Synthesis of Thiophenedicarbonyldiazides and Di-*t*-butyl Thiophendicarbamates

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Dicarbamates **1b** and **1c**, and dicarbonyldiazides **2b** and **2c** are obtained in good yields starting from thiophenedicarboxylic acids **3b** and **3c**, but the vicinal diacids **3a** and **3d** are not suitable for the synthesis of dicarbamates **1a** and **1d** and dicarbonyldiazides **2a** and **2d**; **1a** is prepared by a stepway procedure previously described, and **1d** by *t*-butoxycarbonylation of the recently known 3,4-thiophenediamine.

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In one of our previous papers [1] we have reported the synthesis of dicarbamate **1a** by metallation and reaction with carbon dioxide of *t*-butyl thiophene-3-carbamate and subsequent reaction of the acid obtained with diphenyl phosphorazidate (DPPA) in *t*-butyl alcohol. Dicarbamate **1a** is a very useful compound because it can be considered as a suitably protected 2,3-diaminothiophene. Heteroaromatic *ortho*-diamines may be easily transformed into a variety of condensed heterocyclic systems [2] but many of these amines are unstable compounds, in contrast, dicarbamate **1a** is stable and it can be transformed into a pentacyclic system derived from the unstable diamino compound [1].

In our present paper we report our studies on the synthesis of the four isomeric di-*t*-butyl thiophenedicarbamates **1** and their precursors, the corresponding dicarbonyldiazides **2**.

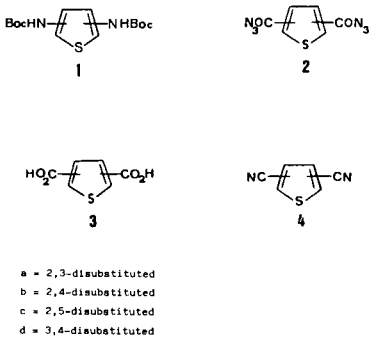


Figure 1

A synthetic option would be desirable which could be applied to the four isomers. Curtius rearrangement of the unknown azides **2** in *t*-butyl alcohol seems the best procedure leading to dicarbamates **1**; however, by means of DPPA [3] the rearrangement can be made starting from diacids **3** without isolation of the intermediate azides **2**. Thus, thiophenedicarboxylic acids **3** were prepared from the readily available dibromothiophenes using a modified procedure previously used for the synthesis of thiophene 3,4-dicarboxylic acid [4] and thiophene 2,3-dicarboxylic acid [5]. Hydrolysis of dicyanothiophenes **4** with concentrated hydrochloric acid instead of the previously used ethylene glycol-potassium hydroxide or aqueous sodium hydroxide allowed a more facile isolation of diacids **3**. When diacids **3b** and **3c** were made to react with DPPA, dicarbamates **1b** and **1c** were obtained in good yields, but vicinal diacids **3a** and **3d** led to a mixture of products with low yields in dicarbamates **1a** and **1d**. Thus, diacid **3a** allowed us to isolate three compounds: *t*-butyl 2-azidocarbonylthiophene-3-carbamate (**5**), 2-azidocarbonyl-3-aminothiophene (**6**) and dicarbamate **1a**. The structure of carbamate **5** could be established without ambiguity because we obtained the same compound from 3-*t*-butoxycarbonylaminothiophene-2-carboxylic acid (see Experimental). The structure of amine **6** was established owing to the fact that it also can be obtained from other precursor as we shall explain subsequently.

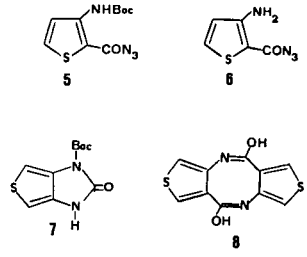
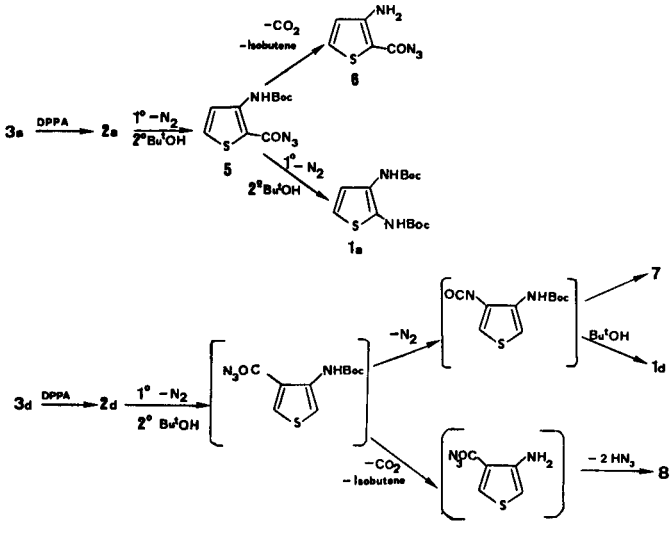


Figure 2

Diacid **3d** gave a complex mixture of products but we only could separate three compounds: thienoimidazolone **7**, dithienodiazocine **8** and dicarbamate **1d**. The compounds isolated in the reactions of vicinal diacids **3a** and **3d** suggest a multistep reaction pathway as can be seen in Scheme 1.

The low yields obtained in **1a** and **1d** make us consider other alternatives. The reaction with DPPA has one acyl azide as the intermediate [3]. We try to obtain the corresponding azides **2** of the four diacids **3** using a recently reported method which permits the obtention of carbonyl



Scheme 1

azides in high yields by one-pot procedure from carboxylic acids and sodium azide by means of phenyl dichlorophosphate reagent [6]. Diazides **2b** and **2c** were obtained with good yields but diacids **3a** and **3d** lead to carbamoylazides **9** and **10**.

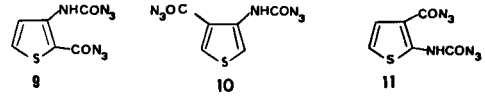
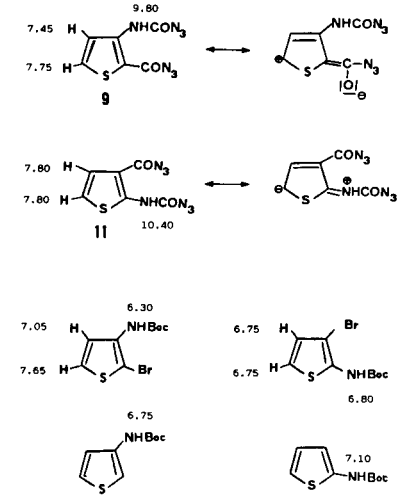


Figure 3

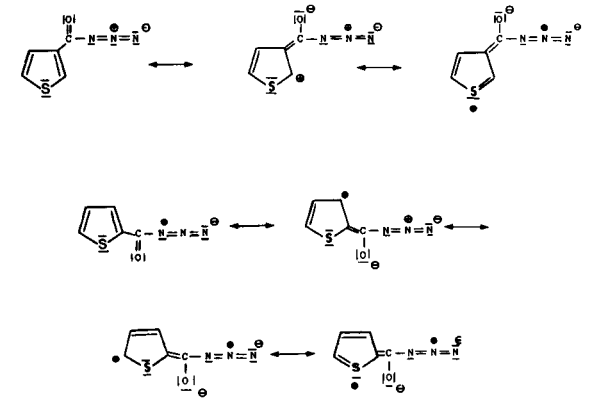
Formation of compounds **9** and **10** can be explained by a spontaneous half-rearrangement of the intermediate diazides **2a** and **2d** followed by addition of hydrazoic acid to the isocyanate formed. Spontaneous half-rearrangement is exhibited by several dicarbonyldiazides [7] and addition of hydrazoic acid is known in Curtius rearrangement [3].

The ^{1}H-nmr spectra of azide **9** and its positional isomer **11**, compound isolated in the reaction of thiophene-2,3-dicarbonyl chloride with sodium azide (see Experimental) allowed us to assign the proposed structure without ambiguity. The ^{1}H-nmr spectra in deuteriochloroform consist of one singlet for the two aromatic protons of one isomer and of a pair of doublets (A B pattern) for the other one. If we examine the resonance structures for both isomers we can see that the CON_3 group in the C-2 position has a deshielding effect on the H-5 (this effect will separate the signals of H-4 and H-5). On the other hand, the $NHCON_3$ group in the C-2 position has a shielding effect on the H-5 (the effect will join the signals of the two aromatic protons). This is in accordance with other similar isomers which we have prepared without ambiguity [8] as can be seen in Scheme 2. The chemical shift of the NH proton for the two isomeric carbamoyl azides confirms the assignment. It is a general fact, in all the carbamates prepared by us, a greater deshielding observed for NH in C-2 against NH in C-3 (see Scheme 2).



Scheme 2

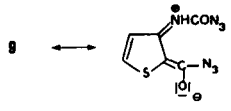
The results obtained in the reactions of thiophenedicarboxylic acids **3** with sodium azide and phenyl dichlorophosphate showed: i) the rate of Curtius rearrangement of the acylazide group in C-3 is faster than that of the acylazide group in C-2, and ii) one group CON_3 "*ortho*" increases the rate of rearrangement of the other. These facts can be explained easily in terms of resonance stabilization [9], the cross conjugation of the carbonyl group with the thiophene ring leads to an increase in the double-bond character of the N-N_2, which breaks in the Curtius reaction, this effect is increased when the CON_3 group is in C-2 position (three resonance structures in front of two for the 3-isomer).



Scheme 3

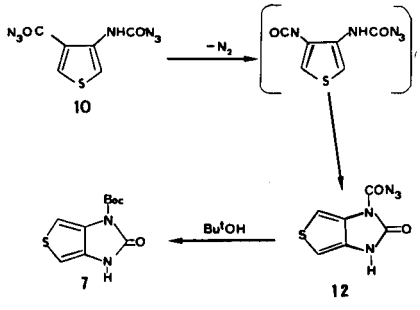
Following the same arguments, one "*ortho*" electron-attracting group (CON_3 in this case) weakens the cross conjugation of the carbonyl group with the thiophene ring

leading to a decrease in the bond order N-N_2 and, as a result, the molecule is destabilized toward the bond fission. In the same way, one "*ortho*" electron-releasing group ($NHCON_3$ in this case) will stabilize the N-N_2 bond of the contiguous CON_3 group. These effects can explain the reactivity of the carbamoylazides when refluxed in *t*-butyl alcohol. While **9** is recovered unaltered, **10** is converted to the imidazolone **7**. The greater stability of carbamoylazide **9** in front of carbamoylazide **10** can be explained because the bond order N-N_2 is greater for **9**, due to the cross conjugation of the $NHCON_3$ group with the CON_3 group:



Scheme 4

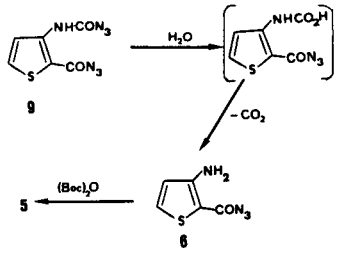
The formation of the cyclic compound **7** can be explained by the steps showed in Scheme 5.



Scheme 5

This reaction sequence was confirmed because when the rearrangement was carried out in toluene, the imidazolone **12** was the only product formed.

On the other hand, when carbamoylazide **9** was heated in acetone-water (see experimental), the amine **6** was obtained, which confirmed the structure of compound **6**. The formation of compound **6** can be explained by a nucleophilic attack of the molecule of water to the carbamoyl group and the subsequent elimination of carbon dioxide of the carbamic acid formed. Amine **6** was transformed into carbamate **5** by reaction with di-*t*-butyl dicarbonate which confirms the structure of azide **9**.



Scheme 6

Due to **1d** was obtained in very low yield, starting from diacid **3d**, we try a similar route to the procedure described by us for the synthesis of **1a** [1]. Thus, 4-iodo-3-thiophenecarboxylic acid [10] was transformed into *t*-butyl 4-iodothiophene-3-carbamate (**13**) by using DPPA. In this reaction urea **15** was separated as a by-product. By reaction of carbamate **13** with butyl-lithium followed by addition of carbon dioxide, the acid **14** was isolated but by reaction of this acid **14** with DPPA in *t*-butyl alcohol, imidazolone **7** was isolated instead of dicarbamate **1d**. The formation of the thienoimidazolone **7** can be explained as an intramolecular reaction between the isocyanate intermediate and the amino-protected group, as is shown in Scheme 1.

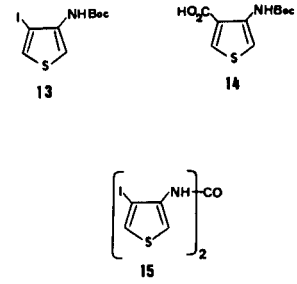


Figure 4

The synthetic option which permitted us the preparation of **1d** with good yield was the *t*-butoxycarbonylation of 3,4-thiophenediamine, compound which has been prepared recently [11]. Thus, by reaction of the amine with di-*t*-butyl dicarbonate as described in the experimental section, **1d** was obtained in good yield.

Analytical data for all the new compounds are shown in Table 1.

EXPERIMENTAL

Melting points were determined on a Buchi aparatus. The nmr spectra were recorded on a Perkin-Elmer R-12 B using TMS as an internal standard. The ir spectra were measured on a Perkin-Elmer 681 spectrophotometer. Elemental analyses were performed by Instituto de Química Orgánica, Barcelona. Mass spectra were obtained using a Hewlett-Packard Model 5930 A instrument.

Dicyanothiophenes **4**.

These compounds were prepared from dibromothiophenes [12] accordingly to the method reported for 2,3-dicyanothiophene (**4a**). 2,3-Dicyanothiophene (**4a**) [5] (58%) had mp 122-124°; 2,4-dicyanothiophene (**4b**) [13] (70%) had mp 160-162°; 2,5-dicyanothiophene (**4c**) [13] (65%) had mp 92-95°; 3,4-dicyanothiophene (**4d**) [4] (70%) had mp 167-168°.

Thiophenedicarboxylic Acids **3**.

Dicyanothiophenes **4** (13.42 g, 0.1 mole) were refluxed in concentrated hydrochloric acid (250 ml) for 6 hours. After cooling, the precipitated

Table 1

Characterisation of New Compounds

Compound	Mp / °C	ν max/cm⁻¹ (KBr)	m/z (%)	Molecular formula	Found (Calcd.) (%) C	H	I	N	S
1b	230-231	3340 (NH), 1690 (CO)	314 (M^+, 12), 202 (100) 158 (32), 57 (27)	$C_{14}H_{22}N_2O_4S$	53.3 (53.5)	6.9 (7.05)		8.95 (8.9)	10.1 (10.2)
1c	193-194	3290 (NH), 1695 (CO)	314 (M^+, 8), 202 (100), 158 (24), 57 (27)	$C_{14}H_{22}N_2O_4S$	53.4 (53.5)	7.1 (7.05)		8.8 (8.9)	10.15 (10.2)
1d	157-158	3380 (NH), 1730, (1680) (CO)	314 (M^+, 14), 202 (31) 114 (97), 57 (500)	$C_{14}H_{22}N_2O_4S$	53.35 (53.5)	7.2 (7.05)		8.85 (8.9)	10.2 (10.2)
2b	92	2290, 2150 (N_3) 1690, (CO)	222 (M^+, 57), 180 (100) 96 (61)	$C_6H_2N_6O_4S$	32.3 (32.4)	0.95 (0.9)		37.7 (37.8)	14.1 (14.1)
2c	94	2300, 2150 (N_3) 1680, 1660 (CO)	222 (M^+, 89), 180 (100) 96 (85)	$C_6H_2N_6O_4S$	32.15 (32.4)	0.85 (0.9)		37.7 (37.8)	14.2 (14.1)
5	143	3340 (NH), 2150 (N_3) 1760 (CO_2), 1650 (CON_3)	268 (M^+, 11), 212 (20) 112 (30), 57 (100)	$C_{10}H_{12}N_4O_3S$	45.05 (44.8)	4.5 (4.5)		29.5 (29.8)	8.2 (8.35)
6	124	3450, 3340 (NH_2), 2150 (N_3), 1635, 1620 (CO)	168, (M^+, 31), 112 (44) 85 (100), 45 (87)	$C_5H_4N_4OS$	35.9 (35.7)	2.3 (2.4)		33.3 (33.3)	18.8 (19.0)
7	250 dec	3280 (NH), 1785 (CO)	240 (M^+, 10), 140 (100) 57 (70)	$C_{10}H_{12}N_2O_3S$	49.9 (50.0)	5.1 (5.0)		11.7 (11.7)	13.35 (13.3)
8	149-150	3430, 3240 (OH) 1590, 1550, 1490	250 (M^+, 16), 249 (100) 248 (68), 170 (79), 77 (89)	$C_{10}H_6N_2O_2S_2$	48.2 (48.0)	2.35 (2.4)		11.2 (11.2)	25.5 (25.6)
9	128-129	3310 (NH), 2190, 2150 (N_3), 1720 (NHCO) 1655 (CON_3)	237 (M^+, 5), 139 (20) 111 (M, 31), 45 (100)	$C_6H_3N_7O_2S$	30.35 (30.4)	1.3 (1.3)		41.5 (41.35)	13.6 (13.5)
10	143-145	3340 (NH), 2270 (N_3) 1715 (NHCO), 1675 (CON_3)	237 (M^+, 89), 166 (73) 139 (63), 45 (100)	$C_6H_3N_7O_2S$	30.2 (30.4)	1.35 (1.3)		41.4 (41.35)	13.4 (13.5)
11	156	3300 (NH), 2190, 2150 (N_3), 1720 (NHCO), 1630 (CON_3)	237 (M^+, 20), 149 (91) 111 (45), 43 (100)	$C_6H_3N_7O_2S$	30.25 (30.4)	1.2 (1.3)		41.5 (41.35)	13.4 (13.5)
12	200 dec	3270 (NH), 2190, 2150 (N_3), 1790 (NHCO), 1760 (CON_3)	209 (M^+, 1), 166 (2) 139 (9), 70 (42), 45 (100)	$C_6H_3N_5O_2S$	34.35 (34.5)	1.5 (1.45)		33.4 (33.5)	15.2 (15.3)
13	57-58	3420 (NH), 1730 (CO)	32 (M^+, 36), 269 (89) 225 (100), 57 (82)	$C_9H_{12}INO_2S$	33.5 (33.2)	3.6 (3.7)	39.3 (39.0)	4.3 (4.3)	9.8 (9.9)
14	168-169	3700-2500 (OH), 3375 (NH), 1720 (CO_2Bu^t) 1670 (CO_2H)	243 (M^+, 14), 187 (30) 143 (64), 125 (72), 57 (100)	$C_{10}H_{13}NO_4S$	49.35 (49.4)	5.3 (5.4)		5.8 (5.8)	13.1 (13.2)
15	213-215	3270 (NH), 1645, 1632 (CO)	476 (M^+, 18), 349 (10), 225 (100), 98 (27)	$C_9H_6I_2N_2O_2S$	22.9 (22.7)	1.5 (1.3)	53.0 (53.3)	5.9 (5.9)	13.3 (13.5)

acids were collected and recrystallized from water-ethanol (2:1). 2,3-Thiophenedicarboxylic acid (**3a**) [5] (13.42 g, 78%) had mp 277-280°; 2,4-thiophenedicarboxylic acid (**3b**) [14] (11.18 g, 65%) had mp 325° dec; 2,5-thiophenedicarboxylic acid (**3c**) [15] (13.59 g, 79%) had mp 325 °; 3,4-thiophenedicarboxylic acid (**3d**) [4] (14.62 g, 85%) had mp 230°.

Reaction of Dicarboxylic Acids **3** with Diphenyl Phosphorazidate in *t*-Butyl Alcohol.

A mixture of the acid **3** (1.722 g, 0.01 mole), diphenyl phosphorazidate (5.50 g, 0.02 mole) and triethylamine (2.04 g, 0.02 mole) in *t*-butyl alcohol (50 ml) was stirred under reflux for 20 hours. The mixture was evaporated and the residue was dissolved in methylene chloride. The solution was washed successively with 5% aqueous citric acid, water, saturated aqueous sodium bicarbonate, and saturated aqueous sodium chloride. Drying (magnesium sulfate) followed by evaporation gave a residue which was chromatographed on silica gel. **3a** gave (hexane-methylene chloride 3:2 as eluant) di-*t*-butyl thiophene-2,3-dicarbamate (**1a**) [1] (0.063 g, 2%), mp 165-167°, *t*-butyl 2-azidocarbonylthiophene-3-carbamate (**5**) (0.107 g, 4%); ^{1}H-nmr (deuteriochloroform): δ 1.51 (s, *t*-butyl), 7.51 (d, H-4), 7.92 (d, H-5, $J_{4,5}$ 5.4 Hz), 9.48 (br, s, NH), and 2-azidocarbonyl-3-aminothiophene (**6**) (0.235 g, 14%) ^{1}H-nmr (deuteriochloroform): δ 5.70 (br, s, NH_2), 6.40 (d, H-4), 7.20 (d, H-5, $J_{4,5}$ 5.7 Hz). Compound **3b** gave (methylene chloride as eluant) di-*t*-butyl thiophene-2,4-dicarbamate (**1b**) (2.04 g, 65%); ^{1}H-nmr (acetone-d_6): δ 1.48 (s, 2x *t*-butyl), 6.68 (d, H-3), 6.75 (d, H-5, $J_{3,5}$ 1.9 Hz). Compound **3c** gave (methylene chloride as eluant) di-*t*-butyl thiophene-2,5-dicarbamate (**1c**) (1.89 g, 60%); ^{1}H-nmr (deuteriochloroform): δ 1.53 (s, 2 × *t*-butyl), 6.40 (s, H-3 and H-4), and 6.83 (br, s, 2 × NH). Compound **3d** gave (methylene chloride as eluant) di-*t*-butyl thiophene-3,4-dicarbamate (**1d**) (0.160 g, 5%); ^{1}H-nmr (deuteriochloroform): δ 1.49 (s, 2 × *t*-butyl), 6.75 (br, s, 2 × NH), and 7.08 (s, H-2 and H-5), 1-*t*-butoxycarbonylthieno[3,4-*d*]imidazolone (**7**) (0.415 g, 17%); ^{1}H-nmr (deuteriochloroform): δ 1.65 (s, *t*-butyl), 6.45 (d, H-6), 6.75 (d, H-4, $J_{4,6}$ 2.8 Hz) and 9.70 (s, NH), and 5,10-dihydroxydithieno[3,4-*b*:3′,4′-*f*][1,5]-diazocine (**8**) (0.355 g, 28%); ^{1}H-nmr (deuteriochloroform): δ 7.15 (s, H-aromatics)

Reaction of Dicarboxylic Acids **3** with Phenyl Dichlorophosphate and Sodium Azide.

Phenyl dichlorophosphate (5.275 g, 0.025 mole) is added at room tem-

perature to a stirred suspension of the carboxylic acid **3** (1.722 g, 0.01 mole), pyridine (3.995 g, 0.05 mole), and sodium azide (3.250 g, 0.05 mole) in dichloromethane (125 ml). The mixture is stirred overnight at the same temperature and then washed with water (75 ml) followed by 1*M* hydrochloric acid (50 ml). Drying (magnesium sulfate) followed by evaporation gives the crude carbonyl azide which was recrystallized from hexane-dichloromethane (7:3). Compound **3a** gave 2-azidocarbonyl-3-azidocarbonylaminothiophene (**9**) (1.849 g, 78%); ^{1}H-nmr (deuteriochloroform): δ 7.45 (d, H-4), 7.75 (d, H-5, $J_{4,5}$ 5.6 Hz), and 9.80 (br, s, NH). Compound **3b** gave 2,4-thiophenedicarbonyldiazide (**2b**) (2.11 g, 95%); ^{1}H-nmr (deuteriochoroform): δ 8.19 (d, H-3), and 8.41 (d, H-5, $J_{3,5}$ 1.4 Hz). Compound **3c** gave 2,5-thiophenedicarbonyldiazide (**2c**) (1.70 g, 76%); ^{1}H-nmr (deuteriochloroform): 7.72 (s, H-3 and H-4). Compound **4d** gave 3-azidocarbonyl-4-azidocarbonylaminothiophene (**10**) (2.252 g, 95%); ^{1}H-nmr (deuteriochloroform): δ 7.70 (d, H-2), 8.00 (d, H-5, $J_{2,5}$ 3.2 Hz), and 9.40 (s, NH).

Reaction of Thiophene-2,3-dicarbonylchloride with Sodium Azide.

2,3-Thiophenedicarboxylic acid (**3a**) (1 g, 5.8 mmoles) and phosphorus pentachloride (2.54 g, 12.2 mmoles) were heated under reflux for 14 hours. Phosphoryl chloride formed was removed under reduced pressure and the residue was dissolved in acetone (5 ml). To the stirred acetone solution sodium azide (1.150 g, 17.7 mmoles) in a minimum of water was added dropwise and the resulting mixture was allowed to stir for 15 minutes. After this time cold water was added (5 ml), the precipitate obtained was filtered off, dried and chromatographed on silica gel with hexane-methylene chloride (3:2) as eluant giving 2-azidocarbonyl-3-azidocarbonylaminothiophene (**9**) (0.260 g, 19%) and 3-azidocarbonyl-2-azidocarbonylaminothiophene (**11**) (0.101 g, 7%); ^{1}H-nmr (deuteriochloroform): δ 7.80 (s, H-4 and H-5), and 10.40 (br, s, NH).

Reaction of Diazides **2b**, **2c**, **9** and **10** with *t*-Butyl Alcohol.

The corresponding diazide (5 mmoles) was refluxed in *t*-butyl alcohol (40 ml) for 3 hours. The solvent was evaporated and the residue was chromatographed on silica gel with hexane-methylene chloride (3:7) as eluant, 2,4-thiophenedicarbonyldiazide (**2b**) gave di-*t*-butyl thiophene-2,4-dicarbamate (**1b**) (1.01 g, 70%). 2,5-Thiophenedicarbonyldiazide **2c** gave di-*t*-butyl thiophene-2,5-dicarbamate (**1c**) (1.290 g, 82%). 2-Azidocarbonyl-3-azidocarbonylaminothiophene (**9**) was recovered unaltered. 3-Azidocarbonyl-4-azidocarbonylaminothiophene (**10**) gave the thienoimidazolone **7** (0.602 g, 50%).

Reaction of Diazide **10** in Toluene.

The carbamoylazide **10** (0.237 g, 1 mmole) was refluxed in toluene (50 ml) for 4 hours. The solvent was evaporated and the residue was recrystallized from chloroform to give *N*-azidocarbonylthieno[3,4-*b*]imidazolone (**12**) (0.168 g, 80%); ^{1}H-nmr (acetone-d_6): δ 6.70 (s, H-aromatics).

Reaction of Diazide **9** with Water.

To a solution of the carbamoylazide **9** (0.237 g, 1 mmole) in acetone (10 ml) was added sodium azide (0.130 g, 2 mmoles) in a minimum of water. The mixture was heated under reflux for 24 hours. The acetone was removed under reduced pressure and the residue was extracted with methylene chloride and water. The organic layer was separated, dried (magnesium sulfate) and evaporated. The solid obtained was recrystallized from hexane giving 2-azidocarbonyl-3-aminothiophene (**6**) (0.105 g, 60%).

t-Butyl 4-Iodothiophene-3-carbamate.

A mixture of 4-iodothiophene-3-carboxylic acid (4.572 g, 0.018 mole), diphenyl phosphorazidate (4.953 g, 0.018 mole) and triethylamine (1.821 g, 0.018 mole) in *t*-butyl alcohol (75 ml) was stirred under reflux for 15 hours. The solution was washed successively with 5% aqueous citric acid, water, saturated aqueous sodium bicarbonate and saturated aqueous sodium chloride. Drying (magnesium sulfate) followed by evaporation gave a residue which was chromatographed on silica gel with hexane-methylene-chloride (7:3) as eluant to afford the carbamate **13** (4.0 g, 70%) ^{1}H-nmr (deuteriochloroform): δ 1.51 (s, *t*-butyl), 6.67 (br s, NH), 7.23 (d, H-5), and 7.35 (s, H-2, $J_{2,5}$ 3.7 Hz), and the urea **15** (0.170 g, 4%); (acetone-d_6): δ 7.62 (s, H-aromatic) and 8.20 (br, s, 2 × NH).

4-*t*-Butoxycarbonylamino-3-thiophenecarboxylic Acid (**14**).

To a stirred solution of the carbamate **13** (2.43 g, 7.5 mmoles) in anhydrous ether (20 ml) cooled to −70°, under nitrogen, was added dropwise *n*-butyl-lithium-hexane solution (5 ml, 8 mmoles) in anhydrous ether (10 ml). The solution was allowed to stir at −70° for 10 minutes and was then poured slowly into a slurry of solid carbon dioxide in anhydrous ether. After evaporation of the solid carbon dioxide, water was slowly added. The aqueous layer was separated and the ether layer was extracted several times with 2*M*-sodium hydroxide solution. The combined aqueous phase was acidified with hydrochloric acid (1:1). The acid **14** was filtered off and recrystallized from chloroform-hexane (1:1) (0.6 g, 33%); ^{1}H-nmr (deuteriochloroform): δ 1.51 (s, *t*-butyl), 7.60 (d, H-5), 8.15 (d, H-2, $J_{2,5}$ 4 Hz), 8.85 (br, s, NH), and 9.50 (br, s, CO_2H). The ether layer was dried (magnesium sulfate) and evaporated giving a residue which was purified by recrystallization from hexane to afford *t*-butyl thiophen-3-carbamate (**8**) (0.7 g, 46%), mp 142°.

Reaction of the Acid **14** with Diphenyl Phosphorazidate in *t*-Butyl Alcohol.

A mixture of the acid **14** (0.49 g, 2 mmoles), diphenyl phosphorazidate (0.55 g, 2 mmoles) and triethylamine (0.202 g, 2 mmoles) in *t*-butyl alcohol (15 ml) was stirred under reflux for 16 hours. Work up as usual gave the thienoimidazolone **7** (0.34 g, 71%).

Di-*t*-butyl Thiophene-3,4-dicarbamate (**1d**).

3,4-Thiophenediamine [11] (0.62 g, 5.4 mmoles) and di-*t*-butyl dicarbonate (3.54 g, 16.2 mmoles) were dissolved in THF (30 ml). The solution was stirred overnight at 25°. After this time the solvent was evaporated and the residue was chromatographed on silica gel with methylene chloride as eluant affording the carbamate **1d** (1.375 g, 68%).

t-Butyl-2-azidocarbonylthiophene-3-carbamate (**5**).

A) Phenyl dichlorophosphate (0.75 ml , 5 mmoles) is added at room temperature to a stirred suspension of 3-*t*-butoxycarbonylaminothiophene-2-carboxylic acid [1] (0.970 g, 4 mmoles), pyridine (0.8 ml, 10 mmoles) and sodium azide (0.65 g, 10 mmoles) in dichloromethane (25 ml). The mixture is stirred overnight at the same temperature and then washed with water (15 ml) followed by 1 *N* hydrochloric acid (10 ml). After drying (magnesium sulfate) the organic layer was evaporated giving a residue which was recrystallized from hexane to afford the carbamate **5** (0.965 g, 90%).

B) 2-azidocarbonyl-3-aminothiophene (**6**) (0.168 g, 1 mmole) and di-*t*-butyl dicarbonate (0.655 g, 3 mmoles) were dissolved in THF (10 ml). The solution was stirred overnight at 25°. After this time the solvent was evaporated and the residue was chromatographed on silica gel with methylene chloride as eluant affording the carbamate **5** (0.18 g, 70%).

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