Notes

A General Synthesis of Unsymmetrical Tetrasubstituted Ureas

Alan R. Katritzky,* David P. M. Pleynet, and Baozhen Yang

Center for Heterocyclic Compounds, Department of Chemistry, University of Florida, Gainesville, Florida 32611-7200

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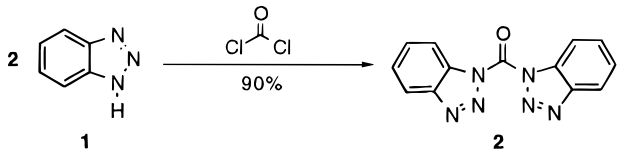
Introduction

Substituted ureas have been the subject of much attention and synthetic effort due to their applications which range widely including the dyeing of hair and cellulose fibers, serving as antioxidants in gasoline for automobiles, as additives in detergents to prevent carbon deposits, and acting as corrosion inhibitors.[1] Their biological activities as plant growth regulators, pesticides, herbicides, tranquillizing, and anticonvulsant medicinal preparations are also important.[1] Recently, unsymmetrical substituted ureas have been shown to be potent HIV-1 protease inhibitors.[2,3]

Although numerous methods are available for the preparation of symmetrical and unsymmetrical di- or trisubstituted ureas in good to excellent yields,[4] until now the only reported synthesis of unsymmetrical[26] tetrasubstituted ureas is by reaction of carbamoyl chloride (prepared from the interaction of a secondary amine and phosgene) with a secondary amine.[28] Moreover, this method, used more recently by Voss[29] and Somlo,[29] suffers from several drawbacks. An excess of amine and/or the use of an acid scavenger (such as pyridine or triethylamine) is required, and the carbamoyl chloride intermediate can be both unstable and difficult to isolate when needed. Moreover, the production of hydrochloric acid prevents the application of this method when acid-sensitive functionalities are present. We now report that 1,1′-carbonylbisbenzotriazole (**2**) is a safe, mild, and versatile reagent for the synthesis of unsymmetrical tetrasubstituted ureas. It can also be used to make di- and trisubstituted ureas.

Scheme 1



Results and Discussion

1,1′-Carbonylbisbenzotriazole (**2**) has previously been described[30] and utilized for the dehydration of aldoxime amides to nitriles.[31] A simplified high-yielding method (90%) to prepare **2** involves vigourous stirring for 3 days of 2 equiv of benzotriazole with phosgene (Scheme 1). This allows complete evolvement of the HCl byproduct. Attempts using 4 equiv of benzotriazole (in order to neutralize the HCl formed) gave lower yields, and the isolation of **2** proved less effective. The NMR spectra of **2** showed that it was essentially 1,1′-carbonylbisbenzotriazole (**2**) although traces of the isomers containing one and two benzotriazol-2-yl groups were detected by NMR on the crude product. A one-pot reaction of reagent **2** successively with 1 mol each of the two amines, aniline and *n*-octylamine, produced the expected unsymmetrical disubstituted urea **4a** in high yield (85%, Table 1, Scheme 2).

Trisubstituted ureas were synthesized by one-pot reactions of **2** successively with a primary amine and a

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(4) The most important of the wide variety of methods to prepare mono-, di-, and trisubstituted ureas[1,5] mostly fall into three main groups. In the first place, primary amines are reacted with carbonyl insertion compounds such as phosgene,[5] trisphosgene,[6] various carbonates,[7−9] *S,S*-dimethyl thiocarbonate,[10] and *N,N*′-carbonyldiimidazole.[11] The second class comprises the reactions of primary amines with NCO equivalent compounds like carbamates,[12−14] formamides (in the presence of a ruthenium catalyst),[15] and most importantly isocyanates.[5,16] Thirdly, ureas have been prepared by the catalyzed carbonylation of amines using carbon monoxide[17−20] or carbon dioxide[21,22] in the presence of metal complexes, selenium,[17] phosphorus compounds,[23,24] and *N,N*′-dicyclohexylcarbodiimide.[25]
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Table 1. Preparation of Ureas by Successive Treatments with (i) R^1NHR^2 and (ii) R^3NHR^4

product	R^1	R^2	R^3	R^4	yield (%)
4a	phenyl	H	*n*-octyl	H	85[a]
4b	phenyl	H	$-(CH_2)_2O(CH_2)_2-$		16[a]
4b	phenyl	H	$-(CH_2)_2O(CH_2)_2-$		70[b]
4c	*n*-butyl	methyl	$-(CH_2)_4-$		82[c,d]
4d	*n*-butyl	methyl	phenyl	methyl	80[c,d]
4e	*n*-butyl	methyl	phenyl	phenyl	71[c,d]
4f	$-(CH_2)_2O(CH_2)_2-$		$-(CH_2)_5-$		71[c,d]
4g	$-(CH_2)_2O(CH_2)_2-$		*n*-butyl	methyl	80[c,d]
4h	$-(CH_2)_2O(CH_2)_2-$		benzyl	methyl	25[c,d]
4i	$-(CH_2)_2O(CH_2)_2-$		phenyl	phenyl	51[c,d]
4j	$-(CH_2)_2O(CH_2)_2-$		phenyl	methyl	57[c,d]
4k	$-(CH_2)_2N(CH_3)(CH_2)_2-$		phenyl	phenyl	47[c,d]
4l	$-(CH_2)_2N(CH_3)(CH_2)_2-$		phenyl	methyl	51[c,d]

[a] One-pot procedure carried out at room temperature. [b] One-pot procedure carried out at room temperature after addition of the primary amine and heated under reflux after addition of the secondary amine. [c] Two-pot procedure: yield from corresponding compound **3**. [d] Heated under reflux and use of the sodium salt of the amine.

Scheme 2

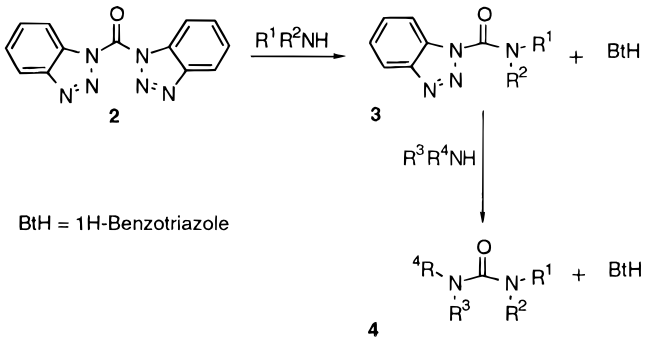

Table 2. Preparation of Carbamoyl Benzotriazoles 3 According to Scheme 2

product	R^1	R^2	yield (%)
3a	$-(CH_2)_2O(CH_2)_2-$		74[a]
3b	$-(CH_2)_2N(CH_3)(CH_2)_2-$		73[a]
3c	*n*-butyl	methyl	65[a]
3d	phenyl	phenyl	23[b]
3e	phenyl	methyl	40[b]
3f	benzyl	benzyl	50[c]
3g	benzyl	methyl	76[c]

[a] Room temperature. [b] Heated under reflux and use of the sodium salt of the amine. [c] Heated under reflux.

secondary amine: the second step now required more forceful conditions (reflux) than for the reaction of a primary amine with the carbamoylbenzotriazole intermediate **3**. The yield of **4b** was improved from 16% at room temperature to 70% by carrying out the reaction under reflux. Attempts to reverse the order of addition, *i.e.* to react **2** first with the secondary amine and then with a primary amine did not give satisfactory yields of trisubstituted ureas in one-pot procedures. However, secondary amines were reacted with **2** to form carbamoylbenzotriazoles **3a**−**g** in good yields (Scheme 2, Table 2). The reaction conditions and the yields of **3** obtained were significantly affected by the steric hindrance emanating from the substituents of the secondary amine. The procedure succeeded at room temperature in good yields for cyclic, aliphatic, and aromatic amines whereas harsher conditions were required and lower yields obtained from congested secondary amines.

The carbamoylbenzotriazoles **3a**−**g** were used to prepare the ten diverse unsymmetrical tetrasubstituted ureas **4c**−**l** (Table 1). Carbamoyl **3c** was reacted with three secondary amines, pyrrolidine, *N*-methylaniline, and diphenylamine, to prepare the desired tetrasubstituted unsymmetrical ureas **4c**, **4d**, and **4e** in yields of 82%, 80%, and 71%, respectively. Reactions of carbamoyl **3a** with piperidine and *N*-*n*-butyl-*N*-methylamine afforded ureas **4f** and **4g** in good yields (71% and 80%, respectively). However, the interaction of carbamoyl **3a** with *N*-methylbenzylamine, diphenylamine, and *N*-methylaniline provided the corresponding ureas **4h**, **4i**, and **4j** in lower yields (25%, 51%, and 57%, respectively). Similar reactions between carbamoyl **3b** and diphenylamine or *N*-methylaniline afforded ureas **4k** and **4l** in yields of 47% and 51%, respectively. Especially the preparations of ureas **4i** and **4k** illustrate the efficiency of this method to produce ureas as evidenced by the reported low reactivity of diphenylamine, *e.g.* toward isocyanates.[1] The use of diphenylcarbamoyl chloride was previously required to prepare a *N*,*N*-diphenyl-substituted urea.[32] The low yield of formation of **4h** can be explained by the difficult purification of **4h** (compound not UV-active and need to use phosphomolybdic acid (PMA) as a stain). The range of unsymmetrical tetrasubstituted ureas prepared (aromatic, aliphatic, bicyclic) shows that this method can accommodate a wide variety of amines.

In conclusion, the present work shows that unsymmetrical tetrasubstituted ureas in particular can be efficiently prepared from 1,1′-carbonylbisbenzotriazole (**2**). The application of this method should provide a safe and versatile route to these ureas which are difficult to obtain by other methods.

Experimental Section

General Comments. Melting points are uncorrected. ^1H NMR spectra were recorded at 300 MHz with tetramethylsilane (TMS) as an internal reference. ^{13}C NMR spectra were recorded at 75 MHz, using the middle peak of $CDCl_3$ (δ = 77.0 ppm) as the reference. The ^1H and ^{13}C broad signals reported for compounds **3a**−**c** and **3f**,**g** are due to the relation to the NMR time scale of the rate of the s-cis to s-trans interconversions about the N−CO bonds. All reagents were purchased from chemical suppliers and used without further purification unless otherwise indicated. Tetrahydrofuran (THF) was distilled from sodium/benzophenone prior to use. Hexanes used in elution systems for purification by column chromatography were in the boiling range of 40−60 °C. HRMS spectra were obtained by using the positive FAB method unless otherwise indicated.

Preparation of 1,1′-Carbonylbisbenzotriazole (2). Benzotriazole (5.96 g, 50 mmol) was dissolved in dry THF (200 mL) under a dry atmosphere of nitrogen, and phosgene (12.95 mL, 1.93 M solution in toluene) was added dropwise. The reaction was stirred vigourously for 72 h, and the solvent was removed under reduced pressure. The solid obtained was washed with copious amounts of diethyl ether (5 × 100 mL) and dried to give **2** as a white solid (5.90 g, 90%): mp 182−184 °C (lit.[30] mp 183−185 °C); ^1H NMR δ 8.26−8.21 (m, 4H), 7.81−7.75 (m, 2H), 7.65−7.59 (m, 2H); ^{13}C NMR δ 145.6, 144.7, 132.4, 130.7, 126.7, 120.8, 113.3. Anal. Calcd for $C_{13}H_8N_6O$: C, 59.09; H, 3.05; N, 31.80. Found: C, 59.09; H, 2.93; N, 31.89.

Procedure for the Preparation of *N*-Phenyl-*N*′-*n*-octylurea (4a). Compound **2** (1.06 g, 4 mmol) was dissolved in dry THF (40 mL) under a dry atmosphere of nitrogen, and aniline (0.37 mL, 4 mmol) was added. The reaction mixture was stirred at room temperature for 27 h, octylamine (0.65 mL, 4 mmol) was then added, and the resulting reaction mixture was stirred at room temperature for 27 h before being extracted with diethyl ether (3 × 40 mL). The ethereal extracts were successively washed with 2 N HCl (2 × 20 mL), 2 N NaOH (2 × 20 mL), and

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saturated NaCl (30 mL), dried with $MgSO_4$, and filtered. Removal of the solvent under reduced pressure gave **4a** as a white powder (840 mg, 85%): mp 74−75 °C (lit.[33] mp 74−74.5 °C); ^{1}H NMR δ 7.61 (br s, 1H), 7.29−7.18 (m, 4H), 7.01−6.95 (m, 1H), 5.76 (br s, 1H), 3.17−3.11 (m, 2H), 1.43−1.39 (m, 2H), 1.28−1.22 (m, 10H), 0.86 (t, J = 7 Hz, 3H); ^{13}C NMR δ 156.7, 139.1, 129.0, 123.0, 120.3, 40.3, 31.8, 30.2, 29.3, 29.2, 26.9, 22.6, 14.0. Anal. Calcd for $C_{15}H_{24}N_2O$: C, 72.54; H, 9.74; N, 11.28. Found: C, 72.38; H, 9.73; N, 11.25.

Procedure for the Preparation of *N*-Phenyl-*N′*,*N′*-(3-oxapentamethylene)urea (4b). Compound **2** (1.06 g, 4 mmol) was dissolved in dry THF (40 mL) under a dry atmosphere of nitrogen, and aniline (0.37 mL, 4 mmol) was added. The reaction mixture was stirred at room temperature for 24 h, and morpholine (0.35 mL, 4 mmol) was added. The resulting reaction mixture was heated under reflux for 24 h, cooled, and extracted with diethyl ether (3 × 40 mL), and the ethereal extracts were successively washed with 2 N HCl (2 × 20 mL), 2 N NaOH (2 × 20 mL), and saturated NaCl (30 mL), dried with $MgSO_4$, and filtered. Removal of the solvent under reduced pressure gave a solid which was purified by column chromatography, eluting with diethyl ether/hexane (70:30). Compound **4b** was obtained as a white powder (571 mg, 70%): mp 157−159 °C; ^{1}H NMR δ 7.36−7.26 (m, 4H), 7.05 (t, J = 7 Hz, 1H), 6.47 (br s, 1H), 3.71 (t, J = 5 Hz, 4H), 3.46 (t, J = 5 Hz, 4H); ^{13}C NMR δ 155.2, 138.7, 128.9, 123.4, 120.2, 120.1, 66.5, 44.3. Anal. Calcd for $C_{11}H_{14}N_2O_2$: C, 64.06; H, 6.84; N, 13.58. Found: C, 63.95; H, 7.03; N, 13.31.

General Procedure for the Preparation of Carbamoylbenzotriazoles 3a-c,f,g. Compound **2** was dissolved in dry THF under a dry atmosphere of nitrogen, and the secondary amine (1.1 equiv) added. The reaction mixture was stirred at room temperature for 2 days for **3a** and **3b** and 1 day for **3c** or heated under reflux for 1 day for **3f** and **3g**. The crude reaction mixtures were purified by column chromatography without prior workup because compounds **3** were not stable to base washings.

1-(*N*,*N*-(3-Oxapentamethylene)carbamoyl)benzotriazole (3a): white powder (eluent diethyl ether/hexane (50:50), 680 mg, 74%): mp 102−103 °C; ^{1}H NMR δ 8.10 (d, J = 8 Hz, 1H), 8.00 (d, J = 8 Hz, 1H), 7.64−7.59 (m, 1H), 7.49−7.43 (m, 1H), 3.95−3.88 (m, 8H); ^{13}C NMR δ 149.4, 145.3, 133.1, 129.4, 125.3, 119.8, 113.5, 66.6, 48−46 (weak broad signal). Anal. Calcd for $C_{11}H_{12}N_4O_2$: C, 56.89; H, 5.21; N, 24.12. Found: C, 57.12; H, 5.32; N, 24.15.

1-(*N*,*N*-(*N*-Methyl-3-azapentamethylene)carbamoyl)benzotriazole (3b): off-white powder (eluent ethyl acetate/hexane (90:10), 710 mg, 73%); mp 78−80 °C; ^{1}H NMR δ 8.09 (d, J = 8 Hz, 1H), 7.99 (d, J = 8 Hz, 1H), 7.60 (t, J = 8 Hz, 1H), 7.45 (t, J = 8 Hz, 1H), 3.94 (br s, 4H), 2.60 (t, J = 4.5Hz, 4H), 2.38 (s, 3H); ^{13}C NMR δ 149.3, 145.3, 133.1, 129.3, 125.1, 119.8, 113.5, 54.7, 48−46 (weak broad signal), 45.9. Anal. Calcd for $C_{12}H_{15}N_5O$: C, 58.76; H, 6.16; N, 28.55. Found: C, 58.93; H, 6.25; N, 28.67.

1-(*N*-*n*-Butyl-*N*-methylcarbamoyl)benzotriazole (3c): pale yellow oil (eluent diethyl ether/hexane (50:50), 600 mg, 65%); ^{1}H NMR δ 8.09 (d, J = 8 Hz, 1H), 7.99 (d, J = 8 Hz, 1H), 7.59 (t, J = 8 Hz, 1H), 7.44 (t, J = 8 Hz, 1H), 3.66 (t, J = 9 Hz, 2H), 3.33 (br s, 3H), 1.82−1.72 (m, 2H), 1.41 (br s, 2H), 0.97 (br s, 3H); ^{13}C NMR δ 150.3, 145.0, 133.0, 129.0, 124.9, 119.5, 113.5, 50.4 (broad signal), 37.7 (broad signal), 29.0 (broad signal), 19.7, 13.6. Anal. Calcd for $C_{12}H_{16}N_4O$: C, 62.05; H, 6.94; N, 24.12. Found: C, 62.01; H, 7.03; N, 24.10.

1-(*N*,*N*-Dibenzylcarbamoyl)benzotriazole (3f): white powder (eluent diethyl ether/hexane (50:50), 1.36 g, 50%); mp 114−116 °C; ^{1}H NMR δ 8.09 (d, J = 4 Hz, 1H), 8.05 (d, J = 4 Hz, 1H), 7.61 (t, J = 7 Hz, 1H), 7.44 (t, J = 7 Hz, 1H), 7.35 (br s, 10H), 4.86 (br s, 4H); ^{13}C NMR δ 151.2, 145.3, 135.8, 133.4, 129.4, 128.8, 127.9, 125.2, 119.9, 113.6, 52 (weak broad signal). Anal. Calcd for $C_{21}H_{18}N_4O$: C, 73.65; H, 5.30; N, 16.37. Found: C, 73.28; H, 5.28; N, 16.43.

1-(*N*-Benzyl-*N*-methylcarbamoyl)benzotriazole (3g): white powder (eluent diethyl ether/hexane (50:50), 1.53 g, 76%); mp 54−57 °C; ^{1}H NMR δ 8.11−8.04 (m, 2H), 7.61 (t, J = 7 Hz, 1H), 7.48−7.38 (m, 6H), 4.89 (br s, 2H), 3.28 (br s, 3H); ^{13}C NMR δ 150.8, 145.2, 135.7, 133.2, 129.2, 128.7, 125.1, 119.7, 113.6, 54 (broad signal), 37−36 (broad signal). Anal. Calcd for $C_{14}H_{12}N_4O$: C, 67.65; H, 5.30; N, 21.04. Found: C, 67.54; H, 5.31; N, 20.96.

General Procedure for the Preparation of Ureas 4c−l and Carbamoylbenzotriazoles 3d,e. To a secondary amine (1.2 equiv) dissolved in dry THF under a dry atmosphere of nitrogen was added sodium hydride (60% solution in mineral oil), and the resulting mixture was added *via* canula to a solution of the corresponding compounds **3** or **2** (for **3f** and **3g**) in dry THF. The reaction mixture was heated under reflux for 1 day for **3d**, **4i**, and **4j**, 1.5 days for **4g**,**h**, **4c**−**e**, and **4k**,**l**, 3 days for **3e**, and 4 days for **4f** before being extracted with diethyl ether. The ethereal extracts were successively washed with 2 N NaOH and saturated NaCl, dried with $MgSO_4$, and filtered. Removal of the solvent under reduced pressure gave oils which were purified by column chromatography unless otherwise indicated. Compounds **3d** and **3e** were purified by column chromatography without any prior workup.

***N*-*n*-Butyl-*N*-methyl-*N′*,*N′*-tetramethyleneurea (4c):** pale yellow oil (Kugelrohr distillation, 750 mg, 82%); ^{1}H NMR δ 3.34 (t, J = 6 Hz, 4H), 3.17 (t, J = 7.5 Hz, 8H), 2.81 (s, 3H), 1.81 (t, J = 6 Hz, 4H), 1.54 (quintet, J = 8 Hz, 2H), 1.35−1.26 (m, 2H), 0.93 (t, J = 7.5 Hz, 3H); ^{13}C NMR δ 163.2, 49.7, 48.2, 35.8, 29.7, 25.3, 19.9, 13.7; HRMS calcd for $C_{10}H_{20}N_2O$ 185.1653 (M + 1), found 185.1648 (M + 1).

***N*-*n*-Butyl-*N*,*N′*-dimethyl-*N′*-phenylurea (4d):** pale yellow oil (eluent diethyl ether/hexane (30:70), 525 mg, 80%); ^{1}H NMR δ 7.34−7.28 (m, 2H), 7.12−7.05 (m, 3H), 3.19−3.11 (m, 5H), 2.58 (s, 3H), 1.42−1.35 (m, 2H), 1.26−1.18 (m, 2H), 0.87 (t, J = 7 Hz, 3H); ^{13}C NMR δ 161.8, 147.1, 129.3, 124.1, 123.7, 49.6, 39.6, 35.9, 29.2, 20.0, 13.7; HRMS calcd for $C_{13}H_{20}N_2O$ 221.1653 (M + 1), found 221.1650 (M + 1).

***N*-*n*-Butyl-*N*-methyl-*N′*,*N′*-diphenylurea (4e):** pale yellow oil (eluent diethyl ether/hexane (50:50), 600 mg, 71%): ^{1}H NMR δ 7.29 (t, J = 7.7 Hz, 4H), 7.10 (t, J = 7.5 Hz, 2H), 7.02 (d, J = 7.5 Hz, 4H), 3.23 (t, J = 7.5 Hz, 2H), 2.76 (s, 3H), 1.49−1.41 (m, 2H), 1.27 (sextet, J = 7.5 Hz, 2H), 0.90 (t, J = 7.5 Hz, 3H); ^{13}C NMR δ 160.5, 145.0, 129.1, 124.8, 124.4, 49.7, 35.8, 29.3, 20.0, 13.8. Anal. Calcd for $C_{18}H_{22}N_2O$: C, 76.56; H, 7.85; N, 9.92. Found: C, 76.95; H, 8.21; N, 10.15.

***N*,*N*-Pentamethylene-*N′*,*N′*-(3-oxapentamethylene)urea (4f):** white powder (Kugelrohr distillation, 700 mg, 71%): mp 40−43 °C; ^{1}H NMR δ 3.74−3.66 (m, 4H), 3.25−3.21 (m, 8H), 1.60−1.50 (m, 6H); ^{13}C NMR δ 164.2, 66.6, 47.7, 47.4, 25.7, 24.6; HRMS calcd for $C_{10}H_{18}N_2O_2$ 199.1446 (M + 1), found 199.1447 (M + 1).

***N*-*n*-Butyl-*N*-methyl-*N′*,*N′*-(3-oxapentamethylene)urea (4g):** pale yellow oil (Kugelrohr distillation, 800 mg, 80%); ^{1}H NMR δ 3.69 (t, J = 4.5 Hz, 4H), 3.22−3.16 (m, 6H), 2.83 (s, 3H), 1.53 (m, 2H), 1.30 (sextet, J = 7.7 Hz, 2H), 0.92 (t, J = 7.5 Hz, 3H); ^{13}C NMR δ 164.5, 66.5, 128.6, 49.7, 47.3, 35.9, 29.4, 19.8, 13.7; HRMS calcd for $C_{10}H_{20}N_2O_2$ 201.1603 (M + 1), found 201.1611 (M + 1).

***N*-Benzyl-*N*-methyl-*N′*,*N′*-(3-oxapentamethylene)urea (4h):** pale yellow oil (eluent diethyl ether/hexane (50:50), 250 mg, 25%); ^{1}H NMR δ 7.36−7.23 (m, 5H), 4.40 (s, 2H), 3.69 (t, J = 4.5 Hz, 4H), 3.27 (t, J = 4.5 Hz, 4H), 2.76 (s, 3H); ^{13}C NMR δ 164.7, 137.5, 128.6, 127.9, 127.3, 66.6, 53.9, 47.4, 36.3; HRMS (pos. CI) calcd for $C_{13}H_{18}N_2O_2$ 235.1446 (M + 1), found 235.1416 (M + 1).

***N*,*N*-Diphenyl-*N′*,*N′*-(3-oxapentamethylene)urea (4i):** white powder (eluent diethyl ether/hexane (50:50), 307 mg, 51%); mp 107−109 °C; ^{1}H NMR δ 7.31 (t, J = 8 Hz, 4H), 7.13 (t, J = 7 Hz, 4H), 7.05 (d, J = 8 Hz, 4H), 3.54 (t, J = 5 Hz, 4H), 3.35 (t, J = 5 Hz, 4H); ^{13}C NMR δ 159.7, 144.7, 129.2, 125.1, 124.9, 66.4, 45.9. Anal. Calcd for $C_{17}H_{18}N_2O_2$: C, 72.32; H, 6.43; N, 9.92. Found: C, 72.08; H, 6.56; N, 9.80.

***N*-Methyl-*N*-phenyl-*N′*,*N′*-(3-oxapentamethylene)urea (4j):** pale yellow oil (eluent diethyl ether/hexane (70:30), 270 mg, 57%); ^{1}H NMR δ 7.37−7.31 (m, 2H), 7.15−7.10 (m, 3H), 3.49−3.46 (m, 4H), 3.24 (s, 3H), 3.24−3.18 (m, 4H); ^{13}C NMR δ 160.9, 146.5, 129.4, 124.7, 123.8, 66.3, 46.0, 39.6; HRMS (pos. CI) calcd for $C_{12}H_{16}N_2O_2$ 221.1290 (M + 1), found 221.1294 (M + 1).

***N*,*N*-Diphenyl-*N′*,*N′*-(*N*-methyl-3-azapentamethylene)urea (4k):** white powder (eluent diethyl ether/ethyl acetate (30:70), 330 mg, 47%): mp 89−91 °C; ^{1}H NMR δ 7.29 (t, J = 7.5 Hz, 4H), 7.11 (t, J = 7 Hz, 2H), 7.04 (d, J = 8 Hz, 4H), 3.38 (t,

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J = 5 Hz, 4H), 2.27−2.24 (m, 4H), 2.24 (s, 3H); ^{13}C NMR δ 159.6, 144.8, 129.1, 125.0, 124.6, 54.5, 46.0, 45.4. Anal. Calcd for $C_{18}H_{21}N_3O$: C, 73.19; H, 7.17; N, 14.23. Found: C, 72.83; H, 7.49; N, 14.50.

***N*-Methyl-*N*-phenyl-*N′*,*N′*-(*N*-methyl-3-azapentamethylene)urea (4l):** pale yellow oil (eluent dichloromethane/diethyl ether/methanol/ethyl acetate (10:15:5:70), 290 mg, 51%); ^{1}H NMR δ 7.32 (t, J = 7.5 Hz, 2H), 7.11−7.08 (m, 3H), 3.24−3.21 (m, 7H), 2.21−2.18 (m, 7H); ^{13}C NMR δ 160.7, 146.6, 129.2, 124.3, 123.6, 54.3, 45.9, 45.4, 39.4. Anal. Calcd for $C_{13}H_{19}N_3O$: C, 66.92; H, 8.21; N, 18.01. Found: C, 66.55; H, 7.83; N, 17.88.

1-(*N*,*N*-Diphenylcarbamoyl)benzotriazole (3d): white powder (eluent diethyl ether/hexane (20:80), 570 mg, 23%); mp 103−105 °C; ^{1}H NMR δ 8.07−7.99 (m, 2H), 7.63−7.57 (m, 1H), 7.45−7.20 (m, 11H); ^{13}C NMR δ 150.1, 145.1, 142.8, 132.7, 129.5, 129.4, 127.2, 126.6, 125.3, 120.0, 113.3. Anal. Calcd for $C_{19}H_{14}N_4O$: C, 72.60; H, 4.49; N, 17.82. Found: C, 72.41; H, 4.37; N, 17.86.

1-(*N*-Methyl-*N*-phenylcarbamoyl)benzotriazole (3e): white powder (eluent diethyl ether/hexane (20:80), 800 mg, 40%): mp 76−78 °C; ^{1}H NMR δ 8.07−7.98 (m, 2H), 7.60 (t, J = 7.5 Hz, 1H), 7.43 (t, J = 7 Hz, 8H), 7.34−7.16 (m, 5H); ^{13}C NMR δ 150.0, 144.9, 143.6, 132.7, 129.4, 129.1, 127.2, 125.8, 125.0, 119.7, 113.1. Anal. Calcd for $C_{14}H_{12}N_4O$: C, 66.65; H, 4.79; N, 22.21. Found: C, 66.68; H, 4.91; N, 22.40.

Supporting Information Available: Spectra for **4c**,**d**,**f**−**h**,**j** (15 pages). This material is contained in libraries on microfiche, immediately follows this article in the microfilm version of the journal, and can be ordered from the ACS; see any current masthead page for ordering information.

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