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Sequential Removal of Photolabile Protecting Groups for Carbonyls with Controlled Wavelength

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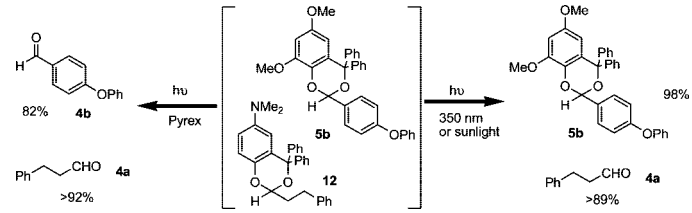

A group of robust and easy-to-make photolabile protecting groups (PPGs) for carbonyl compounds has been developed. Sequential removal of different PPGs is achieved via control of irradiation wavelength.

Introduction

Protecting groups are essential tools in organic chemistry.[1] Among various protecting groups, photolabile protecting groups (PPGs) have very valuable features, including their neutral removal by light without the use of any chemical reagent and the capability of releasing substrates in a spatially and temporally controlled manner. These advantages are appealing to both basic and applied sciences, and development of practically useful PPGs is highly sought.[1,2]

As a reactive functionality, carbonyl groups often need to be protected in the course of a multistep synthesis. The search for practically useful PPGs for carbonyl groups was initiated several decades ago. Despite progress in the field, inherent drawbacks of the early approaches hindered their wide utilization in synthetic chemistry and other disciplines.[3]

Recently, we have developed two novel PPGs for carbonyl protection, α,α-diphenyl-5-methoxysalicyl alcohol (**1**),[4] evolved from the triphenylmethyl dye photochemistry, and 3,5-dimethoxysalicyl alcohol (**2**),[5] designed on the basis of the excited-state meta effect.[6] To further enrich the PPG tool box for carbonyl protection and to provide more options for different applications, herein we report our work on other PPGs for carbonyls. With this extension of our previous work, we were able to sequentially release carbonyl compounds protected with different PPGs by controlling the irradiation wavelength.

Results and Discussion

The first new addition to the toolbox is α,α-diphenyl-3,5-dimethoxysalicyl alcohol (**3**),[7] another robust PPG for carbonyl protection. When the protection procedures developed for **1** were adopted for **3**, protection of carbonyl compounds **4a**−**4e** led to acetals/ketals (**5a**−**5e**) in excellent yields (Table 1). These protection procedures require an acid catalyst. For example, the

(1) Greene, T. W.; Wuts, P. G. M. *Protective Groups in Organic Synthesis*; Wiley: New York, 1999.

(2) For reviews and monographs, see: (a) Pillai, V. N. R. *Synthesis* **1980**, 1. (b) Binkley, R. W.; Flechtner, T. W. In *Synthetic Organic Photochemistry*; Horspool, W. M., Ed.; Plenum: New York, 1984; p 375. (c) Pillai, V. N. R. *Org. Photochem.* **1987**, *9*, 225. (d) Givens, R. S.; Kueper, L. W., III *Chem. Rev.* **1993**, *93*, 55. (e) Pirrung, M. C. *Chem. Rev.* **1997**, *97*, 473. (f) Guillier, F.; Orain, D.; Bradley, M. *Chem. Rev.* **2000**, *100*, 2091. (g) Bochet, C. G. *J. Chem. Soc., Perkin Trans. 1* **2002**, 125. (h) Pelliccioli, A. P.; Wirz, J. *Photochem. Photobiol. Sci.* **2002**, *1*, 441. (i) *Dynamic Studies in Biology*; Goeldner, M., Givens, R. S., Eds.; Wiley-VCH: Weinheim, Germany, 2005. (j) Mayer, G.; Heckel, A. *Angew. Chem., Int. Ed.* **2006**, *45*, 4900.

(3) (a) Hebert, J.; Gravel, D. *Can. J. Chem.* **1974**, *52*, 187. (b) Gravel, D.; Herbert, J.; Thoraval, D. *Can. J. Chem.* **1983**, *61*, 400. (c) Gravel, D.; Murray, S.; Ladouceur, G. *J. Chem. Soc., Chem. Commun.* **1985**, *24*, 1828. (d) Friedrich, E.; Lutz, W.; Eichenauer, H.; Enders, D. *Synthesis* **1977**, *12*, 893. (e) Hoshino, O.; Sawaki, S.; Umezawa, B. *Chem. Pharm. Bull.* **1979**, *27*, 538. (f) Aurell, M. J.; Boix, C.; Ceita, M. L.; Llopis, C.; Tortajada, A.; Mestres, R. *J. Chem. Res. Synop.* **1995**, *12*, 452. (g) Ceita, L.; Maiti, A. K.; Mestres, R.; Tortajada, A. *J. Chem. Res. Synop.* **2001**, *10*, 403. (h) McHale, W. A.; Kutateladze, A. G. *J. Org. Chem.* **1998**, *63*, 9924. (i) Lu, M.; Fedoryak, O. D.; Moister, B. R.; Dore, T. M. *Org. Lett.* **2003**, *5*, 2119. (j) Blanc, A.; Bochet, C. G. *J. Org. Chem.* **2003**, *68*, 1138. (k) Kantevari, S.; Narasimhaji, C. V.; Mereyala, H. B. *Tetrahedron* **2005**, *61*, 5849.

(4) Wang, P.; Hu, H.; Wang, Y. *Org. Lett.* **2007**, *9*, 1533.

(5) (a) Wang, P.; Hu, H.; Wang, Y. *Org. Lett.* **2007**, *9*, 2831. (b) Irradiation of acetals formed by **4a** with salicyl alcohol, 5-methoxysalicyl alcohol, and **2** afforded **4a** in 51%, 51%, and 73% yield, respectively, when the photoreactions were carried out in CH_3CN/water for 1 h with a 450 W medium pressure mercury lamp equipped with a Vycor filter sleeve.

(6) (a) Zimmerman, H. E.; Sandel, V. R. *J. Am. Chem. Soc.* **1963**, *85*, 915. (b) Zimmerman, H. E.; Somasekhara, S. *J. Am. Chem. Soc.* **1963**, *85*, 922. (c) Zimmerman, H. E. *J. Am. Chem. Soc.* **1995**, *117*, 8988. (d) Zimmerman, H. E. *J. Phys. Chem. A* **1998**, *102*, 5616.

(7) PPG **3** was readily synthesized from the known 3,5-dimethoxysalicylic acid.[4]

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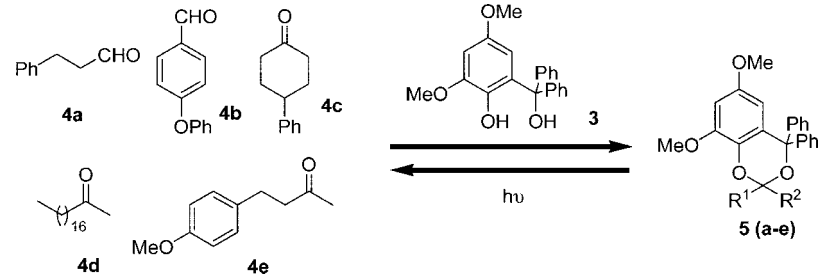
TABLE 1. Protection and Photorelease of Carbonyl Compounds



entry	carbonyls	protection yield (%)	deprotection yield (%)[d]	recovered **3** (%)[f]	irradiation time (min)
1	**4a**	99[a]	92[e]	35	30
2	**4b**	93[b]	82	0	44
3	**4c**	99[c]	86	39	25
4	**4d**	99[c]	88	30	25
5	**4e**	99[c]	91	46	25

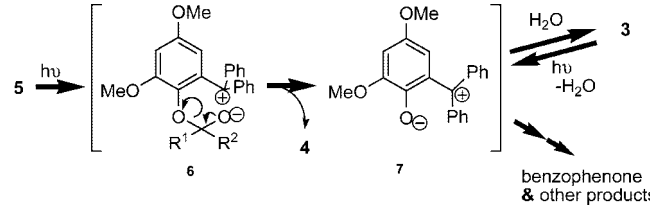
[a] PPG **3** (0.23 mmol), **4a** (0.2 mmol), and *p*TsOH (0.02 mmol) in 0.8 mL of benzene, 23 °C, 20 h. [b] PPG **3** (0.3 mmol), **4b** (0.2 mmol), *p*TsOH (0.01 mmol), and $MgSO_4$ (0.8 mmol) in 1.0 mL of benzene, 23 °C, 24 h. [c] PPG **3** (0.3 mmol), carbonyl compound (0.2 mmol), *p*TsOH (0.01 mmol), and P_2O_5 (0.4 mmol) in 1.0 mL of benzene, 23 °C, 1 h. [d] Compound **5** (8.0×10^{-4} M) in CH_3CN with 4−10% (v/v) H_2O was irradiated with a 450 W medium pressure mercury lamp equipped with a Pyrex filter sleeve (<280 nm) without excluding air. [e] Isolated as the oxime derivative due to the volatile nature of **4a**. The acetal **5a** is stable under the derivatization conditions. [f] Isolated yields.

TABLE 2. Comparison of Photochemical Efficiency

entry	PPG	$\epsilon(\lambda)$ of acetal[a]	Φ^b	deprotection yield (%) [c,d]	irradiation time (min)
1	**1**	4737 (296 nm)	0.11	90	60
2	**2**	3241 (290 nm)	0.03	81	240
3	**3**	4169 (297 nm)	0.17	92	30

[a] Extinction coefficient (M^{-1} cm^{-1}) of the acetal of **4a**. [b] Quantum yields for producing of **4a** in $MeCN/H_2O$ (9:1) upon irradiation with monochromatic light (centered at 285 nm). [c] Acetal in $MeCN/H_2O$ (9:1) irradiated with a 450 W medium pressure mercury lamp equipped with a Pyrex filter sleeve (>280 nm) without excluding air. [d] Isolated as the oxime derivative due to the volatile nature of **4a**.

SCHEME 1. Mechanism of Deprotection Reactions



aliphatic aldehyde **4a** was conveniently protected in an excellent yield in the presence of 5−10 mol % of *p*TsOH and a slight excess of **3** (Table 1, entry 1). For ketones, the dehydrating reagent (P_2O_5) was necessary for a fast and quantative protection (Table 1, entries 3−5).

With ready access to acetals/ketals (**5a**−**5e**), we studied the photochemical removal of the PPG from **5**. In the cases examined (Table 1), photochemical reactions went smoothly to release aldehydes and ketones in high yields, similar to the results obtained with PPGs **1** and **2**.[4,5] It is noteworthy that there are two major improvements of PPG **3** when compared with **1** and **2**. One is that the rate of removing **3** was faster than that of removing **1** and **2** under the same irradiation conditions (Table 2). The quantum yields of releasing **4a** from protection of **1**, **2**, and **3** were 0.11, 0.03, and 0.17, respectively.[8,9] In preparative runs, it took less than 30 min to remove **3**, whereas removal of **1** and **2** typically took 60−80 min and 3−4 h, respectively.[4,5]

The other improvement of the new PPG is that various amounts of PPG **3** were recovered from Pyrex-filtered irradiation of **5** when water was used as a cosolvent. On the contrary, there were no detectable amounts of **1** or **2** in the corresponding photochemical deprotection reactions under the same conditions. Several factors influenced the amounts of recovered **3**. For example, the yield of **3** increased with more water present in the reaction solution, but the yields of obtained carbonyl compounds were essentially not affected. Irradiation of **5a** and **5e** in $MeCN/H_2O$ (9:1) led to **3** in 35% and 46% yield, respectively; the recovery of **3** from **5a** increased to 58% in $MeCN/H_2O$ (3:1) and to 68% from **5e** in $MeCN/H_2O$ (1:1). We hypothesized that **3** was produced in the reaction of water with the intermediate **7** generated from fragmentation of zwitterion **6** (Scheme 1). Extended exposure of **3** to light caused severe decomposition. For example, irradiation of **5a** in $MeCN/H_2O$ (3:1) for 40 min led to only 23% recovered **3**, significantly lower than 58% from 30 min of irradiation. Decomposition of **3** via **7** could be a possible pathway, since benzophenone formed in both photoreactions of **5** and pure PPG **3** without deoxygenation.[10] Pisova and co-workers observed formation of benzophenone upon irradiation of various *o*-fuchsones, which was attributed to [8 + 2] cycloaddition of molecular oxygen to the quinonoid trienone π-system and the subsequent fragmentations

(8) (a) Quantum yields were determined by chemical actinometry. Defoin, A.; Defoin-Straatmann, R.; Hildenbrand, K.; Bittersmann, E.; Kreft, D.; Kuhn, H. J. *J. Photochem.* **1986**, *33*, 237. (b) The monochromatic light centering at 285 nm (and opaque above 325 nm and below 250 nm) was obtained by passing light from a 450 W medium pressure mercury lamp through three quartz cuvettes containing 2 M $NiSO_4$ in 5% H_2SO_4 (cell 1), 0.8 M $CoSO_4$ in 5% H_2SO_4 (cell 2), and 2.46×10^{-4} M $BiCl_3$ in concentrated HCl/H_2O (2:3) (cell 3).[9] (c) The monochromatic light centering at 330 nm (and opaque above 368 nm and below 292 nm) was obtained by passing light from a 450 W medium pressure mercury lamp through a filter solution in a quartz cuvette. The filter solution was prepared by dissolving $NiSO_4 \cdot 7H_2O$ (11.2 g), $CoSO_4 \cdot 7H_2O$ (5.5 g), $CuSO_4 \cdot 5H_2O$, and KNO_3 (0.5 g) in 25 mL of 10% H_2SO_4.[9]

(9) (a) Zimmerman, H. E.; Nuss, J. M.; Tantillo, A. W. *J. Org. Chem.* **1988**, *53*, 3792. (b) Zimmerman, H. E. *Mol. Photochem.* **1971**, *3*, 281.

(10) PPG 3 (0.2 mmol) in 250 mL of CH_3CN/H_2O (9:1) was irradiated with a Pyrex-filtered 450 W medium pressure mercury lamp for 10 min, and an unknown compound formed (unknown/**3** = 1:1). The characteristic ^1H NMR peaks of this unknown are 5.98 (d, $J = 2.6$ Hz, 1 H), 5.74 (d, $J = 2.6$ Hz, 1 H), 3.70 (s, 3 H), and 3.54 (s, 3 H). After another 15 min of irradiation, the unknown compound decomposed and a significant amount of benzophenone formed, along with a complex mixture of other unknowns.

TABLE 3. Stability of 5a under Various Conditions

entry	reagent[a]	solvent	conditions	**5a** (%)[c]
1	PhLi[b]	THF	−78 to 23 °C, 6 h	100
2	$LiAlH_4$	THF	23 °C, 24 h	100
3	$NaBH_4$	THF	23 °C, 24 h	100
4	H_2, Pd/C[d]	THF	23 °C, 18 h	100
5	*t*-BuOK	MeCN	23 °C, 24 h	100
			80 °C, 2 h	100
6	DDQ	MeCN	23 °C, 24 h	100
			80 °C, 2 h	94
7	CAN	MeCN	23 °C, 24 h	0
			80 °C, 2 h	0
8	AcOH	MeCN	23 °C, 24 h	100
			80 °C, 2 h	100
9	TFA	MeCN	23 °C, 24 h	100
			80 °C, 2 h	91
10	HCl (37%)	MeCN	23 °C, 24 h	100
			80 °C, 2 h	65
11	*p*TsOH	MeCN	23 °C, 24 h	47
			80 °C, 2 h	0

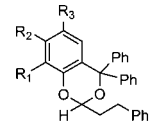
[a] Acetal **5a** (0.01 mmol) in 1.0 mL of MeCN or THF treated with reagent (>0.20 mmol). [b] Acetal **5a** (0.05 mmol) in 1.0 mL of dry THF treated with 0.4 mL of PhLi (2.0 M in Bu_2O) under argon. [c] Yields determined by ^1H NMR. [d] Acetal **5a** (0.02 mmol) in 2.0 mL of THF.

of the resulting 1,2,3-trioxanaphthalene.[11] When the photoreactions were conducted under nitrogen, the production of benzophenone from **5** and **3** diminished. With **5b**, PPG **3** was not observed after 44 min of irradiation (Table 1, entry 2) and was observed in only <10% (based on released **4b**) after 10 min of irradiation (with conversion of **5b** > 50%). Presumably, the decomposition pathway of **3** was altered in the presence of **4b**. Indeed, irradiation of PPG **3** with 1 equiv of **4b** in CD_3CN/D_2O (9:1) for only 10 min led to decomposition of more than 80% **3** to a complex mixture.[12] Without **4b**, only 37% **3** was consumed under the same irradiation conditions and was converted mainly to an unknown compound that was also observed in a larger scale run.[10]

The obtained acetals/ketals (**5a**−**5e**) displayed a useful range of dark stability toward various chemical reagents and were stable under laboratory lighting (Table 3, exemplified with **5a**). Acetal **5a** withstood mild acid conditions (Table 3, entries 8−10) yet was susceptible in the presence of excess *p*TsOH (entry 11). However, the electron-rich aromatic system of **5a** did not survive strong oxidation conditions, and the acetal completely decomposed upon treatment with cerium ammonium nitrate (CAN).

Structural modification of the salicyl alcohol chromophore by changing the position and nature of the substituents resulted in more PPGs with considerably different photochemical properties. For comparison, acetals of 3-phenylpropanal (**4a**) with these PPGs were prepared and studied (Table 4). Irradiation with Pyrex-filtered light for 30 min released more **4a** from **5a** (with two *meta* methoxyl groups) than from **8** (with one *meta* methoxyl group).[4] Without a *meta* methoxyl group, acetal **9** released much less **4a** (only 5%). For acetal **10**, most of the acetal (>99%) was recovered under the same irradiation conditions. However, 10 min of irradiation with Vycor-filtered light (>210 nm) led to efficient release of **4a** from acetals **5a** and **8**−**10** in high yields. With a dimethylamino auxochrome in the PPGs, there is a notable bathochromic shift of the UV bands of both acetal **11** (with a *para* amino group) and **12** (with a *meta* amino group), when compared with their counterparts having a methoxyl auxochrome (**9** and **8**, Figure 1). Pyrex-filtered irradiation of **11** and **12** for 16 min provided **4a** in 87% and 99% yield, respectively. These data along with the UV spectra of the acetals (Figure 1, $c = 2.0 \times 10^{-5}$ M) suggested that the auxochrome(s) located at different position(s) of the salicyl alcohol skeleton mainly affected the photolysis by changing chromophore absorption profiles. Nonetheless, the *meta* effect also influenced the reaction outcome to some extent, as shown in the photoreaction of **12** versus **11** (99% vs 87%) and **8** versus **9** (99% vs 92%) under the same conditions. Since the photochemical removal of **2** to release **4a** (Table 1) was significantly slower than the photoreactions of acetals **5a** and **8**−**12**, the two benzylic phenyl groups of the salicyl alcohol skeleton seemed to have a more important role in facilitating the benzylic C−O bond cleavage than the *meta* effect.

TABLE 4. Evaluation of Different PPGs



8: $R_1 = R_2 = H$, $R_3 = OMe$
9: $R_1 = H$, $R_2 = OMe$, $R_3 = H$
10: $R_1 = R_2 = OMe$, $R_3 = H$
11: $R_1 = H$, $R_2 = N(Me)_2$, $R_3 = H$
12: $R_1 = R_2 = H$, $R_3 = N(Me)_2$

	yields (%) of obtained **4a**[a,b]					
	5a	**8**	**9**	**10**	**11**	**12**
Pyrex	92[c]	88[c]	5[c]	<1[c]	87[d]	99[d]
Vycor	96[e]	99[e]	92[e]	82[e]		

[a] Irradiated with a 450 W medium pressure mercury lamp equipped with a Pyrex or a Vycor filter sleeve without excluding air, with the substrate concentration of 8.0×10^{-4} M in CH_3CN/H_2O (9:1) (v/v). [b] Isolated as the oxime. [c] 30 min of irradiation. [d] 16 min of irradiation. [e] 10 min of irradiation.

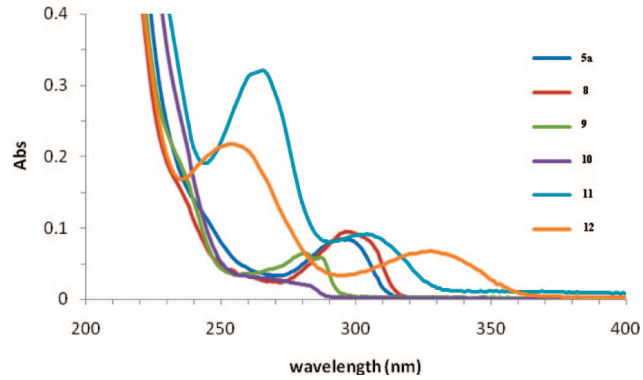


FIGURE 1. UV spectra of acetals.

Among various new PPGs studied, α,α-diphenyl-5-(dimethylamino)salicyl alcohol (**14**) used in acetal **12** appeared to be more robust, with higher potential for biological applications due to its longer absorption wavelength and good photochemical efficiency ($\Phi = 0.13$).[8,9] PPG **14** was readily prepared from the commercially available 5-aminosalicylic acid (**13**) (Scheme 2). Installation of **14** onto **4a** was relatively inefficient at room temperature, but reflux in toluene afforded the desired acetal **12** in 94% yield.

As anticipated, on one hand, acetal **12** was more stable than **5a** upon acid treatment (Table 5). Presumably the inductive effect from protonated dimethylamino group in **12** made acid-activation of acetal oxygens and subsequent heterolysis of a C−O bond more difficult. On the other hand, acetal **12** became more susceptible toward oxidants, degrading completely upon the DDQ treatment at room temperature, whereas **5a** remained intact under the same conditions.

(11) Pisova, M.; Soucek, M. *Collect. Czech. Chem. Commun.* **1982**, *47*, 3318.
(12) The small scale runs were conducted in quartz cuvettes, with **3** (2.7 mg, 8×10^{-3} mmol) in 2.0 mL of solvent with Pyrex-filtered light from a 450 W medium pressure mercury lamp.

SCHEME 2. Synthesis and Application of PPG 14

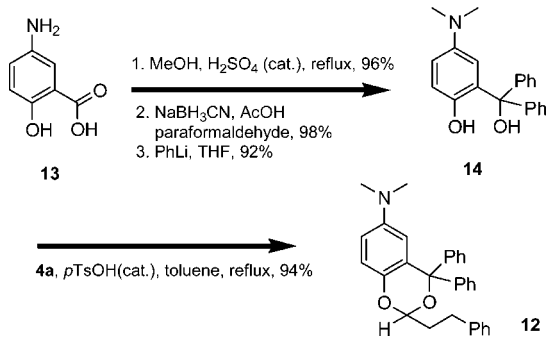
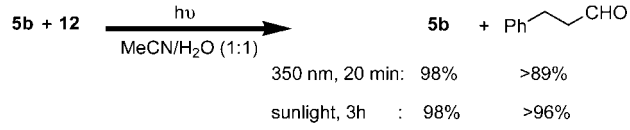


TABLE 5. Stability of 12 under Acidic Conditions

entry	reagent [a]	solvent	conditions	**12** (%)[b]
1	AcOH	MeCN	23 °C, 24 h	100
2	TFA	MeCN	23 °C, 24 h	100
			80 °C, 2 h	99
3	HCl (37%)	MeCN	23 °C, 24 h	96
			80 °C, 2 h	91
4	*p*TsOH	MeCN	23 °C, 24 h	89
			80 °C, 2 h	44

[a] Acetal **12** (0.01 mmol) in 1.0 mL of MeCN treated with reagent (>0.2 mmol). [b] Yields determined by ^{1}H NMR.

SCHEME 3. Selective Removal of PPG



The relatively distinct absorption maximum of acetal **12** at 327 nm (ϵ =3.38 × 10^3 M^{-1} cm^{-1}) compared with others below 310 nm (Figure 1) suggested that selective removal of **14** in the presence of other PPGs such as **3** could be feasible by control of the irradiation wavelength. Indeed, irradiation of **5a** at 350 nm in MeCN/H_2O (9:1) for 20 min in a Rayonet reactor only led to recovery of unreacted **5a** in 97% yield. Under the same conditions, released aldehyde **4a** from **12** was obtained in 96% yield (after conversion to its oxime derivative due to the volatile nature of **4a**). A mixture of **5b** and **12** (1:1) in MeCN/H_2O (9:1) was also irradiated at 350 nm for 20 min, leading to **4a** in 89% yield after derivatization and recovered **5b** in 98% yield (Scheme 3). Interestingly, the same selectivity could be achieved with sunlight, even though acetal **12** was stable as a solid and in solutions under laboratory lighting. Thus, **5b** and **12** (1:1) in MeCN/H_2O (9:1) were exposed to sunlight for 3 h, resulting in 96% released **4a** from **12** (after derivatizing) and 98% recovered **5b**.

In summary, a group of structurally simple PPGs for carbonyl compounds have been developed. These PPGs were readily prepared, demonstrated high protection/deprotection efficiencies, and furthermore displayed excellent dark stability. The diversity of new PPGs allowed highly efficient sequential removal of PPGs by control of the irradiation wavelength.

Experimental Section

Preparation of α,α-Diphenyl-3,5-dimethoxysalicyl Alcohol (3). The known compound 3,5-dimethoxysalicylic acid[5] was refluxed in MeOH in the presence of concentrated H_2SO_4 for 3 days. The reaction mixture was cooled and concentrated. Flash chromatography (petroleum ether/ethyl acetate = 7:1, R_f 0.37) afforded the methyl ester. The ester (2.19 g, 10 mmol) in 15 mL of THF was treated with PhLi (22.5 mL, 2.0 M in Bu_2O) slowly and stirred at −78 °C under Ar for 1.5 h. The reaction mixture was quenched with saturated aqueous NH_4Cl and extracted with ethyl acetate (30 mL × 2). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified with flash chromatography (petroleum ether/ethyl acetate = 3:1, R_f 0.5) to provide **3** in 99% yield. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.33−7.24 (m, 10 H), 6.47 (d, J = 2.7 Hz, 1 H), 5.92 (s, 1 H), 5.70 (d, J = 2.7 Hz, 1 H), 5.07 (s, 1 H), 3.86 (s, 3 H), 3.54 (s, 3 H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 152.2, 147.4, 145.9, 137.5, 132.7, 127.84, 127.79, 127.3, 106.8, 98.2, 82.3, 56.2, 55.5; IR (neat) 3502, 3059, 2941, 2838, 1600, 1490, 1449, 1429, 1372, 1317, 1229; HRMS (ESI) *m/z* calcd for $C_{21}H_{20}O_4Na$ (M + Na$^+$) 359.1259, found 359.1258.

Preparation of Acetal 5a. PPG **3** (79.0 mg, 0.23 mmol), 3-phenylpropanal (**4a**) (27.8 μL, 0.20 mmol), and *p*TsOH (3.8 mg, 0.02 mmol) in 1 mL of benzene were stirred at room temperature for 20 h. The reaction mixture was concentrated for flash column chromatography (petroleum ether/ethyl acetate = 7/1, R_f 0.33) to yield **5a** (92 mg, 99%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.44−7.12 (m, 13 H), 7.01 (dd, J = 7.5, 1.5 Hz, 2 H), 6.41 (d, J = 2.7 Hz, 1 H), 5.97 (d, J = 2.7 Hz, 1 H), 5.02 (dd, J = 6.6, 3.6 Hz, 1 H), 3.88 (s, 3 H), 3.60 (s, 3 H), 2.87−2.79 (m, 1 H), 2.70−2.60 (m, 1 H), 2.33−2.21 (m, 2 H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 152.7, 149.0, 146.0, 144.2, 141.4, 136.8, 129.5, 128.4, 128.24, 128.18, 128.05, 127.9, 127.5, 125.9, 125.7, 104.6, 98.8, 94.7, 84.3, 56.0, 55.5, 35.9, 29.7; IR (neat) 3059, 3027, 2935, 2837, 1602, 1491, 1450, 1402, 1359, 1338, 1280, 1233; HRMS (ESI) *m/z* calcd for $C_{30}H_{29}O_4$ (M + H$^+$) 453.2066, found 453.2070.

Preparation of Acetal 5b. PPG **3** (103 mg, 0.30 mmol), 4-phenoxybenzaldehyde (**4b**) (37.5 μL, 0.20 mmol), *p*TsOH (1.9 mg, 0.01mmol), and $MgSO_4$ (100 mg, 0.80 mmol) in 1.0 mL of benzene were stirred at room temperature for 24 h. The reaction mixture was concentrated for flash column chromatography (petroleum ether/ethyl acetate = 7/1, R_f 0.60) to yield **5b** (95 mg, 93%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.54 (d, J = 8.8 Hz, 2 H), 7.48−7.45 (m, 2 H), 7.39−7.21 (m, 10H), 7.08 (t, J = 7.3 Hz, 1 H), 7.02−6.98 (m, 4 H), 6.44 (d, J = 2.7 Hz, 1 H), 6.00 (d, J = 2.7 Hz, 1 H), 5.91 (s, 1 H), 3.85 (s, 3 H), 3.60 (s, 3 H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 157.9, 157.0, 152.8, 149.2, 145.6, 144.0, 136.8, 132.3, 129.7, 129.3, 128.3, 128.2, 128.1, 127.9, 127.6, 125.8, 123.3, 119.0, 118.6, 104.5, 98.8, 94.5, 85.1, 56.0, 55.5; IR (neat) 3059, 2937, 2837, 1592, 1510, 1490, 1386, 1357, 1280, 1236, 1200; HRMS (ESI) *m/z* calcd for $C_{34}H_{28}NaO_5$ (M + Na$^+$) 539.1834, found 539.1832.

General Procedure for the Preparation of Ketals 5c, 5d, and 5e under Acidic Condition with a Dehydrating Reagent. PPG **3** (103 mg, 0.30 mmol), ketone **4c**−**4e** (0.20 mmol), *p*TsOH (1.9 mg, 0.01 mmol), and P_2O_5 (60 mg, 0.40 mmol) in 1.0 mL of benzene were stirred at room temperature for 1 h. The mixture was poured into saturated aqueous $NaHCO_3$ and extracted with CH_2Cl_2 (15 mL × 2). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated for flash column chromatography.

5c (isomer A): 74%, R_f 0.50 (petroleum ether/ethyl acetate = 9/1); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.36−7.15 (m, 15 H), 6.44 (d, J = 2.7 Hz, 1 H), 6.00 (d, J = 2.8 Hz, 1 H), 3.86 (s, 3 H), 3.60 (s, 3 H), 2.49 (tt, J = 12.3, 3.5 Hz, 1 H), 2.13 (d, J = 12.6 Hz, 2 H), 1.93 (qd, J = 13.0, 3.1 Hz, 2 H), 1.71 (d, J = 10.8 Hz, 2 H), 1.56 (td, J = 13.2, 4.0 Hz, 2 H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 153.2, 150.3, 146.8, 146.4, 134.3, 128.6, 128.39, 128.37, 127.8, 127.4, 126.9, 126.5, 126.1, 104.9, 101.4, 99.1, 81.5, 56.3, 55.6, 43.2, 36.3, 30.6; IR (neat) 3060, 3027, 2936, 2862, 2838, 1604, 1492, 1447, 1336, 1284, 1230, 1200; HRMS (ESI) *m/z* calcd for $C_{33}H_{33}O_4$ (M + H$^+$) 493.2379, found 493.2380.

5c (isomer B): 25%, R_f 0.30 (petroleum ether/ethyl acetate = 9/1); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.45−7.41 (m, 4 H), 7.34−7.23 (m, 8 H), 7.19−7.09 (m, 3H), 6.43 (d, J = 2.7 Hz, 1 H), 6.08 (d, J = 2.7 Hz, 1 H), 3.89 (s, 3 H), 3.63 (s, 3 H), 2.51 (tt, J = 11.2,

4.4 Hz, 1 H), 2.23 (dd, J = 10.8, 3.0 Hz, 2 H), 1.78 (dt, J = 13.0, 4.7 Hz, 2 H), 1.59−1.43 (m, 4 H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 153.0, 149.9, 146.7, 146.6, 134.4, 128.6, 128.2, 127.7, 127.4, 127.2, 126.8, 125.9, 104.5, 101.4, 98.8, 81.3, 56.1, 55.5, 43.3, 35.9, 29.8; IR (neat) 3059, 3026, 2935, 2861, 1604, 1492, 1449, 1337, 1284, 1240, 1200; HRMS (ESI) m/z calcd for $C_{33}H_{33}O_4$ (M + H^+) 493.2379, found 493.2381.

5d: 99%, R_f 0.47 (petroleum ether/ethyl acetate = 9/1); ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.41 (dd, J = 8.2, 1.8 Hz, 2 H), 7.28−7.22 (m, 8 H), 6.41 (d, J = 2.7 Hz, 1 H), 6.02 (d, J = 2.8 Hz, 1 H), 3.85 (s, 3 H), 3.61 (s, 3 H), 1.82−1.78 (m, 2 H), 1.43−1.39(m, 2 H), 1.30−1.16 (m, 31 H), 0.88 (t, J = 6.8 Hz, 3 H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 152.9, 150.2, 147.6, 146.5, 135.0, 128.9, 128.7, 128.2, 128.1, 127.7, 127.6, 126.5, 105.2, 103.0, 99.1, 81.4, 56.5, 55.9, 41.2, 32.4, 30.2, 30.1, 30.04, 29.97, 29.8, 25.2, 24.1, 23.2, 14.6; IR (neat) 2923, 2852, 1595, 1491, 1466, 1379, 1340, 1248, 1200; HRMS (ESI) m/z calcd for $C_{40}H_{57}O_4$ (M + H^+) 601.4257, found 601.4266.

5e, 99%, R_f 0.57 (petroleum ether/ethyl acetate = 5/1); ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.42 (dd, J = 7.8, 1.4 Hz, 2 H), 7.30−7.22 (m, 8 H), 7.01 (d, J = 8.6 Hz, 2 H), 6.78 (d, J = 8.6 Hz, 2 H), 6.42 (d, J = 2.7 Hz, 1 H), 6.01 (d, J = 2.8 Hz, 1 H), 3.86 (s, 3 H), 3.75 (s, 3 H), 3.61 (s, 3 H), 2.83−2.66 (m, 2 H), 2.18−2.05 (m, 2 H), 1.31 (s, 3 H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 156.6, 151.7, 148.8, 146.0, 144.8, 133.3, 133.0, 128.3, 127.4, 127.2, 126.7, 126.4, 126.3, 125.5, 112.6, 103.7, 101.2, 97.7, 80.2, 55.0, 54.5, 54.2, 41.7, 28.0, 24.0; IR (neat) 2998, 2938, 2835, 1609, 1512, 1491, 1465, 1376, 1339, 1279, 1245, 1200; HRMS (ESI) m/z calcd for $C_{32}H_{32}NaO_5$ (M + Na^+) 519.2147, found 519.2144.

General Procedure of Photolysis. Ketal/acetal **5** (0.20 mmol) in 225 mL of acetonitrile and 25 mL of water was irradiated with a 450 W medium pressure mercury lamp filtered with a Pyrex sleeve without excluding air (for **5d**, 240 mL of acetonitrile and 10 mL of water were used because of the solubility limitation). The reaction mixture was then concentrated, and the residue was subject to flash column chromatography. For volatile 3-phenylpropanal (**4a**), derivatization is necessary prior to chromatography. Thus, to the reaction solution was added $HONH_2$·HCl (1.112 g, 16.0 mmol) and NaOAc (1.690 g, 19.2 mmol). The resulting mixture was stirred at room temperature for 24 h, concentrated, and extracted with CH_2Cl_2 (2 × 30 mL). The organic layers were combined, dried over Na_2SO_4, filtered, and concentrated. The residue was purified with flash column chromatography to provide the corresponding oxime derivative.

Selective Removal of 14 with 350 nm Wavelength Irradiation. In 225 mL of MeCN and 25 mL of H_2O were dissolved **5b** (51.7 mg, 0.1 mmol) and **12** (43.6 mg, 0.1 mmol). The obtained colorless solution was irradiated in a Rayonet photoreactor equipped with 350 nm lamps for 20 min. The resulting purple color reaction mixture was then derivatized with NaOAc and $HONH_2$·HCl as describe above. The crude products were purified with flash column chromatography, eluted with petroleum/ethyl acetate (5:1) to provide the oxime of **4a** (13 mg, 89%) and unreacted **5b** (50 mg, 98%).

Selective Removal of 14 with Sunlight. In 225 mL of MeCN and 25 mL of H_2O were dissolved **5b** (51.7 mg, 0.1 mmol) and **12** (43.5 mg, 0.1 mmol). The obtained colorless solution was exposed to outdoor sunlight for 3 h, and a purple solution was obtained. Derivatization and workup as described above afforded oxime of **4a** (14 mg, 96%) and unreacted **5b** (50 mg, 98%).

Preparation of Acetal 9. A solution of commercially available methyl 2-hydroxy-4-methoxybenzoate (558 mg, 3.0mmol) in 8.0 mL of freshly distilled THF was added into PhLi (6.0 mL, 2 M in Bu_2O) dropwise at −78 °C under argon, and the mixture was stirred at −78 °C for 1 h and at room temperature for 2 h. Ice-cooled saturated aqueous NH_4Cl was added to quench the reaction. The reaction mixture was adjusted to slightly acidic and extracted with ethyl acetate (50 mL × 2). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated for flash column chromatography (petroleum ether/ethyl acetate = 5/1, R_f 0.30) to yield the PPG α,α-diphenyl- 4-methoxysalicyl alcohol (911 mg, 99%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.21 (s, 1 H), 7.35−7.32 (m, 6 H), 7.23−7.19 (m, 4 H), 6.49 (d, J = 2.7 Hz, 1 H), 6.40 (d, J = 8.1 Hz, 1 H), 6.29 (dd, J = 8.1, 2.4 Hz, 1 H), 3.77 (s, 3 H), 3.48 (s, 1 H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 160.8, 157.4, 145.0, 130.7, 128.2, 128.0, 127.7, 122.4, 105.1, 102.7, 84.3, 55.3; IR (neat) 3455, 3178, 2962, 1614, 1587, 1515, 1491, 1432, 1377, 1297, 1235; HRMS (ESI) m/z calcd for $C_{20}H_{18}NaO_3$ (M + Na^+) 329.1154, found 329.1154.

The obtained PPG α,α-diphenyl-4-methoxysalicyl alcohol (92 mg, 0.30 mmol), 3-phenylpropanal **4a** (27.8 μL, 0.20 mmol), and pTsOH (1.9 mg, 0.01mmol) in 1.0 mL of benzene were stirred at room temperature for 15 h. The mixture was poured into saturated aqueous $NaHCO_3$ and extracted with CH_2Cl_2 (15 mL × 2). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated for flash column chromatography (petroleum ether/ethyl acetate = 20/1, R_f 0.28) to yield **9** (83 mg, 98%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.37−7.33 (m, 5 H), 7.26−7.21 (m, 5 H), 7.19 (d, J = 7.2 Hz, 2H), 7.12 (t, J = 7.6 Hz, 1H), 7.06 (d, J = 7.0 Hz, 2H), 6.71(d, J = 8.6 Hz, 1H), 6.45 (d, J = 2.5 Hz, 1H), 6.41 (dd, J = 8.6, 2.6 Hz, 1 H), 5.03 (dd, J = 5.9, 4.1 Hz, 1H), 3.74 (s, 3 H), 2.86 − 2.67 (m, 2 H), 2.25− 2.09 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 160.0, 153.7, 146.8, 144.9, 141.9, 130.9, 129.9, 128.84, 128.78, 128.5, 128.4, 128.3, 127.9, 126.3, 118.2, 108.1, 101.7, 95.1, 84.5, 55.7, 36.6, 30.0; IR (neat) 3448, 3060, 3028, 2932, 1620, 1583, 1501, 1447, 1399, 1359, 1327, 1258, 1201; HRMS (ESI) m/z calcd for $C_{29}H_{27}O_3$(M + H^+) 423.1960, found 423.1957.

Preparation of Acetal 10. Commercially available 2,3,4-trihydroxybenzoic acid (0.47 g, 2.75 mmol), K_2CO_3 (1.52 g, 11 mmol), and MeI (1.03 mL, 16.5 mmol) were stirred in 10 mL of dry DMF at room temperature for 68 h. The reaction mixture was adjusted to pH 4−5 with 1 N HCl, extracted with EtOAc (50 mL × 2), dried over Na_2SO_4, filtered, and concentrated for flash column chromatography (petroleum ether/ethyl acetate = 5/1, R_f 0.28) to yield methyl 2-hydroxy-3,4-dimethoxy-benzoate (234 mg, 40%).

Into a solution of PhLi (2.1 mL, 2 M in Bu_2O) was added a solution of the obtained methyl 2-hydroxy-3,4-dimethoxy-benzoate (222 mg, 1.05 mmol) in 3 mL of freshly distilled THF dropwise at −78 °C under argon. The reaction mixture was stirred at −78 °C for 1 h and at room temperature for 2 h and then was quenched with ice-cooled saturated aqueous NH_4Cl. The mixture was extracted with ethyl acetate (30 mL × 2), and the combined organic layers were was dried over Na_2SO_4, filtered, and concentrated for flash column chromatography (petroleum ether/ethyl acetate = 3/1, R_f 0.33) to yield the PPG α,α-diphenyl-3,4-dimethoxysalicyl alcohol (346 mg, 98%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.27−7.21 (m, 10 H), 6.86 (s, 1H), 6.25 (d, J = 8.9 Hz, 1H), 6.15 (d, J = 8.8 Hz, 1H), 4.97 (s, 1 H), 3.81 (s, 3 H), 3.76 (s, 3 H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 152.5, 148.0, 146.5, 136.5, 128.32, 128.29, 128.26, 127.7, 126.4, 125.0, 102.9, 82.7, 61.4, 56.2; IR (neat) 3370, 2955, 2845, 1677, 1630, 1593, 1512, 1439, 1369, 1297, 1251, 1233, 1212; HRMS (ESI) m/z calcd for $C_{21}H_{20}NaO_4$ (M + Na^+) 359.1259, found 359.1255.

The PPG (103 mg, 0.30 mmol), 3-phenylpropanal **4a** (27.8 μL, 0.20 mmol), and pTsOH (1.9 mg, 0.01 mmol) in 1.0 mL of benzene were stirred at room temperature for 12.5 h. The mixture was poured into saturated aqueous $NaHCO_3$ and extracted with CH_2Cl_2 (15 mL × 2). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated for flash column chromatography (petroleum ether/ethyl acetate = 9/1, R_f 0.50) to yield **10** (89 mg, 98%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.37−7.33 (m, 5 H), 7.28−7.07 (m, 10 H), 6.50 (d, J = 8.8 Hz, 1H), 6.42 (d, J = 8.8 Hz, 1H), 5.06 (dd, J = 5.8, 4.1 Hz, 1H), 3.89 (s, 3 H), 3.80 (s, 3H), 2.86 − 2.73 (m, 2 H), 2.28 − 2.21 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 152.4, 147.1, 146.8, 144.8, 141.8, 137.3, 129.9, 128.84, 128.79, 128.54, 128.53, 128.49, 128.3, 127.9, 126.3, 124.7, 119.8, 104.6, 95.3, 84.5, 61.4, 56.4, 36.6, 30.1; IR (neat) 3060, 3027, 2934, 2835, 1610, 1498, 1460, 1400, 1355, 1289, 1259, 1238, 1209; HRMS (ESI) m/z calcd for $C_{30}H_{29}O_4$ (M + H^+) 453.2066, found 453.2068.

Preparation of Acetal 11. Commercially available 4-aminosalicylic acid (1.55 g, 10.0 mmol), $NaHCO_3$ (4.2 g, 50.0 mmol) and MeI (2.49 mL, 40.0 mmol) were stirred in 15 mL of DMF at room temperature for 24 h. The reaction mixture was acidified with 1 N HCl to pH 4−5, extracted with EtOAc (50 mL × 2), dried over Na_2SO_4, filtered, and concentrated for flash column chromatography (petroleum ether/ethyl acetate = 5/1, R_f 0.28) to yield methyl 4-(dimethylamino)-2-hydroxybenzoate (777 mg, 40%). Into a solution of PhLi (2.0 mL, 2 M in Bu_2O) was added a solution of methyl 4-(dimethylamino)-2-hydroxybenzoate (200 mg, 1.0 mmol) in 3 mL freshly distilled THF dropwise, at −78 °C under argon. The reaction mixture was stirred at −78 °C for 1 h and at room temperature for 2 h, and then was quenched with ice-cooled saturated aqueous NH_4Cl. The solution was extracted with ethyl acetate (30 mL × 2). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated for flash column chromatography (petroleum ether/ethyl acetate = 3/1, R_f 0.20) to yield the PPG α,α-diphenyl-4-(dimethylamino)salicyl alcohol (315 mg, 99%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.00 (s, 1H), 7.37−7.29 (m, 6 H), 7.23−7.20 (m, 4H), 6.33 (d, J = 8.6 Hz, 1H), 6.29 (d, J = 2.5 Hz, 1 H), 6.10 (dd, J = 8.7, 2.4 Hz, 1H), 3.49 − 3.42 (m, 1 H), 2.92 (s, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 156.9, 151.8, 145.5, 130.5, 128.1, 127.8, 127.7, 118.3, 103.3, 101.1, 84.2, 40.3, 31.0; IR (neat) 3164, 3058, 2909, 1621, 1565, 1528, 1487, 1445, 1366, 1300, 1236; HRMS (ESI) *m*/*z* calcd for $C_{21}H_{22}NO_2$ (M + H^+) 320.1651, found 320.1649.

The PPG (98 mg, 0.30 mmol), 3-phenylpropanal **4a** (27.8 μL, 0.20 mmol), *p*TsOH (1.9 mg, 0.01 mmol), and P_2O_5 (60 mg, 0.8 mmol) in 1.0 mL of benzene was stirred at room temperature for 1.5 h. The mixture was poured into saturated aqueous $NaHCO_3$ and extracted with EtOAc (20 mL × 2). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated for flash column chromatography (petroleum ether/ethyl acetate = 20/1, R_f 0.25) to yield **11** (43 mg, 49%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.42−7.04 (m, 15 H), 6.66 (dd, J = 6.9, 2.4 Hz, 1H), 6.26 − 6.23 (m, 2H), 5.03 (dd, J = 6.0, 4.2 Hz, 1H), 2.88 − 2.65 (m, 8 H), 2.26 − 2.05 (m, 2H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 153.2, 150.7, 146.8, 145.0, 141.6, 130.3, 129.5, 128.5, 128.4, 128.1, 128.0, 127.9, 127.8, 127.3, 125.8, 113.8, 105.7, 99.8, 94.6, 84.1, 40.4, 36.4, 29.7; IR(neat) 3059, 3027, 2929, 2802, 1623, 1564, 1516, 1492, 1447, 1399, 1366, 1314, 1278, 1240; HRMS (ESI) *m*/*z* calcd for $C_{30}H_{30}NO_2$ (M + H^+) 436.2277, found 436.2276.

Preparation of Acetal 12. The commercially available 5-aminosalicylic acid (1.55 g, 10.0 mmol) was refluxed in 10 mL of MeOH in the presence of H_2SO_4 (0.3 mL) for 26 h. After solvent was removed, saturated aqueous $NaHCO_3$ was added into the mixture to adjust the pH to 8−9.The mixture was extracted with EtOAc (20 mL × 3), dried over Na_2SO_4, filtered and concentrated to yield methyl 5-amino-2-hydroxybenzoate (162 mg, 96%).

Into the mixture of methyl 5-amino-2-hydroxybenzoate (1.50 g, 9.0 mmol), paraformaldehyde (2.70 g, 90 mmol), and $NaBH_3CN$ (1.805 g, 27 mmol) was added AcOH (90 mL). The mixture was stirred at room temperature for 4 h and then concentrated. Saturated aqueous Na_2CO_3 was poured into the mixture to adjust the pH to 7−8. The mixture was extracted with CH_2Cl_2 (30 mL × 3). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated to yield methyl 5-(dimethylamino)-2-hydroxybenzoate (1.72 g, 98%)

Into a solution of PhLi (0.9 mL, 2 M in Bu_2O) was added a solution of methyl 5-(dimethylamino)-2-hydroxybenzoate (54 mg, 0.28mmol) in 1 mL of freshly distilled THF dropwise, at −78 °C under argon. The mixture was stirred at −78 °C for 1 h and at room temperature for 2 h and then was quenched with ice-cooled saturated aqueous NH_4Cl. The solution was extracted with ethyl acetate (15 mL × 2). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated for flash column chromatography (petroleum ether/ethyl acetate = 5/1, R_f 0.43) to yield PPG **14**, α,α-diphenyl- 5-(dimethylamino)salicyl alcohol (81 mg, 92%). ^{1}H NMR (CD_3SOCD_3, 300 MHz) δ 9.04 (s, 1H), 7.33−7.18 (m, 10 H), 6.73 (s, 1H), 6.68 (d, J = 8.7 Hz, 1H), 6.59 (dd, J = 8.7, 3.0 Hz, 1H), 5.92 (d, J = 2.7 Hz, 1 H), 3.35 (s, 6 H); ^{13}C NMR (CD_3SOCD_3, 75 MHz) δ 146.9, 146.2, 143.4, 132.2, 127.5, 127.4, 126.8, 116.6, 115.2, 113.6, 81.9, 41.0; IR (neat) 3408, 3058, 2909, 1625, 1494, 1447, 1239; HRMS (ESI) *m*/*z* calcd for $C_{21}H_{22}NO_2$ (M + H^+) 320.1651, found 320.1647.

PPG **14** (128 mg, 0.40 mmol), 3-phenylpropanal **4a** (27.8 μL, 0.20 mmol), and *p*TsOH (3.8 mg, 0.02 mmol) in 2.0 mL of toluene were refluxed under Ar for 35 h. The mixture was poured into saturated aqueous $NaHCO_3$ and extracted with EtOAc (20 mL × 2). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated for flash column chromatography (petroleum ether/ethyl acetate = 5/1, R_f 0.50) to yield **12** (82 mg, 94%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.49−7.07 (m, 15 H), 6.87 (d, J = 9.0 Hz, 1H), 6.71 (dd, J = 9.0, 3.0 Hz, 1H), 6.27 (d, J = 3.0 Hz, 1H), 5.02 (dd, J = 6.0, 4.2 Hz, 1H), 2.91 − 2.67 (m, 8 H), 2.29− 2.09 (m, 2H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 146.4, 144.8, 144.7, 144.6, 141.6, 129.5, 128.4, 128.3, 128.1, 128.0, 127.9, 127.8, 127.3, 125.7, 125.4, 117.3, 114.8, 114.4, 94.3, 84.4, 41.5, 36.2, 29.7; IR (neat) 3060, 3028, 2929, 2884, 2795, 1620, 1504, 1447, 1400, 1361, 1240; HRMS (ESI) *m*/*z* calcd for $C_{30}H_{30}NO_2$ (M + H^+) 436.2277, found 436.2276.

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Supporting Information Available: UV, ^{1}H NMR, and ^{13}C NMR Spectra of **3**, **5a**−**5e**, **9**−**12**, and **14**. This material is available free of charge via the Internet at http://pubs.acs.org.

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