **XII** **XIII**

As noted, a variety of inorganic matrices can also be utilized to adsorb the byproducts of the borane oxidation reaction. We have examined the ability of a series of hydroxylated surfaces including alumina, silica gel, cotton, cellulose acetate, celite, and polyvinyl alcohol to adsorb tributylborane and retain the byproducts of the oxidation

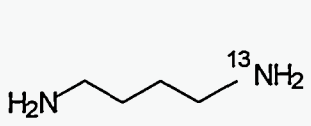
reaction. Alumina, silica gel, cotton, and celite all exhibited satisfactory behavior in that isolated yields of pure [^{15}O]-butanol routinely exceed 40% (corrected for decay). Through the use of boron-11 solid state NMR (SSNMR), we were able to verify that oxidation of tributylborane adsorbed to surfaces is incomplete even in the presence of excess oxygen.



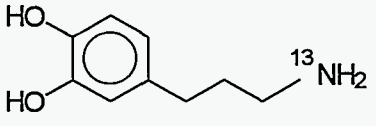
These results contrast those obtained in solution where it has been found that the tributylborane is completely oxidized.[16]

(b) Nitrogen-13

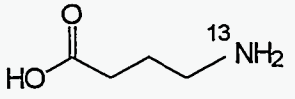
We also developed a series of polymeric borane derivatives which were used to prepare nitrogen-13 labeled amines of potential value in diagnostic Nuclear Medicine. Nitrogen-13 labeled putrescine, **III**, dopamine, **XIV**, and γ-aminobutyric acid, **XV**, were each prepared using modified borane polymers.



III

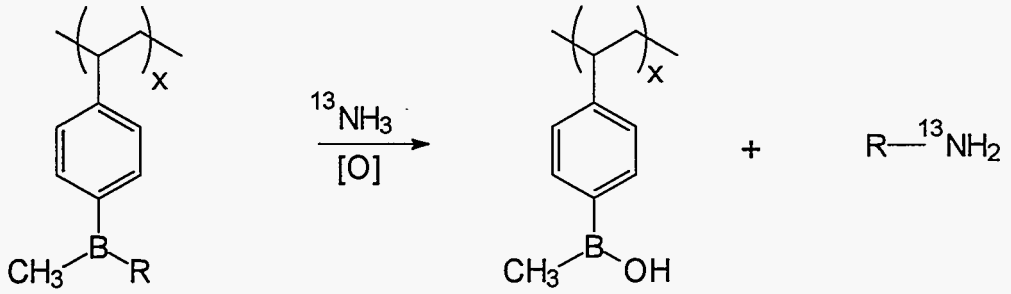


XIV



XV

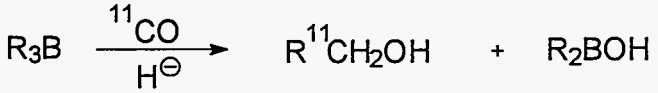
The polymers consisted of methylboronated polystyrene derivatives which were synthesized using chemistry which we developed in an effort to maximize reaction of the desired alkyl group.[2] The isolated yields of the nitrogen-13 labeled reagents, corrected



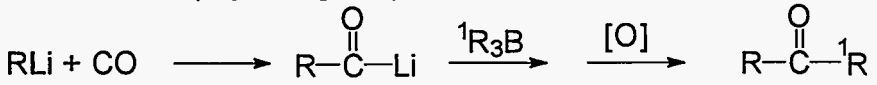
To EOB, ranged from 60 - 80%[17,18] which surpassed the yields obtained in our initial solution studies.[19]

(c) Carbon-11

In the initial stages of this study, we demonstrated that organoboranes could be utilized to incorporate carbon-11 via reaction of trialkylboranes with carbon monoxide.[20]

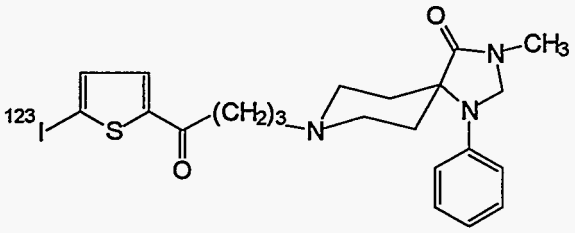


We used the reaction to prepare ketones and secondary alcohols but found it to be somewhat limited by the difficulty inherent in preparing unsymmetrical trialkylboranes.[21] We are in the process of evaluating a new carbonylation reaction as a route to carbon-11 labeled ketones which are physiologically active.[22]

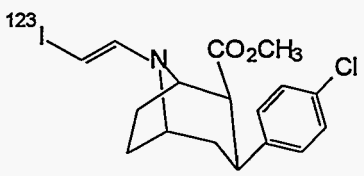


(d) Radiohalogenation

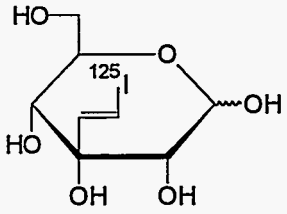
Our early studies on the incorporation of radiohalogens via borane chemistry[23,24,25,26,27,28] provided a means for regiospecifically incorporating radiohalogens and sparked an interest in the use of organometallic reagents in nuclear medicine. This was especially true for our development of the vinyl iodide moiety as a means of stabilizing radioiodine *in vivo*.[29] During the current phase of our research, we prepared a number of radioiodinated reagents via organoborane and organotin reactions. The agents include iodine-123 labeled 3-*N*-methyl-5-iodo-2-thienyl-butyrophenone, **XVI**,[30] *N*-(3-iodopropen-2-yl)-2β-carbomethoxy-3β-(4-chlorophenyl)tropane, **XVII**, and 4-O-(E)-3-iodopropen-2-ylallose, **XVIII**.[31]



XVI



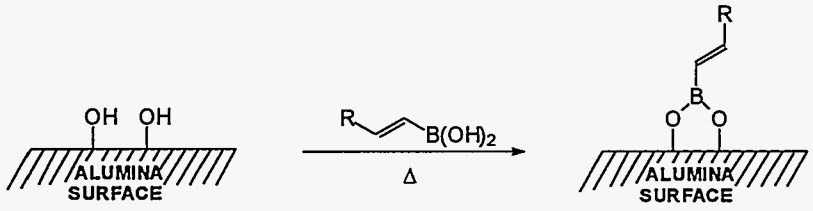
XVII



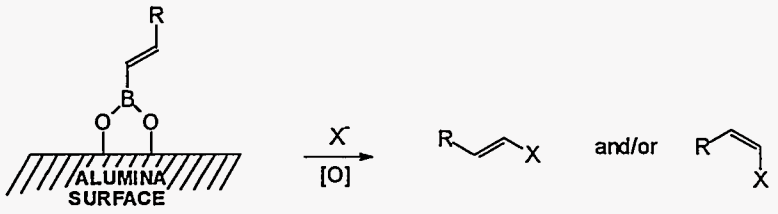
XVIII

Two of these agents have proven to be physiologically active and are currently undergoing evaluation in animal models by our colleagues at Emory University (**XVII**) and the Australian National Science and Technology Organization (**XVI**). We are now focusing our attention on enhancing the utility of the isotope incorporation reactions through the use of reactive solid state matrices.

We are, for example, investigating the preparation of boronic ester derivatives of alumina which are prepared by dehydrating mixtures of boronic acids and aluminas. The studies are based on our earlier observations involving silica gel as the solid support.[32]

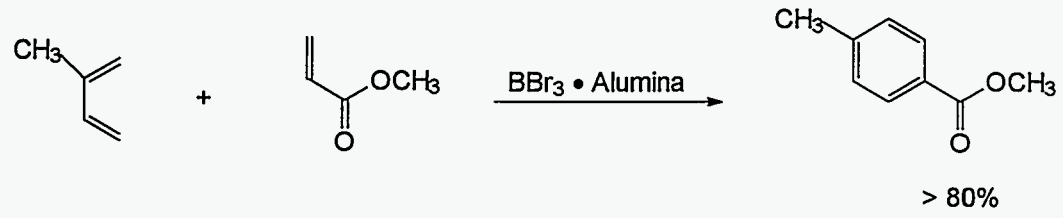


Some of the new materials have been halogenated to produce vinyl halogen derivatives.[33,34,35,36] Interestingly, we have found that the regiochemistry of the vinyl halides appears to be dependent on the surface. A fact that could be significant in



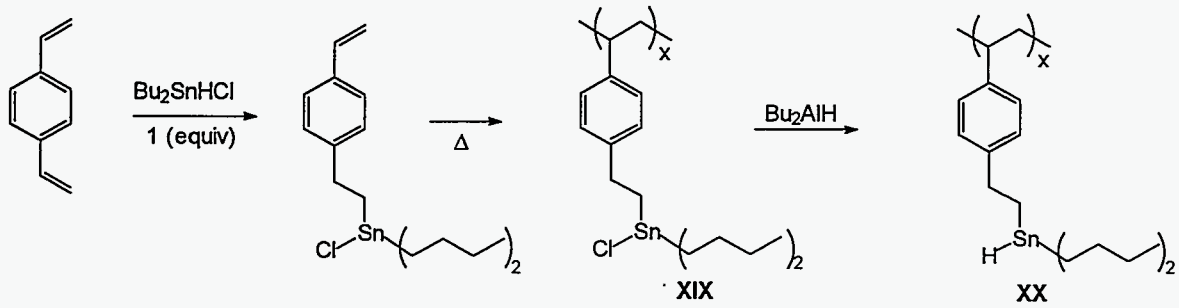
light of recent studies which indicate that the (Z)-vinyliodides often demonstrate enhanced physiological activity.[37,38] As anticipated, the boronic acid byproduct is retained on the alumina which simplifies isolation and purification of the desired products.

The coating of alumina with boron derivatives has led to some exciting discoveries. In addition to the change in regiochemistry of the vinyl iodide noted earlier, we have found that a number of the boronated aluminas have significant regiochemical effects on reactions such as the Diels-Alder reaction.[39] These results, shown on the next page, could prove valuable in our syntheses of radiopharmaceutical precursors.



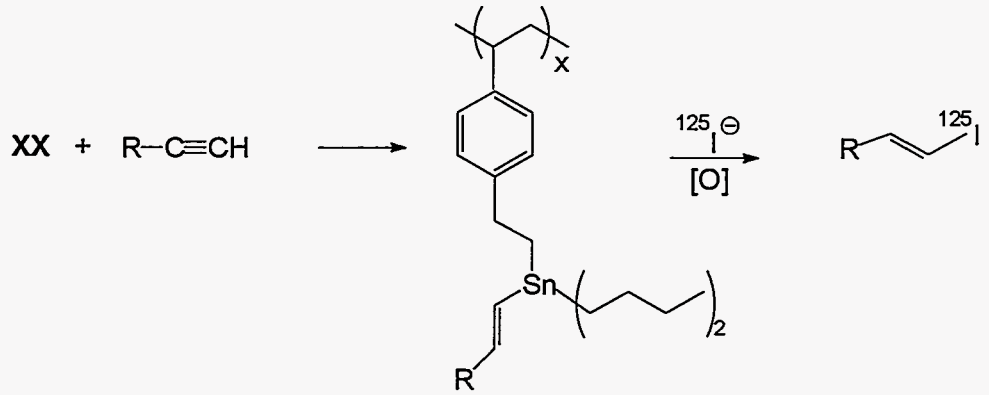
> 80%

Our investigation of new iodination reactions also includes the preparation of polystyrene derivatives of tin,[40] **XX**. This chemistry often compliments that of boron.

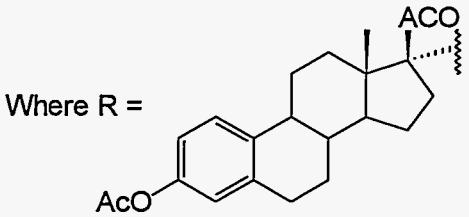


XIX XX

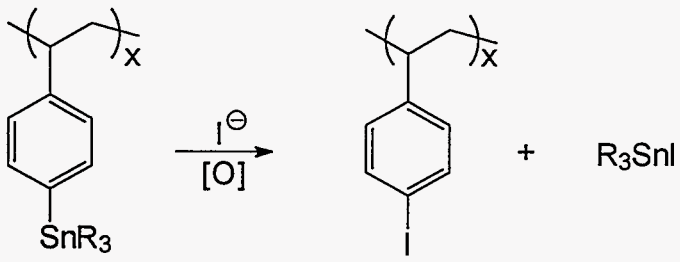
Polymer **XXI** (next page) was used to prepare a radioiodinated estradiol in excellent (47%) radiochemical yield[41] via a stannylation-iodination sequence.



XXI

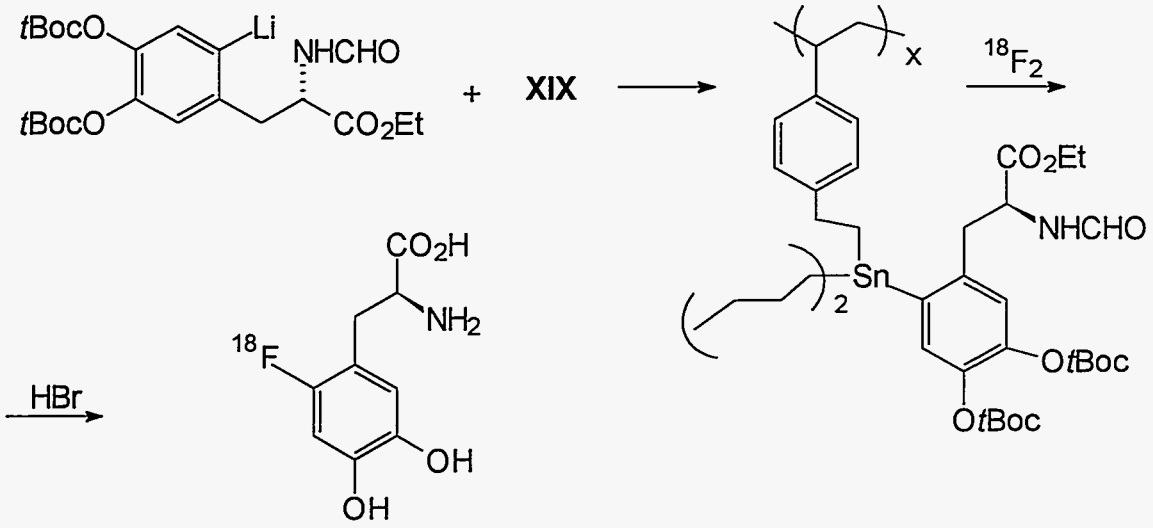


In earlier studies, Culbert and Hunter[42] used simple stannylated polystyrenes to prepare aryl iodides but they discovered that destannylation of the polystyrene backbone occurs when the tin is directly attached to the polymer, as it is in **XXII**.



XXII

Our new polymers, prepared from **XIX,** obviate the problem. We believe that the new technology could be applied to an in-line automated synthesis of fluorine-18 labeled DOPA, **XXIII,** for use in our automated synthesis unit.[43]



XXIII

In summary, many of the goals outlined in the original proposal have been accomplished. New isotope incorporation routes for nitrogen-13, carbon-11, and oxygen-15 have been developed and are being used to prepare clinically useful radiopharmaceutricals. An investigation into new radiohalogen incorporation routes has been initiated but further studies are required before they are applicable to the clinical environment. These studies form the basis for our Renewal Proposal, **Section D**.

2. Students Trained

An important goal of the D.O.E. Nuclear Medicine Program at The University of Tennessee is to provide training for students (predoctoral and postdoctoral) in the scientific aspects of Nuclear Medicine. The academic nature of the program helps to insure the continued availability of scientists dedicated to the advancement of nuclear

medicine. Since 1993, ten postdoctoral, twenty graduate and ten undergraduate students have received support and training under the auspices of the D.O.E. program at The University of Tennessee:

(a) Postdoctoral

POSTDOC	AREA OF RESEARCH	TENURE
Murthy, Akula	Alzheimer Pharmaceuticals	6/94 - 12/96
Narayana, Chatla	Organic Reactions	6/1/89 - 5/31/96
Zhang, Zheng-Yu	Carbon-11 Synthesis	1/1/94 - 12/1/95
Collier, T. Lee	Automation of Radiopharmaceutical Synthesis	8/29/91 - 5/3/93
Shoup, Timothy	Oxidations Using Sodium Perborate	1991
Guindi, Laila H.	Boron Chemistry	1987 - 1990
Meng, Xian-Jun	Radiohalogenated Imaging Agents	1989 - 1990
Matur, Shyam	Radiolabeling	1985 - 1988
Varma, Rajender S.	Construction of Pharmaceutical Precursors	1986 - 1987
Goudgaon, Naganna	Boron-Prepharmaceuticals	1987

(b) Graduate Students

GRADUATE STUDENT	DEGREE/YEAR	TITLE OF THESIS
Moss, Thomas H.	M.S. -- 1986	Preparation of a Modified Gd-DTPA Complex: A Potential Contrast Agent for Magnetic Resonance Imaging
McCollum, Gary W.	Ph.D. -- 1986	The Synthesis of Alkylamines and Dialkylamines Via Organoboranes
Edwards, Robbie M.	M.S. -- 1986	Monophenylborane: Synthesis and Use in Hydroborations
Fabrikiewicz, Ann S.	Ph.D. -- 1987	"Reactions of Boranes With Carbonyl Compounds: An Investigation

GRADUATE STUDENT	DEGREE/YEAR	TITLE OF THESIS
Steward, Jay	M.S. -- 1987	The Addition of HI to UnSaturated Hydrocarbons Using I_2 and Al_2O_3
Bierer, Donald E.	Ph.D. -- 1988	Synthetic Approaches to Iodovinyl Amino Acids
Wang, Zhe	Ph.D. -- 1990	Synthesisof Amines Via Organoboranes
Davis, Mark A.	M.S. -- 1990	Magnetic Resonance In Aging: The Development and Evaluation of Several Gd-DTPA Derivatives for Use as MRI Contrast Enhancements Agents and the Application of Boron-11 Spectroscopy and Imaging For the Detection and Localization of a BNCT Agent *In-Vivo*
Sponholtz, William	M.S. -- 1991	The Addition of Iodine to Vinyl Boronic Acid Intermediates in the Presence of Alumina
Zippi, Elizabeth	Ph.D. -- 1991	Polymer Based Substrate for Potential Generation of Nitrogen-13 for Positron Emission Tomography
Lee, Lay C.	Ph.D. -- 1992	Studies of Organic Reactions
Waterhouse, Rikki	Ph.D. -- 1993	"Radioiodiodination Via Organometallics"
Bowers, Karla	M.S. -- 1993	"Polymer-Based Organoboranes"
Lambert, Steve	Ph.D. -- 1994	"Iodination Via Iodine Monochloride"
Green, James F.	Ph.D. -- 1994	"Polymer-Based Systems for Incorporating Short-Lived Isotopes"
Pace, R. David	Ph.D. -- 1994	"Crotylboration Reactions"
Vagle, Kurt	M.S. -- 1995	"Surface Reactions"
Maddox, John	Ph.D. -- 1995	"New Carbon-Carbon Bond Forming Reactions Via Organoboranes"
Marks, Ronald C.	Ph.D. -- 1995	"Thiophene-based Polymers"
Gotsick, Timothy	Ph.D. -- 1996	"Radiolabeled Opiate-Receptor Agents"

3. Bibliography of Publications Resulting from Research Sponsored by DOE: 1993-1995

(a) Journal Articles

1. Varma, R. S.; Kadkodayan, M.; Kabalka, G. W. "The Synthesis of 2-Phenyl-3-nitro-3,4-dihydro-2H-1-benzopyrans," *Heterocycles* **1986**, *24*, 1647.

2. Varma, M.; Varma, R. S.; Kabalka, G. W.; Srivastava, P. C.; Knapp, F. F. "The Tosylation of Alcohols," *J. Org. Chem.* **1986**, *51*, 2386.

3. Boothe, R.; Dial, C.; Conaway, R.; Pagni, R. M.; Kabalka, G. W."The Iodination of Aromatic Substrates on Alumina," *Tetrahedron Lett.* **1986**, *27*, 2207.

4. Kabalka, G. W. "The Synthesis of Labeled Compounds via Organoboranes," *Aldrichimica Acta*, **1986**, *19*, 11.

5. Kabalka, G. W.; Varma, R. S.; Gai, Y.-Z.; Baldwin, R. M. "A New Route to Iodine-Labeled N-Isopropyl Iodoamphetamine Via Organoboranes," *Tetrahedron Lett.* **1986**, *27*, 3843.

6. Varma, R. S.; Gai, Y.-Z.; Kabalka, G. W. "The Synthesis of 2-Naphthyl-3-nitro-3,4-dihydro-2H-1-benzopyrans," *Synthesis* **1986**, 486.

7. Kothari, P. J.; Finn, R. D.; Kabalka, G. W.; Boothe, T. E.; Vora, M. M.; and Emran A. "Synthesis of Nitrogen-13 Labeled Alkylamines Via Amination of Organoboranes," *Int. J. Rad. App. Instrum.* [A], **1986**, *37*, 471.

8. Kothari, P. J.; Finn, R. D.; Kabalka, G. W.; Boothe, T. E.; Vora, M. M.; Emran, A. "Carbon-11 Labeled Dialkylketones: Synthesis of 9-[^{11}C]-Heptadecan-9-one," *Int. J. Rad. Appl. Instrum. [A]* **1986**, *37*, 469.

9. Kabalka G. W.; Varma, R. S. "Nitroalkenes in the Synthesis of Heterocyclic Compounds," *Heterocycles*, **1986**, *24*, 2645-2677.

10. Varma, R. S.; Varma, M.; Gai, Y.-Z.; Kabalka, G. W. "Stannous Chloride Reduction of α,β-Unsaturated Nitroalkenes: "A Direct Synthesis of 2-Aryl-2H-1-benzopyran-3(4H)-one Oximes," *Heterocycles* **1986**, *24*, 2581.

11. Brown, H. C.; Midland, M. M.; Kabalka, G. W. "Organoboranes for Synthesis. 5. Stoichiometrically Controlled Reaction of Organoboranes with Oxygen Under Mild Conditions to Achieve Quantitative Conversion to Alcohols," *Tetrahedron* **1986**, *42*, 5523.

12. Mohammadi, M.; Kabalka, G. W.; Finn, R. D. "A Convenient Synthesis of Carbon-13 Labeled 1-Keto-7-Methoxyoctahydrophenanthrene," *J. Labelled Compd. Radiopharm.* **1987**, *24*, 317.

13. Varma, R. S.; Gai, Y.-Z.; Kabalka, G. W. "Reduction of α,β-Unsaturated Notroalkenes with Borane and Borohydrides. A Convenient Route to 3-Nitro-, 3-Hydroxylamino-, and 3-Amino-2H-1-benzopyran Derivatives," *J. Hetero. Chem.* **1987**, *24*, 767.

14. Kabalka, G. W.; Henderson, D. A.; Varma, R. S. "The Reaction of Organoboranes with Hydrazoic Acid," *Organometallics* **1987**, *6*, 1369.

15. Buonocore, E.; Hubner, K.; Kabalka, G. W. "Packaging PET Imaging for Community Medicine," *Diagnostic Rad.* **1987**, 110.

16. Varma R. S.; Kabalka, G. W. "Synthesis and Selected Reactions of Conjugated Nitroalkenes," Org. Prep. Proc. Int. **1987**, *19*, 283.

17. Stewart, L. T.; Gray, D.; Pagni, R. M.; Kabalka, G. W. "A Convenient Method for the Addition of HI to Unsaturated Hydrocarbons Using I_2 on Al_2O_3," *Tetrahedron Lett.* **1987**, *28*, 4497.

18. Kabalka, G. W. "Boranes in Organic Synthesis," *J. Organomet. Chem.* **1987**, *337*, l69.

19. Mitchell, D.; Bowen, R. D.; Jennings, K. R.; Varma, R. S.; Kabalka, G. W. "Mass Spectra of 3-Nitro-2H-Chromenes and 3-Nitrochromans," *J. Chem. Soc. Perkin Trans., II* **1987**. 1495.

20. Kabalka, G. W.; Gai, Y.-Z.; Goudgaon, N. M.; Varma, R. S.; Gooch, E. G. "Reaction of Organoboranes with Olefinic α,β-Unsaturated Nitro Compounds," *Organometallics* **1988**, *7*, 493.

21. Larson, S.; Luidhart, T.; Kabalka, G. W.; Pagni, R. M. "The Facile Synthesis of Diiodoalkenes by the Addition of I_2 to Alkynes on Alumina," *Tetrahedron Lett.* **1988**, *29*, 35.

22. Bierer, D. E.; Kabalka, G. W."Syntheses of 1-Alkynyl Ketones and Aldehydes via Oxidation of 1-Alkynyl Alcohols with Pyridinium Dichromate," *Org. Prep. Proc. Int.* **1988**, *20*, 63.

23. Kabalka; Goudgaon, N. M. "A Facile Aldoxime Preparation Via the Reduction of α,β-Unsaturated Nitroalkenes Using Tin(II) Chloride," *Synth. Commun.* **1988**, *18*, 693.

24. Kabalka, G. W. "Isotope Incorporation Via Organoboranes," *Int. J. Appl. Rad. Instrum.* [A], **1988**, *39*, 537.

25. Kabalka, G. W. "Synthetic Approaches to the Preparation of Oxygen-15 Labeled Compounds,"*Int. J. Rad. Appl. Instrum.* [A] **1988**, *39*, 557.

26. Kabalka, G. W.; Goudgaon, N. M.; Liang, Y. "The Reaction of Organoboranes with Trimethylsilylazide in a Neutral Medium,"*Syn. Commun.* **1988**, *18*, 1363.

27. Srivastava, P. C.; Knapp F. F.; Kabalka, G. W. "New Radiohalogenated Alkenyl Tellurium Fatty Acids," *Phosphorus and Sulfur* **1988**, *38*, 49.

28. Kabalka, G. W.; Lambert S. J.; Jinaraj, V. K. "Synthesis of Iodine-125 Labeled 11-Iodoundecenyl Cholesteryl Ether," *Int. J. Rad. Appl. Instrum.* [A], **1988**, *39*, 1113.

29. Pagni, R. M.; Kabalka, G. W.; Boothe, R.; Gaetano. K.; Stewart, L. J.; Conaway, R.; Dial, C.; Gray, D.; Larson, S.; Luidhardt, T "Reactions of Unsaturated Compounds with Iodine and Bromine on Gamma Alumina," *J. Org. Chem.* **1988**, *53*, 4477.

30. Kabalka, G. W.; Bierer, D. E. "Trimethylsilyl Esters: Protection of Carboxylic Acids During Hydroboration Reactions," *Organometallics* **1989**, *8*, 655.

31. Kabalka, G. W.; Wang, Z. "The Reaction of Trialkylboranes with Alkylamines: Synthesis of Dialkylamines," *Organometallics* **1989**, *8*, 1093.

32. Kabalka, G. W.; Shoup, T. M.; Goudgaon, N. M. "Sodium Perborate: A Mild and Convenient Reagent for Efficiently Oxidizing Trialkylboranes," *Tetrahedron Lett.* **1989**, *30*, 1483.

33. Hondrogiannis, G.; Lee, L. C.; Kabalka, G. W.; Pagni, R. M. "The Reaction of Alkynes with I_2 on Unactivated Alumina," *Tetrahedron Lett.* **1989**, *30*, 2069.

34. Kabalka, G. W.; Gai, Y.-Z.; Mathur, S. B. "Synthesis of Iodine-125 Labeled 3-Quinuclidinyl-4'-iodobenzilate," *Nuc. Med. Biol.* **1989**, *16*, 359.

35. Goudgaon, N. M.; Wadgaonkar P. P.; Kabalka, G. W. "The Reduction of α,β-Unsaturated Nitroalkenes to Nitroalkanes with Borohydride Supported on an Anion Exchange Resin," *Synth. Commun.* **1989**, *19*, 805.

36. Kabalka, G. W.; Kennedy, T. P.; Goudgaon, N.; Varma, R. S. "Synthesis of (2-Butyl-3-Benzofuranyl){4-[2-Diethylamino)ethoxy]-3,5-Diodophenyl}methane Derivatives," *Org. Prep. Proced. Int.* **1989**, *21*, 348.

37. Kabalka, G. W.; Bierer, D. E. "Trimethylsilyl Esters: Temporary Protection of Carboxylic Acids During Hydroboration Reactions," *Synth. Commun.* **1989**, *19*, 2783.

38. Kabalka, G. W.; Wadgaonkar, P. P.; Shoup, T. M. "Sodium Percarbonate: A Convenient Reagent for Efficiently Oxidizing Organoboranes," *Tetrahedron Lett.* **1989**, *38*, 5103.

39. Kabalka, G. W.; Wang, Z.; Goudgaon, N. M. "Preparation of Isomerically Pure Alkylamines Via the Reaction of Dimethylalkylboranes with Chloramine," *Synth. Commun.* **1989**, *19*, 2409.

40. Kabalka, G. W.; Varma, R. S. "The Synthesis of Radiolabeled Compounds Via Organometallic Intermediates," *Tetrahedron* **1989**, *45*, 6601.

41. Kabalka, G. W.; Green, J. F.; McCollum, G. "The Synthesis of A Polymeric Organoborane for the Preparation of [^{15}O]-butanol," *J. Labelled Compd. Radiopharm.* **1989**, *24*, 76.

42. Kabalka, G. W.; Green, J. F.; Wang, Z.; Goodman, M. M. "The Synthesis of Nitrogen-13 Labeled Butylamine Using Organoborane Polymers," *J. Labelled Compd. Radiopharm.* **1989**, *24*, 90.

43. Kabalka, G. W.; Shoup, T. M.; Goudgaon, N. M. "Sodium Perborate: A Mild and Convenient Reagent for Efficiently Oxidizing Organoboranes" *J. Org. Chem.* **1989**, 5930.

44. Kabalka, G. W. "Synthetic Approaches to the Preparation of Oxygen-15 Labeled Compounds,"*Synth. Appl. Isot. Labelled Compd.* **1989**, *24*, 437-42.

45. Kabalka, G. W. "Isotope Incorporation Via Organoboranes," *Synth. Appl. Isot. Labelled Compd.* **1989**, *24*, 283.

46. Holmberg, E.; Maruyama, K.; Litzinger, D. C.; Wright, S.; Davis, M.; Kabalka, G. W.; Kennel, S. J.; Huang, L. "Highly Efficient Immunoliposomes Prepared with a Method which is Compatible with Various Lipid Compositions," *BBRC* **1989**, *165*, 1272.

47. Kabalka, G. W.; Wang, Z. "Preparation of Isomerically Pure Dialkylamines Via The Reaction of Dimethylalkylboranes with Chloroalkylamine", *Synth. Commun.* **20**, 231, (1990).

48. Kabalka, G. W.; Wadgaonkar, P. P.; Chatla, N. "The Reduction of Azides With Borohydride Supported On An Ion Exchange Resin" *Synth. Commun.* **1990**, *20*, 293.

49. Kennel, S. J.; Bultman, S.; Lee, R.; Kabalka, G. W. "Rat Monoclonal Antibody Distribution in Mice: An Epitope Inside the Lung Vascular Space Mediates Very Efficient Localization", *Int. J. Rad. Appl. Instrum.* [A], **1990**, *17*, 193.

50. Kabalka, G. W.; Wadgaonkar, P. P.; Shoup, T. M. "Oxidation of Organoboranes with Sodium Percarbonate," *Organometallics*, **1990**, *9*, 1316.

51. Kabalka, G. W.; Deshponde, S. M.; Wadgaonkar, P. P.; Chatla, N. "Transformation of Nitriles Into Amides Using Sodium Percarbonate", *Synth. Commun.* **1990**, *20*, 1445.

52. Kabalka, G. W.; Chatla, N.; Wadgaonkar, P. P.; Deshpande, S. N. "The Conversion of Aliphatic Primary Alcohols to the Corresponding Carboxylics Acids Using Calcium Hypochlorite", *Syn. Commun.* **1990**, *20*, 64.

53. Kabalka, G. W.; Mathur, S. B.; Gai, Y.-Z. "Synthesis of 3-Quinuclidinyl Bennzilate Derivatives", Org. Prep. Int., **1990**, *22*, 87.

54. Kabalka, G. W.; Wang, Z. "The Hydroboration/Amination of N-Trimethylsilyl Protected Olefinic Amines and Diolefins: Synthesis of Isomerically Pure Diamines", *Synth. Commun.* **1990**, *29*, 213.

55. Hondrogiannis, G.; Pagni, R. M.; Kabalka, G. W.; Anosike, P.; Kurt, R. "The Diels-Alder Reaction of Cyclopentadiene and Methyl Acrylate on γ-Alumina", *Tetrahedron Lett.* **1990**, *31*, 5433.

56. Kabalka, G. W.; Pace, R. D.; Wadgaonkar, P. P. "The Palladium Assisted Transfer Reduction of α,β-Unsaturated Nitroalkenes to Oximes Using Ammonium Formate", *Synth. Commun.* **1990**, *20*, 2453.

57. Soderquist, J. A.; Anderson, C. L.; Miranda, E. I.; Rivera, I.; Kabalka, G. W. "Essentially Homochiral 1-Silyl Alcohols From the Reduction of Aliphatic Acylsilanes with Chlorodiisopinocampheyl-borane", *Tetrahedron Lett.* **1990**, *31*, 4677.

58. Kabalka, G. W. "^{17}O-Enrichment Methods," G. W. Kabalka and N. M. Goudgaon, in "^{17}O-NMR Spectroscopy in Organic Chemistry," Boykin, D. ed., CRC Press, Inc., pp 21-38, 1990.

59. Kabalka, G. W.; Wadgaonkar, P. P.; Chatla, N. "An Operationally Simple Hydroboration-Oxidation Experiment", *J. Chem. Ed.* **1990**, *67*, 975.

60. Narayana, C.; Padmanabhan, S.; Kabalka, G. W. "Cleavage of Ethers and Geminal Diacetates Using the Boron Triiodide-N,N-Diethylaniline Complex", Tetrahedron Letters, **1990**, *48*, 6977.

61. Kabalka, G. W.; Guindi, L. H. M.; Varma, R. S. "Selection Reductions of Conjugated Nitroalkenes", *Tetrahedron* **1990**, *46*, 7443.

62. Kabalka, G. W.;M. A. Davis, T. H. Moss, E. Buonocore, K. Hubner, E. Holmberg, K. Maruyama, and L. Huang, "Gadolinium-Labeled Liposomes Containing Various Amphiphilic Gd-DTPA Derivatives: Targeted MRI Contrast Enhancement Agents For The Liver", *Magn. Reson. Med.*, **1991**, *19*, 406.

63. Wang, Z.; Meng, X.; Kabalka, G. W. "Stereoselective Allyl- and Crotylboration of Alpha-Hydroxyketones Via Neighboring Group Control", *Tetrahedron Lett.* **1991**, *32*, 1945.

64. Hondrogiannis, G.; Pagni, R. M.; Kabalka, G. W.; Kurt R.; Cox, D. "The Reaction of Optically Active Menthyl Acrylate with Cyclopentadiene on γ-Alumina. *Tetrahedron Lett.* **1991**, *32*, 2303.

65. Wang, Z.; Meng, X. J; Kabalka, G. W. "The Addition of Allyboration of Alpha-oxocarboxylic Acids", *Tetrahedron Lett.* **1991**, *32*. 4619.

66. Sponholtz, W. R.; Pagni, R. M.; Kabalka, G. W. "The Reaction of Vinylboronic Acids with Iodine on Gamma-Alumina", *J. Org. Chem.* **1991**, *56*, 5700.

67. Wang, Z.; Meng, X.-J.; Kabalka, G. W. "The Stereoselective Crotylboration of Alpha-Oxocarboxylic Acids", *Tetrahedron Lett.* **1991**, *32*, 5677.

68. Narayana, C.; Reddy, N. K.; Kabalka, G. W. "An Efficient Cleavage of Lactones with Boron Triiodide-*N*,*N*-Diethylaniline Complex", *Tetrahedron Lett.* **1991**, *32*, 6855.

69. Wieland, B.; Bida, G.; Padgett, H.; Hendry, G,; Zippi, E.; Kabalka, G. W.; Morelle, J.-L.; Verbruggen, R.; Ghyoot, M. "In-Target Production of [^{13}N]Ammonia Via Proton Irradiation of Dilute Aqueous Ethanol and Acetic Acid Mixtures", *Int. J. Rad. App. Instrum.* [A] **1991**, *42*, 1095.

70. Yang, D. T. C.; Evans, T.; Yamazoki, F.; Kabalka, G. W. "Microscale Preparation of Camphoric Acid", *Newsletter of Microscale Organic Chemistry* **1991**, *5*, 32.

71. Kabalka, G. W.; Goodman, M. M. "Synthesis of Radiopharmaceuticals Via Organoboranes" in "New Trends Radiopharm. Synth. Qual. Assur. Regnl. Control." [Proc. Am. Chem. Soc. Int. Symp.] 239, 1991.

72. Kabalka, G. W.; Pagni, R. M.; Bains, S.; Hondrogiannis, G.; Plesco, M.; Kurt, R. ; Cox, D.; Green, J. "The Effect of Alumina on The Diels-Alder Reaction of Cyclopentadiene with Menthyl Acrylate and Dimethyl Fumarate", *Tetrahedron Asymmetry* **1992**, *2*, 1283.

73. Goodman, M. M.; Kabalka, G. W.; Marks, R. C.; Knapp, F. F.; Lee, J.; Liang, Y. "The Synthesis and Evaluation of Radioiodinated 5-Iodo-(2-thienyl)amphetamines as Brain Imaging Agents", *J. Med. Chem.* **1992**, *35*, 280.

74. Kabalka, G. W.; Wang, Z.; Goodman, M. M. "Synthesis of Isomerically Pure Nitrogen-13 Labeled Gamma Amino-Butyric Acid and Putrescine", *Int. J. Appl. Radiat. Isot.* **1992**, *43*, 389.

75. Kabalka, G. W.; Reddy, N. K.; Narayana, C. "Sodium Percarbonate: A Convenient Reagent for the Dakin Reaction", Tetrahedron Lett., **1992**, *33*, 865.

76. Srivastava, R. R.; Kabalka, G. W. "Cobalt (II) Chloride Catalyzed Syntheses of Acid Anhydrides from Acid Chlorides", *Tetrahedron Lett.* **1992**, *33*, 593.

77. Kabalka, G. W.; Narayana, C.; Reddy, N. K.; "Boron Triiodide-*N*,*N*-Diethylaniline Complex: A New Reagent for Cleaving Esters", *Synth. Commun.* **1992**, *22*. 1793.

78. Goodman, M. M.; Kabalka, G. W.; Meng, X.; Waterhouse, R. N.; Longford,C. P. D. "Facile Radioiodine Incorporation Via Organometallics", *Elsevier*, **1992**, 353.

79. Kabalka, G. W.; Cheng, G. -Q.; Bendel, P. "Boron-11 MRI and MRS", in NMR Microscopy: Methods and Applications in Material Science, Agriculture, and Biomedicine, VCH Publishers, Germany, 533, 1992.

80. Narayana, C.; Reddy, N. K.; Kabalka, G. W. "Sodium Percarbonate: A Mild Reagent for Conversion of Tosylhydrazones and Nitroalkanes to Carbonyl Compounds." *Synth. Commun.* **1992**, *22*, 2587.

81. Tan, L. C.; Pagni, R. M.; Kabalka, G. W.; Hillmeyer, M.; Woosley, J. "The Macrocyclization Reaction of Terminal Dibromalkanes With Sulfide on Alumina. The Use of A Solid Support as an Alternative to the High Dilution Technique. *Tetrahedron Lett.* **1992**, *33*, 7709.

82. Zippi, E.; Kabalka, G. W.; Bida, G.; Satymurthy, N.; Wieland, B. "Deuteron Irradiation of Carbonized Polystyrene/divinylbenzene) Resins for the In-Target Production of [^{13}N]Ammonia", *Appl. Radiat. Isot.* **1992**, *43*, 1363.

83. Bains, S.; Green, J.; Tan, L. C.; Pagni, R. M.; Kabalka, G. W. "The Conversion of Carboxylic Acids into Acid Bromides on Br_3-Modified Alumina", *Tetrahedron Lett.* **1992**, *33*, 7475.

84. Kabalka, G. W.; Reddy N. K; Narayana, C. "Lithium Iodide-Catalyzed Alkylation of Carboranes", *Tetrahedron Lett.* **1992**, *33*, 7687.

85. Wang, Z.; Narayana, C.; Wadgaonkar, P. P.; Kabalka, G. W. "Methylphenyl-borohydride and Methylphenylborane: New Reagents for Preparing Methylphenylborane Derivatives", *J. Organomet. Chem.*, **1992**, *440*, 243.

86. Zrlinghaus, H. F.; Spaar, M. T.; Thonnard, N.; Holloway, P.; Kabalka, G. W.; Switzer, R. C. "Three Dimensional Analysis of Semiconductors and Biological Surfaces Using SIRIS and LARIS", *Inst. Phys. Conf. Ser. No. 128*, **1992**, 24.

87. Tilcock, C.; Ahkong, Q. F.; Koenig, S. H.; Brown, R. D.; Kabalka, G. W. "The Design of Liposomal Paramagnetic MRI Agents: The Effect of Veside Size Upon the Relaxivity of Surface-Incorporating Lipophilic Chelates", *Magn. Reson. Med.* **1992**, *27*, 44.

88. Kabalka, G. W.; Pace, R. D. "Allylboronic Ester Synthesis: A Mechanistic Study", *Tetrahedron Lett.* **1993**, *34*, 783.

89. Goodman, M. M.; Collier, T. L.; Kabalka, G. W.; Longford, C. P. D. "Synthesis of Carbon-11 Labeled (1R-2-exo-3-exo)-2-carbomethoxy-8-methyl-8-azabicyclo [3.2.1.]octyl-3-N-(3'-nitrophenyl) carbamate as a Potential Dopamine Receptor Imaging Agent." *J. Labelled Compd. Radiopharm.* **1993**, *32*, 286-288.

90. Goodman, M. M.; Kabalka, G. W.; Waterhouse, R. N.; Collier, T. L. "Synthesis of Iodine-123 Labeled 3-N-alkyl-5-iodo-2-thienyl-butyrophenones for SPECT Analysis of Dopamine Receptors." *J. Labelled Compd. Radiopharm.* **1993**, *32*, 237.

91. Goodman, M. M.; Kabalka, G. W.; Langford, C. P. D. "Synthesis of Fluorine-18 Labeled 4-Fluoro-4-deoxy-D-glucose as a Potential Brain, Heart and Tumor Imaging Agent." *J. Labelled Compd. Radiopharm.* **1993**, *32*, 568.

92. Kabalka, G. W.; Goodman, M. M.; Maddox, J. T. "The Synthesis of Radioiodinated Vinyl Iodides Via Organoborane Chemistry," *J. Labelled Compd. Radiopharm.* **1993**, *32*, 201.

93. Kabalka, G. W.; Goodman, M. M.; Green, J. F.; Marks, R.; Longford, D. "Synthesis of Nitrogen-13 Labeled Amines Using Organoborane Polymers." *J. Labelled Compd. Radiopharm.* **1993**, *32*, 165.

94. Kabalka, G. W.; Reddy, N. E.; Narayana, C. "Oxidative Deselenylation with Sodium Perborate and Sodium Percarbonate", *Synth. Comm.* **1993**, *23*, 543.

95. Pagni, R. M.; Kabalka, G. W.; Bains, S.; Plesco, M.; Wilson, J.; Bartmess, J. "A Chemical Spectroscopic and Theoretical Assessment of The Lewis Acidity of $LiClO_4$ in Diethyl Ether", *J. Org. Chem.* **1993**, *58*, 3130.

96. Pagni, R. M.; Kabalka, G. W.; Hondrogiannis, G.; Bains, S.; Anosike, P.; Kurt, R. "The Cycloaddition Reactions of Unsaturated Esters with Cyclopentadiene on γ-Alumina", *Tetrahedron* **1993**, *49*, 6743.

97. Yang, D. T. C.; Evans, T. J.; Yamazaki, F.; Narayana, C.; Kabalka, G. W. "Sodium Perborate: A Convenient Oxidative Cleavage of α-Di ketones", *Synth. Commun.* **1993**, *23*, 1183.

98. Kabalka, G. W.; Reddy N. K.; Narayana, C. "Sodium Perborate: A Convenient Reagent for Benzylic Hydroperoxide Rearrangement." *Tetrahedron Lett.* **1993**, *34*, 7667.

99. Kabalka, G. W.; Narayana, C.; Reddy, N. K. "Nickel Catalyzed Hydroboration with Catecholborane", *Synth. Commun.* **1994**, *24*, 1019.

100. Kabalka, G. W.; Goodman, M. M., Srivastava, R. S.; Bowers, K. R.; Marks, R. C. "Synthesis of Radioiodinated Vinyl Iodides", *J. Labelled Compd, Radiopharm.* ***1994,*** *35, 220.*

101. Kabalka, G. W.; Green, J. F.; Goodman, M. M.; Maddox, J. T.; Lambert, S. J. "The Synthesis of Oxygen-15 Butanol Via the Oxidation of Tributylborane Adsorbed on Solid Surfaces", *J. Labelled Compd, Radiopharm.* ***1994,*** 35, *186.*

102. Goodman, M. M.; Devinney, J. L.; Kabalka, G. W.; Ladetsky, M.; Hubner, K. F.; Meyer, M. A.; Lambert, S. J. "Microprocessor-Controlled Open Vessel System for the Production of No-Carrier-Added 1-[^{11}C]-1-Aminocyclobutane-1-Carboxylic Acid", *J. Labelled Compd, Radiopharm.* ***1994,*** 35, *331.*

103. Goodman, M. M.; Kabalka, G. W.; Kung, M. P.; Kung, H. F.; Myer, M. A. "Synthesis of N-3-[^{18}F]Fluoropropyl-2β-carbomethoxy-3β-(4-chlorophenyl)tropane: A High Affinity Neuroligand to Map Dopamine Reuptake Sites by PET", *J. Labelled Compd, Radiopharm.* ***1994,*** 35, *488.*

104. Kabalka, G. W.; Goodman, M. M.; Gotsick, T.; Waterhouse, R. N.; Meyer, M. A.; "Synthesis of [^{18}F]-N-3-Fluoropropyl-2-thienylspiroperidol: A New Radioligand for PET Study of the Dopamine D_2 Receptor", *J. Labelled Compd, Radiopharm.* ***1994,*** 35, *432.*

105. Kabalka, G. W.; Green, J. F.; Goodman, M. M.; Maddox, J. T.; Lambert, S. J. "Radiopharmaceutical Synthesis via Boronated Polymers: in "Current Topics in the Chemistry of Boron, The Royal Society of Chemistry, Cambridge UK, **1994,** 199.

106. Hondrogiannis, G.; Tan, Lay Choo; Pagni, R. M.; Kabalka, G. W.; Herold, S.; Ross, E.; Green, J. F.; McGinnis, M. "Alumina as Reagent. The One-step Conversion of Benzyl Chloride and Bromide in Dibenzyl Ether", *Tetrahedron Lett.* **1994**, *35*, 6211.

107. Goodman, M. M.; Kung, M. P.; Kabalka, G. W.; Kung, H. F.; Switzer, R. "Synthesis and Characterization of Radioiodinated N-(3-Iodopropen-2-yl)-2β-Carbomethoxy-3β-(4-chlorophenyl)tropanes: Potential Dopamine Reuptake Site Imaging Agents", *J. Med. Chem.* , **1994**, *37*, 1535.

108. Kabalka, G. W.; Maddox, J. T.; Bogas, E. "A Facile Alkylation of Aryl Aldehyde Toslhydrazones with Trialkylboranes, *J. Org. Chem.* **1994**, *59*, 5530.

109. Goodman, M.M.; Kabalka, G.W.; Kung, M.-P.; Gotsick, T.; Shoup,T. "Synthesis of Radiohalogen Brain Imaging Agents", in "Synthesis and Applications of Isotopically Labeled Compounds, Allen, J. and Voges, R. ads; Wiley **1994**, 379.

110. Kabalka, G. W.; Goodman, M. M.; Longford, D.; Green, J. Gotsick, J. T. "Automated Synthesis of Positron Emitting Radiopharmaceuticals" in Synthesis and Applications of Isotopically Labelled Compounds, Allen, J. and Voges, R. eds, Wiley, London, **1994**.

111. Willis, D. A.; McGinnis, M. Kabalka, G. W.; Pagni, R. M. "Bromination of Vinylboronic Acids on Alumina" *J. Organometallic Chem.*, **1995**, *487*, 35.

112. Kabalka, G. W.; Li, Nan-Sheng, Yu, S. "Protonation of Acyllithium Reagents by Dichloromethane and Dichloroarylmethane: A New Method for the Synthesis of α,α-Dichloro Alcohols", *Organometallics*, **1995**, *14*, 1565.

113. Kabalka, G. W.; Li, N.-S.; Pace, R. D. "N-t-Butoxycarbonyl Protection of Primary and Secondary Amines in the Hydroboration Reaction: Synthesis of Amino Alcohols", *Synth. Commun.*, **1995**, *25*, 2135.

114. Wilgus, C. P.; Downing, S.; Baines, S.; Pagni, R. M.; Kabalka, G. W. "The Acid-Catalyzed and Uncatalyzed Hydrolysis of Nitriles on Unactivated Alumina", *Tetrahedron Lett.*, **1995**, *36*, 3469.

115. Hondrogiannis, G.; Kabalka, G. W. "Hydroboration of Alkenylcarboranes: A Regiochemical Investigation", *Tetrahedron Lett.* **1995**, *36*, 4365.

116. Pace, R. D.; Kabalka, G. W. "The Allylboration of α-Aminoketones", *J. Org. Chem.*, **1995**, *60*, 4838.

117. Li, N. S.; Yu, S.; Kabalka, G. W. "The Protonation of Acyllithium Reagents by Acetonitrile: Synthesis of B-Hydroxynitriles", *J. Org. Chem.* **1995**, *60*, 5973.

118. Kabalka, G. W.; Li, N. -S.; Yu, S. "Alkylation of α,α-Dichloroarylmethane with Trialkylboranes: Synthesis of Alkylarylcarbinols", *Tetrahedron Lett.*, **1995**, *36*, 8545.

119. Gotsick, T.; Goodman, M. M.; Kabalka, G. W.; Keil, R.; Shi, B. "Synthesis of 2β-Carbomethoxy-8-(ω-[^{18}F]fluoroalkyl)-3β-)3'-nitrophenyl)-Carbamoylecgonine: Potential (-)-Cocaine Receptor Imaging Agents for PET", *J. Labelled Compd. Radiopharm.* **1995**, *37*, 43.

120. Waterhouse, R. N.; Gotsick, T.; Kabalka, G. W.; Goodman, M. M.; O'Brien, J. C. "Synthesis and Evaluation of ^{123}I]-3-N-Methyl-2-iodothienylspiroperidol: A Novel Dopamine D_2 Receptor Imaging Agent for SPECT", *J. Labelled Compd. Radiopharm.* **1995**, *37*, 18.

121. Zhang, Z. Y.; Akula, M. R.; Longford, C. P. D.; Kabalka, G. W. "3-[^{18}F]Fluorobenzidine: A Precursor to Fluorine-18 Labeled Congo Red, A Potential Imaging Agent for Alzheimer's Disease", *J. Labelled Compd. Radiopharm.* **1995**, *37*, 601.

122. Kabalka, G. W.; Green, J. F.; Hubner, K. F.; Longford, C. P. D.; Roberts, T. G.; "A Convenient Synthesis of 1-Aminocyclobutane-1-[^{11}C]carboxylic Acid (1-[^{11}C]ACBC)", G. W. Kabalka, J. F. Green, K. F. Hubner, C. P. D. Longford, T. G. Roberts, *J. Labelled Compd. Radiopharm.* **1995**, *37*, 622.

123. Reddy, N. K.; Kabalka, G. W.; Longford, C. P. D.; Roberts, T. G. "4-[^{10}B]Borono-2-[^{18}F]fluoro-L-phenylalanine-Fructose Complex for Use in Timing Boron Neutron Capture Therapy (BNCT)", *J. Labelled Compd. Radiopharm.* **1995**, *37*, 599.

124. Zhang, Z. Y.; Kabalka, G. W.; Longford, C. P. D.; Padgett, H. C.; Zigler, S. S. "Automated Production of 6-[^{18}F]Fluoro-L-dopa in a Commercially Available Chemistry Module", *J. Labelled Compd. Radiopharm.* **1995**, *37*, 671.

125. Akula, M. R.; Kabalka, G. W. "A Facile Synthesis of 6-Alkyl-6,7-dihydro-5H-dibenz[c,c]azepines: Potent Hypolipidemics", *Syn. Commun.* **1995**, *25*, 3901.

126. Kabalka, G. W.; Shoup, T.; Maddox, J.; Bower, K. "A Simple and Convenient Method for the Oxidation of Organoboranes Using Sodium Perborate", *Org. Syn.* **1995**, *73*, 116.

127. Yang, D.T.C., Cao, Y. H., Kabalka, G. W. "Sodium Percarbonate: A Convenient Reagent for the Thermal and Sonic Oxidative Cleavage of α-Haloketones, *Synth. Commun.* **1995**, *25*, 3695.

128. DePaoli, D. W.; Harris, M. T.; Alley, M. R.; Morgan, I. L.; Cate, N.; Ellis, M. E.; Heath, K.; Host, D. W.; Kabalka, G. W.; Anderson, C. L.; Tang, C. "Testing and Evaluation of Electrokinetic Decontamination of Concrete", DOE Technical Report, 1995.

129. Kabalka, G. W.; Maddox, J. T.; Bogas, E. "A Facile Alkylation of Arylaldehyde Trisylhydrazones with Trialkylboranes", *Synth. Commun.* **1996**, *26*, 999.

130. Kabalka, G. W.; Narayana, C.; Reddy, N. K., "Stereoselective Synthesis of a*nti*-1,3-diols", *Tetrahedron Lett.* **1996**, *37*, 2181.

131. McGinnis, M.; Green, J. F.; Tan, L. C.; Palmer, R.; Siler, J.; Vagle, K.; Pagni, R. M.; Kabalka, G. W. "Selectivities of Diels-Alder Reactions Catalyzed by Highly Acidic Boronated Aluminas", *J. Org. Chem.* **1996**, *61*, 3496.

132. Zippi, E. M.; Grover, J.; Valiulis, M. B.; Tibbets, C.; Kabalka, G. W. "Functionalization of Cross-Linked Poly(Styrene) in the Preparation of a PET Target Material." *App. Radia. Iso.* **1996**, *47*, 513.

133. Yang, D. T. C.; Cao, Y. H.; Evans, T. T.; Kabalka, G. W. "The Ultrasound Assisted Oxidation of α-Substituted Carbonyl Compounds. *Synth. Commun.* ***1996,*** *26*, 4275.

134. Akula, M. R.; Kabalka, G. W. "Reduction of Azobenzenes to Diphenylhydrazines." *Synth. Commun.* **1996**, *26*, 3821.

135. Zippi, E. M.; Kabalka, G. W. "Synthesis, Characterization and Pyrolysis of Poly(Styrene/Divinylbenzene) Derivatives." *Carbon* **1996**, *34*, 1539.

(b) Published Abstracts

191 Abstracts have been published from 1986 to 1996.

(c) Invited Presentations

134 Invited presentations have been presented from 1986 to 1996.

References:

1. Kabalka, G. W. "Use of Organoboranes in Modern Medical Imaging." *Pure Appl. Chem.* **1991**, *63*, 379.

2. Kabalka, G. W. "Incorporation of Stable and Radioactive Isotopes Via Organoborane Chemistry." *Acc. Chem. Res.* **1984**, *17*, 215.

3. Kabalka, G. W.; Varma, R. S. "The Synthesis of Radiolabeled Compounds Via Organometallic Intermediates." *Tetrahedron* **1989**, *45*, 6601.

4. Kabalka, G. W.; Gooch, E. E. "Rapid and Mild Syntheses of Radioiodine Labeled Radiopharmaceuticals." *J. Nucl. Med.* **1981**, *22*, 908.

5. Kabalka, G. W.; Gooch, E. E.; Smith, T. L.; Sells, M. A. "Rapid Incorporation of Iodine-123 Via the Reaction of ^{123}I-Sodium Iodide with Organoboranes." *Int. J. Appl. Rad. Isot.* **1982**, *33*, 223.

6. Kabalka, G. W.; Gai, Y.-Z.; Mathur, S. B. "Synthesis of Iodine-125 Labeled 3-Quinuclidinyl-4'-Iodobenzilate." *Nuc. Med. Biol.* **1989**, *16*, 359.

7. Goodman, M. M.; Knapp, F. F.; Kabalka, G. W.; Sastry, K. A. R. "Synthesis and Evaluation of 18-[^{125}I]-Iodo-17-octadecanoic Acid." *J. Med. Chem.* **1984**, *27*, 94.

8. Kabalka, G. W.; McCollum, G. W.; Fabrikiewitz, A. S.; Lambrecht, R. M.; Fowler, J. S.; Sajjad, M. "Synthesis of ^{15}O-Labeled Butanol Via Organoborane Chemistry: Preliminary Report." *J. Labelled Compd. Radiopharm.* **1984**, *21*, 1247.

9. Quarles, R. P.; Mintun, M. A.; Larson, K. B.; Markham, J.; MacLeod, A. M.; Raichle, M.E. "Measurement of Regional Cerebral Blood Flow with Positron Emission Tomography: A Comparison of [^{15}O]Water to [^{11}C]Butanol with Distributed-Parameter and Compartmental Models." *J. Cereb. Blood Flow Metab.* **1993**, *13*, 733.

10. Takashashi, K.; Murakami, M.; Hagami, E.; Sasaki, H.; Kondo, Y.; Mizusawa, S.; Nakamichi, H.; Iida, H.; Miura, S.; Kanno, I.; Uemura, K.; Ido, T. "Radiosynthesis of ^{15}O-Labeled Butanol Available for Clinical Use." *J. Labelled Compd. Radiopharm.* **1986**, *23*, 1111.

11. Berridge, M. S.; Cassidy, E. H.; Terris, A. H. "A Routine, Automated Synthesis of Oxygen-15-Labeled Butanol for Positron Tomography." **1990**, *31*, 1727.

12. Kabalka, G. W.; Green, J. F.; Goodman, M. M.; Maddox, J. T.; Lambert, S. J. "The Synthesis of Oxygen-15 Butanol Via the Oxidation of Tributylborane Adsorbed on Solid Surfaces", *J. Labelled Compd, Radiopharm. **1994**, 35, 186.*

13. Kabalka, G. W.; Green, J. F.; McCollum, G. "The Synthesis of A Polymeric Organoborane for the Preparation of [^{15}O]-butanol." *J. Labelled Compd. Radiopharm.* **1989**, *24*, 76.

14. Wang, Z.; Narayana, C.; Wadgaonkar, P. P.; Kabalka, G. W. "Methylphenyl-borohydride and Methylphenylborane: New Reagents for Preparing Methylphenylborane Derivatives." *J. Organomet. Chem.*, **1992**, *440*, 243.

15. Unpublished results, Ph.D. Thesis "Surface Supported Boranes for Use in Catalysts and the Production of Radiopharmaceuticals." of James F. Green, University of Tennessee, **1994**.

16. Brown, H. C.; Midland, M. M.; Kabalka, G. W. "Organoboranes for Synthesis. 5. Stoichiometrically Controlled Reaction of Organoboranes with Oxygen Under Mild Conditions to Achieve Quantitative Conversion to Alcohols." *Tetrahedron* **1986**, *42*, 5523.

17. Kabalka, G. W.; Green, J. F.; Wang, Z.; Goodman, M. M. "The Synthesis of Nitrogen-13 Labeled Butylamine Using Organoborane Polymers." *J. Labelled Compd. Radiopharm.* **1989**, *24*, 90.

18. Kabalka, G. W.; Goodman, M. M.; Green, J. F.; Marks, R.; Longford, D. "Synthesis of Nitrogen-13 Labeled Amines Using Organoborane Polymers." *J. Labelled Compd. Radiopharm.* **1993**, *32*, 165.

19. Kothari, P. J.; Finn, R. D.; Kabalka, G. W.; Boothe, T. E.; Vora, M. M.; and Emran A. "Synthesis of Nitrogen-13 Labeled Alkylamines Via Amination of Organoboranes." *Int. J. Rad. App. Instrum.* [A] **1986**, *37*, 471.

20. Kothari, P. J.; Finn, R. D.; Kabalka, G. W.; Vora, M. M.; Boothe, T. E.; Emran, A. M. "1-^{11}C-Butanol: Synthesis and Development as a Radiopharmaceutical for Blood Flow Measurements." *Int. J. Appl. Rad. Isotopes* **1985**, *36*, 412.

21. Kothari, P. J.; Finn, R. D.; Kabalka, G. W.; Boothe, T. E.; Vora, M. M.; Emran, A. "Carbon-11 Labeled Dialkylketones: Synthesis of 9-[^{11}C]-Heptadecan-9-One." *Int. J. Rad. Appl. Instrum. [A]* **1986**, *37*, 469.

22. Kabalka, G. W.; Gotsick, J. T.; Pace, R. D.; Li, N.-S. "Evidence for the Formation of Acylboronate Intermediates in the Carbonylation Reactions of Organoboranes." *Organometallics* **1994**, *13*, 5163.

23. Kabalka, G. W.; Gooch, E. E. "A Rapid and Mild Method for Labeling Functionally Substituted Molecules with Iodine Radionuclides." *J. Labelled Compd. Radiopharm.* **1981**, *18*, 117.

24. Knapp, F. F., Jr.; Srivastava, P. C.; Callahan, A. P.; Cunningham, E. B.; Kabalka, G. W.; Sastry, K. A. "Effect of Tellurium Position on the Myocardial Uptake of Radioiodinated 18-Iodotellura-17-octadecenoic Acid Analogs." *J. Med. Chem.* **1984**, *27*, 57.

25. Kabalka, G. W.; Sastry, K. A. R.; Knapp, F. F.; Srivastava, P. C. "Synthesis of Vinyl Bromides Via Reaction of Vinyl Boronic Acids with Sodium Bromide." *Synth. Commun.* **1983**, *13*, 1027.

26. Knapp, F. F.; Goodman, M. M.; Callahan, A. P.; Ferren, L. A.; Kabalka, G. W.; Sastry, K. A. R. "New Myocardial Imaging Agents: Stabilization of Radioiodine as a Terminal Vinyl Iodide Moiety on Tellurium Fatty Acids." *J. Med. Chem.* **1983**, *26*, 1293.

27. Kabalka, G. W.; Sastry, K. A. R.; Pagni, P. G. "Rapid Incorporation of Radiobromine via the Reaction of Labeled Sodium Bromide with Organoboranes." *J. Radioanalyt. Chem.* **1982**, *74*, 315.

28. Srivastava, P. C.; Knapp, F. F., Jr.; Kabalka, G. W. New Radiohalogenated Alkenyl Tellurium Fatty Acids." *Phosphorus and Sulfur*, **1987**, *38*, 49.

29. Kabalka, G. W.; Gooch, E. E.; Hsu, H. C.; Washburn, L. C.; Sun, T. T.; Hayes, R. L. "Rapid and Mild Synthesis of Radioiodinated Estrogen Derivatives." in "Applications of Nuclear and Radiochemistry." R. M. Lambrecht and N. Morcos, Eds. Pergamon Press, N.Y., Chapter 17, 1981.

30. Goodman, M. M.; Kabalka, G. W.; Waterhouse, R. N.; Collier, T. L. "Synthesis of Iodine-123 Labeled 3-*N*-Alkyl-5-iodo-2-thienyl-butyrophenones for SPECT Analysis of

Dopamine Receptors." *J. Labelled Compd. Radiopharm.* **1993**, *32*, 237.

31. Goodman, M. M.; Kabalka, G. W.; Meng, C. "Synthesis of Iodine-123 Labeled 4-O-(E)-3-Iodopropen-2-yl Branched Carbohydrates." *Carbohydrate Res.* in press.

32. Boothe, T. E.; Finn, R. D.; Vora, M. M.; Emran, A.; Kothari, P.; Kabalka, G. W. "Radioiodinations of Organic Molecules on Silica Gel Surfaces." *J. Labeled Compd.* **1985**, *22*, 1109.

33. Sponholtz, W. R.; Pagni, R. M.; Kabalka, G. W. "The Reaction of Vinylboronic Acids with Iodine on Gamma-Alumina." *J. Org. Chem.* **1991**, *56*, 5700.

34. Willis, D. A.; Kabalka, G. W.; Pagni, R. M. "Bromination of Vinylboronic Acids on Alumina." *J. Organometallic Chem.* **1995**, *487*, 35.

35. Bains, S.; Green, J.; Tan, L. C.; Pagni, R. M.; Kabalka, G. W. "The Conversion of Carboxylic Acids into Acid Bromides on BBr_3-Modified Alumina." *Tetrahedron Lett.* **1992**, *33*, 7475.

36. Wilgus, C. P.; Downing, S.; Baines, S.; Pagni, R. M.; Kabalka, G. W. "The Acid-Catalyzed and Uncatalyzed Hydrolysis of Nitriles on Unactivated Alumina." *Tetrahedron Lett.* **1995**, *36*, 3469.

37. Ali, H.; Rousseau, A. J.; VanLier, J. E. "Synthesis of (17α, 20*E/Z*) Iodovinyl Testosterone and 19-Nor Testosterone Derivatives as Potential Radioligands for Androgen and Progesterone Receptors." *J. Steroid Biochem. Mol. Biol.* **1994**, *49*, 15.

38. Ali, H.; Rousseau, J.; Van Lier, J. E. "Synthesis A-ring Fluorinated Derivatives of 17-α,20 (E/Z)-[^{125}I] iodovinylestradiols: Effect on Receptor Binding and Receptor-Mediated Target Tissue Iptake." *J. Med. Chem.* **1993**, *36*, 3061.

39. Kabalka, G. W.; Pagni, R. M.; Bains, S.; Hondrogiannis, G.; Plesco, M.; Kurt, R. ; Cox, D.; Green, J. "The Effect of Alumina on The Diels-Alder Reaction of Cyclopentadiene with Menthyl Acrylate and Dimethyl Fumarate." *Tetrahedron Asymmetry* **1992**, *2*, 1283.

40. Ph.D. dissertation, R. C. Marks "New Tetraarylborate and ethyldibutylstannone Reagents." University of Tennessee, December 1994.

41. Goodman, M. M., Srivastiva, R. S.; Bowers, K. R.; Marks, R. C. "Synthesis of Radioiodinated Vinyl Iodides." *J. Labelled Compd, Radiopharm.* ***1994,*** 35, *220.*

42. Culbert, P.; Hunter, D. "Polymer-Supported Radiopharmaceuticals: Iodine-123 and Iodine-131-Labeled N-Isopropyl-4-Iodoamphetamine." *React. Polym.* **1993**, *19*, 247.

43. "Automated Production of 6-[^{18}F]Fluoro-L-dopa in a Commercially Available Chemistry Module." Z. Y. Zhang, G. W. Kabalka, C. P. D. Longofrd, H. C. Padgett, S. S. Zigler, XI International Symposium on Radiopharmaceutical Chemistry, Vancouver, B. C. Canada (August, 1995).

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