β-(2-FURYL AND 2-THIENYL)ACROLEINS IN REACTIONS WITH VINYLOXYANILINES

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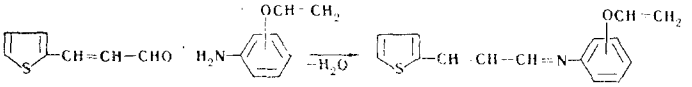
Equimolecular amounts of β-(2-furyl and 2-thienyl)acroleins and o-, m-, and p-vinyloxyanilines react at room temperature to form β-(2-furyl and 2-thienyl)acrylidinevinyloxyanilines. Their structures were proved by hydrogenation, hydrolysis, and IR spectroscopy. Their capacity for complexing with hydrated stannic chloride was established. The bacteriostatic activity of some of the synthesized substances was tested.

In order to obtain new polyfunctional vinyl monomers containing furan or thiophene rings, we investigated the condensation of vinyloxyanilines with β-(2-furyl and 2-thienyl)acroleins.

Only examples of the reaction of aromatic amines with β-(2-furyl)acrolein [1], the anils of which were isolated in yields that did not exceed 50% by heating the starting reagents for 2-3 h, are known in the literature. The reaction of vinyloxyanilines with acroleins containing heterocyclic substituents has not yet been studied.

It seemed of interest to us to ascertain the effect of furan and thiophene rings in β-substituted acroleins on the activity of the aldehyde group during condensation with vinyloxyanilines and to compare the results with those previously published [2, 3]. In searching for the optimum conditions, we varied the ratio of starting components, the order of mixing, and the reaction temperature and duration. Our investigations established that the aminoaldehyde condensation of β-(2-furyl)- and β-(2-thienyl)acroleins with vinyloxyanilines proceeds quite rapidly with equimolecular ratios of the reagents at room temperature and in the absence of special catalysts:



The yields of the o-, m-, and p-isomers of the anils of β-(2-furyl and 2-thienyl)acroleins reach 80-98%.

Replacement of the vinyl group by an ethyl group in the starting amine does not have any effect on the optimum conditions of the process. When the order of addition of the starting reagents and their quantitative ratios are changed, the formation of other reaction products is not observed. The temperature conditions and reaction time (from 24 h to 10 days) also do not have a substantial effect on the condensation. In all cases, the corresponding anils are isolated, and excess unchanged arylamine is recovered completely.

All of the synthesized β-(2-furyl and 2-thienyl)acrylidinevinyloxy(ethoxy)anilines were isolated as bright-yellow crystalline powders or oils that fluoresce strongly in light. They are quite stable in air and do not decompose during vacuum distillation. The purities of the products were confirmed by thin-layer chromatography. The physical constants and yields of the substances obtained are presented in Table 1.

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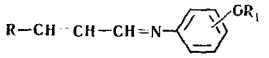
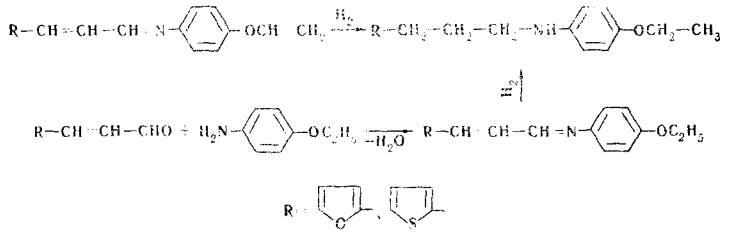
TABLE 1.



R	R_1	Compound	bp, °C (mm) or mp, °C	Empirical formula	Found, %				Calc., %				Yield, %
					C	H	N	S	C	H	N	S	
	*o*-CH=CH$_2$	β-(2-Furyl)acrylidine-o-vinyloxyaniline	93—94	$C_{15}H_{13}NO_2$	75,36	5,65	5,70	—	75,31	5,43	5,86	—	97,8
	*m*-CH=CH$_2$	β-(2-Furyl)acrylidine-m-vinyloxyaniline	166—167 (1)	$C_{15}H_{13}NO_2$	74,67	5,56	5,94	—	75,31	5,43	5,86	—	82,6
	*p*-CH=CH$_2$	β-(2-Furyl)acrylidine-p-vinyloxyaniline	83—84	$C_{15}H_{13}NO_2$	75,02	5,48	5,29	—	75,31	5,43	5,86	—	92,4
	*p*-C_2H_5	β-(2-Furyl)acrylidine-p-ethoxyaniline	100—101	$C_{15}H_{15}NO_2$	74,25	6,26	5,99	—	74,34	6,25	5,80	—	94,0
	*p*-C_2H_5	1-Ethoxyphenylamino-3-furylpropane	68—69	$C_{15}H_{19}NO_2$	73,13	7,78	5,94	—	73,42	7,75	5,71	—	99,0
	*o*-CH=CH$_2$	β-(2-Thienyl)acrylidine-o-vinyloxyaniline	25—27	$C_{15}H_{13}NOS$	70,43	5,33	5,20	12,40	70,55	5,13	5,48	12,55	97,1
	*m*-CH=CH$_2$	β-(2-Thienyl)acrylidine-m-vinyloxyaniline	120—122 (1)*	$C_{15}H_{13}NOS$	70,30	5,10	5,48	12,56	70,55	5,13	5,48	12,55	89,2
	*p*-CH=CH$_2$	β-(2-Thienyl)acrylidine-p-vinyloxyaniline	73—74	$C_{15}H_{13}NOS$	70,93	4,90	—	13,03	70,55	5,13	5,48	12,55	89,7
	*o*-C_2H_5	β-(2-Thienyl)acrylidine-o-ethoxyaniline	44—45,5	$C_{15}H_{15}NOS$	70,07	6,00	—	12,25	70,01	5,88	5,44	12,45	91,3
	*p*-C_2H_5	β-(2-Thienyl)acrylidine-p-ethoxyaniline	107—108	$C_{15}H_{15}NOS$	70,38	5,62	—	12,80	70,01	5,88	5,44	12,45	96,5
	*p*-C_2H_5	1-Ethoxyphenylamino-3-thienylpropane	193—195 (1)†	$C_{15}H_{19}NOS$	68,76	7,11	—	11,78	68,92	7,32	5,35	12,26	67,7

*n_D^{20} 1.5930 and d_4^{20} 1.1210. Found: MR_D 77.22. Calculated: MR_D 76.86.
†n_D^{20} 1.5780 and d_4^{20} 1.1010. Found: MR_D 78.82. Calculated: MR_D 78.57.

The structures of the synthesized anils of β-(2-furyl and 2-thienyl)acroleins are confirmed by IR spectroscopy, determination of their molecular weights by cryoscopy (in benzene), and also by their hydrolytic cleavage and hydrogenation.



The addition of hydrogen to the synthesized β-(2-furyl and 2-thienyl)acrylidinevinyloxyanilines in the presence of a catalyst (Raney nickel) proceeds readily and simultaneously at all of the unsaturated bonds. As a result, the corresponding 1-ethoxyphenylamino-3-(2-furyl and 2-thienyl)propanes are obtained in quantitative yields. These same compounds are obtained by hydrogenation of the products of the condensation of phenetidines with β-(2-furyl and 2-thienyl)acroleins. The absence of a depression of the melting point of mixed samples of the corresponding propanes confirms their identity. The positions of the most characteristic vibrational frequencies in their IR spectra are also absolutely identical: intense bands of the stretching vibrations corresponding to C=C and C=N bonds at 1630-1640 cm^{-1} are absent, as are frequencies of the deformation out-of-plane vibrations at 960 cm^{-1}. There are absorption bands at 2930 and 2976 cm^{-1}, caused by vibrations of the ethyl group, and characteristic bands of a secondary amino group at 3404 cm^{-1}.

To compare the acid stability of β-(2-furyl and 2-thienyl)acrylidinevinyloxyanilines with the monomers that we previously obtained on the basis of acrolein [2], furfural [4], and α-formylthiophene [5], we studied their hydrolytic cleavage in dilute sulfuric acid. As the result of a study of the dependence of the hydrolysis on the acid concentration, temperature, and heating time, we found that the anils of β-(2-furyl and 2-thienyl)acroleins are hydrolyzed under more severe conditions. The degree of hydrolysis of β-(2-furyl)acrylidine-p-vinyloxyaniline reaches 92.7% in the presence of 5% H_2SO_4 after heating at 40° for 4 h. It should be noted that the high degree of hydrolysis indicates once more the correctness of the proposed structure of the synthesized materials. The existence of two reaction centers in the hydrolytic cleavage, i.e., the azomethine and vinyl groups [6, 7], was taken into account in calculating the degree of hydrolysis.

The anils of β-(2-furyl and 2-thienyl)acroleins react with hydrated stannic chloride at room temperature in absolute solvents (diethyl ether or benzene). According to the results of elementary analysis, 1:1 complexes are obtained, regardless of the ligand–salt ratio (1:1 or 2:1). The complexes are bright, reddish-orange powders that melt below 180° and have dielectric properties.

The bactericidal action of some of the synthesized compounds was studied.* The tests demonstrated that the compounds have bacteriostatic ability with respect to acid-resisting bacteria.

EXPERIMENTAL

Starting Materials. o-, m-, and p-Vinyloxyanilines were obtained by the vinylation of the corresponding aminophenols [8], and o-phenetidine was obtained by the reduction of o-vinyloxyaniline over a nickel catalyst [8]. Commercially available p-phenetidine was used. The β-(2-furyl, 2-thienyl)acroleins were synthesized, respectively, by the methods in [9, 10].

Thin-layer chromatography was performed on activity II aluminum oxide with a hexane–ethyl acetate (5:2) system and development by iodine vapors. The IR spectra of microlayers (for liquids) and KBr pellets (for crystalline substances) were recorded with a UR-10 spectrophotometer at 400-3600 cm^{-1}. The specific electrical conductivity of the complexes was determined by the direct-current method with a type VI-2 amplifier.

β-(2-Furyl)acrylidine-o-vinyloxyaniline. A solution of 7.08 g (0.058 mole) of β-(2-furyl)acrolein in 50 ml of benzene was placed in a three-necked flask equipped with a stirrer and reflux condenser, and 7.84 g (0.058 mole) of o-vinyloxyaniline was added dropwise with stirring. One hour after the addition of the necessary amount of arylamine, the solvents were removed with a rotary evaporator. The residual waxy

*The tests for bacteriostatic action were carried out in the S. Ordzhonikidze All-Union Scientific-Research Institute of Pharmaceutical Chemistry under the direction of Corresponding Member of the Academy of Medical Sciences of the USSR, G. N. Pershin.

yellow mass was dried in vacuo or over anhydrous calcium chloride and recrystallized from hot n-heptane to give 12.08 g (97.8%) of yellow leaflets of β-(2-furyl)acrylidine-o-vinyloxyaniline with mp 93-94°. The product was quite soluble in diethyl ether, benzene, acetone, and alcohol, and slightly soluble in n-heptane, n-hexane, and water. Found: M 244, 243. $C_{15}H_{13}NO_2$. Calculated: M 239.

The physical constants and yields of the remaining synthesized anils of β-(2-furyl)- and β-(2-thienyl)-acroleins and their hydrogenation products are presented in Table 1.

Hydrolytic Cleavage of β-(2-Furyl)acrylidine-p-vinyloxyaniline. A mixture of 0.0814 g (0.34 mmole) of β-(2-furyl)acrylidine-p-vinyloxyaniline and 20 ml of 5% H_2SO_4 was heated in an ampul at 40° (in a thermostate for 4 h. The ampul was cooled and opened, and 10 ml of sodium bisulfite was added to the reaction mixture. (The excess sodium bisulfite was back-titrated after 20 min with 0.1 N iodine solution.) The degree of hydrolysis was 92.7% based on calculation of the aldehydes isolated [acetaldehyde and β-(2-furyl)-acrolein].

Condensation of β-(2-Furyl)acrolein with a Twofold Excess of m-Vinyloxyaniline. β-(2-Furyl)acrolein [2.64 g (0.0209 mole)] and 5.68 g (0.0418 mole) of m-vinyloxyaniline were mixed. The reaction mixture was held at room temperature for 10 days and worked up. Vacuum distillation gave 2.82 g of starting m-vinyloxyaniline and 4.33 g (84.4%) of the anil of β-(2-furyl)acrolein as a yellow oil with bp 165-167° (1 mm) that fluoresces strongly in light.

1-Ethoxyphenylamino-3-(2-furyl)propane. A) A mixture of 0.8664 g (3.62 mmole) of β-(2-furyl)acrylidine-p-vinyloxyaniline and 45 ml of absolute benzene was placed in a long-necked hydrogenation flask, and 0.85 g of Raney nickel catalyst was added. After 10 h, 299 ml of hydrogen (100% of the theoretical amount) had been absorbed. The catalyst was removed by filtration, and the solvent was removed in vacuo. The residual pinkish solid mass was recrystallized from n-heptane to give 0.879 g (99%) of white crystals with mp 68°.

B) The hydrogenation of 0.4749 g (1.96 mmole) of β-(2-furyl)acrylidine-p-phenetidine under similar conditions gave 0.4674 g (96.8%) of 1-ethoxyphenylamino-3-(2-furyl)propane with mp 68-69°. This product did not depress the melting point of the sample obtained by method A.

Reaction of Hydrated Stannic Chloride with β-(2-Furyl)acrylidine-p-vinyloxyaniline. A solution of 0.147 g (0.4 mmole) of $SnCl_4 \cdot 5H_2O$ in 10 ml of absolute diethyl ether was added dropwise with constant stirring to 0.1 g (0.4 mmole) of β-(2-furyl)acrylidine-p-vinyloxyaniline dissolved in 5 ml of absolute diethyl ether. An orange precipitate formed immediately. This precipitate was washed with a large amount of ether and dried in vacuo to give 0.206 g (83.6%) of a complex with mp 155° (dec.). Found: C 35.65, 35.66; H 2.54, 2.97; Sn 22.92, 22.93%. $C_{15}H_{13}NO_2 \cdot SnCl_4$. Calculated (for 1:1 ligand – salt ratio): C 34.91; H 2.62; Sn 23.11%. $\sigma_{30°}$ $1.5 \cdot 10^{-5}$ $\Omega^{-1}cm^{-1}$, $\sigma_{100°}$ $6.2 \cdot 10^{-13}$ $\Omega^{-1}cm^{-1}$, ΔE 0.7 eV.

Formation of a Complex of $SnCl_4 \cdot 5H_2O$ with β-(2-Thienyl)acrylidine-p-vinyloxyaniline. The method used to obtain this complex was similar to that described above. This method gave 0.211 g (88.9%) of a red-orange powder with mp 178° (dec.) from 0.1 g (0.39 mmole) of β-(2-thienyl)acrylidine-p-vinyloxyaniline and 0.1375 g (0.39 mmole) of hydrated stannic chloride. Found: N 2.84, 2.73; S 5.22, 5.51%. $C_{15}H_{13}NOS \cdot SnCl_4$. Calculated (at ligand–salt ratio 1:1): N 2.31; S 5.28%. $\sigma_{30°}$ $3.5 \cdot 10^{-14}$ $\Omega^{-1}cm^{-1}$, $\sigma_{100°}$ $9.6 \cdot 10^{-3}$ $\Omega^{-1}cm^{-1}$, ΔE 0.5 eV.

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