A facile synthesis of β-(4-azuleno[1,2-*b*]thienyl) α,β-unsaturated ketones

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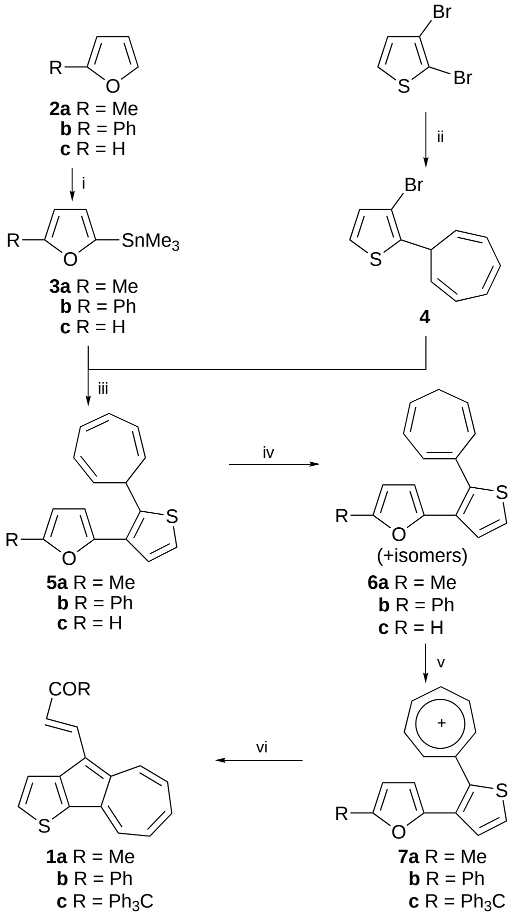
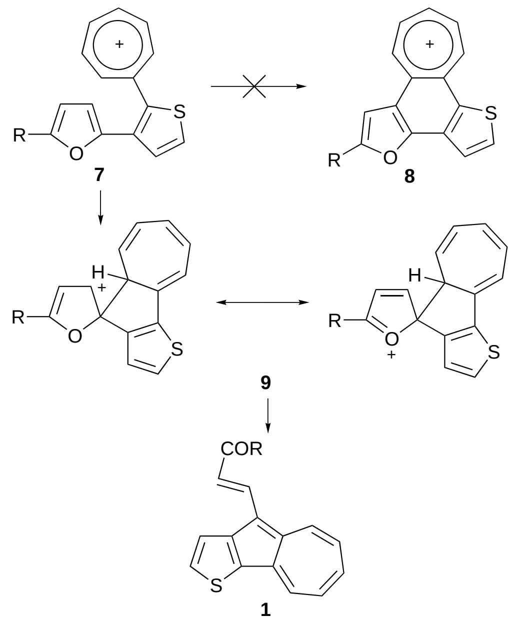
The facile and novel synthesis of β-(4-azuleno[1,2-*b*]thienyl) α,β-unsaturated ketones 1 from 2-tropylio-3-(2-furyl)thiophenes 7 is reported; a mechanism involving a novel ring cyclization by intramolecular attack of the tropylium ion at the 2-position of the furan ring is postulated.

The azulenoid heterocyclic aromatic compounds which consist of the azulene ring condensed with heterocyclic aromatic nuclei are of interest not only for their physical and chemical properties, but also their pharmaceutical and physiological activity. Several azulene derivatives condensed with heteroaromatics such as thiophene, furan, pyrrole and pyridine rings are known.[1] Most of them were prepared by the heteroaromatization of the azulene derivatives, and were restricted to the parent compounds and alkyl-, aryl- or alkoxycarbonyl-substituted derivatives. Herein we disclose a novel and facile synthesis of azuleno[1,2-*b*]thiophenes having an α,β-unsaturated ketone group from the corresponding 2-tropylio-3-(2-furyl)thiophenes **7**.



Scheme 1 *Reagents and conditions*: i, BuLi, Me_3SnCl, THF, −78 °C; ii, BuLi, $C_7H_7^+$, THF, −78 °C to room temp; iii, $PdCl_2(Ph_3P)_2$, THF, reflux; iv, xylene, reflux; v, $Ph_3C^+BF_4^-$, CH_2Cl_2, room temp; vi, CH_2Cl_2 or CH_2ClCH_2Cl



Scheme 2

The synthetic sequence leading to **1** from the readily available 2-substituted furans **2** is depicted in Scheme 1.† 2-Cycloheptatrienyl-3-(2-furyl)thiophenes **5** were prepared by the palladium(II)-catalysed Stille reaction[2] of 2-trimethylstannylfurans **3** with 2-cycloheptatrienyl-3-bromothiophene **4**. Thermal sigmatropic rearrangement of **5** to **6** and subsequent hydride abstraction using triphenylmethyl tetrafluoroborate gave 2-tropylio-3-(2-furyl)thiophenes **7** in 65–85% yields.‡ It might be expected that the intramolecular electrophilic substitution reaction of the tropylium moiety with the furan ring would afford the tetracyclic carbocations **8**, which are isoelectronic with triphenylene.[3] However, when a CH_2Cl_2 solution of **7a**§ was refluxed for 7 h, neutral red–black prisms were obtained instead of the expected carbocations **8a**. The structure of these prisms was confirmed to be 4-(4-azuleno[1,2-*b*]thienyl)but-3-ene-2-one **1a** *via* its spectral data,[5] together with elemental analysis. In the same manner, the chalcone-type compound **1b** and triphenylmethyl derivative **1c** were obtained as green–black needles (43%) and black needles (36%), respectively, from the corresponding tropylio derivatives **7b** and **7c**.

A possible mechanism for the formation of β-(4-azuleno-[1,2-*b*]thienyl) α,β-unsaturated ketones **1** from the corresponding 2-tropylio-3-(2-furyl)thiophenes **7** is illustrated in Scheme 2. The intramolecular electrophilic attack of the tropylium ion on the 2-poisition of the furan ring gives the spiro-type intermediate **9**, which can be converted to **1** by a ring-opening reaction. Although it is well-known that the 2-position of the furan ring is much more reactive towards electrophiles than the 3-position and that furans are readily ring-opened under acidic conditions,[4] this is to the best of our knowledge the first tropylium ion-mediated furan ring-opening reaction to yield α,β-unsaturated carbonyl derivatives of azuleno[1,2-*b*]thiophene compounds. Since 2-substituted furans **2** are readily available and the procedure is simple and easy, it is considered that this is a valuable general synthetic route to various β-(4-azuleno[1,2-*b*]thienyl) α,β-unsaturated ketones.

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Footnotes and References

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† All new compounds were fully characterized by mass and ^{1}H NMR spectroscopy and elemental analysis.

‡ With **6c**, triphenylmethyl tetrafluoroborate acts as both a hydride abstraction reagent and an electrophile, and triphenylmethyl-substituted tropylium ion derivative **7c** was obtained.

§ *Selected data* for **7a**: (δ_H CD_2Cl_2, 250 MHz) 2.22 (3 H, s, CH_3), 6.20 (1 H, d, furan-H), 6.75 (1 H, d, furan-H), 7.43 (1 H, d, thiophene-H), 7.95 (1 H, d, thiophene-H), 8.68–8.83 (4 H, m, tropylium-H), 8.93–9.00 (2 H, m, tropylium-H). For **1a**: δ_H (CD_3Cl, 250 MHz) 2.46 (3 H, s, CH_3), 6.90 (1 H, d, olefinic-H), 7.26 (2 H, dd, seven-membered ring-H), 7.62 (1 H, dd, seven-membered ring-H), 7.73 (1 H, d, thiophene-H), 7.89 (1 H, d, thiophene-H), 8.28 (1 H, d, olefinic H), 8.29 (1 H, d, seven-membered ring-H), 8.49 (1 H, d, seven-membered ring-H), δ_C (CD_3Cl, 75 MHz) 198.2 (C=O), 150.1 (quaternary), 143.6 (quaternary), 137.3, 135.7 (quaternary), 134.8, 134.0, 133.7, 133.1 (quaternary), 131.9, 126.4, 125.4, 123.3, 119.8, 116.4 (quaternary), 27.8 (CH_3). Calc. for $C_{16}H_{12}SO$: C, 76.16; H, 4.79. Found: C, 76.30; H, 4.63%.

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