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Dedicated to Professor Thomas Kappe on the occasion of his 70th birthday

3-Hydroxy-2-[1-(arylhydrazono)ethyl]-1*H*-phenalen-1-ones **3**, obtained from 2-acetyl-3-hydroxy-1*H*-phenalen-1-one (**1**) and arylhydrazines **2**, cyclize under acidic conditions to 8-methyl-10-aryl-10*H*-naphtho-[1,8a,8-*fg*]indazol-7-ones **4**. Indazoles **4** are also obtained from 2-acetyl-3-hydroxy-1*H*-phenalen-1-one (**1**) and arylhydrazines **2** in a one-pot reaction. 2-Acetyl-3-azido-1*H*-phenalen-1-one (**6**) does not give 8-methyl-9-arylamino-9*H*-naphtho[1,8a,8-*fg*]indazol-7-ones *via* azide decomposition but gives again by nucleophilic replacement of the azide moiety in **6** the indazole **4**.

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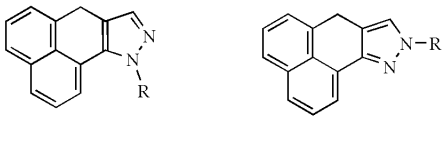
Indazole derivatives are of great interest because of their pharmaceutical activity, use in agrochemistry, in dye chemistry and in photographic processes [2]. Whereas the basic ring system of indazole is investigated thoroughly, polyfused derivatives are rarely described. In the course of our investigations of ring closure reactions of phenalene derivatives [3-5] we focused our interest on the synthesis of indazoles of type **A** (typus of a 1*H*-indazole) and of type **B** (typus of a 2*H*-indazole). In the literature, only one example of such an indazole of type **A** is described as a follow-up product in the ring enlargement of acenaphthenequinone [6].

Scheme 1



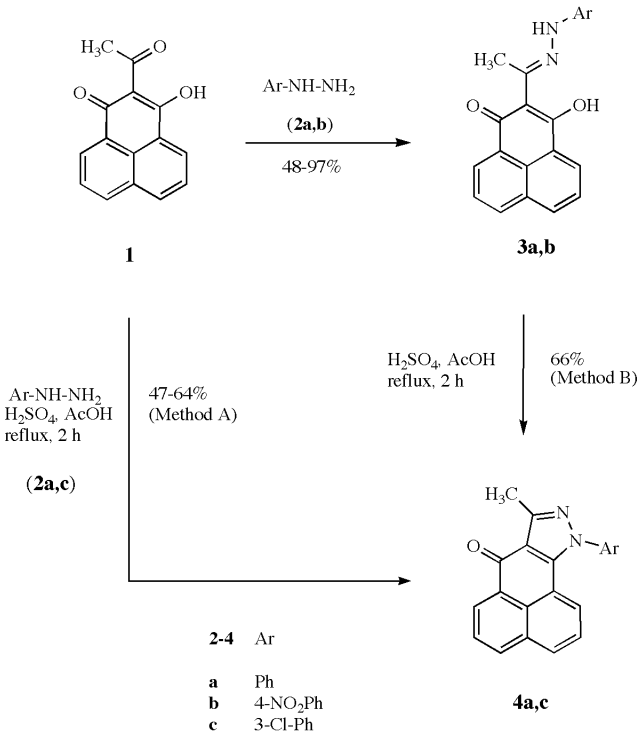
A **B**

We started our synthesis program with a 2-acyl-1-hydrazinoarene synthon, which should give in the cyclization step the formation of one new N-C bond. As the first step in this reaction the hydrazinolysis of 2-acetyl-3-hydroxy-1*H*-phenalen-1-one (1) was planned. 2-Acetyl-3-hydroxy-1*H*-phenalen-1-one (**1**) was obtained in a 2-step reaction from phenalene-1,3-dione by cyclocondensation with diethyl malonate, followed by a ring-opening reaction in sodium hydroxide solution and subsequent spontaneous decarboxylation upon acidification as described recently [5]. Attempts to obtain 2-acetyl-3-hydroxy-1*H*-phenalen-1-one (**1**) in a one step reaction by direct acetylation of phenalene-1,3-dione using acetic acid with acid catalysts as described in several heterocyclic systems [7] was not successful.

The reaction of 2-acetyl-3-hydroxy-1*H*-phenalen-1-one (**1**) with arylhydrazines **2** was performed either in dimethylformamide without catalyst in the case of phenylhydrazine (**2a**) or with glacial acetic acid and sulfuric acid as catalyst in the case of 4-nitrophenylhydrazine (**2b**). In both cases 3-hydroxy-2-[1-(arylhydrazono)ethyl]-1*H*-phenalen-1-ones **3** were obtained in 48 and 97% yield, respectively.

Because of the high reactivity of **3a**, in all experiments, traces of the follow-up ring closed compound **4a** were formed which made it impossible to obtain correct analytical data. However, the spectroscopic data confirmed the

Scheme 2



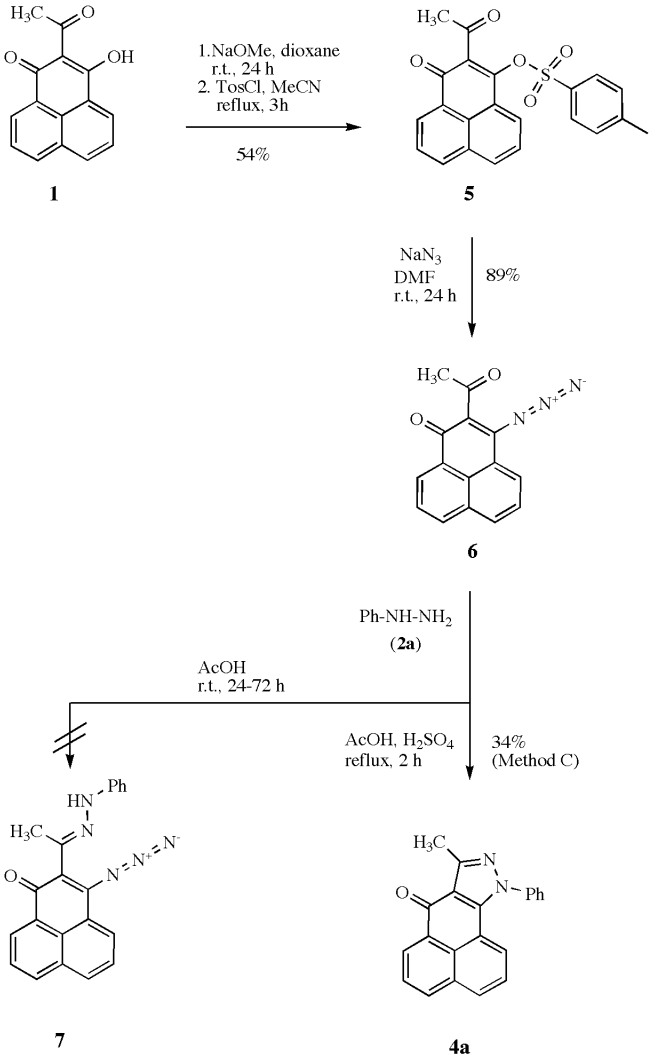
structure of **3a**. 3-Hydroxy-2-[1-(arylhydrazono)ethyl]-1*H*-phenalen-1-one **3a** cyclized upon thermolysis in refluxing acetic acid with sulfuric acid as catalyst to give in 66% yield 10*H*-naphtho[1,8a,8-*fg*]indazol-7-one **4a**. The 4-nitrophenyl derivative **3b** did not react under similar conditions to give in an analogous way **4b**; in all cases, unchanged starting material **3b** was recovered.

The reaction of 2-acetyl-3-hydroxyphenalen-1-one (**1**) and 3-chlorophenylhydrazine (**2c**) could not be stopped at the 3-hydroxy-2-[1-(phenylhydrazono)ethyl]-1*H*-phenalen-1-one (**3c**) step. Under various conditions, either no reaction was observed, *e.g.* without acid catalysts at elevated temperatures, whereas in solvents such as dimethylformamide, *N*-methylpyrrolidone or 1-butanol already at room temperature cyclization to 10-(3-chlorophenyl)-8-methyl-10*H*-naphtho[1,8a,8-*fg*]indazol-7-one (**4c**) took place. In a similar way in moderate yields also 8-methyl-10-phenyl-10*H*-naphtho[1,8a,8-*fg*]indazol-7-one (**4a**) could be obtained in a one pot reaction starting from 2-acetyl-3-hydroxyphenalen-1-one (**1**) and phenylhydrazine (**2a**) in acetic acid with acid catalysis.

In the indazole series a number of syntheses are described using the photo- or thermolysis of azido arenes with reactive *ortho*-substituents as the ring closure step leading to the indazole nucleus [2,8]. Reaction of hydrazines with 1-acyl-2-azidoarenes, however, is reported to give in an unexpected way - either by nucleophilic exchange of the azido group or through pentacene intermediates [9] - 1*H*-indazoles of type **A** (Scheme 1, R = H, alkyl, aryl). The expected 2-amino-2*H*-indazoles of type **B** (Scheme 1, R= NH_2, NH-alkyl, NH-aryl), which should be formed by initial hydrazone formation followed then by thermolytical nitrene or electrocyclic reaction [10] are not observed. This fact was surprising for us because we could recently show that analogous heterocyclic 1-acyl-2-azido compounds such as 3-acetyl-4-azido-2(1*H*)-quinolones react easily to 4-azido-3-hydrazonoalkylquinolines. These hydrazones gave upon thermolysis the desired 2-arylaminopyrazolo[4,3-*c*]quinolin-4(5*H*)-ones [11]. This fact prompted us to transform the reaction sequence investigated in ref. [11] to 2-acyl-3-azidophenalenones.

The reaction sequence started from 2-acetyl-3-hydroxy-1*H*-phenalen-1-one (**1**), which was converted into the reactive 2-acetyl-1-oxo-1*H*-phenalen-3-yl 4-methylbenzenesulfonate (**5**) by a two-step reaction *via* the sodium salt of **1** followed then by reaction with tosyl chloride as previously described in ref. [5]. Attempts to obtain the similar reactive 2-acetyl-3-chloro-1*H*-phenalen-1-one failed, probably because of strong hydrogen bondings between the hydroxy group and the acetyl group in **1**. The tosyloxy compound **5** is rather unstable; however it reacts smoothly with a threefold excess of sodium azide at ambient temperature to give 2-acetyl-3-azido-1*H*-phenalen-1-one (**6**) in good yields [5].

Scheme 3



In a similar manner as described for the preparation of **3a**, the azide **6** was treated with phenylhydrazine (**2a**) in acetic acid at room temperature. However, no reaction to the desired hydrazono intermediate **7** could be detected, and after 72 hours only starting material **6** was isolated. The variation of the reaction conditions such as temperature, solvent, catalyst and reaction time gave no other results with one exception: when the reaction was performed in refluxing acetic acid with sulfuric acid as catalyst, a reaction could be observed; however the product obtained in 34% was not the desired hydrazone **7** but the cyclized 1*H*-indazole, 8-methyl-10-phenyl-10*H*-naphtho[1,8a,8-*fg*]indazol-7-one (**4a**). So again - as described in the literature [9] for similar systems - this reaction resulted in nucleophilic replacement of the azido group by attack of the NH-Ph moiety of the intermediate hydrazone **7** and cyclization to the corresponding 1*H*-indazol.

EXPERIMENTAL

Melting points were determined on a Gallenkamp Melting Point Apparatus, Mod. MFB-595 in open capillary tubes. The ^{1}H nmr spectra were recorded on a Varian Gemini 200 instrument (200 MHz) or a Bruker AM 360 instrument (360 MHz). The ^{13}C nmr spectra were recorded on a Bruker AM 360 instrument (90 MHz). The solvent for nmr spectra was deuteriodimethyl sulfoxide. Chemical shifts are reported in ppm from internal tetramethylsilane standard and are given in δ-units. Infrared spectra were acquired on a Perkin-Elmer 298 spectrophotometer or a Galaxy Series FTIR 7000 in potassium bromide pellets. Elemental analyses were performed on a Fisons elemental analyzer, Mod. EA 1108 and are within ±0.4 of the theoretical percentages. Mass spectra were taken on a HP LC/MSD mass spectral instrument (EI: 70 eV, CI: 120 eV, methane).

All reactions were monitored by thin layer chromatography carried out on 0.2 mm silica gel F-254 (Merck) plates using uv light (254 and 366 nm) for detection. Common reagent-grade chemicals are either commercially available and were used without further purification or prepared by standard literature procedures.

2-Acetyl-3-hydroxy-1*H*-phenalen-1-one (**1**).

This compound was obtained from phenalene-1,3-dione and diethyl malonate in a 2-step reaction according to the procedure described in ref. [5].

3-Hydroxy-2-[1-(phenylhydrazono)ethyl]-1*H*-phenalen-1-one (**3a**).

A solution of 2-acetyl-3-hydroxyphenalen-1-one (**1**) (1.00 g, 4.2 mmol) in dimethylformamide (30 mL) was treated with phenylhydrazine (**2a**) (0.54 g, 5.0 mmol) and stirred for 5 hours at 20 °C. The dark colored solution was poured onto ice/water (100 mL) and stirred until solid formed, which was collected by suction filtration and washed with water. The yield was 0.66 g (48%) brownish prisms, mp 189 °C dec (ethanol/water); ir: 1630 m, 1600 m, 1570 s cm^{-1}; ^{1}H nmr: δ 2.80 (s, CH_3), 6.95 (m, 2 ArH), 7.15 (t, *J* = 7 + 1.5 Hz, 1 ArH), 7.18-7.22 (m, 2 ArH), 7.55-7.55 (m, 2 ArH), 7.75 (t, *J* = 7 + 1.5 Hz, 1 ArH), 8.00-8.05 (m, 1 ArH), 8.15 (dd, *J* = 7 + 1.5 Hz, 1 ArH), 8.20 (dd, *J* = 7 + 1.5 Hz, 1 ArH), 9.1 (s, NH).

Anal. Calcd. for $C_{21}H_{16}N_2O_2$: C, 76.81; H, 4.91; N, 8.53. Found: C, 77.35; H, 5.34; N, 7.86. No satisfactory elemental analysis data have been obtained because of the ease of decomposition of this compound.

3-Hydroxy-2-[1-(4-nitrophenylhydrazono)ethyl]-1*H*-phenalen-1-one (**3b**).

A solution of 2-acetyl-3-hydroxyphenalen-1-one (**1**) (2.00 g, 8.4 mmol) in glacial acetic acid (50 mL) was treated with 4-nitrophenylhydrazine (**2b**) (1.54, 10.1 mmol) and some drops of conc. sulfuric acid. The reaction mixture was heated under reflux for 2 hours, poured onto ice/water (200 mL) and stirred until solid. The solid was collected by suction filtration and washed with water until neutral. The yield was 2.89 g (97%) brownish prisms, mp 217 °C dec (bromobenzene); ir: 3200-3340 m, 1645 m, 1570-1595 m cm^{-1}; ^{1}H nmr: δ 1.90 (s, CH_3), 6.80 (dd, *J* = 7 + 1.5 Hz, 2 ArH), 7.45-7.55 (m, 1 ArH), 7.70-8.60 (m, 7 ArH), 9.05 (s, NH), 10.00 (s, OH).

Anal. Calcd. for $C_{21}H_{15}N_3O_4$: C, 67.56; H, 4.05; N, 11.25. Found: C, 67.92; H, 4.35; N, 10.88.

8-Methyl-10-phenyl-10*H*-naphtho[1,8a,8-*fg*]indazol-7-one (**4a**).

Method A.

To a suspension of 2-acetyl-3-hydroxyphenalen-1-one (**1**) (1.00 g, 4.2 mmol) and phenylhydrazine (**2a**) (0.54 g, 5.0 mmol) in glacial acetic acid (30 mL) some drops of conc. sulfuric acid were added. The mixture was then heated under reflux for 2 hours poured onto ice/water (300 mL) and stirred until solid formed. The solid was collected by suction filtration and washed with water until neutral. The yield was 0.61 g (47%) yellow prisms, mp 154 °C dec (ligroin).

Method B.

A suspension of 3-hydroxy-2-[1-(phenylhydrazono)ethyl]-1*H*-phenalen-1-one (**3a**) (1.00 g, 3.0 mmol) in glacial acetic acid (30 mL) was combined with some drops of conc. sulfuric acid, heated under reflux for 2 hours, poured onto ice/water (300 mL) and stirred until solid formed. The solid was collected by suction filtration and washed with water until neutral. The yield was 0.62 g (66 %) yellow prisms, mp 155 °C dec (ligroin).

Method C.

A solution of 2-acetyl-3-azido-1*H*-phenalen-1-one (**6**) (1.00 g, 2.8 mmol) in glacial acetic acid (30 mL) was laced with some drops of conc. sulfuric acid, heated under reflux for 2 hours, poured onto ice/water (300 mL) and stirred until solid formed. The solid was collected by suction filtration and washed with water until neutral, dried and recrystallized several times from ligroin. The yield was 0.30 g (34 %) yellow prisms, mp 155 °C dec (ligroin); ir: 1645 m, 1615 w, 1575 w cm^{-1}; ^{1}H nmr: δ 2.60 (s, CH_3), 7.30 (dd, *J* = 7+1.5 Hz, 1 ArH), 7.50 (t, *J* = 7+1.5 Hz, 1 ArH), 7.65-7-75 (m, 5 ArH), 7.90 (*t*, J = 7+1.5 Hz, 1 ArH), 8.15 (dd, *J* = 7+1.5 Hz, 1 ArH), 8.40 (dd, *J* = 7+1.5 Hz, 1 ArH), 8.60 (dd, *J* = 7+1.5 Hz, 1 ArH).

Anal. Calcd. for $C_{21}H_{14}N_2O$: C, 81.27; H, 4.55; N, 9.03. Found: C, 81.38; H, 4.51; N, 8.60.

10-(3-Chlorophenyl)-8-methyl-10*H*-naphtho[1,8a,8-*fg*]indazol-7-one (**4c**).

A suspension of 2-acetyl-3-hydroxyphenalen-1-one (**1**) (2.00 g, 8.4 mmol) and 3-chlorophenylhydrazine (**2c**) (1.44 g, 10.1 mmol) in glacial acetic acid (30 mL) was laced with some drops of conc. sulfuric acid, heated under reflux for 2 hours, poured onto ice/water (400 mL) and stirred until solid formed. The solid was collected by suction filtration and washed with water until neutral. The yield was 1.84 g (64 %) brownish prisms, mp 199-201 °C (ligroin); ir: 1640 m, 1575 m cm^{-1}; ^{1}H nmr: δ 2.60 (s, CH_3), 6.70 (dd, *J* = 7 + 1.5 Hz, 1 ArH), 7.00-8.50 (m, 9 ArH).

Anal. Calcd. for $C_{21}H_{13}ClN_2O$: C, 73.15; H, 3.80; Cl, 10.28; N, 8.12. Found: C, 72.76; H, 4.18; Cl, 9.92; N, 7.74.

2-Acetyl-1-oxo-1*H*-phenalen-3-yl 4-methylbenzenesulfonate (**5**).

This compound was obtained from 2-acetyl-3-hydroxy-1*H*-phenalen-1-one (**1**) and toluenesulfonyl chloride according to the procedure described in ref. [5].

2-Acetyl-3-azido-1*H*-phenalen-1-one (**6**).

This compound was obtained from 2-acetyl-1-oxo-1*H*-phenalen-3-yl 4-methylbenzenesulfonate (**5**) and sodium azide according to the procedure described in ref. [5].

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