ORGANIC
LETTERS

2010
Vol. 12, No. 24
5776−5779

Synthesis of Stilbene and Distyrylbenzene Derivatives through Rhodium-Catalyzed *Ortho*-Olefination and Decarboxylation of Benzoic Acids

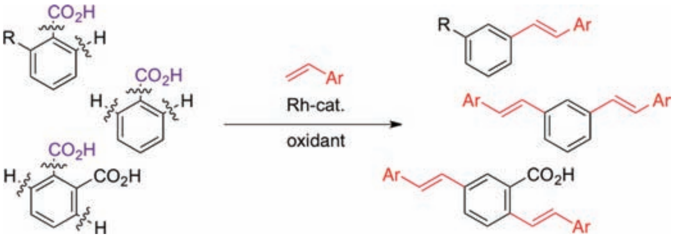
Satoshi Mochida, Koji Hirano, Tetsuya Satoh,* and Masahiro Miura*

Department of Applied Chemistry, Faculty of Engineering, Osaka University,
Suita, Osaka 565-0871, Japan

satoh@chem.eng.osaka-u.ac.jp; miura@chem.eng.osaka-u.ac.jp

Received November 12, 2010

ABSTRACT

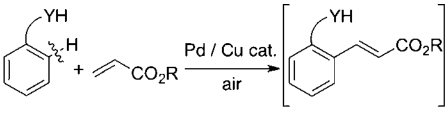


***Ortho*-substituted benzoic acids efficiently undergo precisely ordered *ortho*-olefination/decarboxylation upon treatment with styrenes in the presence of a rhodium catalyst and silver salt oxidant to afford the corresponding *meta*-substituted stilbene derivatives. The selective syntheses of 1,3- and 1,4-distyrylbenzenes have also been realized through the reactions of simple benzoic acid and phthalic acid, respectively, with styrene under similar conditions.**

Since stilbene and distyrylbenzene structures are found in various natural products[1] and organic materials,[2] the development of methods for their effective construction has attracted considerable attention in organic synthesis. The conventional syntheses of such derivatives through transition-metal-catalyzed cross-coupling and Mizoroki−Heck reactions or Wittig-type reactions usually need complicated multisteps forming halogen- and phosphorus-containing byproducts.

On the other hand, direct olefination reactions on aromatic rings involving regioselective C−H bond cleavage have been developed to provide more simple synthetic routes for vinylarene derivatives.[3] As early examples, we reported that 2-phenylphenols (Scheme 1, YH = 2-HOC$_6$H$_4$),[4] *N*-(arylsulfonyl)-2-phenylanilines (YH = 2-(ArSO$_2$NH)C$_6$H$_4$),[5] and benzoic acids (YH = CO$_2$H)[5] undergo regioselective olefination at the *ortho*-position of YH upon treatment with an alkene such as acrylate ester and an appropriate oxidant under

Scheme 1



YH = 2-HOC$_6$H$_4$, 2-(ArSO$_2$NH)C$_6$H$_4$, CO$_2$H

---

(1) For recent examples, see: (a) Hua, X.; Fu, Y.-J.; Zu, Y.-G.; Wu, N.; Kong, Y.; Li, J.; Peng, X.; Efferth, T. *J. Pharm. Biomed. Anal.* **2010**, *52*, 273. (b) Kong, Y.; Fu, Y.-J.; Zu, Y.-G.; Liu, W.; Wang, W.; Hua, X.; Yang, M. *Food Chem.* **2010**, *117*, 152. (c) Vitrac, X.; Bornet, A.; Vanderlinde, R.; Valls, J.; Richard, T.; Delaunay, J.-C.; Mérillon, J.-M.; Teissédre, P.-L. *J. Agric. Food Chem.* **2005**, *53*, 5664. (d) Syah, Y. M.; Aminah, N. S.; Hakim, E. H.; Aimi, N.; Kitajima, M.; Takayama, H.; Achmad, S. A. *Phytochemistry* **2003**, *63*, 913.

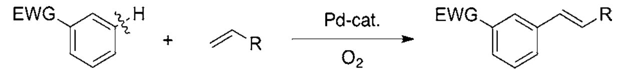
(2) For selected reviews, see: (a) Grimsdale, A. C.; Chan, K. L.; Martin, R. E.; Jokisz, P. G.; Holmes, A. B. *Chem. Rev.* **2009**, *109*, 897. (b) Kraft, A.; Grimsdale, A. C.; Holmes, A. B. *Angew. Chem., Int. Ed.* **1998**, *37*, 402. (c) Marder, S. R.; Kippelen, B.; Jen, A. K.-Y.; Peyghambarian, N. *Nature* **1997**, *388*, 845.

10.1021/ol1027392

palladium/copper catalysis. In each case, subsequent nucleophilic cyclization takes place to afford the corresponding heterocyclic product. Later, acetanilides,[6] benzylamines,[7] phenylacetic acids,[8] 1-phenylprazoles,[9] and 2-phenylethanols[10] have also been shown to undergo direct *ortho*-olefination under palladium or rhodium catalysis.

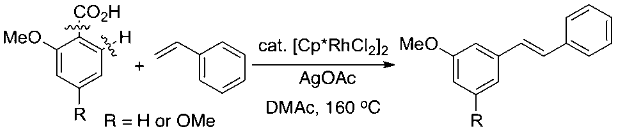
Recently, Yu and co-workers reported the novel palladium-catalyzed *meta*-olefination of arenes possessing an electron-withdrawing group (Scheme 2).[11] In this case, however, considerable amounts of *para*-olefinated byproduct are also formed.

Scheme 2



In the course of our further study of the direct olefination of benzoic acids,[12] we unexpectedly observed that *meta*-methoxystilbenes were exclusively produced upon treatment of 2-methoxybenzoic acids with styrene under rhodium catalysis, accompanied by decarboxylation[13−15] (Scheme 3).

Scheme 3



Note that methoxy-substituted stilbenes are of considerable interest due to their unique biological[16] and photophysical and -chemical properties.[17] The procedure was also found to be applicable to the syntheses of 1,3- and 1,4-distyrylbenzenes as well as a range of *meta*-substituted stilbenes. Expectedly, some distyrylbenzenes obtained have been found to show solid-state fluorescence. These new findings are described herein.

---

(3) For selected reviews concerning C−H bond functionalization, see: (a) Satoh, T.; Miura, M. *Chem.—Eur. J.* **2010**, *16*, 11212. (b) Satoh, T.; Miura, M. *Synthesis* **2010**, 3395. (c) Karimi, B.; Behzadnia, H.; Elhamifar, D.; Akhavan, P. F.; Esfahani, F. K. *Synthesis* **2010**, 1399. (d) Colby, D. A.; Bergman, R. G.; Ellman, J. A. *Chem. Rev.* **2010**, *110*, 624. (e) Sun, C.-L.; Li, B.-J.; Shi, Z.-J. *Chem. Commun.* **2010**, *46*, 677. (f) Ackermann, L.; Vicente, R.; Kapdi, A. R. *Angew. Chem., Int. Ed.* **2009**, *48*, 9792. (g) Chen, X.; Engle, K. M.; Wang, D.-H.; Yu, J.-Q. *Angew. Chem., Int. Ed.* **2009**, *48*, 5094. (h) Daugulis, O.; Do, H.-Q.; Shabashov, D. *Acc. Chem. Res.* **2009**, *42*, 1074. (i) McGlacken, G. P.; Bateman, L. M. *Chem. Soc. Rev.* **2009**, *38*, 2447. (j) Kakiuchi, F.; Kochi, T. *Synthesis* **2008**, 3013. (k) Lewis, J. C.; Bergman, R. G.; Ellman, J. A. *Acc. Chem. Res.* **2008**, *41*, 1013. (l) Ferreira, E. M.; Zhang, H.; Stoltz, B. M. *Tetrahedron* **2008**, *64*, 5987. (m) Park, Y. J.; Park, J.-W.; Jun, C.-H. *Acc. Chem. Res.* **2008**, *41*, 222. (n) Beccalli, E. M.; Broggini, G.; Martinelli, M.; Sottocornola, S. *Chem. Rev.* **2007**, *107*, 5318. (o) Herrerias, C. I.; Yao, X.; Li, Z.; Li, C.-J. *Chem. Rev.* **2007**, *107*, 2546. (p) Alberico, D.; Scott, M. E.; Lautens, M. *Chem. Rev.* **2007**, *107*, 174. (q) Godula, K.; Sames, D. *Science* **2006**, *312*, 67. (r) Conley, B. L.; Tenn, W. J., III; Young, K. J. H.; Ganesh, S. K.; Meier, S. K.; Ziatdinov, V. R.; Mironov, O.; Oxgaard, J.; Gonzales, J.; Goddard, W. A., III; Periana, R. A. *J. Mol. Catal. A: Chem.* **2006**, *251*, 8. (s) Kakiuchi, F.; Chatani, N. *Adv. Synth. Catal.* **2003**, *345*, 1077. (t) Ritleng, V.; Sirlin, C.; Pfeffer, M. *Chem. Rev.* **2002**, *102*, 1731. (u) Kakiuchi, F.; Murai, S. *Acc. Chem. Res.* **2002**, *35*, 826. (v) Dyker, G. *Angew. Chem., Int. Ed.* **1999**, *38*, 1698. (w) Kakiuchi, F.; Murai, S. *Top. Organomet. Chem.* **1999**, *3*, 47. (x) Shilov, A. E.; Shul'pin, G. B. *Chem. Rev.* **1997**, *97*, 2879.

(4) Miura, M.; Tsuda, T.; Satoh, T.; Nomura, M. *Chem. Lett.* **1997**, 1103.

(5) (a) Miura, M.; Tsuda, T.; Satoh, T.; Nomura, M. *J. Org. Chem.* **1998**, *63*, 5211. For the Rh-catalyzed version, see: (b) Ueura, K.; Satoh, T.; Miura, M. *J. Org. Chem.* **2007**, *72*, 5362.

(6) (a) Patureau, F. W.; Glorius, F. *J. Am. Chem. Soc.* **2010**, *132*, 9982. (b) Nishikata, T.; Lipshutz, B. H. *Org. Lett.* **2010**, *12*, 1972. (c) Rauf, W.; Thompson, A. L.; Brown, J. M. *Chem. Commun.* **2009**, 3874. (d) Houlden, C. E.; Bailey, C. D.; Ford, J. G.; Gagné, M. R.; Lloyd-Jones, G. C.; Booker-Milburn, K. I. *J. Am. Chem. Soc.* **2008**, *130*, 10066. (e) Wang, J.-R.; Yang, C.-T.; Liu, L.; Guo, Q.-X. *Tetrahedron Lett.* **2007**, *48*, 5449. (f) Amatore, C.; Cammoun, C.; Jutand, A. *Adv. Synth. Catal.* **2007**, *349*, 292. (g) Lee, G. T.; Jiang, X.; Prasad, K.; Repič, O.; Blacklock, T. J. *Adv. Synth. Catal.* **2005**, *347*, 1921. (h) Boele, M. D. K.; van Strijdonck, G. P. F.; de Vries, A. H. M.; Kamer, P. C. J.; de Vries, J. G.; van Leeuwen, P. W. N. M. *J. Am. Chem. Soc.* **2002**, *124*, 1586.

(7) Cai, G.; Fu, Y.; Li, Y.; Wan, X.; Shi, Z. *J. Am. Chem. Soc.* **2007**, *129*, 7666.

(8) (a) Engle, K. M.; Wang, D.-H.; Yu, J.-Q. *J. Am. Chem. Soc.* **2010**, *132*, 14137. (b) Engle, K. M.; Wang, D.-H.; Yu, J.-Q. *Angew. Chem., Int. Ed.* **2010**, *49*, 6169. (c) Shi, B.-F.; Zhang, Y.-H.; Lam, J. K.; Wang, D.-H.; Yu, J.-Q. *J. Am. Chem. Soc.* **2010**, *132*, 460. (d) Wang, D.-H.; Engle, K. M.; Shi, B.-F.; Yu, J.-Q. *Science* **2010**, *327*, 315.

(9) Umeda, N.; Hirano, K.; Satoh, T.; Miura, M. *J. Org. Chem.* **2009**, *74*, 7094.

(10) Lu, Y.; Wang, D.-H.; Engle, K. M.; Yu, J.-Q. *J. Am. Chem. Soc.* **2010**, *132*, 5916.

(11) Zhang, Y.-H.; Shi, B.-F.; Yu, J.-Q. *J. Am. Chem. Soc.* **2009**, *131*, 5072.

(12) Compared with benzoic acids, heteroarene carboxylic acids tend to readily lose their carboxyl group. For our recent studies on the decarboxylative arylation and vinylation of heteroarene carboxylic acids, see: (a) Miyasaka, M.; Fukushima, A.; Satoh, T.; Hirano, K.; Miura, M. *Chem.—Eur. J.* **2009**, *15*, 3674. (b) Nakano, M.; Tsurugi, H.; Satoh, T.; Miura, M. *Org. Lett.* **2008**, *10*, 1851. (c) Maehara, A.; Tsurugi, H.; Satoh, T.; Miura, M. *Org. Lett.* **2008**, *10*, 1159. (d) Okazawa, T.; Satoh, T.; Miura, M.; Nomura, M. *J. Am. Chem. Soc.* **2002**, *124*, 5286.

(13) For Pd-catalyzed decarboxylative *ipso*-vinylation of *ortho*-substituted benzoic acids, see: (a) Hu, P.; Kan, J.; Su, W.; Hong, M. *Org. Lett.* **2009**, *11*, 2341. (b) Tanaka, D.; Romeril, S. P.; Myers, A. G. *J. Am. Chem. Soc.* **2005**, *127*, 10323. (c) Tanaka, D.; Myers, A. G. *Org. Lett.* **2004**, *6*, 433. (d) Myers, A. G.; Tanaka, D.; Mannion, M. R. *J. Am. Chem. Soc.* **2002**, *124*, 11250.

(14) For Pd-catalyzed decarboxylative *ipso*-arylation of activated benzoic acids, see: (a) Goossen, L. J.; Lange, P. P.; Rodriguez, N.; Linder, C. *Chem.—Eur. J.* **2010**, *16*, 3906. (b) Goossen, L. J.; Rodriguez, N.; Lange, P. P.; Linder, C. *Angew. Chem., Int. Ed.* **2010**, *49*, 1111. (c) Goossen, L. J.; Linder, C.; Rodriguez, N.; Lange, P. P. *Chem.—Eur. J.* **2009**, *15*, 9336. (d) Shang, R.; Fu, Y.; Wang, Y.; Xu, Q.; Yu, H.-Z.; Liu, L. *Angew. Chem., Int. Ed.* **2009**, *48*, 9350. (e) Goossen, L. J.; Rodriguez, N.; Linder, C. *J. Am. Chem. Soc.* **2008**, *130*, 15248. (f) Goossen, L. J.; Zimmermann, B.; Knauber, T. *Angew. Chem., Int. Ed.* **2008**, *47*, 7103. (g) Voutchkova, A.; Coplin, A.; Leadbeater, N. E.; Crabtree, R. H. *Chem. Commun.* **2008**, 6312. (h) Becht, J.-M.; Le Drian, C. *Org. Lett.* **2008**, *10*, 3161. (i) Becht, J.-M.; Catala, C.; Le Drian, C.; Wagner, A. *Org. Lett.* **2007**, *9*, 1781. (j) Goossen, L. J.; Rodríguez, N.; Melzer, B.; Linder, C.; Deng, G.; Levy, L. M. *J. Am. Chem. Soc.* **2007**, *129*, 4824. (k) Goossen, L. J.; Deng, G.; Levy, L. M. *Science* **2006**, *313*, 662.

(15) For protodecarboxylation of benzoic acids, see: (a) Cornella, J.; Sanchez, C.; Banawa, D.; Larrosa, I. *Chem. Commun.* **2009**, 7176. (b) Gooβen, L. J.; Linder, C.; Rodríguez, N.; Lange, P. P.; Fromm, A. *Chem. Commun.* **2009**, 7173. (c) Goossen, L. J.; Thiel, W. R.; Rodríguez, N.; Linder, C.; Melzer, B. *Adv. Synth. Catal.* **2007**, *349*, 2241. (d) Dickstein, J. S.; Mulrooney, C. A.; O'Brien, E. M.; Morgan, B. J.; Kozlowski, M. C. *Org. Lett.* **2007**, *9*, 2441.

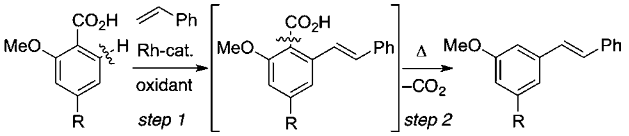
(16) For recent example, see: (a) Mazué, F.; Colin, D.; Gobbo, J.; Wegner, M.; Rescifina, A.; Spatafora, C.; Fasseur, D.; Delmas, D.; Meunier, P.; Tringali, C.; Latruffe, N. *Eur. J. Med. Chem.* **2010**, *45*, 2972. (b) Wang, T. T. Y.; Schoene, N. W.; Kim, Y. S.; Mizuno, C. S.; Rimando, A. M. *Mol. Nutr. Food Res.* **2010**, *54*, 335. (c) Weng, C.-J.; Wu, C.-F.; Huang, H.-W.; Wu, C.-H.; Ho, C.-T.; Yen, G.-C. *J. Agric. Food Chem.* **2010**, *58*, 2886. (d) Sarpietro, M. G.; Ottimo, S.; Giuffrida, M. C.; Spatafora, C.; Tringali, C.; Castelli, F. *Int. J. Pharm.* **2010**, *388*, 144.

(17) (a) Chen, G.; Cao, C. *J. Phys. Org. Chem.* **2010**, *23*, 776. (b) Roberts, J. C.; Pincock, J. A. *Can. J. Chem.* **2003**, *81*, 709. (c) Papper, V.; Pines, D.; Likhtenshtein, G.; Pines, E. *J. Photochem. Photobiol., A* **1997**, *111*, 87.

In an initial attempt, the reaction of 2,4-dimethoxybenzoic acid (**1a**) with styrene (**2a**) (2 equiv) was conducted under different conditions (Table S1 in the Supporting Information). Although $[Cp^*RhCl_2]_2$ (1 mol %) and AgOAc (2−3 equiv) were found to be suitable choices for the catalyst and oxidant, respectively, the yield of 3,5-dimethoxystilbene (**3a**) was moderate (~50%).

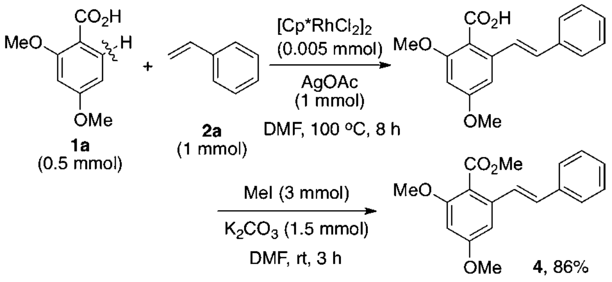
The reaction appears to proceed via (i) the regioselective olefination at the 6-position of 2-methoxybenzoic acids under rhodium catalysis (Scheme 4, step 1) and (ii) the subsequent decarboxylation of resulting 2-methoxy-6-styrylbenzoic acids (step 2).

Scheme 4



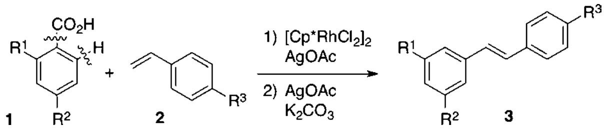
It was revealed that a relatively high temperature (160 °C) was needed for not step 1 but step 2. Thus, the olefination of **1a** with **2a** proceeded smoothly even at 100 °C to produce the corresponding 2-stilbenecarboxylic acid, which was subsequently methyl-esterified for quantification (Scheme 5).

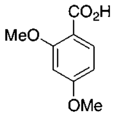
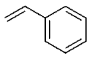
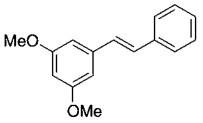
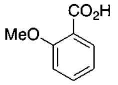
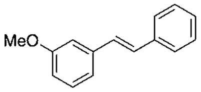
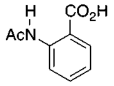
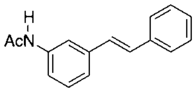
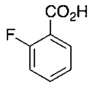
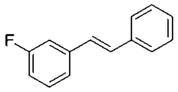
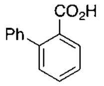
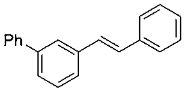
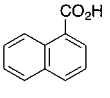
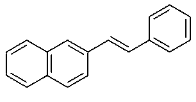
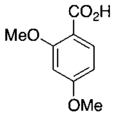
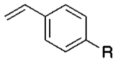
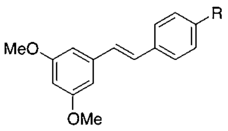
Scheme 5



To our delight, the stepwise heating, at 120 °C for 8 h (olefination) and then at 160 °C for 4 h (decarboxylation), significantly increased the yield of **3a**. It was further improved by the addition of K_2CO_3 and AgOAc[15] at the second step up to 85% (Table 1, entry 1). Under similar conditions, 2-methoxy- (**1b**), 2-acetylamino- (**1c**), 2-fluoro- (**1d**), and 2-phenyl- (**1e**) benzoic acids also underwent decarboxylative olefination to afford the corresponding *meta*-substituted stilbenes **3b**−**e** (entries 2−5). 2-Styrylnaphthalene (**3f**) could be synthesized effectively from 1-naphthoic acid (**1f**) and **2a** (entry 6). Substituted styrenes **2b**−**d** also reacted with **1a** to give substituted stilbenes **3g**−**i** (entries 7−9). It should be noted that the thus obtained 3,5,4′-trimethoxystilbene (**3g**), an analog of naturally occurring resveratrol,[18] is of particular interest for its biological activities including anticancer properties.[16]

Table 1. Reaction of Benzoic and Naphthoic Acids **1** with Styrenes **2**[a]

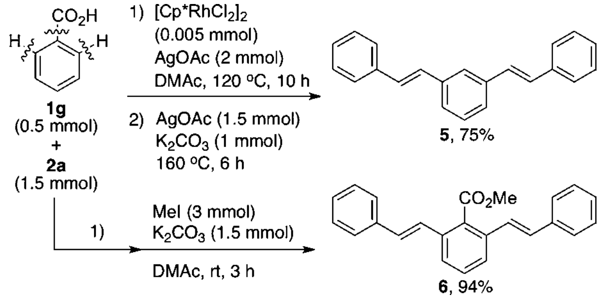


entry	1	2	product, % yield[b]
1	 **1a**	 **2a**	 **3a**, 85 (80)
2	 **1b**	**2a**	 **3b**, 71 (66)
3	 **1c**	**2a**	 **3c**, 74 (66)
4	 **1d**	**2a**	 **3d**, 74 (66)
5	 **1e**	**2a**	 **3e**, 55 (54)
6	 **1f**	**2a**	 **3f**, (70)
7	 **1a**	 **2b**: R = OMe	 **3g**: R = OMe, 75 (73)
8		**2c**: R = Bu^t	**3h**: R = Bu^t, 81 (67)
9		**2d**: R = Cl	**3i**: R = Cl, 76 (65)

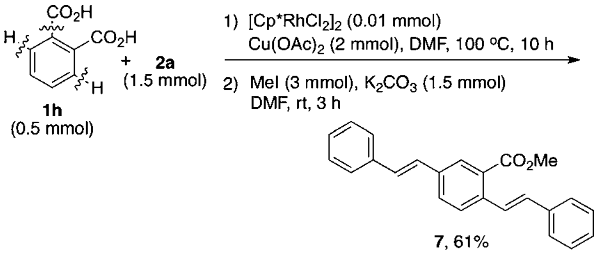
[a] Reaction conditions: (1) **1** (0.5 mmol), **2** (1 mmol), $[(Cp^*RhCl_2)_2]$ (0.005 mmol), AgOAc (1−1.5 mmol), DMAc (2.5 mL) at 120 °C under N_2 for 8 h; (2) With the addition of AgOAc (1 mmol) and K_2CO_3 (1 mmol) at 160 °C under N_2 for 4 h. [b] GC yield based on the amount of **1** used. Value in parentheses indicates yield after isolation.

Unsubstituted benzoic acid (**1g**) also underwent the present decarboxylative olefination upon treatment with **2a** under the stepwise heating conditions (Scheme 6). In this case, double olefination took place at the 2- and 6-positions to form 1,3-distyrylbenzene (**5**)[19] selectively. As in the reaction of **1a** (Scheme 5), the intermediary formation of 2,6-distyrylben-

Scheme 6



Scheme 7



zoic acid was confirmed and quantitated after esterifiaction to the methyl ester (**6**) (Scheme 6).

Interestingly, a 1,4-distyrylbenzene derivative, which is of importance in organic materials field,[20] could be obtained through the reaction of phthalic acid (**1h**) with **2a** (Scheme 7). Thus, treatment of **1h** with **2a** in the presence of $[Cp^*RhCl_2]_2$ and $Cu(OAc)_2{\cdot}H_2O$, as a catalyst and an oxidant, respectively, in DMF at 100 °C for 10 h followed by methyl esterification resulted in the selective formation of methyl 2,5-distyrylbenzoate (**7**).

Some obtained distyrylbenzenes showed solid-state fluorescence as described above. Notably, **6** exhibited a relatively strong emission compared to a typical emitter, anthracene, by a factor of 2.2 (λ_{emis} = 413 nm, Figure S1 in the Supporting Information).

In summary, we have succeeded in preparing a series of *meta*-substituted stilbenes as well as 1,3- and 1,4-distyrylbenzene derivatives from readily available benzoic acids and styrenes through precisely ordered *ortho*-olefination/decarboxylaion under rhodium catalysis. In these reactions, the carboxyl function acts as a unique, removable directing group. Work is underway toward further development of relevant reactions around the key functional group.

Acknowledgment. This work was partly supported by Grants-in-Aid from the Ministry of Education, Culture, Sports, Science and Technology, Japan.

Supporting Information Available: Additional results, standard experimental procedure, and characterization data of products. This material is available free of charge via the Internet at http://pubs.acs.org.

OL1027392

---

[18] (a) Iriti, M.; Faoro, F. *Med. Hypotheses* **2006**, *67*, 833. (b) Heynekamp, J. J.; Weber, W. M.; Hunsaker, L. A.; Gonzales, A. M.; Orland, R. A.; Deck, L. M.; Vander Jagt, D. L. *J. Med. Chem.* **2006**, *49*, 7182. (c) Vessières, A.; Top, S.; Pigeon, P.; Hillard, E.; Boubeker, L.; Spera, D.; Jaouen, G. *J. Med. Chem.* **2005**, *48*, 3937. (d) Jang, M.; Cai, L.; Udeani, G. O.; Slowing, K. V.; Thomas, C. F.; Beecher, C. W. W.; Fong, H. H. S.; Farnsworth, N. R.; Kinghorn, A. D.; Mehta, R. G.; Moon, R. C.; Pezzuto, J. M. *Science* **1997**, *275*, 218.

[19] For example, see: (a) Ginocchietti, G.; Mazzucato, U.; Spalletti, A. *J. Photochem. Photobiol., A* **2008**, *196*, 233. (b) Tang, Y.; Wang, Y.; Wang, X.; Xun, S.; Mei, C.; Wang, L.; Yan, D. *J. Phys. Chem. B* **2005**, *109*, 8813. (c) Marri, E.; Galiazzo, G.; Mazzucato, U.; Spalletti, A. *Chem. Phys.* **2008**, *312*, 205. (d) Tang, Y.; Wang, Y.; Wang, G.; Wang, H.; Wang, L.; Yan, D. *J. Phys. Chem. B* **2004**, *108*, 12921. (e) Konstandakopoulou, F. D.; Iconomopoulou, S. M.; Gravalos, K. G.; Kallitsis, J. K. *Chem. Mater.* **2000**, *12*, 2957. (f) Lane, P. A.; Mellor, H.; Martin, S. J.; Hagler, T. W.; Bleyer, A.; Bradley, D. D. C. *Chem. Phys.* **2000**, *257*, 41. (g) Hidaka, T.; Nakatani, H.; Yamanaka, K. *Jpn. Kokai Tokkyo Koho* **1991**; 03056449. (h) Pavia, M. R.; Moos, W. H.; Hershenson, F. M. *J. Org. Chem.* **1990**, *55*, 560. (i) Noller, K.; Kosteyn, F.; Meier, H. *Chem. Ber.* **1988**, *121*, 1609. (j) Colle, R.; Gozzo, F.; Camaggi, G.; Siddi, G. *Jpn. Kokai Tokkyo Koho* **1978**, 53127425.

[20] For example, see: (a) Wang, Y.; Liu, D.; Ikeda, S.; Kumashiro, R.; Nouch, R.; Xu, Y.; Shang, H.; Ma, Y.; Tanigaki, K. *Appl. Phys. Lett.* **2010**, *97*, 033305. (b) Shimizu, M.; Hiyama, T. *Chem.—Asian J.* **2010**, *5*, 1516. (c) Nielsen, C. B.; Arnbjerg, J.; Johnsen, M.; Jørgensen, M.; Ogilby, P. R. *J. Org. Chem.* **2009**, *74*, 9094. (d) Xie, Z.; Xie, W.; Li, F.; Liu, L.; Wang, H.; Ma, Y. *J. Phys. Chem. C* **2008**, *112*, 9066. (e) Xie, W.; Li, F.; Wang, H.; Xie, Z.; Shen, F.; Ma, Y.; Lu, W.; Zhang, D.; Ma, D. *Appl. Opt.* **2007**, *46*, 4431. (f) Xie, Z.; Yang, B.; Li, F.; Cheng, G.; Liu, L.; Yang, G.; Xu, H.; Ye, L.; Hanif, M.; Liu, S.; Ma, D.; Ma, Y. *J. Am. Chem. Soc.* **2005**, *127*, 14152. (g) Koch, F.; Heitz, W. *Macromol. Chem. Phys.* **1997**, *198*, 1531. (h) Oberski, J.; Bolle, B.; Schaper, A.; Greiner, A. *Polym. Adv. Technol.* **1993**, *5*, 105. (i) Vestweber, H.; Oberski, J.; Greiner, A.; Heitz, W.; Mahrt, R. F.; Bässler, H. *Adv. Mater. Opt. Electron.* **1993**, *2*, 197.