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2-[2-(DIMETHYLAMINO)VINYL]-6-PENTAFLUOROPHENYL-4-PHENYLPYRYLIUM PERCHLORATE AND ITS HYDROLYSIS PRODUCTS: SYNTHESIS AND ISOMERISM

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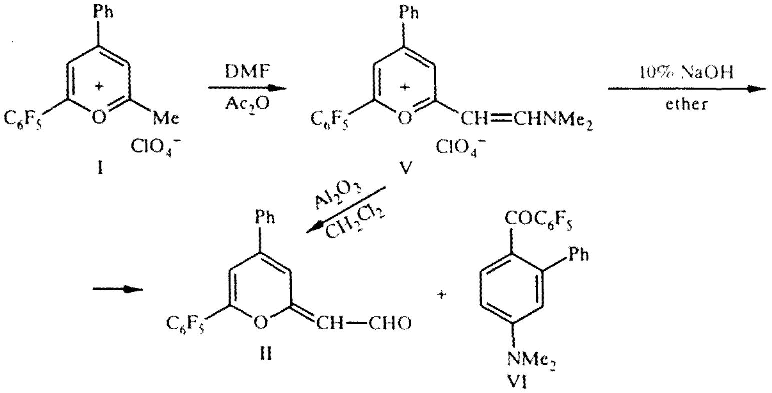
2-[2-(Dimethylamino)vinyl]-6-pentafluorophenyl-4-phenylpyrylium perchlorate has been synthesized and it was shown that it is readily converted into 2-formylmethylene-6-pentafluorophenyl-4-phenyl-2H-pyran on chromatography on alkaline Al_2O_3*. The stereoisomerism of the synthesized compounds has been studied by PMR spectroscopy.*

We previously obtained polyfluoro substituted pyrylium salts with a methyl or methylene group in position 2 [1] and used them in the synthesis of pyrylocyanines [2]. It was shown that 2-methyl-6-pentafluorophenyl-4-phenylpyrylium perchlorate (I) in difference to its nonfluorinated analog [3] did not form a symmetrical trimethinecyanine on interaction with triethyl orthoformate. Nevertheless, we obtained the corresponding fluorine substituted dye on using 2-formylmethylene-6-pentafluorophenyl-4-phenyl-2H-pyran (II) in the condensation (see [4]). The present work is devoted to a synthesis of the latter.

2-Formylmethylene-4,6-diphenyl-2H-pyran (III) was obtained in [5] by the alkaline hydrolysis of the corresponding iminium salt (IV) which had been synthesized from 2-methyl-4,6-diphenylpyrylium perchlorate. The pentafluorophenyl substituted iminium salt (V) was synthesized by us in 92% yield from compound (I) in a similar way. However, hydrolysis of it in dilute aqueous alkali by the procedure of [5] leads to the formation of a mixture of the aldehyde (II) and 4-dimethylamino-2-phenyl-2',3',4',5',6'-pentafluorobenzophenone (VI) with a significant predominance of the latter [yields of (II) and (VI) were 21 and 57% respectively].

Scheme 1



The structure of compound (VI) is compatible with the data of elemental analysis, IR spectra, and ^{19}F NMR spectra. The PMR spectrum was similar to the spectrum of the unfluorinated analog, which was isolated together with aldehyde (III) on hydrolysis of the iminium salt (IV) (see Tables 1, 2). The scheme proposed for forming the unfluorinated product includes

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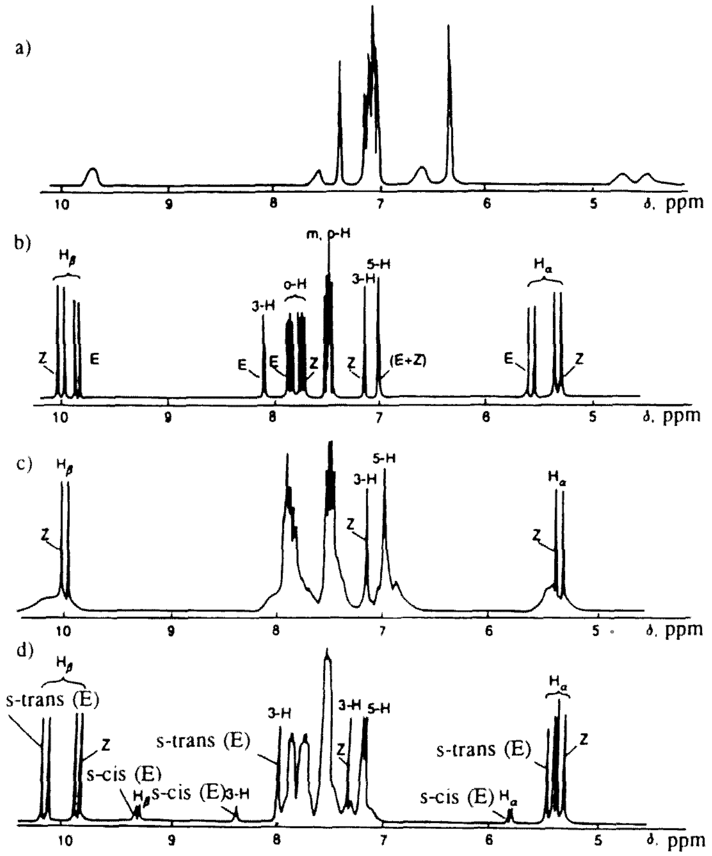


Fig. 1. PMR spectra of compound (II): a) in DMSO-D_6 at 130°C; b) in $(CD_3)_2CO$ at 30°C; c) in $(CD_3)_2CO$ at −40°C; d) in $(CD_3)_2CO$ at −85°C.

attack of the dimethylamine molecule liberated in alkaline medium at position 2 of the pyran ring with subsequent recyclization [5]. The relative ease of such a conversion in our case is possibly explained by the increase in electrophilicity of the point of attack as a result of the large electron-accepting C_6F_5 group.

It was found by us that the hydrolysis of salt (V) proceeds more readily under conditions of chromatographing it on alkaline aluminum oxide and aldehyde (II) was isolated in 67% yield. The use of Al_2O_3 to carry out various reactions catalyzed by bases is known [6].

The structure of compounds (II) and (V) was confirmed by data of the IR spectra containing intense absorption bands in the region of pentafluorophenyl ring vibrations (~1500 cm^{-1}). The spectrum of the iminium salt (V) contains strong absorption bands for the pyrylium ring (1630 cm^{-1}) and the perchlorate anion (1100 cm^{-1}). The spectrum of aldehyde (II) contains an absorption band for the carbonyl group (1635 cm^{-1}). The data of elemental analysis corresponded to the individual compounds. However, the presence in the ^{19}F NMR of two groups of signals corresponding to the C_6F_5 residue and also the character of the PMR spectra taken under different conditions (Fig. 1) enabled compounds (II) and (V) to be considered as mixtures of isomers.

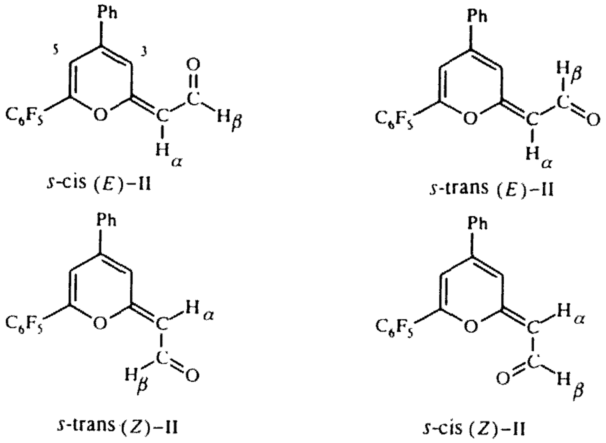
It is possible to propose E,Z isomers for compound (II) caused by the asymmetry of the heteroaromatic ring (see Scheme 2). Each isomer in its turn may exist as two conformers with a cis or a trans disposition of the substituents relative to the $C_\alpha-C_\beta$ bond. In the Z conformers the 3-H proton of the heteroaromatic ring is close in space to the methine proton H_α, and in the s-trans(E) conformer the 3-H is close to the aldehyde proton H_β. We have used the nuclear over hauser effect to determine the isomeric composition of the mixture (Fig. 1, b). On saturating the signal at 7.08 ppm belonging to the 3-H proton of one of the isomers, a small increase (12%) was observed in the H_α signal at 5.34 ppm. Quenching of the 3-H signal at 8.06 ppm belonging to the other isomer leads to an increase of 12% in the signal of the aldehyde group proton H_β at 9.88 ppm. An increase of 4% was also observed for the signals corresponding to ortho protons of the phenyl group (7.78 and 7.88 ppm). The ratio of the intensities of the signals at 7.08 and 8.06 ppm was 55:45. The data obtained confirm that compound (II) exists as

TABLE 1. Characteristics of the Compounds Synthesized

Compound	Empirical formula	Found, % / Calculated, %					mp, °C (solvent for recrystallization)	IR spectrum, cm^{-1} (solvent)	UV spectrum, λ_{max}, nm (log ε)	Yield, %
		C	H	Cl	F	N				
II	$C_{19}H_9F_5O_2$	62,39 62,65	2,49 2,49	–	26,11 26,08	–	140...142 (heptane)	1540, 1635	274 (4,18), 300 sh (4,11), 316 sh (4,06), 424 (3,98)	67
V	$C_{21}H_{15}ClF_5NO_5$	51,29 51,28	3,98 3,07	7,10 7,21	19,27 19,32	2,84 2,85	218...221 (acetic acid)	1100, 1505, 1630	294 sh (4,27), 319 (4,38), 465 (4,31)	92
VI	$C_{21}H_{14}F_5NO$	64,80 64,45	3,77 3,61	–	24,40 24,27	3,62 3,58	118...120 (alcohol)	1500, 1590, 1650	268 (4,25), 366 (4,57)	57

a mixture of E and Z isomers with the latter predominating somewhat. An increase in the temperature of plotting to 130°C leads to broadening of all lines and coalescence of the pairs of signals belonging to the E and Z isomers.

Scheme 2



s-cis (*E*)-II

s-trans (*E*)-II

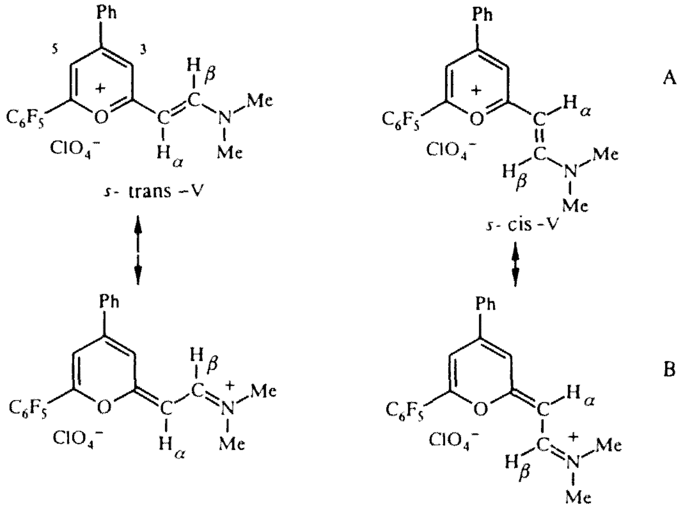
s-trans (*Z*)-II

s-cis (*Z*)-II

The presence of conformers was confirmed by the character of the PMR signals taken at low temperature. Reduction of the temperature to −90°C causes broadening and then separation of the signals of the E isomer which is evidently linked with freezing of the rotation about the $C_\alpha-C_\beta$ bond (coalescence temperature of the H_α and H_β signals of the E conformers was −40°C). The ratio of s-trans(E) and s-cis(E) conformers at −85°C was ~90:10, J_{cis} = 2.5 Hz, J_{trans} = 8.8 Hz. No similar splitting of lines was observed for the Z isomer down to the freezing point of the solvent. The significant difference in the rates of rotation around the $C_{(2)}-C_\alpha$ and $C_\alpha-C_\beta$ bonds indicates the high double bond character of the $C_{(2)}-C_\alpha$ bond.

The presence of two groups of signals belonging to two isomers was also observed in the PMR spectra of the iminium salt (V). In the PMR spectrum of this compound in $(CD_3)_2CO$ the greatest difference in chemical shifts was detected for the signals belonging to the methine proton H_α (two doublets at 6.04 and 6.14 ppm with J = 12.5 and 12.0 Hz respectively), H_β (doublet at 8.55 ppm with J = 12.0 Hz and a doublet at 8.95 ppm with J = 12.5 Hz), and the 3-H heteroaromatic proton (7.68 and 8.14 ppm, J = 1.5 Hz). Increasing the temperature to 110°C (in DMSO-D_6) leads to a broadening and coalescence of the signals for the two isomers (coalescence of H_α at +80°C and of H_β at +110°C). The coupling constants for the protons at the $C_\alpha-C_\beta$ bond point to a trans disposition in both isomers (see [7]).

Scheme 3



s- trans -V

s- cis -V

The data obtained support that isomerism takes place for the iminium salt (V) caused by inhibition of rotation about the $C_{(2)}-C_\alpha$ bond (Scheme 3), which may be linked with an increase in the order of the bond being considered due to the

TABLE 2. Data of NMR Spectra of Compounds (II)-(V)

Compound	PMR spectrum, chemical shifts ^1H, δ, ppm									NMR spectrum, ^{19}F chemical shifts (solvent)		
	Solvent (T, °C)	Isomer (content in mixture, %*)	NMe_2, s, s	H_α (J, Hz), d	5-H, s	3-H, s	H_β (J, Hz), d	H_{Ph}		o-	m-	p-
								o-	m-, p-			
II	$(CD_3)_2CO$ (+30)	*Z* (55)	–	5,34 (8,5)	7,00	7,08	9,98 (8,5)	7,78 q	7,53 q	22,86	1,84	12,34
		E (45)	–	5,54 (6,3)	7,00	8,06	9,88 (6,3)	7,81 q	7,53 q	22,77 ($CDCl_3$)	1,68 ($CDCl_3$)	12,15
II	$(CD_3)_2CO$ (-85)	*Z* (50)	–	5,36 (9,0)	7,24	7,33	9,90 (9,0)	7,82 q	7,54 q			
		s-trans (*E*) (45)	–	5,42 (8,8)	7,21	8,00	10,17 (8,8)	7,90 q	7,54 q			
		s-cis (*E*) (5)	–	5,77 (2,5)	7,30	8,37	9,32 (2,5)	7,82 q	7,47 q			
V	$(CD_3)_2CO$ (+30)	*s*-cis (70)	3,40, 3,59	6,14 (12,0)	7,62	7,68	8,55 (12,0)	7,93 q	7,61 q	24,01	1,71	13,74
		s-trans (30)	3,42, 3,64	6,04 (12,5)	7,62	8,14	8,95 (12,5)	8,02 q	7,61 q	23,46 DMSO-D_6	1,73 DMSO-D_6	13,19
III*	$CDCl_3$ (+30)	*Z* (62)	–	5,30 (8,5)	6,73	6,51	10,13 (8,5)	7,58...7,75 m	7,45 q			
		E (38)	–	5,68 (5,5)	6,73	6,77	9,67 (5,5)	7,58...7,75 m	7,45 q			
IV†	CD_3CN (+30)	*s*-cis (65)	3,13, 3,41	5,62 (12,0)	7,44	7,19	8,16 (12,0)	7,80...8,05 m	7,58 q			
		s-trans (35)	3,13, 3,37	5,79 (12,5)	7,44	7,58	8,27 (12,5)	7,80...8,05 m	7,58 q			

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*From PMR spectral data using NOE.

†Compound described in [5].

contribution of the resonance structure B with a positive charge on the nitrogen atom. The magnetic nonequivalence of the N-methyl groups apparent in the PMR spectrum of iminium salt (V), which is retained on heating up to 110°C, is in agreement with this suggestion.

The NOE experiment carried out in deuteroacetone at 30°C and an isomer ratio ~30:70 showed that saturating the 3-H signal at 7.68 ppm belonging to the predominant isomer leads to an increase of 10% in the signal corresponding to the H_α proton at 6.14 ppm, i.e., under the conditions indicated above the s-cis conformer with 3-H and H_α close in space is the more stable (Scheme 3).

The stereoisomerism of heteroaromatic derivatives containing double bonds conjugated with the ring has been widely investigated, including the example of the polymethine dyes [8-10]. It was shown in [11] by PMR spectroscopy that two isomeric structures were formed for 2,4-diphenylthiopyranylideneacetaldehyde, which is a thio analog of aldehyde (II). We are unaware of NMR spectroscopic data on the immobilization of various conformations of enamine molecules like (Vb). In this connection we investigated the NMR spectra of compounds (III) and (IV) obtained by the procedure of [5] and showed that they also exist in solution as mixtures of two isomers (see Table 2). The conformational features detected by us for the pyranylidene derivatives are unconnected with the presence of the C_6F_5 group in the molecule but are of a general nature.

EXPERIMENTAL

The IR spectra were taken on a UR 20 instrument in $CHCl_3$ (II, VI) or in KBr disks (V). The UV spectra were taken on a Beckman DU 8 instrument in acetonitrile. The PMR spectra were drawn on Bruker AC 400, Bruker AC 200, and Bruker WP 200 SY instruments at frequencies of 400 and 200 MHz. Chemical shifts for ^{19}F are given in ppm from C_6F_6, ^1H chemical shifts are given in ppm on the δ scale. When carrying out NOE experiments, solutions of compounds (II) and (IV) in deuteroacetone were purged with dry nitrogen to remove oxygen.

Yields of compounds, physicochemical properties, spectral characteristics, and elemental analysis data are given in Tables 1 and 2.

2-[2-(Dimethylamino)vinyl]-6-pentafluorophenyl-4-phenylpyrylium Perchlorate (V). A mixture of salt (I) (1.31 g: 0.3 mmole) and DMF (0.75 ml: 10 mmole) in acetic anhydride (30 ml) was boiled with stirring for 30 min. After cooling, the mixture was poured into ether (150 ml), the precipitated solid was filtered off, and dried in the air.

2-Formylmethylene-6-pentafluorophenyl-4-phenyl-2H-pyran (II). A solution of iminium salt (V) in CH_2Cl_2 (150 ml) was chromatographed on a column of Al_2O_3 (Brockmann grade II activity, pH 9-10), collecting the first orange fraction. Compound (II) (1.2 g) was obtained after evaporating the solvent.

4-Dimethylamino-2′,3′,4′,5′,6′-pentafluorophenyl-2-phenylbenzophenone (VI). A mixture of iminium salt (V) (0.49 g: 1 mmole), 10% NaOH (8 ml), and ether (8 ml) was stirred at 20°C for 10 h, then extracted with ether. The extract was washed with water and dried over $CaCl_2$. After distilling off the solvent, the residue was chromatographed on a column of Al_2O_3 (eluent CH_2Cl_2), collecting two fractions. Compound (VI) (0.22 g: 57%) was obtained from the first bright yellow fraction after evaporating the solvent. ^{19}F NMR spectrum ($CDCl_3$): −0.51, 8.63, 21.46 ppm (intensity ratio of signals was 2:1:2). PMR spectrum ($CDCl_3$): 3.09 (6H, s, NMe_2), 6.46 (1H, br s, 3-H), 6.71 (1H, d d, J_{ortho} = 9 Hz, J_{meta} = 2 Hz, 5-H), 7.21 (5H, s, Ph), 7.86 ppm (1H, d, J = 9 Hz, 6-H).

Compound (II) (0.08 g: 21%) was obtained from the second fraction (orange in color) after evaporation.

REFERENCES

1. N. A. Orlova, T. N. Gerasimova, M. A. Kudinova, and A. I. Tolmachev, Zh. Org. Khim., **26**, 1313 (1990).
2. N. A. Orlova, T. N. Gerasimova, N. A. Derevyanko, M. A. Kudinova, and A. I. Tolmachev, Physics and Chemistry of Polymethine Dyes, Abstracts, Fifth All-Union Symposium, Chernogolovka (1989).
3. M. A. Kudinova, N. A. Derevyanko, G. G. Dyadyusha, A. A. Ishchenko, and A. I. Tolmachev, Khim. Geterotsikl. Soedin., No. 7, 898 (1980).
4. A. I. Tolmachev, N. A. Derevyanko, and A. A. Ishchenko, Khim. Geterotsikl. Soedin., No. 9, 1178 (1982).
5. G. A. Reynolde and J. A. Van Allan, J. Org. Chem., **34**, 2736 (1969).

6. G. H. Posner, Preparative Chemistry Using Supported Reagents, P. Laszlo (ed.), Academic Press, New York (1987), p. 293.
7. A. T. Balaban, A. Dinculescu, G. N. Dorofeenko, G. W. Fischer, A. V. Koblik, V. V. Mezheritskii, and W. Schroth, Pyrylium Salts: Syntheses, Reactions, and Physical Properties, Academic Press, New York (1982), p. 190.
8. A. M. Kolesnikov and F. A. Mikhailenko, Usp. Khim., **56**, 466 (1987).
9. D. Noukakis, M. Van der Auweraer, S. Toppet, and F. De Schryver, J. Phys. Chem., **99**, 11860 (1995).
10. Yu. L. Slominskii, A. V. Turov, A. L. Smirnova, M. Yu. Kornilov, and A. I. Tolmachev, Zh. Nauch. Prikl. Fotogr. Kinematogr., **35**, 457 (1990).
11. D. H. Wadsworth, M. R. Detty, B. J. Murray, C. H. Weidner, and N. F. Haley, J. Org. Chem., **49**, 2676 (1984).