

## A New Procedure for Formylation of Less Active Aromatics

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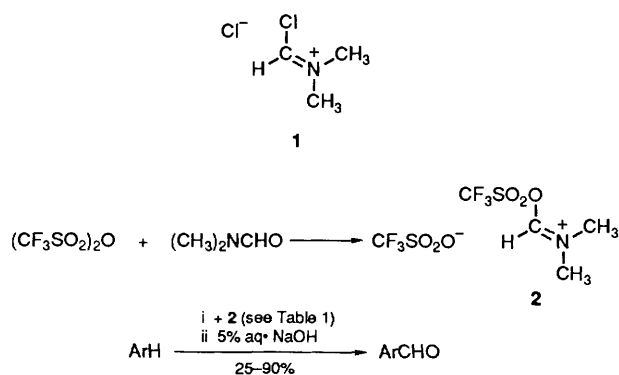
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The formylation of aromatic compounds with trifluoromethanesulphonic anhydride/dimethylformamide complex **2** takes place easily as compared to the normal Vilsmeier–Haack reaction.

The formylation of aromatic compounds is an important synthetic step in organic chemistry.<sup>1</sup> A simple procedure for this involves the reaction of aromatic compounds with dimethylformamide/phosphorus oxychloride complex **1** (Vilsmeier–Haack reaction<sup>2</sup>). However, this reaction is suitable only for electron-rich substrates.<sup>3</sup>

We have now found that the use of trifluoromethanesulphonic anhydride, instead of phosphorus oxychloride, leads to a very reactive iminium salt **2**<sup>†</sup> resulting in the functionalization of relatively less activated aromatic compounds under mild conditions. Thus, the hydrocarbons **3–7** afford the corresponding formylated products **10–14**, respectively, in a much better yield than the DMF/POCl<sub>3</sub> complex **1**<sup>‡</sup> (see Table 1).



<sup>†</sup> M.p. = 52–54°C. IR (KBr):  $\nu = 1705$  (C=N), 1250, 1160, 1030 (OTf)  $\text{cm}^{-1}$ . <sup>1</sup>H NMR (CD<sub>3</sub>CN):  $\delta$  3.00 (s, 3H, CH<sub>3</sub>), 3.20 (s, 3H, CH<sub>3</sub>), 8.0 (s, 1H, CH).

<sup>‡</sup> *General Procedure:* Trifluoromethanesulphonic anhydride (2.82 g, 10 mmol) was added dropwise to DMF (10 mmol) at 0°C, whereby a white precipitate of trifluoromethanesulphonyloxy-methylen-*N,N*-dimethyliminium trifluoromethanesulphonate **2** is formed. A solution of the aromatic substrate (10 mmol) in the corresponding solvent (10 ml) (Table 1) (or without solvent) was added and the mixture heated in a sealed glass ampoule. After cooling, the mixture was hydrolysed with 5% NaOH (20 ml) and extracted with CH<sub>2</sub>Cl<sub>2</sub> (3 × 20 ml). The combined CH<sub>2</sub>Cl<sub>2</sub> layers were washed with water (2 × 20 ml) and dried (MgSO<sub>4</sub>). After removal of the solvent, the crude product was purified by column chromatography on silica gel (2 × 45 cm, eluent: hexane–CH<sub>2</sub>Cl<sub>2</sub>) or recrystallized.

**Table 1** Formylation of aromatic compounds with trifluoromethanesulphonic anhydride/DMF complex **2**‡

Substrate	Reagent/solvent	Reaction conditions Time/h; Temp./°C	Product(s)	Yield <sup>a</sup> (%)
1,3,5-Trimethylbenzene <b>3</b>	<b>1</b> <b>2</b> /—	— 96/125	No reaction 2,4,6-Trimethylbenzaldehyde <b>10</b>	60
Naphthalene <b>4</b>	<b>1</b> <b>2</b>	— 48/130	No reaction <sup>3</sup> 1-Naphthalenecarbaldehyde <b>11</b>	50
Acenaphthene <b>5</b>	<b>1</b> /xylene <b>2</b> /CHCl <sub>3</sub>	6/95 72/130	5-Acenaphthenecarbaldehyde <b>12</b>	30 <sup>6</sup> 90
Anthracene <b>6</b>	<b>1</b> /1,2-Cl <sub>2</sub> C <sub>6</sub> H <sub>4</sub> <b>2</b> /CH <sub>2</sub> Cl <sub>2</sub>	2/95 48/37	9-Anthracenecarbaldehyde <b>13</b>	63 <sup>7</sup> 98
Phenanthrene <b>7</b>	<b>1</b> <b>2</b> /—	— 168/130	No reaction <sup>3</sup> 3-Phenanthrenecarbaldehyde <b>14</b>	25
Anisole <b>8</b>	<b>1</b> <b>2</b> /toluene	15/95 24/110	4-Methoxybenzaldehyde <b>15</b> + 2-Methoxybenzaldehyde <b>16</b>	70 <sup>9</sup> 80
Pyrrole <b>9</b>	<b>1</b> /(CH <sub>2</sub> ) <sub>2</sub> Cl <sub>2</sub> <b>2</b> /CH <sub>2</sub> Cl <sub>2</sub>	0.25/70 12/—10	<b>15</b> (78%) + <b>16</b> (22%) <sup>b</sup> 2-Pyrrolecarbaldehyde <b>17</b>	79 <sup>10</sup> 75

<sup>a</sup> Yield of isolated products. All products are known<sup>4-10</sup> and were fully characterized by comparing the spectral data with an authentic sample. <sup>b</sup> The *o/p* ratio was determined by GC (Column OV-101, 50 m, temp. 120°C).

A definite advantage of our method is the easy work-up that avoids any necessity to remove high-boiling solvents. Toluene and cumene do not react under our reported conditions.

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