JOC The Journal of Organic Chemistry

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# Synthesis of 5-Amino-2,5-dihydro-1*H*-benzo[*b*]azepines Using a One-Pot Multibond Forming Process

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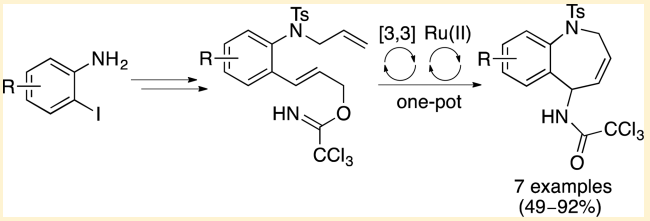
Supporting Information

**ABSTRACT:** Rapid access to allylic trichloroacetimidates bearing a 2-allylaminoaryl group from readily available 2-iodoanilines combined with a one-pot multibond forming process has allowed the efficient synthesis of a series of 5-amino-2,5-dihydro-1*H*-benzo[*b*]azepines. The potential of these compounds as synthetic building blocks was demonstrated by the preparation of a late-stage intermediate of the hyponatremia agent, mozavaptan.




## INTRODUCTION

1*H*-Benzo[*b*]azepines are an important class of seven-membered heterocyclic compound found as a key structural element in a wide variety of pharmaceutically active substances.[1,2] Within this class, 5-amino-2,3,4,5-tetrahydro-1*H*-benzo[*b*]azepines are of particular significance and include compounds such as mozavaptan (**1**), a nonpeptide vasopressin V2-receptor antagonist used for the treatment of hyponatremia (low blood sodium levels),[3] and 3,5-bis(trifluoromethyl)benzyl protected 2,3,4,5-tetrahydro-1*H*-benzo[*b*]azepine **2**, developed for the treatment of dyslipidemia (Figure 1).[4] The interest in 5-amino-2,3,4,5-tetrahydro-1*H*-benzo[*b*]azepines has led recently to a detailed analysis of their conformational bias and a greater understanding of their physicochemical properties.[5]

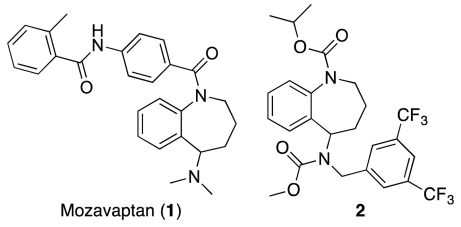
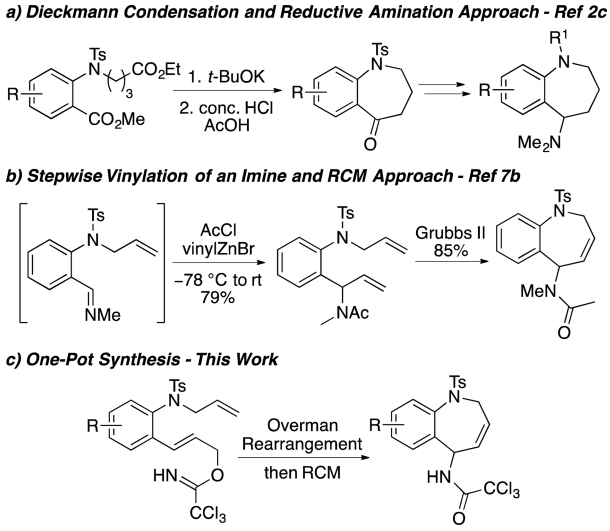



**Figure 1.** Structures of pharmacologically active 5-amino-2,3,4,5-tetrahydro-1*H*-benzo[*b*]azepines.

Due to the pharmacological importance of 5-amino-2,3,4,5-tetrahydro-1*H*-benzo[*b*]azepines, a number of methods have been developed for their synthesis.[2,3c,6] Traditionally, a Dieckmann condensation has been used to prepare 1*H*-benzo[*b*]azepin-5-ones, followed by introduction of the amino substituent by reductive amination of the ketone (Scheme 1a).[2c] More recently, the azepine ring system in these compounds has been prepared using methods such as the Beckmann rearrangement,[6b] the Mitsunobu reaction,[6a] reductive ring opening of aza-bridged azepines,[6e] and ring closing metathesis (RCM) (Scheme 1b).[6d,7] With the aim of developing new methods for the preparation of highly functional polycyclic compounds, we have demonstrated that benzannulated alkene derived allylic alcohols could be used in one-pot multireaction processes for the efficient synthesis of amino-substituted indenes, dihydronaphthalenes, and 1-benzoxepines.[8] We now report a short and general synthesis of allylic trichloroacetimidates bearing a 2-allylaminoaryl group from readily available 2-iodoanilines and demonstrate the application of these compounds in a one-pot multibond forming process for the efficient synthesis of 5-amino-2,5-dihydro-1*H*-benzo[*b*]azepines (Scheme 1c).

**Scheme 1. Synthetic Approaches for the Preparation of 5-Amino-Substituted 1*H*-Benzo[*b*]azepines**




**Received:** June 4, 2016
**Published:** July 14, 2016

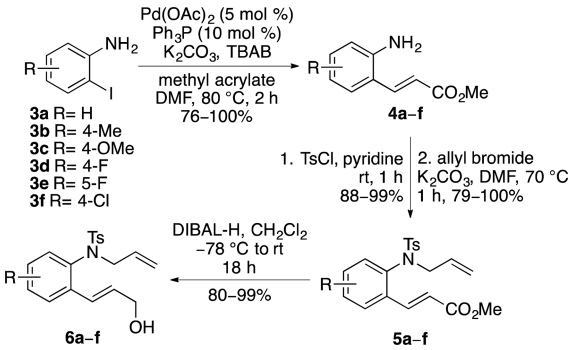



DOI: 10.1021/acs.joc.6b01357
J. Org. Chem. 2016, 81, 6697–6706

## RESULTS AND DISCUSSION

The substrates for the one-pot process, (*E*)-(2-allylamino)-cinnamyl alcohols, were prepared using a four-step route from commercially available 2-iodoanilines (Scheme 2). Mizoroki–

**Scheme 2. Synthesis of Allylic Alcohols 6a–f**[a]

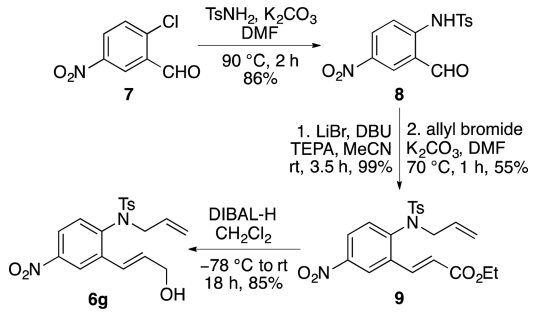



[a]Isolated yields are shown.

Heck reaction of 2-iodoanilines **3a–f** with methyl acrylate and palladium(II) acetate (5 mol %) under standard conditions gave the corresponding methyl (*E*)-2′-aminocinnamates **4a–f** in excellent yields (76–100%).[9,10] The amines were protected with the tosylate group, and this allowed monoallylation using allyl bromide and potassium carbonate.[11] Finally, reduction of the (*E*)-*α*,*β*-unsaturated methyl esters **5a–f** with DIBAL-H gave (*E*)-(2-allylamino)cinnamyl alcohols **6a–f** in high overall yields.

While this synthetic route allowed access to a range of (*E*)-(2-allylamino)cinnamyl alcohols, the preparation of a 4′-nitro analogue was not possible. Attempted Mizoroki–Heck coupling of 2-iodo-4-nitroaniline with methyl acrylate instead gave the conjugate addition product. An alternative approach was developed for this compound (Scheme 3). 2-Chloro-5-

**Scheme 3. Synthesis of Allylic Alcohol 6g**[a]

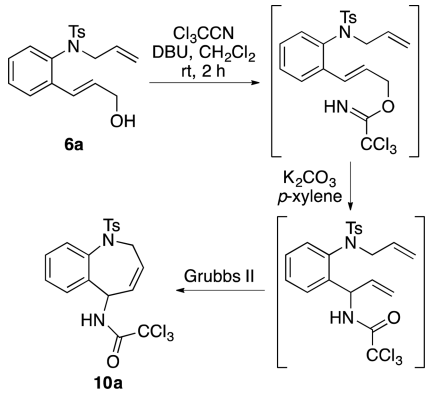



[a]Isolated yields are shown.

nitrobenzaldehyde (7) was subjected to a nucleophilic aromatic substitution reaction with *p*-toluenesulfonamide, which gave **8** in 86% yield.[12] Horner–Wadsworth–Emmons reaction of **8** under Masamune–Roush conditions with triethyl phosphonoacetate (TEPA) gave the ethyl (*E*)-2′-aminocinnamate in quantitative yield.[13] Analysis of the $^1$H NMR spectrum of the crude reaction mixture showed exclusive formation of the *E*-alkene. Allylation of the amino group was then performed under the same conditions as before. However, due to decreased nucleophilicity of this compound, the product was isolated in a modest 55% yield. DIBAL-H reduction of the ethyl ester then completed the four-step synthesis of nitro-substituted cinnamyl alcohol **6g**.

Having prepared a small library of (*E*)-(2-allylamino)-cinnamyl alcohols, **6a** was used for optimization of the one-pot process (Table 1). Based on previous work,[8,14] the

**Table 1. Optimization of the One-Pot Process**[a]




| entry | Overman rearrangement | RCM reaction | yield (%)[a] |
|---|---|---|---|
| 1 | 140 °C, 48 h | Grubbs II (10 mol %), 50 °C, 48 h | 69 |
| 2 | 160 °C, 24 h | Grubbs II (10 mol %), 50 °C, 48 h | 70 |
| 3 | 160 °C, 24 h | Grubbs II (2.5 mol %), 60 °C, 48 h | 58 |
| 4 | 160 °C, 24 h | Grubbs II (5 mol %), 60 °C, 18 h | 81 |

[a]Isolated yields are shown.

thermally mediated Overman rearrangement was performed at 140 °C and the RCM step was done using Grubbs' second generation catalyst (10 mol %) (entry 1).[15] While this gave a yield of 69% over the three steps, both the rearrangement and metathesis stages required reaction times of 48 h. Increasing the temperature of the Overman rearrangement to 160 °C allowed a shorter reaction time (24 h) with a similar overall yield (entry 2). The catalyst loading and temperature of the RCM step was then investigated. It was found that a catalyst loading of 5 mol % and a temperature of 60 °C was optimal for the RCM step, with the reaction complete after 18 h (entry 4). Using the optimized conditions for both key steps gave 5-amino-2,5-dihydro-1*H*-benzo[*b*]azepine **10a** in 81% yield from **6a**.

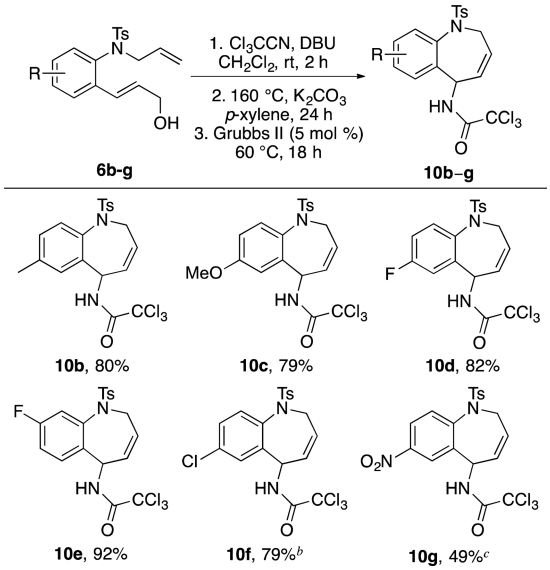
Using the optimized one-pot procedure, the scope of the process with various (*E*)-(2-allylamino)cinnamyl alcohol substrates was explored (Scheme 4). Overall, the process was found to be general and high yielding (79–92%) for the preparation of 5-amino-2,5-dihydro-1*H*-benzo[*b*]azepines bearing a range of substituents. Only in the case of the strongly electron-deficient 4′-nitrophenyl analogue **6g** did the conditions require significant modification. For this compound, both key steps entailed longer reaction times and this likely accounts for the lower overall yield of 49%.

The synthetic potential of these products was demonstrated with the three-step conversion of **10a** to 5-amino-2,3,4,5-tetrahydro-1*H*-benzo[*b*]azepine **12**, a late-stage intermediate for the preparation of mozavaptan and its analogues (Scheme 5).[3] A one-pot procedure was used to remove the trichloroacyl group and reprotect the amine as the Boc-derivative. Hydrogenation at atmospheric pressure, followed by detosylation with magnesium under mild conditions, gave 5-amino-2,3,4,5-



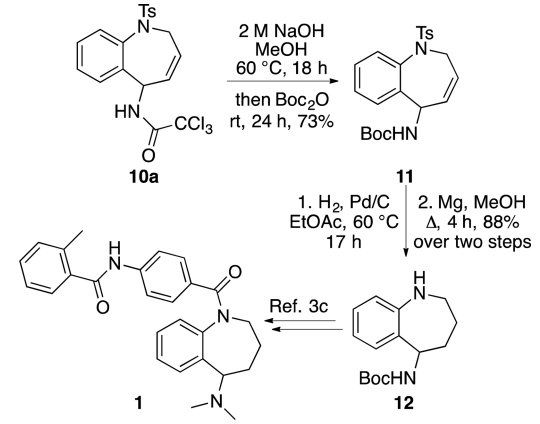
DOI: 10.1021/acs.joc.6b01357
J. Org. Chem. 2016, 81, 6697–6706

**Scheme 4. Synthesis of 5-Amino-2,5-Dihydro-1*H*-benzo[*b*]azepines 10b–g**[a]




[a]Isolated yields are shown. [b]The RCM step required a reaction time of 24 h. [c]The Overman rearrangement and RCM step required reaction times of 43 and 31 h, respectively.

**Scheme 5. Formal Synthesis of Mozavaptan (1)**[a]




[a]Isolated yields are shown.

tetrahydro-1*H*-benzo[*b*]azepine **12** in 88% yield. Overall, the highly efficient four-step route to allylic alcohol **6a**, combined with the one-pot multibond forming strategy has allowed the synthesis of 5-amino-2,3,4,5-tetrahydro-1*H*-benzo[*b*]azepine **12** in 46% overall yield from commercially available 2-iodoaniline (**3a**). Mozavaptan is easily prepared from **12** by benzoylation of the 1*H*-benzo[*b*]azepine ring nitrogen, removal of the Boc-protecting group, and reductive amination of the resulting amine with formaldehyde.[3c]

## CONCLUSIONS

In summary, a four-step synthesis of (*E*)-(2-allylamino)-cinnamyl alcohols has been developed from readily available 2-iodoanilines using a highly efficient Mizoroki–Heck coupling. Following transformation to the corresponding allylic trichloroacetimidates, these compounds were converted to a series of 5-amino-2,5-dihydro-1*H*-benzo[*b*]azepines using a one-pot multibond forming process. As demonstrated with the straightforward synthesis of 5-amino-2,3,4,5-tetrahydro-1*H*-benzo[*b*]-azepine **12**, a late-stage intermediate for the synthesis of mozavaptan, these compounds have potential for synthetic and medicinal chemistry applications. Work is currently underway to investigate further synthetic applications of 5-amino-2,5-dihydro-1*H*-benzo[*b*]azepines and extend the use of one-pot multibond forming reaction processes.

## EXPERIMENTAL SECTION

All reagents and starting materials were obtained from commercial sources and used as received. All dry solvents were purified using a solvent purification system. All reactions were performed under an atmosphere of argon unless otherwise mentioned. Brine refers to a saturated solution of sodium chloride. Flash column chromatography was performed using silica gel 60 (35–70 μm). Aluminum-backed plates precoated with silica gel $60F_{254}$ were used for thin layer chromatography and were visualized with a UV lamp or by staining with potassium permanganate. $^1$H NMR spectra were recorded on an NMR spectrometer at either 400 or 500 MHz, and data are reported as follows: chemical shift in ppm relative to tetramethylsilane or the solvent ($CDCl_3$, $\delta$ 7.26 ppm) as the internal standard, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet or overlap of nonequivalent resonances, integration). $^{13}$C NMR spectra were recorded on an NMR spectrometer at either 101 or 126 MHz, and data are reported as follows: chemical shift in ppm relative to tetramethylsilane or the solvent ($CDCl_3$, $\delta$ 77.0 ppm) as the internal standard, multiplicity with respect to hydrogen (deduced from DEPT experiments, C, CH, $CH_2$, or $CH_3$). Infrared spectra were recorded on an FTIR spectrometer; wavenumbers are indicated in $cm^{-1}$. Mass spectra were recorded using the electrospray technique. HRMS spectra were recorded using a dual-focusing magnetic analyzer mass spectrometer. Melting points are uncorrected.

**Methyl (2*E*)-3-(2′-Aminophenyl)prop-2-enoate (4a).**[10] Methyl acrylate (1.53 mL, 18.3 mmol) was added to a solution of 2-iodoaniline (**3a**) (2.00 g, 9.13 mmol), palladium acetate (0.110 g, 0.460 mmol), triphenylphosphine (0.239 g, 0.913 mmol), potassium carbonate (1.26 g, 9.13 mmol), and tetrabutylammonium bromide (0.741 g, 2.30 mmol) in *N*,*N*′-dimethylformamide (90 mL). The reaction mixture was stirred at 80 °C for 2 h. The mixture was cooled to room temperature, diluted with water (50 mL), and extracted with diethyl ether (3 × 50 mL). The organic layer was washed with 5% aqueous lithium chloride solution (10 mL) and brine (10 mL), dried ($MgSO_4$), filtered, and concentrated *in vacuo*. The residue was purified by column chromatography (diethyl ether/petroleum ether, 1:4) to give methyl (2*E*)-3-(2′-aminophenyl)prop-2-enoate (**4a**) (1.59 g, 99%) as a yellow solid. Mp 64–66 °C; $R_f$ = 0.33 (diethyl ether/petroleum ether = 1:1). Spectroscopic data were consistent with the literature.[10] $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 3.80 (s, 3H), 3.98 (br s, 2H), 6.36 (d, *J* = 15.8 Hz, 1H), 6.70 (dd, *J* = 8.0, 1.3 Hz, 1H), 6.77 (ddd, *J* = 8.0, 7.3, 1.3 Hz, 1H), 7.17 (ddd, *J* = 7.9, 7.3, 1.3 Hz, 1H), 7.38 (dd, *J* = 7.9, 1.3 Hz, 1H), 7.83 (d, *J* = 15.8 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 51.7 ($CH_3$), 116.7 (CH), 117.7 (CH), 119.0 (CH), 119.9 (C), 128.1 (CH), 131.3 (CH), 140.3 (CH), 145.6 (C), 167.7 (C); MS (ESI) *m*/*z* 200 ($MNa^+$, 4), 168 (26), 146 (100), 128 (31).

**Methyl (2*E*)-3-(2′-Amino-5′-methylphenyl)prop-2-enoate (4b).**[16] The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-aminophenyl)prop-2-enoate (**4a**) using 4-methyl-2-iodoaniline (**3b**) (2.00 g, 8.58 mmol). Purification by column chromatography (diethyl ether/petroleum ether, 1:3) gave methyl (2*E*)-3-(2′-amino-5′-methylphenyl)prop-2-enoate (**4b**) (1.64 g, 100%) as a yellow solid. Mp 84–86 °C; $R_f$ = 0.28 (diethyl ether/petroleum ether = 1:1). Spectroscopic data were consistent with the literature.[16] $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.24 (s, 3H), 3.79 (s, 3H), 3.86 (br s, 2H), 6.34 (d, *J* = 15.8 Hz, 1H), 6.62 (d, *J* = 8.1 Hz, 1H), 6.99 (dd, *J* = 8.1, 1.5 Hz, 1H), 7.19 (d, *J* = 1.5 Hz, 1H), 7.82 (d, *J* = 15.8 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 20.4 ($CH_3$), 51.6 ($CH_3$), 117.0 (CH), 117.4 (CH), 119.9 (C), 128.2 (C), 128.2 (CH),


DOI: 10.1021/acs.joc.6b01357
J. Org. Chem. 2016, 81, 6697–6706

132.3 (CH), 140.4 (CH), 143.3 (C), 167.8 (C); MS (ESI) $m/z$ 214 ($MNa^+$, 100), 192 (11), 182 (23).

**Methyl (2*E*)-3-(2′-Amino-5′-methoxyphenyl)prop-2-enoate (4c).**[17] The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-aminophenyl)prop-2-enoate (**4a**) using 4-methoxy-2-iodoaniline (**3c**) (0.170 g, 0.680 mmol) and potassium carbonate (0.188 g, 1.36 mmol). Purification by column chromatography (diethyl ether/petroleum ether, 1:3) gave methyl (2*E*)-3-(2′-amino-5′-methoxyphenyl)prop-2-enoate (**4c**) (0.141 g, 100%) as a yellow solid. Mp 93−95 °C; $R_f$ = 0.20 (diethyl ether/petroleum ether = 1:1). Spectroscopic data were consistent with the literature.[17] $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 3.71 (br s, 2H), 3.76 (s, 3H), 3.81 (s, 3H), 6.35 (d, $J$ = 15.8 Hz, 1H), 6.67 (d, $J$ = 8.7 Hz, 1H), 6.82 (dd, $J$ = 8.7, 2.9 Hz, 1H), 6.92 (d, $J$ = 2.9 Hz, 1H), 7.82 (d, $J$ = 15.8 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 51.7 ($CH_3$), 55.8 ($CH_3$), 111.6 (CH), 117.9 (CH), 118.4 (CH), 118.7 (CH), 120.8 (C), 139.6 (C), 140.2 (CH), 152.8 (C), 167.6 (C); MS (ESI) $m/z$ 208 ($MH^+$, 100).

**Methyl (2*E*)-3-(2′-Amino-5′-fluorophenyl)prop-2-enoate (4d).**[10] The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-aminophenyl)prop-2-enoate (**4a**) using 4-fluoro-2-iodoaniline (**3d**) (3.77 g, 16.0 mmol) and potassium carbonate (4.40 g, 32.0 mmol). Purification by column chromatography (ethyl acetate/petroleum ether, 1:3) gave methyl (2*E*)-3-(2′-amino-5′-fluorophenyl)-prop-2-enoate (**4d**) (2.50 g, 81%) as a yellow solid. Mp 96−98 °C (lit.[10] 93−95 °C); $R_f$ = 0.28 (diethyl ether/petroleum ether = 1:1); $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 3.80 (s, 3H), 3.86 (br s, 2H), 6.33 (d, $J$ = 15.8 Hz, 1H), 6.65 (dd, $J$ = 8.7, $^4J_{HF}$ = 4.8 Hz, 1H), 6.90 (td, $J$ = 8.7, 2.9 Hz, 1H), 7.08 (dd, $^3J_{HF}$ = 9.5, $J$ = 2.9 Hz, 1H), 7.76 (dd, $J$ = 15.8, $^5J_{HF}$ = 1.1 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 51.8 ($CH_3$), 113.4 (d, $^2J_{CF}$ = 22.7 Hz, CH), 118.0 (d, $^3J_{CF}$ = 7.7 Hz, CH), 118.3 (d, $^2J_{CF}$ = 23.0 Hz, CH), 118.8 (CH), 120.8 (d, $^3J_{CF}$ = 7.2 Hz, C), 139.1 (d, $^4J_{CF}$ = 2.2 Hz, CH), 141.8 (C), 156.2 (d, $^1J_{CF}$ = 237.0 Hz, C), 167.3 (C); MS (ESI) $m/z$ 218 ($MNa^+$, 100), 169 (25), 186 (13), 164 (20).

**Methyl (2*E*)-3-(2′-Amino-4′-fluorophenyl)prop-2-enoate (4e).**[17] The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-aminophenyl)prop-2-enoate (**4a**) using 5-fluoro-2-iodoaniline (**3e**) (0.926 g, 3.90 mmol) and potassium carbonate (1.08 g, 7.80 mmol). Purification by column chromatography (ethyl acetate/petroleum ether, 1:3) gave methyl (2*E*)-3-(2′-amino-4′-fluorophenyl)prop-2-enoate (**4e**) (0.639 g, 84%) as a yellow solid. Mp 107−109 °C; $R_f$ = 0.25 (diethyl ether/petroleum ether = 1:1). Spectroscopic data were consistent with the literature.[17] $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 3.80 (s, 3H), 4.11 (br s, 2H), 6.29 (d, $J$ = 15.8 Hz, 1H), 6.39 (dd, $^3J_{HF}$ = 10.5, $J$ = 2.5 Hz, 1H), 6.47 (td, $J$ = 8.7, 2.5 Hz, 1H), 7.34 (dd, $J$ = 8.7, $^4J_{HF}$ = 6.4 Hz, 1H), 7.74 (d, $J$ = 15.8 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 51.7 ($CH_3$), 102.9 (d, $^2J_{CF}$ = 24.8 Hz, CH), 106.3 (d, $^2J_{CF}$ = 22.2 Hz, CH), 116.0 (d, $^4J_{CF}$ = 2.4 Hz, C), 117.2 (CH), 130.0 (d, $^3J_{CF}$ = 10.6 Hz, CH), 139.3 (CH), 147.4 (d, $^3J_{CF}$ = 11.5 Hz, C), 164.9 (d, $^1J_{CF}$ = 248.9 Hz, C), 167.6 (C); MS (ESI) $m/z$ 218 ($MNa^+$, 100), 186 (59), 164 (6).

**Methyl (2*E*)-3-(2′-Amino-5′-chlorophenyl)prop-2-enoate (4f).**[10] The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-aminophenyl)prop-2-enoate (**4a**) using 4-chloro-2-iodoaniline (**3f**) (0.975 g, 3.90 mmol) and potassium carbonate (1.08 g, 7.80 mmol). The reaction mixture was stirred at 80 °C for 8 h. Purification by column chromatography (ethyl acetate/petroleum ether = 1:3) gave methyl (2*E*)-3-(2′-amino-5′-chlorophenyl)prop-2-enoate (**4f**) (0.622 g, 76%) as a yellow solid. Mp 92−94 °C; $R_f$ = 0.18 (diethyl ether/petroleum ether = 1:1). Spectroscopic data were consistent with the literature.[10] $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 3.81 (s, 3H), 3.97 (br s, 2H), 6.34 (d, $J$ = 15.8 Hz, 1H), 6.64 (d, $J$ = 8.6 Hz, 1H), 7.12 (dd, $J$ = 8.6, 2.4 Hz, 1H), 7.34 (d, $J$ = 2.4 Hz, 1H), 7.73 (d, $J$ = 15.8 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 51.8 ($CH_3$), 117.9 (CH), 119.0 (CH), 121.1 (C), 123.7 (C), 127.3 (CH), 131.0 (CH), 138.9 (CH), 144.0 (C), 167.3 (C); MS (ESI) $m/z$ 234 ($MNa^+$, 64), 202 (46), 186 (100).

**Methyl (2*E*)-3-(2′-[*N*-(*p*-Toluenesulfonyl)amino]phenyl)-prop-2-enoate.**[18] *p*-Toluenesulfonyl chloride (2.50 g, 13.0 mmol) was added to a solution of methyl (2*E*)-3-(2′-aminophenyl)prop-2-enoate (**4a**) (1.53 g, 8.70 mmol) in pyridine (43 mL) at 0 °C. The reaction mixture was allowed to warm to room temperature and stirred for 1 h. The reaction mixture was diluted with water (50 mL) and extracted with dichloromethane (3 × 50 mL), washed with lithium chloride solution (10 mL) and brine (10 mL), dried ($MgSO_4$), filtered, and concentrated *in vacuo*. Flash column chromatography (diethyl ether/petroleum ether, 1:1) afforded methyl (2*E*)-3-(2′-[*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (2.66 g, 93%) as a white solid. Mp 156−158 °C (lit.[18] 160−162 °C); $R_f$ = 0.13 (diethyl ether/petroleum ether = 1:1); $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.35 (s, 3H), 3.77 (s, 3H), 6.11 (d, $J$ = 15.8 Hz, 1H), 7.17 (d, $J$ = 8.2 Hz, 2H), 7.20−7.27 (m, 2H), 7.34 (td, $J$ = 8.0, 1.5 Hz, 1H), 7.40 (dd, $J$ = 8.0, 1.2 Hz, 1H), 7.45 (dd, $J$ = 8.0, 1.5 Hz, 1H), 7.54 (d, $J$ = 8.2 Hz, 2H), 7.62 (d, $J$ = 15.8 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.5 ($CH_3$), 51.9 ($CH_3$), 120.1 (CH), 127.1 (CH), 127.2 (CH), 127.3 (2 × CH), 127.6 (CH), 129.6 (2 × CH), 130.6 (C), 130.9 (CH), 134.8 (C), 135.9 (C), 139.3 (CH), 143.9 (C), 167.0 (C); MS (ESI) $m/z$ 354 ($MNa^+$, 100), 233 (8).

**Methyl (2*E*)-3-(5′-Methyl-2′-[*N*-(*p*-toluenesulfonyl)amino]-phenyl)prop-2-enoate.**[19] The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-[*N*-(*p*-toluenesulfonyl)amino]-phenyl)prop-2-enoate using methyl (2*E*)-3-(2′-amino-5′-methyl-phenyl)prop-2-enoate (**4b**) (1.50 g, 7.84 mmol). Purification by column chromatography (ethyl acetate/petroleum ether = 1:4) gave methyl (2*E*)-3-(5′-methyl-2′-[*N*-(*p*-toluenesulfonyl)amino]phenyl)-prop-2-enoate (2.68 g, 99%) as a white solid. Mp 164−166 °C (lit.[19] 160−162 °C); $R_f$ = 0.20 (diethyl ether/petroleum ether = 1:1); $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.32 (s, 3H), 2.35 (s, 3H), 3.77 (s, 3H), 6.10 (d, $J$ = 15.9 Hz, 1H), 6.99 (br s, 1H), 7.12−7.19 (m, 3H), 7.23−7.26 (m, 2H), 7.50−7.57 (m, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.0 ($CH_3$), 21.5 ($CH_3$), 51.8 ($CH_3$), 119.7 (CH), 127.3 (2 × CH), 127.4 (CH), 128.0 (CH), 129.6 (2 × CH), 130.7 (C), 131.8 (CH), 132.1 (C), 135.9 (C), 137.4 (C), 139.4 (CH), 143.8 (C), 167.0 (C); MS (ESI) $m/z$ 368 ($MNa^+$, 100).

**Methyl (2*E*)-3-(5′-Methoxy-2′-[*N*-(*p*-toluenesulfonyl)amino]-phenyl)prop-2-enoate.** The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-[*N*-(*p*-toluenesulfonyl)amino]-phenyl)prop-2-enoate using methyl (2*E*)-3-(2′-amino-5′-methoxy-phenyl)prop-2-enoate (**4c**) (0.014 g, 0.070 mmol). Purification by column chromatography (ethyl acetate/petroleum ether = 1:4) gave methyl (2*E*)-3-(5′-methoxy-2′-[*N*-(*p*-toluenesulfonyl)amino]phenyl)-prop-2-enoate (0.023 g, 93%) as a white solid. Mp 162−164 °C; $R_f$ = 0.23 (petroleum ether/ethyl acetate = 2:1); IR (neat) 3256, 3023, 1701, 1637, 1495, 1214, 1325, 1161, 750 $cm^{-1}$; $^1$H NMR (500 MHz, $CDCl_3$) $\delta$ 2.37 (s, 3H), 3.78 (s, 3H), 3.81 (s, 3H), 6.09 (d, $J$ = 15.9 Hz, 1H), 6.53 (br s, 1H), 6.89 (dd, $J$ = 8.8, 2.9 Hz, 1H), 6.95 (d, $J$ = 2.9 Hz, 1H), 7.19 (d, $J$ = 8.2 Hz, 2H), 7.23 (d, $J$ = 8.8 Hz, 1H), 7.46 (d, $J$ = 15.9 Hz, 1H), 7.52 (d, $J$ = 8.2 Hz, 2H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.5 ($CH_3$), 51.8 ($CH_3$), 55.5 ($CH_3$), 111.4 (CH), 116.7 (CH), 120.1 (CH), 127.3 (C), 127.4 (2 × CH), 129.6 (2 × CH), 130.6 (CH), 133.1 (C), 135.8 (C), 139.2 (CH), 143.9 (C), 158.9 (C), 166.7 (C); MS (ESI) $m/z$ 384 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{18}H_{19}NNaO_5S$ ($MNa^+$), 384.0876; found, 384.0864.

**Methyl (2*E*)-3-(5′-Fluoro-2′-[*N*-(*p*-toluenesulfonyl)amino]-phenyl)prop-2-enoate.**[19] The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-[*N*-(*p*-toluenesulfonyl)amino]-phenyl)prop-2-enoate using methyl (2*E*)-3-(2′-amino-5′-fluoro-phenyl)prop-2-enoate (**4d**) (2.50 g, 13.0 mmol). Purification by column chromatography (ethyl acetate/petroleum ether = 1:5) gave methyl (2*E*)-3-(5′-fluoro-2′-[*N*-(*p*-toluenesulfonyl)amino]phenyl)-prop-2-enoate (3.94 g, 88%) as a white solid. Mp 156−158 °C (lit.[19] 156−158 °C); $R_f$ = 0.13 (diethyl ether/petroleum ether = 1:1); $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.36 (s, 3H), 3.78 (s, 3H), 6.07 (d, $J$ = 15.8 Hz, 1H), 6.96 (br s, 1H), 7.06 (ddd, $J$ = 8.8, $^3J_{HF}$ = 7.7, $J$ = 2.9 Hz, 1H), 7.14 (dd, $^3J_{HF}$ = 9.2, $J$ = 2.9 Hz, 1H), 7.19 (d, $J$ = 8.1 Hz, 2H), 7.35 (dd, $J$ = 8.8, $^4J_{HF}$ = 5.2 Hz, 1H), 7.50 (dd, $J$ = 15.8, $^5J_{HF}$ = 1.5 Hz, 1H), 7.52 (d, $J$ = 8.1 Hz, 2H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.5 ($CH_3$), 52.0 ($CH_3$), 113.3 (d, $^2J_{CF}$ = 23.5 Hz, CH), 117.9 (d, $^2J_{CF}$ = 22.7 Hz, CH), 121.2 (CH), 127.3 (2 × CH), 129.7 (2 × CH), 130.6 (d, $^4J_{CF}$ = 2.9 Hz, C), 130.7 (d, $^3J_{CF}$ = 8.8 Hz, CH), 133.4 (d, $^3J_{CF}$ = 8.4


DOI: 10.1021/acs.joc.6b01357
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Hz, C), 135.6 (C), 138.2 (d, $^4J_{CF}$ = 2.2 Hz, CH), 144.2 (C), 161.5 (d, $^1J_{CF}$ = 248.4 Hz, C), 166.5 (C); MS (ESI) *m*/*z* 372 ($MNa^+$, 100).

**Methyl (2*E*)-3-(4′-Fluoro-2′-[*N*-(*p*-toluenesulfonyl)amino]-phenyl)prop-2-enoate.**[17] The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-[*N*-(*p*-toluenesulfonyl)amino]-phenyl)prop-2-enoate using methyl (2*E*)-3-(2′-amino-4′-fluoro-phenyl)prop-2-enoate (**4e**) (0.620 g, 3.20 mmol). Purification by column chromatography (ethyl acetate/petroleum ether = 1:5) gave methyl (2*E*)-3-(4′-fluoro-2′-[*N*-(*p*-toluenesulfonyl)amino]phenyl)-prop-2-enoate (1.08 g, 97%) as a yellow solid. Mp 157−159 °C; $R_f$ = 0.13 (diethyl ether/petroleum ether = 1:1). Spectroscopic data were consistent with the literature.[17] $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.38 (s, 3H), 3.79 (s, 3H), 6.11 (d, *J* = 15.8 Hz, 1H), 6.92 (td, *J* = 8.7, 2.6 Hz, 1H), 7.00 (br s, 1H), 7.20−7.26 (m, 3H), 7.41 (dd, *J* = 8.7, $^4J_{HF}$ = 6.1 Hz, 1H), 7.48 (d, *J* = 15.8 Hz, 1H), 7.63 (d, *J* = 8.3 Hz, 2H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.5 ($CH_3$), 51.9 ($CH_3$), 112.8 (d, $^2J_{CF}$ = 24.9 Hz, CH), 114.1 (d, $^2J_{CF}$ = 21.8 Hz, CH), 120.5 (CH), 125.1 (d, $^4J_{CF}$ = 3.4 Hz, C), 127.3 (2 × CH), 128.9 (d, $^3J_{CF}$ = 9.5 Hz, CH), 129.9 (2 × CH), 135.7 (C), 136.5 (d, $^3J_{CF}$ = 10.8 Hz, C), 137.8 (CH), 144.4 (C), 163.8 (d, $^1J_{CF}$ = 251.8 Hz, C), 166.7 (C); MS (ESI) *m*/*z* 372 ($MNa^+$, 100), 363 (37).

**Methyl (2*E*)-3-(5′-Chloro-2′-[*N*-(*p*-toluenesulfonyl)amino]-phenyl)prop-2-enoate.**[19] The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-[*N*-(*p*-toluenesulfonyl)amino]-phenyl)prop-2-enoate using methyl (2*E*)-3-(2′-amino-5′-chlorophenyl)prop-2-enoate (**4f**) (0.406 g, 1.90 mmol). The reaction mixture was stirred at room temperature for 18 h. Purification by column chromatography (ethyl acetate/petroleum ether = 1:5) gave methyl (2*E*)-3-(5′-chloro-2′-[*N*-(*p*-toluenesulfonyl)amino]phenyl)-prop-2-enoate (0.638 g, 91%) as a yellow solid. Mp 152−154 °C (lit.[19] 149−151 °C); $R_f$ = 0.43 (petroleum ether/ethyl acetate = 2:1); $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.36 (s, 3H), 3.78 (s, 3H), 6.09 (d, *J* = 15.8 Hz, 1H), 7.19 (d, *J* = 8.0 Hz, 2H), 7.28 (br s, 1H), 7.31 (dd, *J* = 8.6, 2.4 Hz, 1H), 7.36 (d, *J* = 8.6 Hz, 1H), 7.40 (d, *J* = 2.4 Hz, 1H), 7.50−7.56 (m, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.5 ($CH_3$), 52.1 ($CH_3$), 121.3 (CH), 126.9 (CH), 127.3 (2 × CH), 129.1 (CH), 129.8 (2 × CH), 130.8 (CH), 132.2 (C), 133.1 (C), 133.3 (C), 135.6 (C), 138.1 (CH), 144.2 (C), 166.7 (C); MS (ESI) *m*/*z* 388 ($MNa^+$, 100).

**Methyl (2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]-phenyl)prop-2-enoate (5a).** Allyl bromide (0.830 mL, 9.60 mmol) was added to a stirred solution of methyl (2*E*)-3-(2′-[*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (2.66 g, 8.00 mmol) and potassium carbonate (2.21 g, 16.0 mmol) in *N*,*N*′-dimethylformamide (50 mL). The reaction mixture was heated to 70 °C for 1 h. The reaction mixture was cooled to room temperature, diluted with 5% aqueous lithium chloride solution (20 mL), and extracted with diethyl ether (50 mL). The organic layer was washed with 5% aqueous lithium chloride solution (3 × 10 mL), brine (10 mL), dried ($MgSO_4$), filtered, and concentrated *in vacuo*. Purification by column chromatography (diethyl ether/petroleum ether = 1:1) gave methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (**5a**) (2.98 g, 100%) as a white solid. Mp 104−106 °C; $R_f$ = 0.38 (diethyl ether/petroleum ether = 1:1); IR (neat) 2951, 1716, 1636, 1436, 1319, 1164, 763 $cm^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.42 (s, 3H), 3.79 (s, 3H), 4.02 (br s, 1H), 4.27 (br s, 1H), 4.93−5.02 (m, 2H), 5.74 (ddt, *J* = 17.0, 10.0, 6.8 Hz, 1H), 6.33 (d, *J* = 16.1 Hz, 1H), 6.84 (dd, *J* = 7.8, 1.1 Hz, 1H), 7.24−7.35 (m, 4H), 7.56 (d, *J* = 8.2 Hz, 2H), 7.64 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.86 (d, *J* = 16.1 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.5 ($CH_3$), 51.7 ($CH_3$), 54.9 ($CH_2$), 119.7 (CH), 119.7 ($CH_2$), 127.1 (CH), 128.0 (2 × CH), 128.8 (CH), 129.6 (2 × CH), 129.9 (CH), 130.3 (CH), 132.1 (CH), 135.6 (C), 135.6 (C), 138.3 (C), 140.3 (CH), 143.8 (C), 166.9 (C); MS (ESI) *m*/*z* 394 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{20}H_{21}NNaO_4S$ ($MNa^+$), 394.1083; found, 394.1067.

**Methyl (2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-methylphenyl)prop-2-enoate (5b).** The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (**5a**) using methyl (2*E*)-3-(5′-methyl-2′-[*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (2.00 g, 5.79 mmol) and a reaction time of 3 h. Purification by column chromatography (ethyl acetate/petroleum ether = 1:5) gave methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-methylphenyl)-prop-2-enoate (**5b**) (2.03 g, 91%) as a white solid. Mp 118−120 °C; $R_f$ = 0.25 (diethyl ether/petroleum ether = 1:1); IR (neat) 2950, 1717, 1639, 1435, 1347, 1160, 759 $cm^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.34 (s, 3H), 2.42 (s, 3H), 3.78 (s, 3H), 3.99 (br s, 1H), 4.26 (br s, 1H), 4.93−5.02 (m, 2H), 5.74 (ddt, *J* = 17.0, 10.1, 6.8 Hz, 1H), 6.31 (d, *J* = 16.1 Hz, 1H), 6.71 (d, *J* = 8.1 Hz, 1H), 7.08 (dd, *J* = 8.1, 1.6 Hz, 1H), 7.26 (d, *J* = 8.2 Hz, 2H), 7.43 (d, *J* = 1.6 Hz, 1H), 7.56 (d, *J* = 8.2 Hz, 2H), 7.82 (d, *J* = 16.1 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.2 ($CH_3$), 21.5 ($CH_3$), 51.7 ($CH_3$), 54.9 ($CH_2$), 119.4 (CH), 119.6 ($CH_2$), 127.6 (CH), 128.0 (2 × CH), 129.5 (2 × CH), 129.6 (CH), 131.3 (CH), 132.3 (CH), 135.2 (C), 135.7 (C), 135.7 (C), 138.7 (C), 140.5 (CH), 143.7 (C), 167.0 (C); MS (ESI) *m*/*z* 408 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{21}H_{23}NNaO_4S$ ($MNa^+$), 408.1240; found, 408.1220.

**Methyl (2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-methoxyphenyl)prop-2-enoate (5c).** The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (**5a**) using methyl (2*E*)-3-(5′-methoxy-2′-[*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (0.145 g, 0.400 mmol) and a reaction time of 2 h. Purification by column chromatography (ethyl acetate/petroleum ether = 1:5) gave methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-methoxy-phenyl)prop-2-enoate (**5c**) (0.149 g, 92%) as a white solid. Mp 153−155 °C; $R_f$ = 0.40 (petroleum ether/ethyl acetate = 2:1); IR (neat) 3022, 1709, 1642, 1495, 1289, 1215, 1163, 751 $cm^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.42 (s, 3H), 3.79 (s, 3H), 3.81 (s, 3H), 3.96−4.01 (m, 1H), 4.24−4.29 (m, 1H), 4.93−5.03 (m, 2H), 5.74 (ddt, *J* = 16.9, 10.1, 6.8 Hz, 1H), 6.29 (d, *J* = 16.1 Hz, 1H), 6.74 (d, *J* = 8.8 Hz, 1H), 6.81 (dd, *J* = 8.8, 2.8 Hz, 1H), 7.09 (d, *J* = 2.8 Hz, 1H), 7.26 (d, *J* = 8.2 Hz, 2H), 7.56 (d, *J* = 8.2 Hz, 2H), 7.79 (d, *J* = 16.1 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.5 ($CH_3$), 51.7 ($CH_3$), 55.0 ($CH_2$), 55.5 ($CH_3$), 111.2 (CH), 116.4 (CH), 119.7 ($CH_2$), 119.8 (CH), 128.0 (2 × CH), 129.6 (2 × CH), 131.0 (CH), 132.3 (CH), 135.7 (C), 136.6 (C), 140.4 (CH), 143.7 (2 × C), 159.3 (C), 166.8 (C); MS (ESI) *m*/*z* 424 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{21}H_{23}NNaO_5S$ ($MNa^+$), 424.1189; found, 424.1176.

**Methyl (2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-fluorophenyl)prop-2-enoate (5d).** The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (**5a**) using methyl (2*E*)-3-(5′-fluoro-2′-[*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (3.74 g, 11.0 mmol). Purification by column chromatography (ethyl acetate/petroleum ether = 1:7) gave methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-fluorophenyl)prop-2-enoate (**5d**) (3.50 g, 84%) as a white solid. Mp 108−110 °C; $R_f$ = 0.43 (diethyl ether/petroleum ether = 1:1); IR (neat) 2951, 1718, 1650, 1488, 1323, 1275, 1160, 862, 728 $cm^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.40 (s, 3H), 3.77 (s, 3H), 3.95 (br s, 1H), 4.25 (br s, 1H), 4.95 (dd, *J* = 17.0, 1.2 Hz, 1H), 5.00 (dd, *J* = 10.1, 1.2 Hz, 1H), 5.71 (ddt, *J* = 17.0, 10.1, 6.8 Hz, 1H), 6.28 (d, *J* = 16.1 Hz, 1H), 6.80 (dd, *J* = 8.8, $^4J_{HF}$ = 5.3 Hz, 1H), 6.95 (ddd, *J* = 8.8, $^3J_{HF}$ = 7.6, *J* = 2.9 Hz, 1H), 7.26 (d, *J* = 8.2 Hz, 2H), 7.28 (dd, $^3J_{HF}$ = 9.4, *J* = 2.9 Hz, 1H), 7.54 (d, *J* = 8.2 Hz, 2H), 7.76 (dd, *J* = 16.1, $^5J_{HF}$ = 1.6 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.5 ($CH_3$), 51.8 ($CH_3$), 55.0 ($CH_2$), 113.5 (d, $^2J_{CF}$ = 23.4 Hz, CH), 117.4 (d, $^2J_{CF}$ = 23.0 Hz, CH), 120.1 ($CH_2$), 120.9 (CH), 127.9 (2 × CH), 129.7 (2 × CH), 131.8 (d, $^3J_{CF}$ = 8.9 Hz, CH), 131.9 (CH), 134.2 (d, $^4J_{CF}$ = 3.1 Hz, C), 135.3 (C), 137.8 (d, $^3J_{CF}$ = 8.5 Hz, C), 139.2 (d, $^4J_{CF}$ = 2.0 Hz, CH), 144.0 (C), 162.0 (d, $^1J_{CF}$ = 249.4 Hz, C), 166.5 (C); MS (ESI) *m*/*z* 412 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{20}H_{20}FNNaO_4S$ ($MNa^+$), 412.0989; found, 412.0969.

**Methyl (2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]-4′-fluorophenyl)prop-2-enoate (5e).** The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (**5a**) using methyl (2*E*)-3-(4′-fluoro-2′-[*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (1.07 g, 3.00 mmol). Purification by column chromatography (ethyl acetate/petroleum ether = 1:7) gave methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-4′-fluorophenyl)prop-2-enoate (**5e**) (0.946 g,


DOI: 10.1021/acs.joc.6b01357
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79%) as a white solid. Mp 111−113 °C; $R_f$ = 0.38 (diethyl ether/petroleum ether = 1:1); IR (neat) 2951, 1712, 1602, 1497, 1353, 1256, 1164, 908, 730 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.43 (s, 3H), 3.78 (s, 3H), 4.02 (br s, 1H), 4.21 (br s, 1H), 4.95−5.05 (m, 2H), 5.72 (ddt, $J$ = 16.9, 10.1, 6.8 Hz, 1H), 6.27 (d, $J$ = 16.1 Hz, 1H), 6.57 (dd, $^3J_{HF}$ = 9.2, $J$ = 2.8 Hz, 1H), 7.06 (td, $J$ = 8.8, 2.8 Hz, 1H), 7.29 (d, $J$ = 8.2 Hz, 2H), 7.58 (d, $J$ = 8.2 Hz, 2H), 7.62 (dd, $J$ = 8.8, $^4J_{HF}$ = 6.2 Hz, 1H), 7.78 (d, $J$ = 16.1 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.6 ($CH_3$), 51.7 ($CH_3$), 54.9 ($CH_2$), 116.4 (d, $^2J_{CF}$ = 21.6 Hz, CH), 117.0 (d, $^2J_{CF}$ = 21.9 Hz, CH), 119.5 (CH), 120.2 ($CH_2$), 128.0 (2 × CH), 128.6 (d, $^3J_{CF}$ = 9.4 Hz, CH), 129.7 (2 × CH), 131.7 (CH), 132.1 (d, $^4J_{CF}$ = 3.7 Hz, C), 135.1 (C), 139.3 (CH), 139.8 (d, $^3J_{CF}$ = 9.2 Hz, C), 144.2 (C), 163.1 (d, $^1J_{CF}$ = 253.1 Hz, C), 166.7 (C); MS (ESI) $m/z$ 412 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{20}H_{20}FNNaO_4S$ ($MNa^+$), 412.0989; found, 412.0970.

**Methyl (2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-chlorophenyl)prop-2-enoate (5f).** The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (**5a**) using methyl (2*E*)-3-(5′-chloro-2′-[*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (0.600 g, 1.60 mmol). Purification by column chromatography (ethyl acetate/petroleum ether = 1:5) gave methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-chlorophenyl)prop-2-enoate (**5f**) (0.664 g, 100%) as a yellow solid. Mp 104−106 °C; $R_f$ = 0.58 (petroleum ether/ethyl acetate = 2:1); IR (neat) 2951, 1720, 1610, 1353, 1164, 908, 730 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.44 (s, 3H), 3.80 (s, 3H), 3.99 (br s, 1H), 4.26 (br s, 1H), 4.97 (dd, $J$ = 17.0, 1.1 Hz, 1H), 5.03 (dd, $J$ = 10.1, 1.1 Hz, 1H), 5.73 (ddt, $J$ = 17.0, 10.1, 6.8 Hz, 1H), 6.31 (d, $J$ = 16.1 Hz, 1H), 6.78 (d, $J$ = 8.6 Hz, 1H), 7.24 (dd, $J$ = 8.6, 2.4 Hz, 1H), 7.29 (d, $J$ = 8.2 Hz, 2H), 7.57 (d, $J$ = 8.2 Hz, 2H), 7.60 (d, $J$ = 2.4 Hz, 1H), 7.75 (d, $J$ = 16.1 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.6 ($CH_3$), 51.8 ($CH_3$), 54.9 ($CH_2$), 120.2 ($CH_2$), 121.0 (CH), 127.1 (CH), 128.0 (2 × CH), 129.7 (2 × CH), 130.3 (CH), 131.2 (CH), 131.8 (CH), 134.7 (C), 135.3 (C), 136.7 (C), 137.4 (C), 139.0 (CH), 144.1 (C), 166.5 (C); MS (ESI) $m/z$ 428 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{20}H_{20}{}^{35}ClNNaO_4S$ ($MNa^+$), 428.0694; found, 428.0673.

**(2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-en-1-ol (6a).** Diisobutylaluminum hydride (4.1 mL, 4.1 mmol, 1 M in hexane) was added dropwise with stirring to a solution of methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (**5a**) (0.690 g, 1.86 mmol) in dichloromethane (19 mL) at −78 °C. The solution was stirred at −78 °C for 2 h and then allowed to warm to room temperature over 16 h. The reaction was quenched with 10% aqueous potassium sodium tartrate solution (5 mL), extracted with diethyl ether (2 × 10 mL), washed with water (20 mL), brine (20 mL), dried ($MgSO_4$), filtered, and concentrated *in vacuo*. Purification by column chromatography (ethyl acetate/petroleum ether = 1:2) gave (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-en-1-ol (**6a**) (0.611 g, 96%) as a colorless oil. $R_f$ = 0.13 (diethyl ether/petroleum ether = 1:1); IR (neat) 3491, 2924, 1597, 1341, 1161, 726 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 1.97 (br s, 1H), 2.43 (s, 3H), 4.00 (br s, 1H), 4.18−4.29 (m, 3H), 4.93−5.01 (m, 2H), 5.72 (ddt, $J$ = 16.9, 10.2, 6.7 Hz, 1H), 6.33 (dt, $J$ = 16.0, 5.4 Hz, 1H), 6.68 (dd, $J$ = 7.8, 1.3 Hz, 1H), 6.83 (d, $J$ = 16.0 Hz, 1H), 7.12 (td, $J$ = 7.8, 1.3 Hz, 1H), 7.23−7.30 (m, 3H), 7.55−7.61 (m, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.5 ($CH_3$), 54.8 ($CH_2$), 63.8 ($CH_2$), 119.4 ($CH_2$), 126.5 (CH), 126.7 (CH), 127.8 (CH), 127.9 (2 × CH), 128.6 (CH), 129.4 (CH), 129.5 (2 × CH), 130.8 (CH), 132.4 (CH), 136.1 (C), 136.6 (C), 137.8 (C), 143.6 (C); MS (ESI) $m/z$ 366 ($MNa^+$, 100); HMRS (ESI) calcd for $C_{19}H_{21}NNaO_3S$ ($MNa^+$), 366.1134; found, 366.1119.

**(2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-methylphenyl)prop-2-en-1-ol (6b).** The reaction was carried out as described for the synthesis of (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-en-1-ol (**6a**) using methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-methylphenyl)prop-2-enoate (**5b**) (1.50 g, 3.89 mmol). Purification by column chromatography (ethyl acetate/petroleum ether = 1:2) gave (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-methylphenyl)prop-2-en-1-ol (**6b**) (1.37 g, 98%) as a colorless oil. $R_f$ = 0.10 (diethyl ether/petroleum ether = 1:1); IR (neat) 3510, 2921, 1598, 1491, 1340, 1159, 859, 734 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.15 (br s, 1H), 2.31 (s, 3H), 2.42 (s, 3H), 3.96 (br s, 1H), 4.19−4.28 (m, 3H), 4.93−5.01 (m, 2H), 5.72 (ddt, $J$ = 16.9, 10.2, 6.7 Hz, 1H), 6.31 (dt, $J$ = 16.0, 5.7 Hz, 1H), 6.56 (d, $J$ = 8.1 Hz, 1H), 6.79 (d, $J$ = 16.0 Hz, 1H), 6.92 (dd, $J$ = 8.1, 1.3 Hz, 1H), 7.27 (d, $J$ = 8.2 Hz, 2H), 7.40 (d, $J$ = 1.3 Hz, 1H), 7.57 (d, $J$ = 8.2 Hz, 2H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.2 ($CH_3$), 21.5 ($CH_3$), 54.8 ($CH_2$), 63.8 ($CH_2$), 119.2 ($CH_2$), 126.7 (CH), 127.0 (CH), 127.9 (2 × CH), 128.7 (CH), 129.1 (CH), 129.5 (2 × CH), 130.5 (CH), 132.5 (CH), 134.1 (C), 136.2 (C), 137.3 (C), 138.4 (C), 143.5 (C); MS (ESI) $m/z$ 380 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{20}H_{23}NNaO_3S$ ($MNa^+$), 380.1291; found, 380.1279.

**(2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-methoxyphenyl)prop-2-en-1-ol (6c).** The reaction was carried out as described for the synthesis of (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-en-1-ol (**6a**) using methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-methoxyphenyl)prop-2-enoate (**5c**) (0.140 g, 0.350 mmol). Purification by column chromatography (ethyl acetate/petroleum ether = 1:2) gave (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-methoxyphenyl)prop-2-en-1-ol (**6c**) (0.104 g, 80%) as a colorless oil. $R_f$ = 0.18 (petroleum ether/ethyl acetate = 2:1); IR (neat) 3523, 2944, 1601, 1495, 1345, 1161, 752 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.07 (t, $J$ = 5.4 Hz, 1H), 2.42 (s, 3H), 3.79 (s, 3H), 3.91−3.98 (m, 1H), 4.18−4.28 (m, 3H), 4.93−5.01 (m, 2H), 5.72 (ddt, $J$ = 16.9, 10.2, 6.7 Hz, 1H), 6.30 (dt, $J$ = 16.0, 5.4 Hz, 1H), 6.58 (d, $J$ = 8.8 Hz, 1H), 6.65 (dd, $J$ = 8.8, 2.9 Hz, 1H), 6.77 (dt, $J$ = 16.0, 1.5 Hz, 1H), 7.07 (d, $J$ = 2.9 Hz, 1H), 7.27 (d, $J$ = 8.2 Hz, 2H), 7.57 (d, $J$ = 8.2 Hz, 2H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.5 ($CH_3$), 54.9 ($CH_2$), 55.4 ($CH_3$), 63.7 ($CH_2$), 110.7 (CH), 113.9 (CH), 119.3 ($CH_2$), 126.6 (CH), 127.9 (2 × CH), 129.4 (C), 129.7 (2 × CH), 130.4 (CH), 130.9 (CH), 132.5 (CH), 136.2 (C), 138.8 (C), 143.5 (C), 159.2 (C); MS (ESI) $m/z$ 396 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{20}H_{23}NNaO_4S$ ($MNa^+$), 396.1240; found, 396.1223.

**(2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-fluorophenyl)prop-2-en-1-ol (6d).** The reaction was carried out as described for the synthesis of (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-en-1-ol (**6a**) using methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-fluorophenyl)prop-2-enoate (**5d**) (3.30 g, 8.50 mmol). Purification by column chromatography (ethyl acetate/petroleum ether = 1:3) gave (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-fluorophenyl)prop-2-en-1-ol (**6d**) (2.99 g, 98%) as a colorless oil. $R_f$ = 0.10 (diethyl ether/petroleum ether = 1:1); IR (neat) 3507, 2920, 1600, 1488, 1345, 1161, 752 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.35 (t, $J$ = 5.6 Hz, 1H), 2.42 (s, 3H), 3.95 (dd, $J$ = 13.4, 6.8, 1H), 4.17−4.28 (m, 3H), 4.91−5.01 (m, 2H), 5.70 (ddt, $J$ = 16.9, 10.1, 6.8 Hz, 1H), 6.30 (dt, $J$ = 16.0, 5.5 Hz, 1H), 6.65 (dd, $J$ = 8.8, $^4J_{HF}$ = 5.4 Hz, 1H), 6.73−6.83 (m, 2H), 7.24 (dd, $^3J_{HF}$ = 10.0, $J$ = 2.9 Hz, 1H), 7.27 (d, $J$ = 8.3 Hz, 2H), 7.56 (d, $J$ = 8.3 Hz, 2H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.5 ($CH_3$), 54.9 ($CH_2$), 63.4 ($CH_2$), 112.8 (d, $^2J_{CF}$ = 23.3 Hz, CH), 114.7 (d, $^2J_{CF}$ = 23.1 Hz, CH), 119.7 ($CH_2$), 125.4 (d, $^4J_{CF}$ = 1.7 Hz, CH), 127.9 (2 × CH), 129.6 (2 × CH), 131.2 (d, $^3J_{CF}$ = 9.1 Hz, CH), 132.1 (CH), 132.3 (CH), 132.4 (d, $^4J_{CF}$ = 2.8 Hz, C), 135.9 (C), 140.2 (d, $^3J_{CF}$ = 8.6 Hz, C), 143.8 (C), 162.2 (d, $^1J_{CF}$ = 247.9 Hz, C); MS (ESI) $m/z$ 384 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{19}H_{20}FNNaO_3S$ ($MNa^+$), 384.1040; found, 384.1023.

**(2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]-4′-fluorophenyl)prop-2-en-1-ol (6e).** The reaction was carried out as described for the synthesis of (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-en-1-ol (**6a**) using methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-4′-fluorophenyl)prop-2-enoate (**5e**) (0.790 g, 2.00 mmol). Purification by column chromatography (ethyl acetate/petroleum ether, 1:3) gave (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-4′-fluorophenyl)prop-2-en-1-ol (**6e**) (0.728 g, 99%) as a colorless oil. $R_f$ = 0.08 (diethyl ether/petroleum ether = 1:1); IR (neat) 3507, 2923, 1600, 1495, 1347, 1161, 908, 727 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.18 (t, $J$ = 5.6 Hz, 1H), 2.43 (s, 3H), 3.96 (br s, 1H), 4.09−4.27 (m, 3H), 4.94−5.03 (m, 2H), 5.69 (ddt, $J$ = 16.9, 10.1, 6.7 Hz, 1H), 6.25 (dt, $J$ = 16.0, 5.3 Hz, 1H), 6.41 (dd, $^3J_{HF}$



DOI: 10.1021/acs.joc.6b01357
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= 9.3, $J$ = 2.6 Hz, 1H), 6.75 (d, $J$ = 16.0 Hz, 1H), 6.99 (td, $J$ = 8.6, 2.6 Hz, 1H), 7.29 (d, $J$ = 8.2 Hz, 2H), 7.55 (dd, $J$ = 8.6, $^4J_{HF}$ = 6.3 Hz, 1H), 7.58 (d, $J$ = 8.2 Hz, 2H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.6 ($CH_3$), 54.7 ($CH_2$), 63.6 ($CH_2$), 116.0 (d, $^2J_{CF}$ = 21.2 Hz, CH), 116.2 (d, $^2J_{CF}$ = 21.2 Hz, CH), 119.8 ($CH_2$), 125.7 (CH), 127.7 (d, $^3J_{CF}$ = 8.9 Hz, CH), 127.9 (2 × CH), 129.7 (2 × CH), 130.7 (d, $^5J_{CF}$ = 1.8 Hz, CH), 131.9 (CH), 134.3 (d, $^4J_{CF}$ = 3.7 Hz, C), 135.7 (C), 137.7 (d, $^3J_{CF}$ = 8.8 Hz, C), 144.0 (C), 161.5 (d, $^1J_{CF}$ = 248.9 Hz, C); MS (ESI) $m/z$ 384 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{19}H_{20}FNNaO_3S$ ($MNa^+$), 384.1040; found, 384.1023.

**(2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-chlorophenyl)prop-2-en-1-ol (6f).** The reaction was carried out as described for the synthesis of (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-en-1-ol (**6a**) using methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-chlorophenyl)prop-2-enoate (**5f**) (0.660 g, 1.60 mmol). Purification by column chromatography (ethyl acetate/petroleum ether = 1:3) gave (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-chlorophenyl)prop-2-en-1-ol (**6f**) (0.566 g, 92%) as a colorless oil. $R_f$ = 0.28 (petroleum ether/ethyl acetate = 2:1); IR (neat) 3505, 2923, 1597, 1478, 1343, 1161, 907, 727 $cm^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.23 (br s, 1H), 2.43 (s, 3H), 3.94 (br s, 1H), 4.17−4.29 (m, 3H), 4.92−5.02 (m, 2H), 5.69 (ddt, $J$ = 17.0, 10.1, 6.8 Hz, 1H), 6.32 (dt, $J$ = 16.0, 5.1 Hz, 1H), 6.60 (d, $J$ = 8.6 Hz, 1H), 6.75 (dt, $J$ = 16.0, 1.5 Hz, 1H), 7.07 (dd, $J$ = 8.6, 2.4 Hz, 1H), 7.28 (d, $J$ = 8.2 Hz, 2H), 7.54−7.59 (m, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.6 ($CH_3$), 54.8 ($CH_2$), 63.4 ($CH_2$), 119.8 ($CH_2$), 125.2 (CH), 126.5 (CH), 127.8 (CH), 127.9 (2 × CH), 129.7 (2 × CH), 130.7 (CH), 132.0 (CH), 132.4 (CH), 134.5 (C), 135.0 (C), 135.8 (C), 139.6 (C), 143.9 (C); MS (ESI) $m/z$ 400 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{19}H_{20}{}^{35}ClNNaO_3S$ ($MNa^+$), 400.0745; found, 400.0729.

**5-Nitro-2-[*N*-(*p*-toluenesulfonyl)amino]benzaldehyde (8).** *p*-Toluenesulfonamide (0.148 g, 0.865 mmol) was added to a solution of 2-chloro-5-nitrobenzaldehyde (**7**) (0.0800 g, 0.432 mmol), and potassium carbonate (0.107 g, 0.780 mmol) in *N*,*N*′-dimethylformamide (2 mL) and heated to 90 °C for 2 h. The reaction mixture was cooled to room temperature, diluted with water (2 mL), and extracted with ethyl acetate (10 mL). The organic layer was washed with 1 M hydrochloric acid solution (3 × 2 mL) and brine (2 mL), dried ($MgSO_4$), filtered, and concentrated *in vacuo*. Purification by column chromatography (ethyl acetate/petroleum ether = 1:5) gave 5-nitro-2-[*N*-(*p*-toluenesulfonyl)amino]benzaldehyde (**8**) (0.122 g, 86%) as a white solid. Mp 172−174 °C; $R_f$ = 0.38 (petroleum ether/ethyl acetate = 2:1); IR (neat) 3164, 1673, 1586, 1345, 1215, 1164, 749 $cm^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.40 (s, 3H), 7.31 (d, $J$ = 8.2 Hz, 2H), 7.81 (d, $J$ = 9.3 Hz, 1H), 7.83 (d, $J$ = 8.2 Hz, 2H), 8.34 (dd, $J$ = 9.3, 2.6 Hz, 1H), 8.54 (d, $J$ = 2.6 Hz, 1H), 9.94 (d, $J$ = 0.6 Hz, 1H), 11.19 (br s, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.6 ($CH_3$), 117.3 (CH), 120.5 (C), 127.4 (2 × CH), 130.2 (2 × CH), 130.5 (CH), 131.5 (CH), 135.6 (C), 142.1 (C), 145.0 (C), 145.3 (C), 193.5 (CH); MS (ESI) $m/z$ 343 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{14}H_{12}N_2NaO_5S$ ($MNa^+$), 343.0359; found, 343.0350.

**Ethyl (2*E*)-3-(5′-Nitro-2′-[*N*-(*p*-toluenesulfonyl)amino]-phenyl)prop-2-enoate.** Lithium bromide (0.043 g, 0.50 mmol) was added to a solution of triethyl phosphonoacetate (0.085 mL, 0.43 mmol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (0.064 mL, 0.43 mmol) in acetonitrile (2 mL) and stirred at room temperature for 0.5 h. 5-Nitro-2-[*N*-(*p*-toluenesulfonyl)amino]benzaldehyde (**8**) (0.040 g, 0.13 mmol) was added, and the solution was stirred at room temperature for 3 h. The reaction was quenched with 10% aqueous potassium sodium tartrate solution (2 mL), concentrated to half volume *in vacuo*, and extracted with diethyl ether (3 × 5 mL). The combined organic layers were washed with water (2 mL), brine (2 mL), dried ($MgSO_4$), filtered, and concentrated *in vacuo*. Purification by column chromatography (ethyl acetate/petroleum ether = 1:3) gave ethyl (2*E*)-3-(5′-nitro-2′-[*N*-(*p*-toluenesulfonyl)amino]phenyl)-prop-2-enoate (0.048 g, 99%) as a white solid. Mp 158−160 °C; $R_f$ = 0.28 (petroleum ether/ethyl acetate = 2:1); IR (neat) 3255, 2980, 1700, 1640, 1527, 1344, 1166, 908, 757 $cm^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 1.34 (t, $J$ = 7.1 Hz, 3H), 2.38 (s, 3H), 4.27 (q, $J$ = 7.1 Hz, 2H), 6.35 (d, $J$ = 15.7 Hz, 1H), 7.26 (d, $J$ = 8.2 Hz, 2H), 7.63 (d, $J$ = 15.7 Hz, 1H), 7.65−7.72 (m, 4H), 8.16 (dd, $J$ = 9.0, 2.6 Hz, 1H), 8.28 (d, $J$ = 2.6 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 14.2 ($CH_3$), 21.6 ($CH_3$), 61.3 ($CH_2$), 123.0 (CH), 123.1 (CH), 124.3 (CH), 125.5 (CH), 127.2 (2 × CH), 127.9 (C), 130.1 (2 × CH), 135.6 (C), 136.5 (CH), 140.6 (C), 144.7 (C), 144.9 (C), 165.9 (C); MS (ESI) $m/z$ 413 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{18}H_{18}N_2NaO_6S$ ($MNa^+$), 413.0778; found, 413.0760.

**Ethyl (2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-nitrophenyl)prop-2-enoate (9).** The reaction was carried out as described for the synthesis of methyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-enoate (**5a**) using ethyl (2*E*)-3-(2′-[*N*-(*p*-toluenesulfonyl)amino]-5′-nitrophenyl)prop-2-enoate (0.020 g, 0.047 mmol). Purification by column chromatography (ethyl acetate/petroleum ether, 1:10) gave ethyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-nitrophenyl)prop-2-enoate (**9**) (0.012 g, 55%) as a white solid. Mp 128−130 °C; $R_f$ = 0.50 (petroleum ether/ethyl acetate = 2:1); IR (neat) 2956, 1716, 1529, 1349, 1215, 908, 730 $cm^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 1.35 (t, $J$ = 7.1 Hz, 3H), 2.44 (s, 3H), 4.16 (br s, 2H), 4.28 (q, $J$ = 7.1 Hz, 2H), 4.98 (dd, $J$ = 17.0, 1.1 Hz, 1H), 5.04 (dd, $J$ = 10.0, 1.1 Hz, 1H), 5.72 (ddt, $J$ = 17.0, 10.0, 6.8 Hz, 1H), 6.47 (d, $J$ = 16.1 Hz, 1H), 7.05 (d, $J$ = 8.8 Hz, 1H), 7.31 (d, $J$ = 8.2 Hz, 2H), 7.57 (d, $J$ = 8.2 Hz, 2H), 7.80 (d, $J$ = 16.1 Hz, 1H), 8.11 (dd, $J$ = 8.8, 2.6 Hz, 1H), 8.49 (d, $J$ = 2.6 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 14.3 ($CH_3$), 21.6 ($CH_3$), 54.8 ($CH_2$), 60.9 ($CH_2$), 120.7 ($CH_2$), 122.3 (CH), 122.9 (CH), 124.3 (CH), 127.9 (2 × CH), 129.9 (2 × CH), 131.1 (CH), 131.4 (CH), 134.9 (C), 137.6 (C), 138.0 (CH), 143.6 (C), 144.6 (C), 147.4 (C), 165.7 (C); MS (ESI) $m/z$ 453 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{21}H_{22}N_2NaO_6S$ ($MNa^+$), 453.1091; found, 453.1073.

**(2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-nitrophenyl)prop-2-en-1-ol (6g).** The reaction was carried out as described for the synthesis of (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-en-1-ol (**6a**) using ethyl (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-nitrophenyl)prop-2-enoate (**9**) (0.143 g, 0.330 mmol). Purification by column chromatography (ethyl acetate/petroleum ether = 1:2) gave (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-nitrophenyl)prop-2-en-1-ol (**6g**) (0.110 g, 85%) as a colorless oil. $R_f$ = 0.18 (petroleum ether/ethyl acetate = 2:1); IR (neat) 3537, 2924, 1525, 1347, 1162, 748 $cm^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.05 (br s, 1H), 2.45 (s, 3H), 4.12 (br s, 2H), 4.33 (br d, $J$ = 4.9 Hz, 2H), 4.92−5.04 (m, 2H), 5.69 (ddt, $J$ = 17.0, 10.1, 6.8 Hz, 1H), 6.49 (dt, $J$ = 16.0, 4.9 Hz, 1H), 6.85 (dt, $J$ = 16.0, 1.6 Hz, 1H), 6.86 (d, $J$ = 8.8 Hz, 1H), 7.32 (d, $J$ = 8.2 Hz, 2H), 7.57 (d, $J$ = 8.2 Hz, 2H), 7.95 (dd, $J$ = 8.8, 2.7 Hz, 1H), 8.43 (d, $J$ = 2.7 Hz, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.6 ($CH_3$), 54.7 ($CH_2$), 63.2 ($CH_2$), 120.4 ($CH_2$), 121.7 (CH), 122.1 (CH), 124.4 (CH), 127.9 (2 × CH), 129.8 (2 × CH), 130.5 (CH), 131.5 (CH), 134.1 (CH), 135.4 (C), 139.9 (C), 142.0 (C), 144.3 (C), 147.5 (C); MS (ESI) $m/z$ 411 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{19}H_{20}N_2NaO_5S$ ($MNa^+$), 411.0985; found, 411.0970.

***N*-(*p*-Toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (10a).** (2*E*)-3-(2′-[*N*-Allyl-*N*-(*p*-toluenesulfonyl)amino]phenyl)prop-2-en-1-ol (**6a**) (0.313 g, 0.911 mmol) was dissolved in dichloromethane (45 mL) and cooled to 0 °C under argon with stirring. Trichloroacetonitrile (0.137 mL, 1.37 mmol) was added to the solution, followed by 1,8-diazabicyclo[5.4.0]undec-7-ene (0.0685 mL, 0.460 mmol), and the reaction was allowed to warm to room temperature over 2 h. The reaction mixture was filtered through a short pad of alumina (neutral, Brockman V) with diethyl ether (150 mL) and concentrated *in vacuo* to yield the crude allylic trichloroacetimidate as a yellow oil. This was used without further purification. The allylic trichloroacetimidate was transferred to a dry Schlenk tube containing a stirrer bar and potassium carbonate (0.0300 g, 5 mg/mL) to which *p*-xylene (6 mL) was then added. The tube was purged with argon, sealed, and heated to 160 °C for 24 h. The reaction mixture was allowed to cool to room temperature, and Grubbs' second generation catalyst (0.0391 g, 0.0460 mmol) and *p*-xylene (51 mL) were added. The reaction mixture was heated to 60 °C for 18 h. The reaction mixture was concentrated *in*


DOI: 10.1021/acs.joc.6b01357
J. Org. Chem. 2016, 81, 6697−6706

*vacuo* and purified by column chromatography (diethyl ether/petroleum ether = 1:3) to give *N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10a**) (0.339 g, 81%) as a white solid. Mp 160−163 °C (decomposition); $R_f$ = 0.28 (diethyl ether/petroleum ether = 1:1); IR (neat) 3337, 2925, 1701, 1496, 1341, 1159, 906, 727 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.47 (s, 3H), 3.86 (br s, 1H), 4.66 (br s, 1H), 5.58 (br t, $J$ = 7.7 Hz, 1H), 5.84 (br d, $J$ = 9.0 Hz, 1H), 6.04 (br s, 1H), 6.82 (br s, 1H), 7.23 (td, $J$ = 8.4, 1.6 Hz, 1H), 7.31 (td, $J$ = 8.4, 1.3 Hz, 1H), 7.36 (d, $J$ = 8.2 Hz, 2H), 7.42 (br d, $J$ = 8.4 Hz, 1H), 7.77 (d, $J$ = 8.2 Hz, 2H), 8.37 (br s, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.6 ($CH_3$), 49.0 ($CH_2$), 52.7 (CH), 92.5 (C), 125.8 (CH), 127.4 (2 × CH), 128.2 (CH), 129.3 (CH), 129.7 (CH), 130.0 (2 × CH), 130.8 (2 × CH), 137.7 (C), 138.1 (C), 139.2 (C), 144.2 (C), 161.4 (C); MS (ESI) $m/z$ 481 ($MNa^+$, 49); HRMS (ESI) calcd for $C_{19}H_{17}{}^{35}Cl_3N_2NaO_3S$ ($MNa^+$), 480.9918; found, 480.9904.

**7-Methyl-*N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (10b).** The reaction was carried out as described for the synthesis of *N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10a**) using (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-methylphenyl)prop-2-en-1-ol (**6b**) (0.170 g, 0.480 mmol). Purification by column chromatography (diethyl ether/petroleum ether = 1:3) gave 7-methyl-*N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10b**) (0.179 g, 80%) as a white solid. Mp 174−176 °C; $R_f$ = 0.30 (diethyl ether/petroleum ether = 1:1); IR (neat) 3333, 2923, 1701, 1505, 1340, 1155, 1112, 909, 727 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.33 (s, 3H), 2.47 (s, 3H), 3.82 (br s, 1H), 4.67 (br s, 1H), 5.53 (br t, $J$ = 7.8 Hz, 1H), 5.84 (br d, $J$ = 8.6 Hz, 1H), 6.04 (br s, 1H), 6.67 (br s, 1H), 7.02 (dd, $J$ = 8.1, 1.4 Hz, 1H), 7.23 (br s, 1H), 7.36 (d, $J$ = 8.2 Hz, 2H), 7.76 (d, $J$ = 8.2 Hz, 2H), 8.43 (br s, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.1 ($CH_3$), 21.6 ($CH_3$), 49.1 ($CH_2$), 52.7 (CH), 92.5 (C), 125.8 (CH), 127.4 (2 × CH), 127.9 (CH), 130.0 (2 × CH), 130.2 (2 × CH), 130.9 (CH), 135.4 (C), 137.8 (C), 138.8 (C), 139.4 (C), 144.1 (C), 161.4 (C); MS (ESI) $m/z$ 495 ($MNa^+$, 48); HRMS (ESI) calcd for $C_{20}H_{19}{}^{35}Cl_3N_2NaO_3S$ ($MNa^+$), 495.0074; found, 495.0053.

**7-Methoxy-*N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (10c).** The reaction was carried out as described for the synthesis of *N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10a**) using (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-methoxyphenyl)prop-2-en-1-ol (**6c**) (0.076 g, 0.20 mmol). Purification by column chromatography (diethyl ether/petroleum ether = 1:3) gave 7-methoxy-*N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10c**) (0.079 g, 79%) as a white solid. Mp 190−195 °C (decomposition); $R_f$ = 0.20 (diethyl ether/petroleum ether = 1:1); IR (neat) 3337, 2935, 1701, 1502, 1215, 1156, 749 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.46 (s, 3H), 3.61−3.84 (m, 4H), 4.72 (br s, 1H), 5.51 (br t, $J$ = 7.6 Hz, 1H), 5.85 (br s, 1H), 6.05 (br s, 1H), 6.64 (br s, 1H), 6.71 (dd, $J$ = 8.6, 2.8 Hz, 1H), 6.93 (br s, 1H), 7.35 (d, $J$ = 8.2 Hz, 2H), 7.74 (d, $J$ = 8.2 Hz, 2H), 8.58 (br s, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.6 ($CH_3$), 49.2 ($CH_2$), 52.9 (CH), 55.6 ($CH_3$), 92.5 (C), 114.9 (CH), 125.5 (CH), 127.4 (2 × CH), 129.2 (CH), 130.0 (2 × CH), 130.4 (CH), 131.2 (CH), 137.7 (C), 140.5 (C), 144.1 (C), 159.7 (2 × C), 161.4 (C); MS (ESI) $m/z$ 513 ($MNa^+$, 51); HRMS (ESI) calcd for $C_{20}H_{19}{}^{35}Cl_2{}^{37}ClN_2NaO_4S$ ($MNa^+$), 512.9994; found, 512.9973.

**7-Fluoro-*N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (10d).** The reaction was carried out as described for the synthesis of *N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10a**) using (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-fluorophenyl)prop-2-en-1-ol (**6d**) (0.189 g, 0.520 mmol). Purification by column chromatography (diethyl ether/petroleum ether = 1:3) gave 7-fluoro-*N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10d**) (0.204 g, 82%) as a white solid. Mp 181−183 °C; $R_f$ = 0.25 (petroleum ether/diethyl ether = 3:1); IR (neat) 3333, 3034, 1705, 1503, 1344, 1159, 907, 729 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.47 (s, 3H), 3.81 (br s, 1H), 4.62 (br s, 1H), 5.52 (br t, $J$ = 7.4 Hz, 1H), 5.85 (br s, 1H), 5.98 (br s, 1H), 6.81 (br s, 1H), 6.91 (td, $J$ = 8.2, 2.9 Hz, 1H), 7.12 (br s, 1H), 7.36 (d, $J$ = 8.2 Hz, 2H), 7.75 (d, $J$ = 8.2 Hz, 2H), 8.40 (br s, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.6 ($CH_3$), 48.9 ($CH_2$), 52.2 (CH), 92.4 (C), 116.1 (CH), 116.4 (CH), 125.4 (CH), 127.4 (2 × CH), 130.1 (3 × CH), 131.1 (CH), 133.9 (C), 137.3 (C), 141.6 (C), 144.4 (C), 161.4 (C), 162.1 (d, $^1J_{CF}$ = 250.6 Hz, C); MS (ESI) $m/z$ 499 ($MNa^+$, 49); HRMS (ESI) calcd for $C_{19}H_{16}{}^{35}Cl_3FN_2NaO_3S$ ($MNa^+$), 498.9823; found, 498.9809.

**8-Fluoro-*N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (10e).** The reaction was carried out as described for the synthesis of *N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10a**) using (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-4′-fluorophenyl)prop-2-en-1-ol (**6e**) (0.222 g, 0.610 mmol). Purification by column chromatography (diethyl ether/petroleum ether = 1:3) gave 8-fluoro-*N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10e**) (0.269 g, 92%) as a white solid. Mp 147−149 °C; $R_f$ = 0.28 (diethyl ether/petroleum ether = 1:1); IR (neat) 3340, 2925, 1704, 1599, 1501, 1343, 1160, 909, 731 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.48 (s, 3H), 3.86 (br d, $J$ = 17.8 Hz, 1H), 4.62 (br d, $J$ = 17.8 Hz, 1H), 5.56 (br t, $J$ = 7.8 Hz, 1H), 5.85 (ddd, $J$ = 11.4, 4.5, 1.8 Hz, 1H), 6.02 (dd, $J$ = 11.4, 7.8 Hz, 1H), 6.55 (br d, $^3J_{HF}$ = 8.0 Hz, 1H), 7.02 (td, $J$ = 8.2, 2.6 Hz, 1H), 7.38 (d, $J$ = 8.2 Hz, 2H), 7.41 (dd, $J$ = 8.2, $^4J_{HF}$ = 6.4 Hz, 1H), 7.77 (d, $J$ = 8.2 Hz, 2H), 8.24 (br s, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.7 ($CH_3$), 48.8 ($CH_2$), 52.1 (CH), 92.4 (C), 115.6 (d, $^2J_{CF}$ = 22.9 Hz, CH), 116.2 (d, $^2J_{CF}$ = 21.0 Hz, CH), 125.6 (CH), 127.4 (2 × CH), 130.2 (2 × CH), 130.7 (CH), 132.0 (CH), 135.3 (d, $^4J_{CF}$ = 3.5 Hz, C), 137.2 (C), 139.4 (d, $^3J_{CF}$ = 9.9 Hz, C), 144.6 (C), 161.4 (C), 162.5 (d, $^1J_{CF}$ = 230.0 Hz, C); MS (ESI) $m/z$ 499 ($MNa^+$, 49); HRMS (ESI) calcd for $C_{19}H_{16}{}^{35}Cl_3FN_2NaO_3S$ ($MNa^+$), 498.9823; found, 498.9804.

**7-Chloro-*N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (10f).** The reaction was carried out as described for the synthesis of *N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10a**) using (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-chlorophenyl)prop-2-en-1-ol (**6f**) (0.290 g, 0.770 mmol). The RCM step was heated to 60 °C for 24 h. Purification by column chromatography (diethyl ether/petroleum ether = 1:3) gave 7-chloro-*N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10f**) (0.300 g, 79%) as a white solid. Mp 158−160 °C; $R_f$ = 0.25 (diethyl ether/petroleum ether = 1:1); IR (neat) 3341, 2925, 1705, 1495, 1343, 1159, 908, 730 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 2.47 (s, 3H), 3.88 (br s, 1H), 4.60 (br s, 1H), 5.51 (br t, $J$ = 7.6 Hz, 1H), 5.84 (br d, $J$ = 9.0 Hz, 1H), 5.97 (br s, 1H), 6.79 (br s, 1H), 7.20 (dd, $J$ = 8.4, 2.4 Hz, 1H), 7.36 (d, $J$ = 8.2 Hz, 2H), 7.40 (br s, 1H), 7.75 (d, $J$ = 8.2 Hz, 2H), 8.26 (br s, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) $\delta$ 21.7 ($CH_3$), 48.9 ($CH_2$), 52.1 (CH), 92.3 (C), 125.4 (CH), 127.4 (2 × CH), 129.6 (2 × CH), 130.2 (2 × CH), 131.0 (2 × CH), 134.9 (C), 136.5 (C), 137.2 (C), 141.0 (C), 144.5 (C), 161.4 (C); MS (ESI) $m/z$ 515 ($MNa^+$, 42); HRMS (ESI) calcd for $C_{19}H_{16}{}^{35}Cl_4N_2NaO_3S$ ($MNa^+$), 514.9528; found, 514.9515.

**7-Nitro-*N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (10g).** The reaction was carried out as described for the synthesis of *N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10a**) using (2*E*)-3-(2′-[*N*-allyl-*N*-(*p*-toluenesulfonyl)amino]-5′-nitrophenyl)prop-2-en-1-ol (**6g**) (0.084 g, 0.22 mmol). The Overman rearrangement was heated to 160 °C for 43 h, and the RCM step was heated to 60 °C for 31 h. Purification by column chromatography (diethyl ether/petroleum ether = 1:3) gave 7-nitro-*N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10g**) (0.053 g, 49%) as a white solid. Mp 180−185 °C (decomposition); $R_f$ = 0.28 (diethyl ether/petroleum ether = 1:1); IR (neat) 3335, 3020, 1709, 1592, 1530,



DOI: 10.1021/acs.joc.6b01357
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1350, 1215, 1161, 749 $cm^{-1}$; $^1H$ NMR (400 MHz, $CDCl_3$) $\delta$ 2.49 (s, 3H), 4.03 (br d, $J$ = 18.5 Hz, 1H), 4.54 (br d, $J$ = 18.5 Hz, 1H), 5.64 (br t, $J$ = 7.2 Hz, 1H), 5.86 (br d, $J$ = 11.4 Hz, 1H), 5.95−6.02 (m, 1H), 7.18 (d, $J$ 8.6 Hz, 1H), 7.41 (d, $J$ = 8.2 Hz, 2H), 7.79 (d, $J$ = 8.2 Hz, 2H), 7.98 (br s, 1H), 8.13 (dd, $J$ = 8.6, 2.6 Hz, 1H), 8.29 (d, $J$ = 2.6 Hz, 1H); $^{13}C$ NMR (101 MHz, $CDCl_3$) $\delta$ 21.7 ($CH_3$), 48.7 ($CH_2$), 51.8 (CH), 92.1 (C), 124.5 (2 × CH), 125.1 (CH), 127.4 (2 × CH), 129.6 (CH), 130.4 (2 × CH), 130.7 (CH), 136.8 (C), 141.1 (C), 143.8 (C), 145.0 (C), 147.4 (C), 161.5 (C); MS (ESI) $m/z$ 526 ($MNa^+$, 49); HRMS (ESI) calcd for $C_{19}H_{16}{}^{35}Cl_3N_3NaO_5S$ ($MNa^+$), 525.9768; found, 525.9761.

**5-*tert*-Butoxycarbonylamino-*N*-(*p*-toluenesulfonyl)-2,5-dihydro-1*H*-benzo[*b*]azepine (11).** Sodium hydroxide (2 M, 5 mL) was added to a solution of *N*-(*p*-toluenesulfonyl)-5-(2′,2′,2′-trichloromethylcarbonylamino)-2,5-dihydro-1*H*-benzo[*b*]azepine (**10a**) (0.165 g, 0.359 mmol) in methanol (3 mL) at 60 °C and stirred for 18 h. The mixture was allowed to cool to room temperature, and then di-*tert*-butyl dicarbonate (0.393 g, 1.80 mmol) was added. The reaction mixture was stirred for a further 24 h. The reaction mixture was extracted with ethyl acetate (3 × 5 mL), dried ($MgSO_4$), filtered, and concentrated *in vacuo*. Purification by column chromatography (ethyl acetate/petroleum ether = 1:20) gave 5-*tert*-butoxycarbonylamino-*N*-(*p*-toluenesulfonyl)-2,5-dihydro-1*H*-benzo[*b*]azepine (**11**) (0.108 g, 73%) as a white solid. Mp 149−151 °C (decomposition); $R_f$ = 0.28 (petroleum ether/ethyl acetate = 2:1); IR (neat) 3393, 2978, 1698, 1494, 1343, 1159, 908, 728 $cm^{-1}$; $^1H$ NMR (400 MHz, $CDCl_3$) $\delta$ 1.44 (s, 9H), 2.45 (s, 3H), 4.14 (br s, 1H), 4.35 (br s, 1H), 5.33 (br t, $J$ = 7.2 Hz, 1H), 5.50 (br s, 1H), 5.61 (br d, $J$ = 10.7 Hz, 1H), 5.81 (br s, 1H), 7.05 (d, $J$ = 7.6 Hz, 1H), 7.21 (td, $J$ = 7.6, 1.6 Hz, 1H), 7.27−7.36 (m, 4H), 7.77 (br d, $J$ = 8.2 Hz, 2H); $^{13}C$ NMR (126 MHz, $CDCl_3$) $\delta$ 21.6 ($CH_3$), 28.4 (3 × $CH_3$), 48.9 ($CH_2$), 51.4 (CH), 79.5 (C), 127.3 (2 × CH), 127.8 (CH), 128.5 (3 × CH), 128.7 (2 × CH), 129.9 (2 × CH), 137.6 (C), 138.0 (C), 141.4 (C), 143.8 (C), 154.9 (C); MS (ESI) $m/z$ 437 ($MNa^+$, 100); HRMS (ESI) calcd for $C_{22}H_{26}N_2NaO_4S$ ($MNa^+$), 437.1505; found, 437.1486.

**5-*tert*-Butoxycarbonylamino-2,3,4,5-tetrahydro-1*H*-benzo[*b*]azepine (12).**[3c] Palladium on charcoal (10%, 0.017 g) was added to a solution of 5-*tert*-butoxycarbonylamino-*N*-(*p*-toluenesulfonyl)-2,5-dihydro-1*H*-benzo[*b*]azepine (**11**) (0.057 g, 0.14 mmol) in ethyl acetate (4 mL). The mixture was stirred under an atmosphere of hydrogen at 60 °C for 17 h. The reaction mixture was filtered through a short pad of Celite with diethyl ether (50 mL) and concentrated *in vacuo* to give 5-*tert*-butoxycarbonylamino-*N*-(*p*-toluenesulfonyl)-2,3,4,5-tetrahydro-1*H*-benzo[*b*]azepine (0.050 g) as a white solid. 5-*tert*-Butoxycarbonylamino-*N*-(*p*-toluenesulfonyl)-2,3,4,5-tetrahydro-1*H*-benzo[*b*]azepine (0.050 g, 0.12 mmol) was dissolved in methanol (5 mL), and magnesium turnings (0.082 g, 3.4 mmol) were added. The mixture was heated under reflux for 4 h. The reaction mixture was cooled to 0 °C, and 1 M hydrochloric acid solution (10 mL) was added dropwise. The solution was extracted with ethyl acetate (3 × 10 mL), dried ($MgSO_4$), and concentrated *in vacuo*. Purification by column chromatography using (ethyl acetate/petroleum ether = 1:20) gave 5-*tert*-butoxycarbonylamino-2,3,4,5-tetrahydro-1*H*-benzo[*b*]-azepine (**12**) (0.032 g, 88%) as a white solid. Mp 151−153 °C (lit.[3c] 153−154 °C); $R_f$ = 0.45 (petroleum ether/ethyl acetate = 2:1); $^1H$ NMR (400 MHz, $CDCl_3$) $\delta$ 1.42 (s, 9H), 1.55−1.80 (m, 2H), 1.94−2.21 (m, 2H), 2.83 (td, $J$ = 12.8, 2.0 Hz, 1H), 3.21−3.35 (m, 1H), 3.61 (br s, 1H), 4.90 (t, $J$ = 8.1 Hz, 1H), 5.72 (br d, $J$ = 8.1 Hz, 1H), 6.73 (dd, $J$ = 7.3, 1.1 Hz, 1H), 6.89 (td, $J$ = 7.3, 1.1 Hz, 1H), 7.08 (td, $J$ = 7.3, 1.6 Hz, 1H), 7.23 (br d, $J$ = 7.3 Hz, 1H); $^{13}C$ NMR (101 MHz, $CDCl_3$) $\delta$ 25.5 ($CH_2$), 28.5 (3 × $CH_3$), 30.9 ($CH_2$), 49.1 ($CH_2$), 55.1 (CH), 79.0 (C), 120.5 (CH), 121.9 (CH), 128.0 (CH), 130.0 (CH), 133.7 (C), 149.1 (C), 155.2 (C); MS (ESI) $m/z$ 285 ($MNa^+$, 100).

## ■ ASSOCIATED CONTENT

### Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.joc.6b01357.

$^1H$ and $^{13}C$ NMR spectra for all novel compounds (PDF)

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### Notes

The authors declare no competing financial interest.

## ■ ACKNOWLEDGMENTS

Financial support from the Ministry of Higher Education and Scientific Research and the University of Benghazi, Libya (studentship to S.A.I.S.), the EPSRC (studentship to E.D.D.C., EP/P505534/1), the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES, grant to F.G.D., Proc. No. 88888.021508/2013-00), and Science without Borders is gratefully acknowledged.

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DOI: 10.1021/acs.joc.6b01357
*J. Org. Chem.* 2016, 81, 6697−6706