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SYNTHESIS OF 3-CYANOBENZENE-1-SULFONYL CHLORIDES

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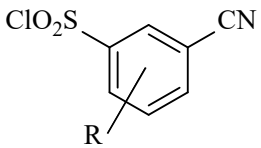
The paper presents a preparation method for 3-cyanobenzene-1-sulfonyl chlorides, valuable reagents for the fine organic synthesis used in the preparation of antiplatelet agents and agricultural germicides, pharmaceutical compositions, and biologically active compounds.

Introduction

3-Cyanobenzene-1-sulfonyl chlorides are valuable reagents for various areas of fine organic synthesis.



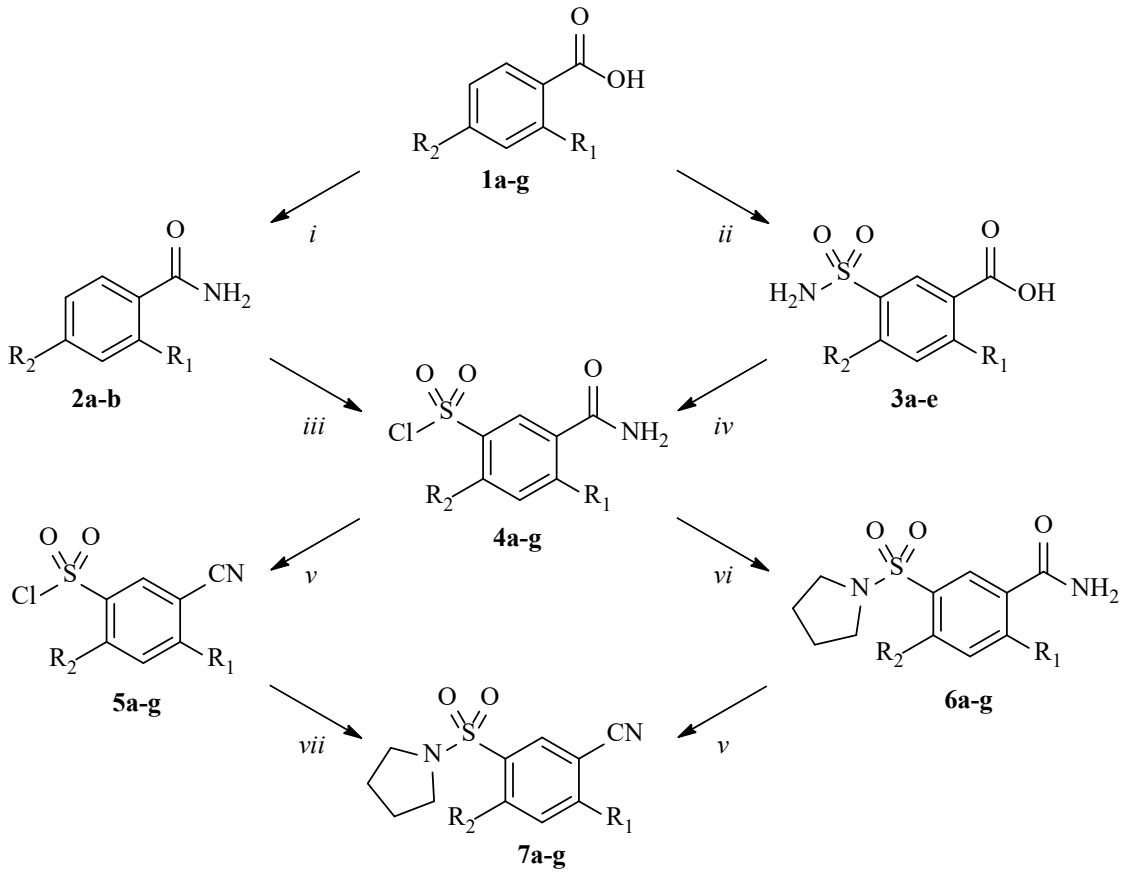
These compounds are used to form the corresponding sulfonamide component in complex functional compounds of various purposes. Specifically, they are used to produce antiplatelet agents [1], agricultural germicides [2], pharmaceutical compositions [3, 4], potential anticancer agents [5, 6], antihelmintic [7] and anti-inflammatory [8, 9] agents, etc.

Despite the apparent simplicity of the structure, 3-cyanobenzene-1-sulfonyl chlorides are not widely available reagents. Commercial drug catalogs offer only a limited list of compounds, and their average price is 70-100 € per 1 gram [10]. The purpose of this study is to develop a general method for the preparation of compounds of this series using inexpensive raw materials and reagents.

Older research of sulphidation reactions [11] shows that it is impossible to synthesize them by direct sulphochlorination of the corresponding benzonitriles [11]. In this case, the formation of cyclic sulfamate during the reaction and its decomposition upon pouring the reaction mixture into water does not preserve the nitrile group in the final products. An alternative and widely known method for the indirect introduction of the sulfonyl chloride group into aromatic compounds is the sulfochlorination reaction of the corresponding diazonium salts [12]. Another research [13] demonstrates a way to obtain various cyanobenzene sulfonyl chlorides using this reaction. However, the disadvantages of the proposed method are the complexity of technological design, the necessity of a number of additional reagents, and commercial availability of a rather narrow list of initial aminobenzonitriles, which do not make it versatile enough.

Study

The study proposes a preparation method for sulfonyl chlorides **5** based on the dehydration of the corresponding benzamides **4**, which are produced using benzoic acids **1**.



i: (1) $SOCl_2$, DMPA; (2) MeCN, NH_2 (25% water solution); *ii:* (1) HSO_3Cl, 140 °C, 2 h; NH_2 (25% water solution); *iii:* HSO_3Cl, 70 °C, 2 h; *iv:* HSO_3Cl, 90–100 °C, 1-1,5 h; *v:* PCl_3, 90 °C, 30 minutes; *vi:* (1) MeCN, pyrrolidine; (2) HCl; *vii:* MeCN, pyrrolidine

1-2, 4-7. R_1 = H (**b**,**c**,**e**), Me (**a**), F (**d**), Cl (**g**); R_2 = H (**a**,**c**,**d**,**f**), OMe (**b**), F (**e**), Cl (**g**).
3. R_1 = H (**a**,**c**), F (**b**), Cl (**d**,**e**); R_2 = H (**a**,**b**,**d**), F (**c**), Cl (**e**).

Depending on the type of substituents in the initial benzoic acid nucleus **1**, 3-carbamoylbenzene-1-sulfonyl chlorides **4** can be prepared by two methods: direct sulfochlorination of benzamides **2** containing electron donor groups [12], or intramolecular reamidation of sulfonamides **3** [14] containing electron acceptor substituents. The yields of compounds **4a-g** obtained by these methods are 42-78%. The IR spectra of benzamides **4a-g** recorded absorption bands common for carboxamide and sulfonyl chloride fragments. To further confirm the structure, sulfonyl chlorides **4a-g** were treated with pyrrolidine, and the resulting sulfonamides **6a-g** were analyzed by ^{1}H NMR and IR spectroscopy. The NMR ^{1}H spectra of compounds **6a-g** in all cases showed proton signals of carboxamide and sulfonamide fragments.

The benzamide dehydration reaction is the simplest and best studied method of benzonitriles production. In this reaction, the initial benzamide is heated in a water-releasing agent ($SOCl_2$, $POCl_3$, $COCl_2$, P_2O_5, etc.) in presence of a base (pyridine, DMPA, $NaHSO_3$, etc.) [15, 16]. However, in the case of compounds **4**, a free sulfonyl chloride group may adversely affect the course of the reaction involving the base agents, which can lead to hydrolysis of this group or other chemical transformation. Therefore, for the synthesis of the target cyanobenzene sulfonyl chlorides **5a-g**, we propose not to use additional reagents. Comparison of the reactivity of benzamides **4a-g** in $SOCl_2$ and $POCl_3$ medium showed that thionyl chloride exhibited weak dehydrating activity even at boiling temperature and prolonged heating. In all cases, only the initial benzamides **4** were detected in the products (by thin-layer chromatography and by melting temperature). Using $POCl_3$ as a water-releasing agent provided much better results. Regardless of the type of substituent in the original compound **4**, at 85–90 °C and reaction time of 30 minutes, the reaction yield is 80-94% of the target cyanobenzene sulfonyl chlorides **5a-g**. In IR spectra of the obtained products, we detected a disappearance of absorption bands of carboxamide fragments and an appearance of corresponding bands in the 2230 cm^{-1} range, indicating the presence of cyanogroup. Also, to further confirm the structure, sulfonyl chlorides **1a-g** were treated with pyrrolidine, and the resulting sulfonamides **7a-g** were analyzed by ^{1}H NMR and IR spectroscopy. In the ^{1}H NMR spectra of compounds **7a-g**, no proton signals of the carboxamide fragment were detected in all cases.

Cyanobenzene sulfonamides **7a-g** were also successfully counter-synthesized based on compounds **6a-g** under similar dehydration reaction conditions. The product yields were 82-92%, and their spectral and physicochemical properties were identical to those recorded for compounds **7** derived from compounds **5**.

Experimental data

A Bruker DRX400 spectrometer (400 MHz) was used to record NMR ^{1}H spectra. Solvent: DMSO-d_6, TMC internal standard. IR spectra were recorded on a RX-1 Perkin Elmer Fourier spectrometer with a 700-4000 cm^{-1} wavelength. A suspension of the analyzed sample in Vaseline oil was placed in the device between KBr plates. Mass spectra were recorded on Shimadzu Prominence LCMS-2020 UFLC/MS equipped with a chromatography column (t = 40 °C, acetonitrile eluent) and mass spectrometer (LCMS-2020, m/z range 0-2000, ionization modes: ESI/ACPI).

3-carbamoyl-4-methylbenzene-1-sulfonyl chloride (4a). 4.4 ml (0.066 mol) of chlorosulfonic acid was added to 3 g (0.022 mol) benzamide **2a**. The reaction mixture was incubated at 70 °C for 2 h. The product was extracted by pouring the reaction mixture on ice and purified by recrystallization from toluene. Yield 3.899 g (75%), beige crystals, m.p. 149.5–151 °C. IR spectrum (KBr), ν, cm^{-1}: 3446, 3302, 3259, 3200 (CON-H), 1663 (C=O), 1620 (CON-H), 1592 (C-$C_{arom.}$), 1374, 1175 (SO_2).

The compound **4b** was prepared similarly.

5-carbamoyl-2-methoxybenzene-1-sulfonyl chloride (4b). Yield 4.120 g (83%), white crystals, m.p. 135.5–136.5 °C. IR spectrum (KBr), ν, cm^{-1}: 3428, 3414, 3367, 3300 (CON–H), 1682 (C=O), 1625 (CON–H), 1601, 1503 (C–$C_{arom.}$), 1556 (CON–H), 1376, 1178 (SO_2).

3-carbamoylbenzene-1-sulfonyl chloride (4c). 4.0 ml (0.060 mol) of chlorosulfonic acid was added to 3 g (0.015 mol) sulfonamide **3a**. After the foam subsided, the reaction mixture was incubated at 100 °C for 1 h. The product was extracted by pouring the reaction mixture on ice and purified by recrystallization from toluene. Yield 2.264 g (69%), white crystals, m.p. 78–80 °C. IR spectrum (KBr), ν, cm^{-1}: 3427, 3290, 3210 (CON–H), 3072 (C–$H_{arom.}$), 1654 (C=O), 1635, 1613 (CON–H), 1569 (C–$C_{arom.}$), 1556 (CON–H), 1382, 1373, 1184 (SO_2).

The compounds **4d-g** were prepared similarly.

3-carbamoyl-4-fluorobenzene-1-sulfonyl chloride (4d). Reaction temperature 100 °C, duration 2 h. Yield 1.438 g (44%), white needle-like crystals, m.p. 110–113 °C. IR spectrum (KBr), ν, cm^{-1}: 3444, 3418, 3283, 3238, 3171 (CON-H), 3098 (C-$H_{arom.}$), 1684, 1663 (C=O), 1628 (CON-H), 1608 (C-$C_{arom.}$), 1569 (CON-H), 1379, 1178 (SO_2).

3-carbamoyl-2-fluorobenzene-1-sulfonyl chloride (4e). Reaction temperature 90 °C, duration 2 h. Yield 1.351 g (42%), white crystals, m.p. 135.5–137 °C. IR spectrum (KBr), ν, cm^{-1}: 3471, 3356, 3289, 3150 (CON-H), 3072 (C-$H_{arom.}$), 1685 (C=O), 1600, 1494 (C-$C_{arom.}$), 1376, |1188 (SO_2).

3-carbamoyl-4-chlorobenzene-1-sulfonyl chloride (4f). Reaction temperature 100 °C, duration 2 h. Yield 2.501 g (77%), white crystals, m.p. 143–145 °C. IR spectrum (KBr), ν, cm^{-1}: 3363, 3183 (CON-H), 1658, 1643 (C=O), 1618 (CON-H), 1589 (C-$C_{arom.}$), 1377, 1176 (SO_2).

5-carbamoyl-2,4-dichlorobenzene-1-sulfonyl chloride (4g). Reaction temperature 90 °C, duration 3 h. Yield 2.504 g (78%), beige crystals, m.p. 138–142 °C. IR spectrum (KBr), ν, cm^{-1}: 3383, 3292, 3223 (CON-H), 3086 (C-$H_{arom.}$), 1655 (C=O), 1619 (CON-H), 1606, 1585 (C-$C_{arom.}$), 1535 (CON-H), 1385, 1179 (SO_2).

3-cyano-4-methylbenzene-1-sulfonyl chloride (5a). 3 ml (32.772 mmol) of phosphorus chloroxide was added to 1 g (4.279 mmol) benzamide **4a**. The reaction mixture was heated for 30 min at 85–90 °C, then cooled down, and 5 ml of acetonitrile was added. The product was extracted by pouring the resulting solution on 10 g ice, and the resulting precipitate was filtered off. The product can be further purified by recrystallization from toluene. Yield 0.806 g (87%), beige crystals, m.p. 70–71 °C. IR spectrum (KBr), ν, cm^{-1}: 3056 (C–$H_{arom.}$), 2236 (C≡N), 1596 (C–$C_{arom.}$), 1376, 1194, 1168 (SO_2).

The compounds **5b-g** were prepared similarly.

5-cyano-2-methoxybenzene-1-sulfonyl chloride (5b). Yield 0.867 g (93%), white crystals, m.p. 129–131 °C. IR spectrum (KBr), ν, cm^{-1}: 3079 (C–$H_{arom.}$), 2233 (C≡N), 1604, 1497 (C–$C_{arom.}$), 1369, 1167 (SO_2).

3-cyanobenzene-1-sulfonyl chloride (5c). Yield 0.747 g (81%), beige crystals, m.p. 44–46 °C. IR spectrum (KBr), ν, cm^{-1}: 3058 (C–$H_{arom.}$), 2233 (C≡N), 1596 (C–$C_{arom.}$), 1378, 1171 (SO_2).

3-cyano-4-fluorobenzene-1-sulfonyl chloride (5d). Yield 0.741 g (80%), beige crystals, m.p. 68–70 °C. IR spectrum (KBr), ν, cm^{-1}: 3083, 3066 (C–$H_{arom.}$), 2242 (C≡N), 1610, 1574, 1492 (C–$C_{arom.}$), 1373, 1192, 1163 (SO_2).

5-cyano-2-fluorobenzene-1-sulfonyl chloride (5e). Yield 0.759 g (82%), dark brown oil.

3-cyano-4-chlorobenzene-1-sulfonyl chloride (5f). Yield 0.850 g (91%), white crystals, m.p. 56.5–57 °C. IR spectrum (KBr), ν, cm^{-1}: 3088, 3064 (C–$H_{arom.}$), 2242 (C≡N), 1585 (C–$C_{arom.}$), 1381, 1180, 1167 (SO_2).

2,4-dichlorobenzene-5-cyano-1-sulfonyl chloride (5g). Yield 0.882 g (94%), white crystals, m.p. 74–77 °C. IR spectrum (KBr), ν, cm^{-1}: 3092, 3068 (C–$H_{arom.}$), 2240 (C≡N), 1581, 1572 (C–$C_{arom.}$), 1390, 1379, 1181 (SO_2).

2-methyl-5-(pyrrolidine-1-ylsulfonyl) benzamide (6a). 0.7 ml (8.560 mmol) pyrrolidine was added to a solution of 1 g (4.280 mmol) benzamide **4a** in 5 ml acetonitrile. The reaction mixture was stirred for 2-3 min, and the product was extracted by adding 5 ml water. The product can be further purified by recrystallization from ethanol-water mixture (1:1). Yield 0.90 g (78%), white crystals, m.p. 205–207 °C. IR spectrum (KBr), ν, cm^{-1}: 3455, 3360, 3327 (CON–H), 1681, 1669 (C=O), 1610 (N–H), 1331, 1171, 1156 (SO_2). NMR spectrum ^{1}H (400 MHz), δ, ppm (*J*, Hz): 1.66 (m, 4H, $2CH_2$), 2.44 (s, 3H, CH_3), 3.14 (m, 4H, $N(CH_2)_2$), 7.49 (d, 1H, H-3, ^3J 8.0), 7.58 (s, 1H, $CONH_2$), 7.67 (d, 1H, H-6, ^4J 1.9), 7.73 (dd, 1H, H-4, ^3J 8.0, ^4J 1.9), 7.96 (s, 1H, $CONH_2$). Mass spectrum (ESI): *m*/*z* 267 $[M]^+$ (100.0). *M* 268.33.

Compounds **6b-c, e-g** were prepared similarly. To synthesize the compound **6d**, we used the molar ratio of **4d** : pyrrolidine : triethylamine = 1 : 1 : 2 instead of twice the molar excess of pyrrolidine.

4-methoxy-3-(pyrrolidin-1-ylsulfonyl) benzamide (6b). Yield 0.975 g (86%), white crystals, m.p. 218–220.5 °C. IR spectrum (KBr), ν, cm^{-1}: 3411, 3367, 3306 (CON–H), 1682 (C=O), 1626 (N–H), 1601, 1504 (C–$C_{arom.}$), 1320, 1158 (SO_2). NMR spectrum ^{1}H (400 MHz), δ, ppm (*J*, Hz): 1.74 (m, 4H, $2CH_2$), 3.23 (m, 4H, $N(CH_2)_2$), 3.96 (s, 3H, OCH_3), 7.31 (d, 1H, H-5, ^3J 8.7), 7.38 (s, 1H, $CONH_2$), 8.08 (s, 1H, $CONH_2$), 8.13 (dd, 1H, H-6, ^3J 8.7, ^4J 2.3), 8.30 (d, H-2, ^4J 2.3). Mass spectrum (ESI): *m*/*z* 283 $[M]^+$ (100.0). *M* 284.33.

3-(pyrrolidine-1-ylsulfonyl) benzamide (6c). Yield 0.943 g (81%), beige needle-like crystals, m.p. 226–229 °C. IR spectrum (KBr), ν, cm^{-1}: 3431, 3370, 3327 (CON–H), 1690, 1664 (C=O), 1617 (N–H), 1335, 1167 (SO_2). NMR spectrum ^{1}H (400 MHz), δ, ppm (*J*, Hz): 1.64 (m, 4H, $2CH_2$), 3.16 (m, 4H, $N(CH_2)_2$), 7.62 (s, 1H, $CONH_2$), 7.72 (t, 1H, H-5, ^3J 7.8), 7.95 (d, 1H, H-6, ^3J 7.8), 8.18 (d, 1H, H-4, ^3J 7.8), 8.25 (m, 1H, H-2), 8.29 (s, 1H, $CONH_2$). Mass spectrum (ESI): *m*/*z* 253 $[M]^+$ (100.0). *M* 254.31.

2-fluoro-5-(pyrrolidin-1-ylsulfonyl) benzamide (6d). Yield 0.835 g (73%), white crystals, m.p. 172–174 °C. IR spectrum (KBr), ν, cm^{-1}: 3374 (CON–H), 1695, 1662 (C=O), 1608

(N–H), 1575 (C–$C_{arom.}$), 1340, 1169 (SO_2). NMR spectrum ^{1}H (400 MHz), δ, ppm (*J*, Hz): 1.67 (m, 4H, $2CH_2$), 3.16 (m, 4H, $N(CH_2)_2$), 7.55 (t, 1H, H-3, $^3J_{H^3-H^4}$ 9.1, $^3J_{H^3-F}$ 9.1), 7.86 (s, 1H, $CONH_2$), 7.96 (m, 2H, H-4, $CONH_2$), 8.00 (dd, 1H, H-6, $^4J_{H^6-F}$ 6.6, $^4J_{H^6-H^4}$ 2.4). Mass spectrum (ESI): *m*/*z* 271 $[M]^+$ (100.0). *M* 272.30.

4-fluoro-3-(pyrrolidin-1-ylsulfonyl) benzamide (6e). Yield 0.867 g (76%), white crystals, m.p. 190–192 °C. IR spectrum (KBr), ν, cm^{-1}: 3454, 3353, 3297 (CON–H), 1686 (C=O), 1616 (N–H), 1598, 1485 (C–$C_{arom.}$), 1337, 1156 (SO_2). NMR spectrum ^{1}H (400 MHz), δ, ppm (*J*, Hz): 1.76 (m, 4H, $2CH_2$), 3.25 (m, 4H, $N(CH_2)_2$), 7.60 (m, 2H, H-5, CONH), 8.27 (m, 3H, H-2, H-6, CONH). Mass spectrum (ESI): *m*/*z* 271 $[M]^+$ (100.0). *M* 272.30.

2-chloro-5-(pyrrolidin-1-ylsulfonyl) benzamide (6f). Yield 0.962 g (85%), white crystals, m.p. 196–198 °C. IR spectrum (KBr), ν, cm^{-1}: 3365 (CON–H), 1654 (C=O), 1628 (N–H), 1592 (C–$C_{arom.}$), 1338, 1150 (SO_2). NMR spectrum ^{1}H (400 MHz), δ, ppm (*J*, Hz): 1.69 (m, 4H, $2CH_2$), 3.17 (m, 4H, $N(CH_2)_2$), 7.75 (m, 2H, H-3, H-6), 7.80 (s, 1H, CONH), 7.83 (dd, 1H, H-4, ^3J 8.4, ^4J 2.2), 8.09 (s, 1H, CONH). Mass spectrum (ESI): *m*/*z* 288 $[M]^+$ (100.0). *M* 288.75.

5-(pyrrolidin-1-ylsulfonyl)-2,4-dichlorobenzamide (6g). Yield 0.920 g (82%), light yellow crystals, m.p. 218–221 °C. IR spectrum (KBr), ν, cm^{-1}: 3358 (CON–H), 1657 (C=O), 1631 (N–H), 1586 (C–$C_{arom.}$), 1352, 1155 (SO_2). NMR spectrum ^{1}H (400 MHz), δ, ppm (*J*, Hz): 1.84 (m, 4H, $2CH_2$), 3.32 (m, 4H, $N(CH_2)_2$), 7.84 (s, 1H, CONH), 7.90 (s, 1H, H-3), 7.98 (s, 1H, H-6), 8.11 (s, 1H, CONH). Mass spectrum (ESI): *m*/*z* 322 $[M]^+$ (100.0). *M* 323.20.

2-methyl-5-(pyrrolidine-1-ylsulfonyl) benzonitrile (7a). Method *a*. 0.38 ml (4.637 mmol) of pyrrolidine was added to a solution of 0.5 g (2.318 mmol) of compound **5a** in 3 ml acetonitrile. The reaction mixture was stirred for 2-3 min, and the product was extracted by adding 5 ml water. The product can be further purified by recrystallization from ethanol-water mixture (1:1). Method *b*. 3 ml (16.386 mmol) of phosphorus chloroxide was added to 0.5 g (1.863 mmol) benzamide **6a**. The reaction mixture was heated for 30 min at 85–90 °C, then cooled down, and 5 ml of acetonitrile was added. The product was extracted by pouring the resulting solution on 10 g ice, and the resulting precipitate was filtered off. The product can be further purified by recrystallization from ethanol-water mixture (1:1). Yield 0.419 g (72%) (method *a*), 0.427 g (91%) (method *b*), white crystals, m.p. 113–115 °C. IR spectrum (KBr), ν, cm^{-1}: 3055 (C–H_{arom}), 2231 (C≡N), 1597 (C–$C_{arom.}$), 1342, 1154 (SO_2). NMR spectrum ^{1}H (400 MHz), δ, ppm (*J*, Hz): 1.66 (m, 4H, $2CH_2$), 2.58 (s, 3H, CH_3), 3.17 (m, 4H, $N(CH_2)_2$), 7.72 (d, 1H, H-3, ^3J 8.1), 8.00 (dd, 1H, H-4, ^3J 8.1, ^4J 1.9), 8.17 (d, H-6, ^4J 1.9). Mass spectrum (ESI): *m*/*z* 249 $[M]^+$ (100.0). *M* 250.32.

Compounds **7b-g** were prepared similarly using both methods. To synthesize the compound **7d** as per method *a*, we used the molar ratio of **5d** : pyrrolidine : triethylamine = 1 : 1 : 2 instead of twice the molar excess of pyrrolidine.

4-methoxy-3-(pyrrolidin-1-ylsulfonyl) benzonitrile (7b). Yield 0.435 g (76%) (method *a*), 0.421 g (90%) (method *b*), white crystals, m.p. 145–148 °C. IR spectrum (KBr), ν, cm^{-1}: 3056 (C–$H_{arom.}$), 2225 (C≡N), 1599, 1487 (C–$C_{arom.}$), 1336, 1151 (SO_2). NMR spectrum ^{1}H (400 MHz), δ, ppm (*J*, Hz): 1.76 (m, 4H, $2CH_2$), 3.25 (m, 4H, $N(CH_2)_2$), 4.01 (s, 3H, OCH_3), 7.45 (d, 1H, H-5, ^3J 8.5), 8.11 (m, 2H, H-2, H-6). Mass spectrum (ESI): *m*/*z* 265 $[M]^+$ (100.0). *M* 266.32.

3-(pyrrolidin-1-ylsulfonyl) benzonitrile (7c). Yield 0.379 g (65%) (method *a*), 0.379 g (82%) (method *b*), white crystals, m.p. 100–103 °C. IR spectrum (KBr), ν, cm^{-1}: 3056 (C–$H_{arom.}$), 2234 (C≡N), 1414 (C–$C_{arom.}$), 1345, 1160 (SO_2). NMR spectrum ^1H (400 MHz), δ, ppm (*J*, Hz): 1.66 (m, 4H, $2CH_2$), 3.19 (m, 4H, $N(CH_2)_2$), 7.84 (t, 1H, H-5, ^3J 7.9), 8.12 (d, 1H, H-4, ^3J 7.9), 8.17 (d, 1H, H-6, ^3J 7.9), 8.25 (m, 1H, H-2). Mass spectrum (ESI): *m*/*z* 235 $[M]^+$ (100.0). *M* 236.29.

2-fluoro-5-(pyrrolidin-1-ylsulfonyl) benzonitrile (7d). Yield 0.337 g (58%) (method *a*), 0.405 g (87%) (method *b*), white crystals, m.p. 142–145 °C. IR spectrum (KBr), ν, cm^{-1}: 3066 (C–$H_{arom.}$), 2236 (C≡N), 1574, 1490 (C–$C_{arom.}$), 1348, 1337, 1156 (SO_2). NMR spectrum ^1H (400 MHz), δ, ppm (*J*, Hz): 1.68 (m, 4H, $2CH_2$), 3.19 (m, 4H, $N(CH_2)_2$), 7.77 (t, 1H, H-3, $^3J_{H3–H4}$ 9.0, $^3J_{H3–F}$ 9.0), 8.20 (ddd, 1H, H-4, $^3J_{H4–H3}$ 9.0, $^4J_{H4–F}$ 5.0, $^4J_{H4–H6}$ 2.4), 8.41 (dd, 1H, H-6, $^4J_{H6–F}$ 6.1, $^4J_{H6–H4}$ 2.4). Mass spectrum (ESI): *m*/*z* 253 $[M]^+$ (100.0). *M* 254.28.

4-fluoro-3-(pyrrolidin-1-ylsulfonyl) benzonitrile (7e). Yield 0.398 g (69%) (method *a*), 0.390 g (84%) (method *b*), white crystals, m.p. 112.5–114.5 °C. IR spectrum (KBr), ν, cm^{-1}: 3061 (C–$H_{arom.}$), 2235 (C≡N), 1600, 1485 (C–$C_{arom.}$), 1344, 1154 (SO_2). NMR spectrum ^1H (400 MHz), δ, ppm (*J*, Hz): 1.78 (m, 4H, $2CH_2$), 3.29 (m, 4H, $N(CH_2)_2$), 7.74 (t, 1H, H-5, $^3J_{H5–H6}$ 9.7, $^3J_{H5–F}$ 9.7), 8.26 (m, 2H, H-2, H-6). Mass spectrum (ESI): *m*/*z* 253 $[M]^+$ (100.0). *M* 254.28.

2-chloro-5-(pyrrolidin-1-ylsulfonyl) benzonitrile (7f). Yield 0.421 g (73%) (method *a*), 0.416 g (89%) (method *b*), white crystals, m.p. 163–165.5 °C. IR spectrum (KBr), ν, cm^{-1}: 3064 (C–$H_{arom.}$), 2231 (C≡N), 1582 (C–$C_{arom.}$), 1358, 1161 (SO_2). NMR spectrum ^1H (400 MHz), δ, ppm (*J*, Hz): 1.68 (m, 4H, $2CH_2$), 3.20 (m, 4H, $N(CH_2)_2$), 7.98 (d, 1H, H-3, ^3J 8.5), 8.10 (dd, 1H, H-4, ^3J 8.5, ^4J 2.2), 8.39 (d, H-6, ^4J 2.2). Mass spectrum (ESI): *m*/*z* 270 $[M]^+$ (100.0). *M* 270.74.

5-(pyrrolidin-1-ylsulfonyl)-2,4-dichlorobenzonitrile (7g). Yield 0.430 g (76%) (method *a*), 0.436 g (92%) (method *b*), yellow crystals, m.p. 148–150.5 °C. IR spectrum (KBr), ν, cm^{-1}: 2230 (C≡N), 1581 (C–$C_{arom.}$), 1356, 1159 (SO_2). NMR spectrum ^1H (400 MHz), δ, ppm (*J*, Hz): 1.84 (m, 4H, $2CH_2$), 3.34 (m, 4H, $N(CH_2)_2$), 8.28 (s, 1H, H-3), 8.39 (s, 1H, H-6). Mass spectrum (ESI): *m*/*z* 304 $[M]^+$ (100.0). *M* 305.18.

Conclusion

Despite the seeming simplicity, the proposed method fits all purposes and allows to synthesize a wide range of highly pure 3-cyanobenzene-1-sulfonide chloride derivatives **5** with the available raw materials and reagents. It also allows us to significantly simplify the possible technological design of the process as compared to the previously proposed [13] and reduce the cost of the final compounds.

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