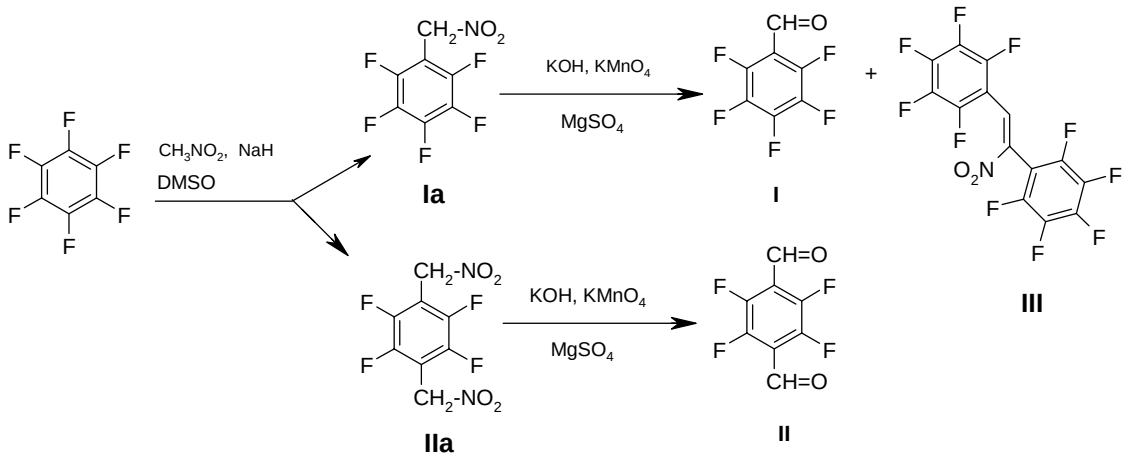
NEW SYNTHESIS AND SYNTHETIC UTILISATION OF PENTA-FLUOROBENZALDEHYDE AND TETRAFLUOROTEREPHTALIC ALDEHYDE AS BUILDING BLOCS FOR NOVEL OPTO-ELECTRONIC MATERIALS

Daniel VÉGH[a], Tomáš SOLČÁN[a], Katarína HRNČARIKOVÁ[a] and Jozef KOŽÍŠEK[b]

[a]Institute of Organic Chemistry, Catalysis and Petrochemy, [b]Institute of Physical Chemistry and Chemical Physics, Slovak University of Technology, Radlinského street 9, SK-812 37 Bratislava, Slovakia, email: daniel.vegh@stuba.sk

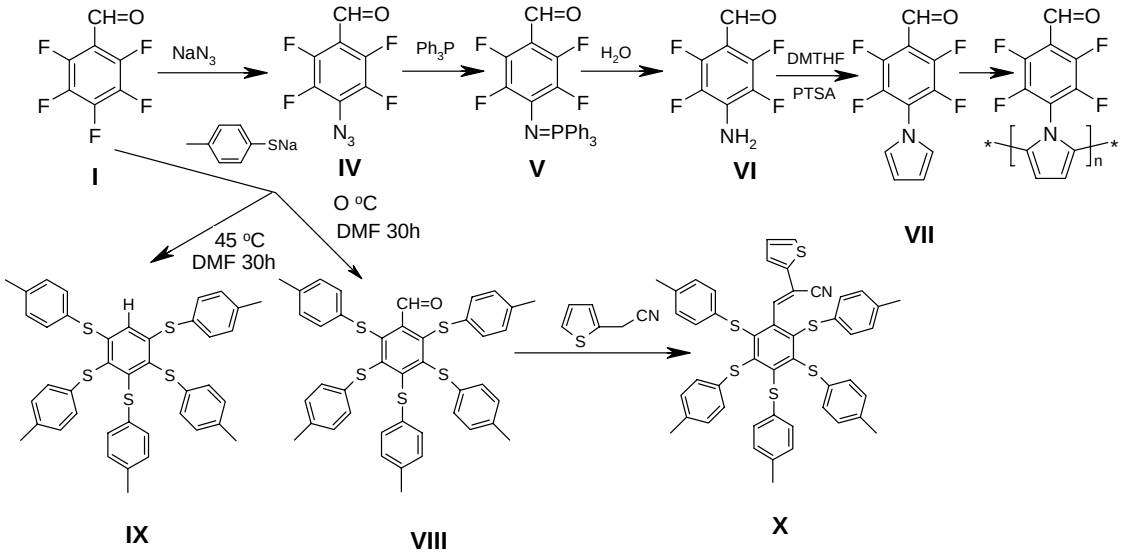
The utilization of perfluoroaromatics for molecular recognition has in recent years been an intensely studied topic. The pentafluorobenzaldehyde (PFBA) (**I**) and tetrafluoroterephtalic aldehyde (TFTA) (**II**), both important starting materials for the above mentioned research have so far been hardly investigated. With the sole exception of the reduction of pentafluorobenzonitrile[1] to pentafluorobenzaldehyde (yield 64%) all the known methods for the synthesis of PFBA [2-9] and TFTA [10,11] involve multi-step processes with low overall yields and starting from rather inaccessible raw materials.

In the course of our search for alternative cheap and accessible starting materials for the preparation of PFBA and TFTA we were intrigued by the possible deployment of the pentafluorobenzene and hexafluorobenzene for this purpose. However, given the electron-deficient nature of pentafluorobenzene standard formylation methods [12] are not plausible. Bearing in mind that Nef [13] reaction would be a straightforward pathway to achieve this transformation through an SN_{Ar} reaction under mild and controlled conditions. The nitromethyl derivatives obtained were readily transformed into the corresponding aryl aldehyde **I, II** overall as an equivalent process of nucleophilic formylation in which nitromethane serves as the synthon for formyl anion. Hexafluorobenzene reacted readily with nitromethane in the presence of NaH in DMFA or DMSO at room temperature. This nitromethylation proceeded well with hexaflourobenzene. Nucleophilic displacement of a single fluorine atom in hexafluorobenzene by nitromethane affords 1,2,3,4,5-pentafluoro-6-nitromethylbenzene (**Ia**) replacement of another fluorine affords then 1,2,4,5-tetrafluoro-3,6-bis-nitromethyl-benzene (**Ib**) a compounds easily undergoing the Neff reaction when treated with KOH and KMnO4 with good yields. The procedure represents a novel, as yet unpublished synthesis (scheme 1.) of PFBA (**I**) and TFTA (**II**). The formation of the by product **III** alsou detected during the preparation of **I**.



Scheme 1.

We investigated the reactivity of fluorine substituents in PFBA (**I**) towards nucleophiles (e.g. azide anion, 4-methylphenylthiolate anion) as well as that of carbonyl group in PFBA towards 2-thenylacetonitrile. The target compounds **VI-X** can be used as building blocks for novel materials with optoelectronic properties and supramolecular structure in solid state.



Scheme 2.

*General procedure for the preparation of **Ia** and **IIa*** Nitromethane (300 mmol) in DMSO (100 mL) was dropped into the suspension of NaH (300 mmol) in 100 mL of dry DMSO with stirring.

a/ **Ia,** After the bubbling subsided, hexafluorobenzene (100 mmol) was added; the mixture was stirred at r.t. 5h, 100^{O}C 1h and 150^{O}C 1h and then poured into ice-water; acidified with 6 N HCl, then extracted with ethyl acetate. The organic

extraction was washed with water and brine and dried over anhydrous $MgSO_4$. Evaporation of the solvent in vacuum gave a residue, which was separated by column chromatography on glass columns packed with silica gel Merck60 using toluene as eluant to afford **Ia** 49% and a small amount of **IIa**.
b/ **Ia** and **IIa** After the bubbling subsided, hexafluorobenzene (50 mmol) was added; the mixture was stirred at r.t. 5h, 100^{O}C 5h and 150^{O}C 1h and then poured into ice-water; acidified with 6 N HCl, then extracted with ethyl acetate. The organic extraction was washed with water and brine and dried over anhydrous $MgSO_4$. Evaporation of the solvent in vacuum gave a residue, which was separated by column chromatography on glass columns packed with silica gel Merck60 using toluene as eluant to afford **Ia** 44% and **Ib** 25%.
Ia. Yellow oil (R_f=0.7 – toluene) ^{1}H NMR (300 MHz, $CDCl_3$) 4.50 (s, CH_2)
IIa. M.p. 149-152 °C, (R_f=0.5 – toluene) ^{1}H NMR (300 MHz, $CDCl_3$) 4.52 (s, CH_2)

*General procedure of the preparation of **I** and **II:*** A stirred suspension of **Ia** or **IIa** (20 mmol) in methanol (140 mL) was cooled to -10 °C to 5 °C and then a freshly prepared solution of KOH (60 mmol) in methanol (200 mL) was added dropwise. After stirring for an additional 30 min, a solution of $KMnO_4$ (15 mmol) and $MgSO_4$ (60 mmol) in water (600 mL) was added dropwise with vigorous stirring. When the reaction was complete, the mixture was filtered over a thin layer of *Celite*. The filtrate was extracted with CH_2Cl_2 and the extract was washed with saturated Na_2CO_3, water, and brine successively and then dried over $MgSO_4$. Removal of the solvent in vacuum gave a residue which was separated by column chromatography on glass columns packed with silica gel Merck60 using toluene as eluant to afford **I** in 64% yield b.p. 55°C/2.4 kPa and **II** in 60% yield as light yellow crystals m.p.132 °C (chloroform) lit. [10,11] 131-132 °C**.**

*4-Azido-2,3,5,6-tetrafluorobenzaldehyde (**IV**).* A mixture of NaN_3 (60 mmol) and **I** (50 mmol) in 100 ml acetone and 40ml water was refluxed for 10 h. The mixture was cooled, diluted with 200 ml water and extracted by ether. The extract was dried and evaporated to leave 95% IV m.p. 44-45°C. ^{1}H NMR (300 MHz, $CDCl_3$) *10.23* (1H, CHO) IR (film) νmax/cm^{-1}: 2125 (N_3). The ether solution of **IV** with equivalent od triphenylfosfine resulted quantitatively **V** m.p. 139-141°C. ^{1}H NMR (300 MHz, $CDCl_3$) *10.07*(1H, CHO), 7.28-7.36 (m,15H, H_{Ar}).

*4-Amino-2,3,5,6-tetrafluorobenzaldehyde (**VI**)* Prepared by hydrolysis of **V** in THF-H_2O 1:1, 20h, 65°C in 90% yield m.p. 110-111°C. lit[14] 110-111°C.

*4-N-pyrrolo--2,3,5,6-tetrafluorobenzaldehyde (**VII**).* Prepared by *Paal-Knorr* pyrrole synthesis [15] in 85% yield m.p. 60-61 °C. ^{1}H NMR (300 MHz, $CDCl_3$), 10.31(1H, CHO), 6.47-6.42 (2H, H_{Ar}), 7.01-7.10 (2H, H_{Ar}), ^{19}F-NMR(C_6F_6): -5,67 (q), -10,30(q).

*Preparation of **VIII** a **IX*** The synthesis of **VIII** were carried out using the *MacNicol*[16] reaction. The 7 eqv. of sodium 4-methylphenylthiolate species generated in situ by treating the thiol with potassium hydroxide , were reacted with **I** in DMFA in various temperature producing the pentasubstituted benzenes **VIII** in 44% yield and **IX** in 37% yield. The moderate yield of analytically pure material **VIII** probably result from the presence of the products of lower degrees of substitution and the potassium hydroxide present in the potassium 4-methylbenzenethiolate effects a

haloform cleavage product **IX.**

VIII. m.p. 119-120°C. ^{1}H NMR (300 MHz, $CDCl_3$) 9.75 (1H, CHO), 6.87-6.95 (m, 20H, H_{Ar}), 2.27 (s, 15H, CH_3), ^{19}F-NMR(C_6F_6): δ = Ø

IX m.p. 107-110°C. ^{1}H NMR (300 MHz, $CDCl_3$) 6.80-7.08 (m, 21H, H_{Ar}), 2.23 (s, 15H, CH_3), *^{19}F-NMR(C_6F_6):* δ = Ø

*Preparation of **X**.* By heating of **I** with 2-thienylacetonitrile in ethanol and 2 drops of 50% NaOH in 64% yield, m.p. 167-169 °C, ^{1}H NMR (300 MHz, $CDCl_3$) 6.72-7.18 (m, 23H, H_{Ar}), 6.41 (s, 1H, CH=C), 2.22 (s, 15H, CH_3),

Structures of target compounds **I-X** were proved by IR, UV, ^{1}H NMR, ^{13}C NMR and ^{19}F NMR spectral methods, and **IIb** by X-ray analysis [17].

This work was financially supported by grants from the Ministry of Education of the Slovak Republic No. 1/1379/04 1/2449/05 and the Science and Technology Assistance Agency (No. APVT-20- 007304).

REFERENCES

[1]. N.B. Chapman, K. Clarke, R.M. Pinder, S.N. Shavney: J.Chem. Soc.C., (1967) 293
[2]. E. Nield, R. Stephens, J.C. Tatlow:J.Chem.Soc., (1959) 166
[3]. A.K. Barbour, M.W. Buxton, P.L. Coe, R. Stephens, J.C. Tatlow:J.Chem.Soc., (1961) 808
[4]. P.L. Coe, R. Stephens, J.C. Tatlow: J.Chem.Soc., (1962) 3227
[5]. N.N. Vorozhotsov, V.A. Barkash, N.G. Ivanova: Dokl.Akad.Nauk.SSSR, 159, (1964) 125
[6]. J.M. Birchall, R.N. Haszeldine, M.E. Jones: J.Chem.Soc.C, (1971) 1343
[7]. N.I. Petrenko : Izv.Akad.Nauk SSSR, Ser.Khim., (1984) 1378
[8]. G.G. Furin, A.O. Miller, Yu.V. Gatilov: J.Fluorine Chem., 28, (1985) 23
[9]. M. Julliard, M. Chanon: Bull.Soc.Chim.Fr., 3, (1992) 242
[10]. C.F. Krebs, T Jensen.: J. Fluorine Chem., 120, (2003) 77
[11]. Sh. Zhu, J. Zhao, X. Cai.: J. Fluorine Chem. 125, (2004) 451
[12]. L. Kurti, B. Czakó,: *in book* Synthetic Applications of Named Reactions in Organic Synthesis, Elsevier Academic Press. 2005 p. 242
[13]. L. Kurti, B. Czakó,: *in book* Synthetic Applications of Named Reactions in Organic Synthesis, Elsevier Academic Press. 2005 p. 308

[14]. K. Kanakarajan, K. Haider, A.W. Czarnik.: Synthesis (1988) 566
[15]. L. Kurti, B. Czakó,: *in book* Synthetic Applications of Named Reactions in Organic Synthesis, Elsevier Academic Press. 2005 p. 328
[16]. D.D. MacNicol, P.R. Mallinson, A. Murphy, G.J. Sym: Tetrahedron Lett., 23, (1982) 4131
[17]. L. Perašinová, I. Svoboda, D. Végh, T. Solčán, J. Kožíšek: Acta Cryst Sect E62, (2006) 1689