



REFERENCES

- [1] Macomber, R. Organic Chemistry I. Sausalito: University Science Books, 1996.
- [2] Dobo, K. L.; Greene, N.; Cyr, M. O.; Caron, S.; Ku, W. W. The Application of Structure-Based Assessment to Support Safety and Chemistry Diligence to Manage Genotoxic Impurities in Active Pharmaceutical Ingredients During Drug Development. Regul. Toxicol. Pharm. 44 (2006) : 282-293.
- [3] Hatakeyama, T.; Ito, S.; Nakamura, M.; Nakamura, E. Alkylation of Magnesium Enamide with Alkyl Chlorides and Fluorides J. Am. Chem. Soc. 127 (2005) : 14192-14193.
- [4] McMurry, J. Organic Chemistry. California: Brooks/Cole Publishing Company, 1996.
- [5] Vogel, A. I. A Textbook of Practical Organic Chemistry. London: Longman Group, 1989.
- [6] Iranpoor, N.; Adibi, H. Iron(III) Trifluoroacetate as an Efficient Catalyst for Solvolytic and Nonsolvolytic Nucleophilic Ring Opening of Epoxides. Bull. Chem. Soc. Jpn. 73 (2000) : 675-680.
- [7] Olah, G. A.; Balaram, B. G.; Malhotra, R.; Narang, S. C. Chlorotrimethylsilanol/ Lithium Bromide and Hexamethyldisilanol/Pyridinium Bromide Perbromide: Effective and Selective Reagents for the Conversion of Allkyl (Cycloalkyl and Aralkyl) Alcohols Into Bromides. J. Org. Chem. 45 (1980) : 1638-1639.
- [8] Burn, A. J.; Cadogan J. I. G. The Reactivity of Organophosphorus Compounds. Part XVIIIX a Novel Oxidation of Some Tervalent Compounds: Reduction of Carbon Tetrachloride to Chloroform by Trialkyl Phosphites. J. Chem. Soc. (1963) : 5788-5796.
- [9] Wiley, G. A.; Hershkowitz, R. L.; Rein, B. M.; Chung, B. C. Studies in Organophosphorus Chemistry. I. Conversion of Alcohols and Phenols to Halides by Tertiary Phosphine Dihalides. J. Am. Chem. Soc. 86 (1964) : 964-965.
- [10] (a) Lee, J. B.; Nolan, T. J. Sugar Esters III New Reagent for Deoxyhalo Sugar Preparation. Can. J. Chem. 44 (1966) : 86-87. (b) Lee, J. B.; Nolan, T. J. Sugar

- Esters IV The Preparation of Chloroesters under Essentially Neutral Conditions. Tetrahedron 23 (1967) : 359-363.
- [11] Weiss, R. G.; Snyder, E. I. Stereochemistry of Chloride Formation from Alcohols and Thiols by Use of Triphenylphosphine and Carbon Tetrachloride. J. Chem. Soc; Chem. Commun. 21 (1968) : 1358-1359.
- [12] Hooz, J.; Gilani, S. S. H. A Rapid, Mild Procedure for the Preparation of Alkyl Chlorides and Bromide. Can. J. Chem. 46 (1968) : 86-87.
- [13] Steven, L. R.; Dan, P. L. Solid Phase Phosphorus Reagents Conversion of Alcohols to Alkyl Chlorides. J. Org. Chem. 40 (1975) : 1669-1670.
- [14] Miyano, S.; Watanabe, H.; Ushiyama, H.; Yamada, Y.; Hashimoto, H. Chlorination of Alcohols with Copper(II) Chloride and Triphenylphosphine J. Chem. Soc. Japan 1 (1978) : 138-140.
- [15] Jones, L. A.; Sumner, C. E.; Franzus, Jr. B.; Huang, T. T.S.; Snyder, E. I. The Intermediate from the Triphenylphosphine-Tetrachloromethane-Alcohol Reaction: Relative Rates of Intermediate Formation, Kinetics, and Mechanism of Intermediate Decomposition. J. Org. Chem. 43 (1978) : 2821-2827.
- [16] Matveeva, E. D.; Yalovskaya, A. I.; Cherepanov, I. A.; Bundel, Y. G.; Kurts, A. L. Regioselective Substitution of the Hydroxyl Group in Alcohols by Derivatives of Trihaloacetic Acids in the Presence of Triphenylphosphine J. Org. Chem. Russia 27 (1991) : 1611-1618.
- [17] Schlama, T.; Gouverneur, V.; Mioskowski, C. One-Step Conversion of Protected Alcohols into Alkyl Halides using Dimethylphosgenium Salt. Tetrahedron Lett. 38 (1997) : 3517-3520.
- [18] Sugimoto, O.; Mori, M.; Tanji, K. A. Facile Halogenation of Some Hydroxyheterocycles using Triphenylphosphine and *N*-halosuccinimide. Tetrahedron Lett. 40 (1999) : 7477-7478.
- [19] Pollastri, M. P.; Sagal, J. F.; Chang, G. The Conversion of Alcohols to Halides using a Filterable Phosphine Source. Tetrahedron Lett. 42 (2001) : 2459-2460.
- [20] Iranpoor, N.; Firouzabadi, H.; Aghapour, G.; Vaez Zadeh, A. R. Triphenylphosphine/2,3-Dichloro-5,6-dicyanobenzoquinone as a New, Selective and Neutral System for the Facile Conversion of Alcohols, Thiols

- and Selenols to Alkyl Halides in the Presence of Halide Ions. Tetrahedron 58 (2002) : 8689-8693.
- [21] Desmaris, L.; Percina N.; Cottier, L.; Sinou, D. Conversion of Alcohols to Bromides using a Fluorous Phosphine. Tetrahedron Lett. 44 (2003) : 7589-7591.
- [22] Iranpoor, N.; Firouzabadi, H.; Jamalian, A.; Kazemi, F. Silicaphosphine (Silphos): a Filterable Reagent for the Conversion of Alcohols and Thiols to Alkyl Bromides and Iodides. Tetrahedron 61 (2003) : 5699-5704.
- [23] Pleumpanupat, W.; Chavasiri, W. An Efficient Method for Chlorination of Alcohols Using $\text{PPh}_3/\text{Cl}_3\text{CCONH}_2$. Tetrahedron Lett. 47 (2006) : 6821-6823.
- [24] Tongkate, P.; Pleumpanupat, W.; Chavasiri, W. Hexabromoacetone and Ethyl Tribromoacetate: A Highly Efficient Reagent for Bromination of Alcohols. Tetrahedron Lett. 49 (2008) : 1146-1148.
- [25] Caserio, F. C.; Dennis, G. E.; Dewolfe, R. H.; Young, W. G. The Reaction of Thionyl Chloride with Allylic Alcohols. J. Am. Chem. Soc. 77 (1955) : 4182-4783.
- [26] Collington, E. W.; Meyers, A. I. A Facile and Special Conversion of Allylic Alcohols to Allylic Chlorides without Rearrangement. J. Org. Chem. 36 (1971) : 3040-3045.
- [27] Snyder, E. I. Conversion of Allylic Alcohols to Chlorides without Rearrangement J. Org. Chem. 37 (1971) : 1466-1467.
- [28] Ronald, M. M.; Stanley, O. F.; William, L. J. Hexachloroacetone/ Triphenylphosphine; a Reagent for the Regio- and Stereoselective Conversion of Allylic Alcohols into Chlorides Tetrahedron Lett. 18 (1977) : 2999-3002.
- [29] Nicolaou, K. C.; Claremon, D. A.; Papahatjis, D. P.; Magolda, R. L. Total Synthesis of Ionophore Antibiotic X-14547A.2. Coupling of the Tetrahydropyran and Tetrahydroindan Systems and Construction of the Butadienyl and Ketopyrrole Moieties J. Am. Chem. Soc. 103 (1981) : 6969-6971.
- [30] Matveeva, E. D.; Kurts, A. L.; Yalovskaya, A. I.; Nikishova, N. G.; Bundel, Y. G. Regio- and Stereospecific Substitution of the Hydroxyl of Aliphatic Alcohols with Halogen J. Org. Chem. Russia 25 (1989) : 716-721.

- [31] Munyemans, F.; Frisque-Hesbain, A. M.; Devos, A.; Ghosez, L. Synthesis of Alkyl Halides under Neutral Condition Tetrahedron Lett. 30 (1989) : 3077-3080.
- [32] Meyer, S. D.; Miwa, T.; Nakatsuka, M.; Schreiber, S. L. Synthetic Investigations of Rapamycin. 1. Synthesis of a C₁₀X₂₁ Fragment. J. Org. Chem. 57 (1992) : 5058-5060.
- [33] Veejendra, K. Y.; Ganesh, K. B. Acetyl Chloride-Ethanol Brings about a Remarkably Efficient Conversion of Allyl Acetates into Allyl Chlorides Tetrahedron Lett. 59 (2003) : 9111-9116.
- [34] Bandger, B. P.; Bettigeri, S. V. Efficient and Selective Halogenation of Allylic and Benzylic Alcohols under Mild Condition Monatshefte für Chemie 135 (2004) : 1251-1255.
- [35] Sanchita, R.; Tarak, D.; Manabendra, S.; Subrata, K. C.; Sanjay, B. Cyanuric Chloride-Mediated Synthesis of Allylic Chloride- *ipso*- versus *tele*-Substitution Synth. Commun. 37 (2007) : 4367-4370.
- [36] Tietze, L. F.; Eicher, T. H. Reactions and Syntheses in the Organic Chemistry Laboratory. California: University Science Book, 1988.
- [37] Gilbert, E. E. Perhaloketones. XVII. Hexabromoacetone and the Bromochloroperhaloacetones. Tetrahedron 25 (1969) : 1801-1806.
- [38] Yongzheng, C.; Junggang, X.; Xiaoying, X.; Yu, X.; Hui, L.; Shiwen, X.; Lixin, W. Enantiocomplementary Preparation of (*S*)- and (*R*)-Mandelic Acid Derivatives *via* α-Hydroxylation of 2-Arylacetic Acid Derivatives and Reduction of α-Ketoester using Microbial Whole Cells. Tetrahedron: Asymmetry 18 (2007) : 2537-2540.
- [39] Khazaei, A.; Vaghei, R. G.; Karkhanei, E. Bromination of Organic Allylic Compounds by Using *N,N'*-Dibromo-*N,N'*-1,2-ethane Diyl Bis(2,5-Dimethyl Benzene Sulfonyl) Amine. Synth. Commun. 32 (2002) : 2107-2113.
- [40] Altamura, M.; Perrota, E. An Efficient Synthesis of 2-(Halogenomethyl)penems. J. Org. Chem. 58 (1993) : 272-274.
- [41] Sheehan, J. C.; Guziec, F. C. Amino Group Protection in Peptide Synthesis. The 4,5-Diphenyl-4-oxazolin-2-one Group. J. Org. Chem. 38 (1973) : 3034-3040.

- [42] Wang, Z.-M.; Shen, M. An Efficient Synthesis of (-)-Pestalotin and Its Enantiomer Using Sharpless Asymmetric Dihydroxylation. Tetrahedron: Asymmetry 8 (1997) : 3393-3396.
- [43] Francis, A. C.; Richard, J. S. Advanced Organic Chemistry 4th Edition. Part B: Reactions and Synthesis. New York: Plenum Publishers, 2001.
- [44] Slagle, J. D.; Huang, T. T.-S.; Franzus, B. Mechanism of the Triphenylphosphine-Tetrachloromethane-Alcohol Reaction: Pericyclic or Clustered Ion Pairs? J. Org. Chem. 46 (1981) : 3526-3530.
- [45] Altamura, M.; Perrotta, E. An Efficient Synthesis of 2-(Halogenomethyl) penems. J. Org. Chem. 58 (1993) : 272-274.
- [46] Griffin, C. E.; Gordon, M. Some Observations on the Proton Magnetic Resonance Spectra of Phosphonium Salts. J. Organomet. Chem. 3 (1965) : 414-419.
- [47] Ji, Y.; Zong, Z.; Wei, X.; Tu, G.; Xu, L.; He, L. Improved Synthesis of Vitamin K₁. Synth. Commun. 33 (2003) : 763-772.
- [48] Grossi, V.; Rontani, J. F. Photosensitized Oxygenation of Phytadienes. Tetrahedron Lett. 36 (1995) : 3141-3144.
- [49] (a) Shabarov, Y. S.; Saginova, L. G. Bromination of Phenylcyclopropane J. Org. Chem. Russia 11 (1975) : 1403-1408. (b) Taguchi, T.; Tomoeda, M.; Aratani, I. Diphenyl Serinols: A New Synthesis and its Stereochemical Findings. J. Am. Chem. Soc. 78 (1956) : 1468-1471. (c) Arcus, C. L.; Strauss, H. E. Addition of Bromine to (+)-1-Phenylallyl Alcohol and the Oxidation of the (+)-Dibromo Alcohol J. Chem. Soc. (1952) : 2669-2671.
- [50] Bauer, D. P.; Macomber, R. S. Iodide Catalysis of Oxidations with Dimethyl Sulfoxide. A Convenient Two-step Synthesis of α -Diketones from α -Methylene Ketones. J. Org. Chem. 40 (1975) : 1990-1992.
- [51] Lee, J. C.; Hwang, E. Y. An Efficient and Fast Method for the Preparation of Benzylic Bromides. Synth. Commun. 34 (2004) : 2959-2963.
- [52] (a) Krief, A.; Laval, A. M. Coupling of Organic Halides with Carbonyl Compounds Promoted by SmI₂, The Kagan Reagent. Chem. Rev. 99 (1999) : 745-777. (b) Fillon, H.; Gosmini, C.; Pe'richon, J. A Convenient Method for the Preparation of Aromatic Ketones from Acyl Chlorides and Arylzinc

- bromides Using a Cobalt Catalysis. *Tetrahedron* 59 (2003) : 8199–8202. (c) Bertrand, M. B.; Wolfe J. P. Stereoselective Synthesis of N-protected Pyrrolidines via Pd-catalyzed Reactions of γ -(N-acylamino) Alkenes and γ - (N-Boc-amino) Alkenes with Aryl Bromides. *Tetrahedron* 61 (2005) : 6447– 6459. (d) Gonza'lez-Bobes, F.; Fu, G. F. Amino Alcohols as Ligands for Nickel-Catalyzed Suzuki Reactions of Unactivated Alkyl Halides, Including Secondary Alkyl Chlorides, with Arylboronic Acids. *J. Am. Chem. Soc.* 128 (2006) 5360-5361. (e) Sonntag, N. O. V. The Reactions of Aliphatic Acid Chlorides. *Chem. Rev.* 52 (1953) : 237-416.
- [53] Hughes, D. L. Progress in the Mitsunobu Reaction. A Review. Organic Preparations and Procedures International. *Org. Prep. Proced. Int.* 28 (1996) : 127-164.
- [54] Imrie, C.; Modro, T. A.; Rohwer, E. R.; Wagener, C. C. P. Photolysis of (Arylmethyl)triphenylphosphonium Salts. Substituent, Counterion, and Solvent Effects on Reaction Products. *J. Org. Chem.* 58 (1993) : 5643-5649.
- [55] Stork, G.; White, W. N. The Stereochemistry of the S_N2' Reaction. II *J. Am. Chem. Soc.* 78 (1956) : 4609-4619.
- [56] Mare, P. B. D.; Vernon, C. A. The kinetics and Mechanism of Nucleophilic Displacements in Allylic Systems. Part I. Reaction of 3: 3-Dichloroprop-1-ene with the Ethoxide Ion *J. Chem. Soc.* (1952) : 3325-3331.
- [57] Streitwieser, A.; Jayasree, E. G.; Hasanayn, F.; Leung, S. S.-H. A Theoretical Study of S_N2' Reactions of Allylic Halides: Role of Ion Pairs *J. Org. Chem.* 73 (2008) : 9426-9434.
- [58] Choi, M. K. W.; He, H. S.; Toy, P. H. Direct Radical Polymerization of 4-Styryldiphenylphosphine: Preparation of Cross-Linked and Non-Cross- Linked Triphenylphosphine-Containing Polystyrene Polymers. *J. Org. Chem.* 68 (2003) : 9831-9834.
- [59] Arnold, D. R.; Wong, P. C. The Photochemistry of Chloroaromatic Compounds. Is " π -Chlorobenzene" an Intermediate? *J. Am. Chem. Soc.* 99 (1977) : 3361- 3366.
- [60] Dvorko, G. F.; Fefer, Yu. I.; Zhovtyak, V. N. Kinetics and Mechanism of Monomolecular Heterolysis of Organic Halides. XVIII. Solvolysis of Benzyl

- Chloride and *m*-Phenoxybenzyl Chloride in Benzyl Alcohol.
J. Org. Chem. Russia 28 (1992) : 1029-1033.
- [61] Sheehan, J. C.; Guziec, F. S. Amino Group Protection in Peptide Synthesis. 4,5-Diphenyl-4-oxazolin-2-one Group. J. Org. Chem. 38 (1973) : 3034-3040.
- [62] Haughton, L.; Williams, J. M. J. Enzymatic Hydrolysis and Selective Racemisation Reaction of α -Chloro Esters. Synthesis 6 (2001) : 943-946.
- [63] Casey, C. P.; Albin, L. D.; Burkhardt, T. J. Generation and Reactions of (Phenylmethylcarbene)pentacarbonyltungsten(0). J. Am. Chem. Soc. 99 (1977) : 2533-2538.
- [64] Firouzabadi, H.; Iranpoor, N.; Karimi, B.; Hazarkhani, H. Silica Chloride ($\text{SiO}_2\text{-Cl}$), a New Heterogeneous Reagent, for the Selective and Efficient Conversion of Benzylic Alcohols to Their Corresponding Chlorides and Iodides. Synth. Commun. 33 (2003) : 3671-3677.
- [65] Bradbury, R. H.; Walker, K. A. M. Synthesis of Analogs of Prostacyclin Containing a Thiazole Ring. J. Org. Chem. 48 (1983) : 1741-1750.

VITA

Miss Piyada Taboonpong was born on June 10, 1985 in Petchaburi, Thailand. She graduated with Bachelor Degree of Science in Chemistry from Chulalongkorn University in 2007. Since then, she has been a graduate student studying Organic Chemistry at Chulalongkorn University. She was supported by research grant for this Master Degree's thesis from the HM. King Rama IX 72th Anniversary scholarship of Chulalongkorn University and Center for Petroleum, Petrochemicals, and Advanced Materials.

Her present address is 70 Moo 5, T. Hnongsanoo, A. Muang, Petchaburi, 76000, Thailand.

