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REACTION OF 3-ARYL-1-(2-METHYLOXIRAN-2-YL)PROP-2-EN-1-ONES WITH TOSYLHYDRAZINE

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It was established that the reaction of 3-aryl-1-(2-methyloxiran-2-yl)prop-2-en-1-ones with tosylhydrazine leads to 3-[(E)-2-arylvinyl]-4-methyl-1-tosyl-1H-pyrazoles and 3-aryl-1-(2-methyloxiran-2-yl)- 3-tosylpropan-1-ones. The latter are formed as a result of rearrangement of the intermediate hydrazino alcohols and/or addition of p-toluenesulfinic acid during reductive degradation of the tosylhydrazine. It was shown that the reaction of 3-aryl-1-(2-methyloxiran-2-yl)-3-tosylpropan-1-ones with an excess of tosylhydrazine leads to 3-(2-aryl-2-tosylethyl)-4-methyl-1-tosyl-1H-pyrazoles.

Keywords: hydrazone, α,β-unsaturated epoxy ketone, pyrazole, tosylhydrazine, β-tosyl ketone, *p*-toluenesulfinic acid.

As shown earlier, the reaction of α,β-unsaturated epoxy ketones with hydrazine includes attack by the nitrogen-containing nucleophile in the enone system of the substrate followed by disproportionation of the intermediate 3-oxiranyl-4,5-dihydro-1H-pyrazoles to 3-β-hydroxyalkanoyl-1H-pyrazoles. At the same time, the introduction of phenyl-substituted hydrazine into the reaction under these conditions leads to 1-phenyl-3-styryl-1H-pyrazoles, formed as a result of cyclization of the intermediate hydrazones at the oxirane ring [2]. In a continuation of these investigations and in order to synthesize 1-tosyl-substituted pyrazoles in the present work we studied the reaction of a series of unsaturated epoxy ketones with tosylhydrazine. Aryl-substituted pyrazoles are of interest as specific ligands of cannabinoid receptors and are being studied intensively as potential products in the fight against alcoholism and drug addiction [3-5].

It was found that the reaction of 3-aryl-1-(2-methyloxiran-2-yl)propan-2-en-1-ones **1a-e** with tosylhydrazine, boiled in isopropyl alcohol for 3-6 h in the presence of acetic acid, leads to the formation of 3-[(*E*)-2-arylvinyl]-4-methyl-1-tosyl-1H-pyrazoles **2a-e** and 3-aryl-1-(2-methyloxiran-2-yl)-3-tosylpropan-1-ones **3a-e** as the main products with overall yields of 52-68% (Table 1). The tosyl ketones **3a-e** are formed as two diastereomers, differing in the relative configuration of the chirality centers, in equal proportions. The initial enones were detected in the reaction mixture with control by TLC irrespective of the duration of the reaction, and increase in the reaction time or heating temperature did not lead to their disappearance but gave rise to the appreciable formation of resinous products. If a 1.4-1.5 excess of the tosylhydrazine was used in the reaction with the monoepoxides **1a-e**, the formation of 3-(2-aryl-2-tosylethyl)-4-methyl-1-tosyl-1H-pyrazoles **4a-e** with yields of up to 21% was observed in addition to the main products.

The structure of the synthesized substances was proved on the basis of data from elemental analysis, IR and ^{1}H NMR spectroscopy (Table 1), and an alternative synthesis of compound **3a** by reaction of the monoepoxide **1a** with *p*-toluenesulfinic acid.

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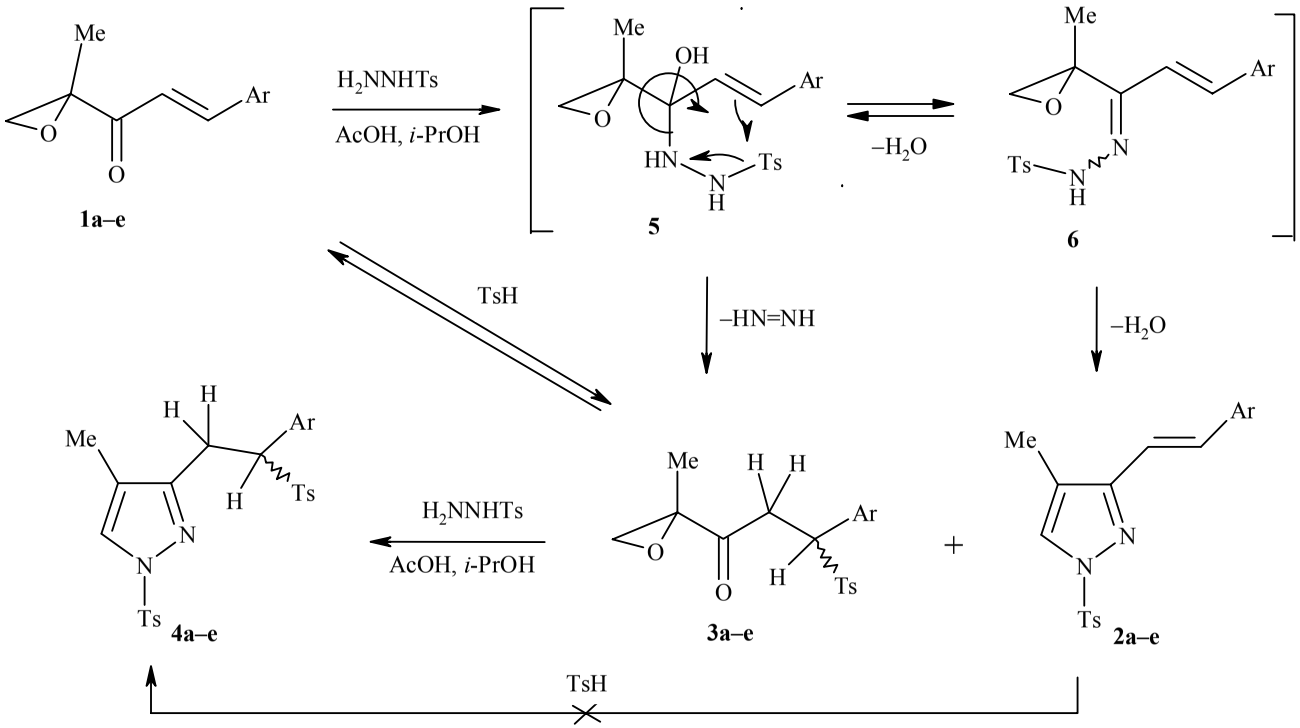

a Ar = Ph, **b** Ar = 4-ClC_6H_4, **c** Ar = 4-BrC_6H_4, **d** Ar = 4-$MeOC_6H_4$, **e** Ar = 2-$PhCH_2OC_6H_4$

TABLE 1. The Characteristics of the Synthesized Compounds

Compound*	Empirical formula	Found, % / Calculated, %			mp, °C	Yield, %*[2]
		C	H	N		
2a	$C_{19}H_{18}N_2O_2S$	67.32 / 67.43	5.44 / 5.36	8.19 / 8.28	151-152	53
2b	$C_{19}H_{17}ClN_2O_2S$	61.01 / 61.20	4.73 / 4.60	7.36 / 7.51	120-121	39
2c	$C_{19}H_{17}BrN_2O_2S$	54.74 / 54.68	4.24 / 4.11	6.47 / 6.71	140-141	41
2d	$C_{20}H_{20}N_2O_3S$	65.08 / 65.20	5.64 / 5.47	7.43 / 7.60	105-107	10
2e	$C_{26}H_{24}N_2O_3S$	70.16 / 70.25	5.59 / 5.44	6.56 / 6.30	136-138	37
3a	$C_{19}H_{20}O_4S$	66.13 / 66.26	5.98 / 5.85		139-143	15
3b	$C_{19}H_{19}ClO_4S$	60.15 / 60.23	5.26 / 5.05		158-160	18
3c	$C_{19}H_{19}BrO_4S$	53.74 / 53.91	4.37 / 4.52		157-162	24
3d	$C_{20}H_{22}O_5S$	64.04 / 64.15	6.12 / 5.92		130-133	42
3e	$C_{26}H_{26}O_5S$	69.28 / 69.31	5.98 / 5.82		Oil	30
4a	$C_{26}H_{26}N_2O_4S_2$	63.01 / 63.14	5.51 / 5.30	5.36 / 5.66	180-183	10
4b	$C_{26}H_{25}ClN_2O_4S_2$	59.31 / 59.02	4.94 / 4.76	5.00 / 5.29	155-157	7
4c	$C_{26}H_{25}BrN_2O_4S_2$	54.32 / 54.45	4.56 / 4.39	5.28 / 4.88	Oil	21
4d	$C_{27}H_{28}N_2O_5S_2$	61.59 / 61.81	5.49 / 5.38	5.03 / 5.34	Oil	2
4e	$C_{33}H_{32}N_2O_5S_2$	65.73 / 65.98	5.16 / 5.37	4.52 / 4.66	185-189	4

* Compounds **3a-d** were isolated as mixtures of diastereomers.

*[2] The yields of compounds **2e**, **3c**,**e**, and **4a**,**c-e** were determined from the ^{1}H NMR spectrum of the reaction mixture.

In contrast to the initial enones, there are no absorption bands for the carbonyl group at 1680 cm^{-1} in the IR spectra of compounds **2a-e**. A characteristic feature of the ^{1}H NMR spectra of the styrylpyrazoles **2a-e** is the presence of a doublet signal for the protons of the methyl group of the pyrazole ring at 2.05-2.17 ppm with spin–spin coupling constant J = 1.0 Hz and a quartet associated with it in the region of 7.80-7.85 ppm, corresponding to the signals of the C(5)–H protons of the azole ring. The signals of the vicinal protons at the multiple bond are observed downfield in the form of an AB system with J_{AB} = 16.6 Hz. The presence of the tosyl fragment in compounds **2a-e** and also in the simultaneously formed tosyl ketones **3a-e** is confirmed by the presence of absorption bands for the symmetrical and asymmetrical stretching vibrations of the sulfonyl S=O bonds at 1195-1140 cm^{-1} and 1375-1300 cm^{-1} [6] in the IR spectra of these compounds and by the data from the ^{1}H NMR spectra, in which singlets in the region of 2.4 ppm and a downfield AB spin system with J_{AB} = 8.3 Hz correspond to absorption of the protons of the CH_3 group and the *p*-substituted aromatic ring. In the mass spectrum of the styrylpyrazole **2a** there is a molecular ion peak with *m*/*z* 338, the low intensity of which is due to the ease of elimination of the tosyl group with the formation of a peak for a fragment ion with *m*/*z* 183, which corresponds to a major part of the ion current.

TABLE 2. The IR Spectra of Compounds **2-4**

Compound	ν, cm^{-1}	Compound	ν, cm^{-1}
2a	1594 (arom.), 1373 (S=O), 1191 (S=O), 965 (=CH)	**3c**	1715 (C=O), 1596 (arom.), 1304 (S=O), 1146 (S=O)
2b	1594 (arom.), 1374 (S=O), 1191 (S=O), 967 (=CH)	**3d**	1710 (C=O), 1611 (arom.), 1312 (S=O), 1147 (S=O)
2c	1594 (arom.), 1375 (S=O), 1192 (S=O), 967 (=CH)	**4a**	1596 (arom.), 1378 ($S=O_{pyr.}$), 1301 (S=O), 1192 ($S=O_{pyr.}$), 1141 (S=O)
2d	1605 (arom.), 1372 (S=O), 1174 (S=O), 963 (=CH)	**4b**	1596 (arom.), 1386 ($S=O_{pyr.}$), 1303 (S=O), 1178 ($S=O_{pyr.}$), 1142 (S=O)
2e	1595 (arom.), 1374 (S=O), 1192 (S=O), 972 (=CH)	**4c**	1596 (arom.), 1386 ($S=O_{pyr.}$), 1302 (S=O), 1178 ($S=O_{pyr.}$), 1143 (S=O)
3a	1708 (C=O), 1596 (arom.), 1315 (S=O), 1145 (S=O)	**4e**	1597 (arom.), 1373 ($S=O_{pyr.}$), 1311 (S=O), 1188 ($S=O_{pyr.}$), 1145 (S=O)
3b	1714 (C=O), 1596 (arom.), 1306 (S=O), 1145 (S=O)		

In the IR spectra of the products **3a-e** the bands for the stretching vibrations of the carbonyl C=O bond appear in the form of absorption bands in the region of 1704-1708 cm^{-1}. The structure of the β-tosyl ketones **3a-e** is also confirmed by the presence of an ABX system of coupled protons in the form of three groups of doublets with J_{AB} = 18.2-18.4, J_{AX} = 7.6-9.7, and J_{BX} = 4.1-5.9 Hz in the region of 3.0-4.9 ppm and also by the retention of the A'B' spin system of the signals for the geminal protons of the oxirane ring in the region of 2.7-3.3 ppm with $J_{A'B'}$ = 4.9 Hz.

In the IR spectra of compounds **4a-e** the absorption bands of the symmetric and asymmetric stretching vibrations of the S=O bonds appear at 1386-1373 and 1178 cm^{-1}, which corresponds to the tosyl substituent of the pyrazole ring, and at 1311-1302 and 1145-1142 cm^{-1}, corresponding to the tosyl fragment in the aliphatic part. In the ^{1}H NMR spectra of these compounds the above-mentioned ABX system for the protons of the β-aryl-β-tosylethyl fragment is retained, and there is an A'_3X' system for the protons of the methyl-substituted pyrazole ring.

The pyrazoles **2a-e** and β-tosyl ketones **3a-e** are probably formed through the intermediate adducts **5**, which are the result of nucleophilic addition of the reagent at the carbonyl group of the initial enones. Subsequent transformation of the adducts **5** to the hydrazones **6** and intramolecular cyclization of the latter with participation of the oxirane ring lead to the pyrazoles **2a-e**. At the same time the intermediate hydrazino alcohols **5** can decompose under the reaction conditions with release of the diimide, migration of the tosyl group to the β-carbon atom, and the formation of the β-tosyl ketones **3a-e**. In the case of the *p*-methoxy-substituted enone **1d** this direction is preferred. Such transformation is characteristic of unsaturated hydrazones and can be realized through a six-center cyclic transition state by concerted transfer of electrons [7]. The intermediate hydrazino alcohols **5** and hydrazones **6** were not isolated in individual form. However, signals for the protons of the methyl groups at 1.76 and 1.91 ppm were recorded in the NMR spectra of the reaction mixture of the enone **1a** with the tosylhydrazine after boiling for 2 h. After boiling for 5 h they disappear, and there is a simultaneous increase in the signals for the protons of the methyl groups of the pyrazole **2a** and β-tosyl ketones **3a**, indicating the possible formation of such intermediates. Compounds **3a-e** may also be formed by nucleophilic addition to the enones **1a-e** of *p*-toluenesulfinic acid, the appearance of which we detected in a separate experiment by heating tosylhydrazine in isopropyl alcohol in the presence of acetic acid, although according to published data in alcohols this process only becomes appreciable at temperatures above 100°C [8].

TABLE 3. The ^{1}H NMR Spectra of Compounds **2-4**

Com-pound*	Chemical shifts, δ, ppm. (*J*, Hz)
1	2
2a	2.17 (3H, d, *J* = 1.0, CH_3); 2.40 (3H, s, CH_3); 6.98 (1H, d, *J* = 16.6, CH=); 7.29 (1H, d, *J* = 16.6, CH=); 7.81 (1H, br. s, H-5); 7.26-7.91 (9H, m, arom.)
2b	2.17 (3H, d, *J* = 1.0, CH_3); 2.30 (3H, s, CH_3); 6.90 (1H, d, *J* = 16.6, CH=); 7.00-7.40 (7H, m, arom., CH=); 7.81 (1H, br. s, H-5); 7.88 (2H, d, *J* = 8.3, C_6H_4)
2c	2.11 (3H, d, *J* = 1.0, CH_3); 2.34 (3H, s, CH_3); 6.85 (1H, d, *J* = 16.6, CH=); 7.20 (1H, d, *J* = 16.6, CH=); 7.15-7.40 (6H, m, arom.); 7.77 (1H, br. s, H-5); 7.83 (2H, d, *J* = 8.3, C_6H_4)
2d	2.16 (3H, d, *J* = 1.0, CH_3); 2.39 (3H, s, CH_3); 2.81 (3H, s, OCH_3); 6.83 (1H, d, *J* = 16.6, CH=); 6.87 (2H, d, *J* = 8.6, C_6H_4–OCH_3); 7.21 (2H, d, *J* = 8.5, C_6H_4–CH_3); 7.41 (2H, d, *J* = 8.6, C_6H_4–OCH_3); 7.80 (1H, br. s, H-5); 7.87 (2H, d, *J* = 8.5, C_6H_4–CH_3)
2e	2.07 (3H, d, *J* = 1.0, CH_3); 2.39 (3H, s, CH_3); 5.11 (2H, s, CH_2); 6.94 (1H, d, *J* = 8.1, C_6H_4); 6.96 (1H, t, *J* = 7.6, C_6H_5); 7.10 (1H, d, *J* = 16.9, CH=); 7.22 (1H, m, C_6H_4); 7.27 (2H, d, *J* = 8.3, C_6H_4); 7.29-7.40 (3H, m, arom.); 7.43 (2H, m, C_6H_5); 7.54 (1H, m, C_6H_4); 7.61 (1H, d, *J* = 16.9, CH=); 7.78 (1H, br. s, H-5); 7.86 (2H, d, *J* = 8.3, C_6H_4)
3a	1.41 (3H, s, CH_3); 2.38 (3H, s, CH_3); 2.91 (1H, d, *J* = 4.9, CH_2–O); 3.16 (1H, dd, *J* = 7.7, *J* = 18.2, C<u>H</u>$_2$–CH); 3.22 (1H, d, *J* = 4.9, CH_2–O); 3.46 (1H, dd, *J* = 5.9, *J* = 18.2, C<u>H</u>$_2$–CH); 4.74 (1H, dd, *J* = 5.9, *J* = 7.7, C<u>H</u>–CH_2); 7.06 (2H, d, *J* = 8.5, C_6H_4); 7.32 (2H, d, *J* = 8.5, C_6H_4); 7.13-7.30 (5H, m, arom.)
	1.40 (3H, s, CH_3); 2.38 (3H, s, CH_3); 2.77 (1H, d, *J* = 4.9, CH_2–O); 2.79 (1H, d, *J* = 4.9, CH_2–O); 3.13 (1H, dd, *J* = 9.7, *J* = 18.2, C<u>H</u>$_2$–CH); 3.44 (1H, dd, *J* = 4.1, *J* = 18.2, C<u>H</u>$_2$–CH); 4.68 (1H, dd, *J* = 4.1, *J* = 9.7, C<u>H</u>–CH_2); 7.10 (2H, d, *J* = 8.5, C_6H_4); 7.30 (2H, d, *J* = 8.5, C_6H_4); 7.15-7.30 (5H, m, arom.)
3b	1.41 (3H, s, CH_3); 2.40 (3H, s, CH_3); 2.91 (1H, d, *J* = 4.9, CH_2–O); 3.12 (1H, dd, *J* = 8.1, *J* = 18.1, C<u>H</u>$_2$–CH); 3.20 (1H, d, *J* = 4.9, CH_2–O); 3.41 (1H, dd, *J* = 5.6, *J* = 18.1, C<u>H</u>$_2$–CH); 4.68 (1H, dd, *J* = 5.6, *J* = 8.1, C<u>H</u>–CH_2); 7.03 (2H, d, *J* = 8.6, C_6H_4); 7.36 (2H, d, *J* = 8.6, C_6H_4); 7.15-7.25 (5H, m, arom.)
	1.41 (3H, s, CH_3); 2.40 (3H, s, CH_3); 2.77 (1H, d, *J* = 4.9, CH_2–O); 2.79 (1H, d, *J* = 4.9, CH_2–O); 3.05 (1H, dd, *J* = 9.8, *J* = 18.1, C<u>H</u>$_2$–CH); 3.43 (1H, dd, *J* = 4.4, *J* = 18.1, C<u>H</u>$_2$–CH); 4.63 (1H, dd, *J* = 4.4, *J* = 9.8, C<u>H</u>–CH_2); 7.10 (2H, d, *J* = 8.6, C_6H_4); 7.45 (2H, d, *J* = 8.6, C_6H_4); 7.15-7.25 (5H, m, arom.)
3c	1.41 (3H, s, CH_3); 2.40 (3H, s, CH_3); 2.92 (1H, d, *J* = 4.9, CH_2–O); 3.13 (1H, dd, *J* = 7.8, *J* = 18.1, C<u>H</u>$_2$–CH); 3.21 (1H, d, *J* = 4.9, CH_2–O); 3.42 (1H, dd, *J* = 5.6, *J* = 18.1, C<u>H</u>$_2$–CH); 4.69 (1H, dd, *J* = 5.6, *J* = 7.8, C<u>H</u>–CH_2); 7.0 (2H, d, *J* = 8.5, C_6H_4); 7.35 (2H, d, *J* = 8.5, C_6H_4); 7.17-7.22 (5H, m, arom.)
	1.41 (3H, s, CH_3); 2.40 (3H, s, CH_3); 2.78 (1H, d, *J* = 4.9, CH_2–O); 2.80 (1H, d, *J* = 4.9, CH_2–O); 3.07 (1H, dd, *J* = 10.0, *J* = 18.1, C<u>H</u>$_2$–CH); 3.43 (1H, dd, *J* = 4.2, *J* = 18.1, C<u>H</u>$_2$–CH); 4.65 (1H, dd, *J* = 4.2, *J* = 10.0, C<u>H</u>–CH_2); 7.06 (2H, d, *J* = 8.5, C_6H_4); 7.43 (2H, d, *J* = 8.5, C_6H_4); 7.18-7.23 (5H, m, arom.)
3d	1.41 (3H, s, CH_3); 2.38 (3H, s, CH_3); 2.91 (1H, d, *J* = 4.9, CH_2–); 3.13 (1H, dd, *J* = 7.7, *J* = 18.2, C<u>H</u>$_2$–CH); 3.21 (1H, d, *J* = 4.9, CH_2–); 3.40 (1H, dd, *J* = 5.9, *J* = 18.2, C<u>H</u>$_2$–CH); 3.76 (3H, s, OCH_3); 4.68 (1H, dd, *J* = 5.9, *J* = 7.7, C<u>H</u>–CH_2); 6.73 (2H, d, *J* = 8.6, C_6H_4–OCH_3); 6.98 (2H, d, *J* = 8.6, C_6H_4–OCH_3); 7.17 (2H, d, *J* = 8.5, C_6H_4); 7.34 (2H, d, *J* = 8.5, C_6H_4)
	1.40 (3H, s, CH_3); 2.38 (3H, s, CH_3); 2.76 (1H, d, *J* = 4.9, CH_2–); 2.79 (1H, d, *J* = 4.9, CH_2–); 3.09 (1H, dd, *J* = 9.7, *J* = 17.9, C<u>H</u>$_2$–CH); 3.38 (1H, dd, *J* = 4.1, *J* = 17.9, C<u>H</u>$_2$–CH); 3.75 (3H, s, OCH_3); 4.64 (1H, dd, *J* = 4.1, *J* = 9.7, C<u>H</u>–CH_2); 6.75 (2H, d, *J* = 8.6, C_6H_4–OCH_3); 7.04 (2H, d, *J* = 8.6, C_6H_4–OCH_3); 7.19 (2H, d, *J* = 8.5, C_6H_4); 7.42 (2H, d, *J* = 8.5, C_6H_4)
3e	1.42 (3H, s, CH_3); 2.34 (3H, s, CH_3); 2.77 (1H, d, *J* = 4.9, CH_2–); 2.84 (1H, d, *J* = 4.9, CH_2–); 3.17 (1H, dd, *J* = 7.8, *J* = 18.3, C<u>H</u>$_2$–CH); 3.47 (1H, dd, *J* = 3.9, *J* = 18.3, C<u>H</u>$_2$–CH); 5.10 (2H, s, O–CH_2); 5.61 (1H, dd, *J* = 3.9, *J* = 7.8, C<u>H</u>–CH_2); 6.60-7.47 (13H, m, arom.)
	1.43 (3H, s, CH_3); 2.34 (3H, s, CH_3); 2.90 (1H, d, *J* = 4.9, CH_2–); 3.22 (1H, dd, *J* = 9.7, *J* = 18.3, C<u>H</u>$_2$–CH); 3.23 (1H, d, *J* = 4.9, CH_2–); 3.50 (1H, dd, *J* = 5.9, *J* = 18.3, C<u>H</u>$_2$–CH); 5.03 (2H, s, O–CH_2); 5.56 (1H, dd, *J* = 5.9, *J* = 9.7, C<u>H</u>–CH_2); 6.60-7.47 (13H, m, arom.)

TABLE 3 (continued)

1	2
4a	1.86 (3H, d, *J* = 1.0, CH_3); 2.36 (3H, s, CH_3); 2.37 (3H, s, CH_3); 3.36 (1H, dd, *J* = 11.7, *J* = 15.4, C<u>H</u>$_2$–CH); 3.59 (1H, dd, *J* = 3.9, *J* = 15.4, C<u>H</u>$_2$–CH); 4.64 (1H, dd, *J* = 11.7, *J* = 3.9, C<u>H</u>–CH_2); 7.03-7.39 (11H, m, arom.); 7.54 (2H, d, *J* = 8.3, C_6H_4); 7.56 (1H, br. s, H-5)
4b	1.90 (3H, d, *J* = 1.0, CH_3); 2.40 (3H, s, CH_3); 2.41 (3H, s, CH_3); 3.32 (1H, dd, *J* = 12.0, *J* = 15.7, C<u>H</u>$_2$–CH); 3.56 (1H, dd, *J* = 3.7, *J* = 15.7, C<u>H</u>$_2$–CH); 4.65 (1H, dd, *J* = 3.7, *J* = 12.0, C<u>H</u>–CH_2); 6.96 (2H, d, *J* = 8.6, C_6H_4); 7.00 (2H, d, *J* = 8.6, C_6H_4); 7.16 (2H, d, *J* = 8.1, C_6H_4); 7.21 (2H, d, *J* = 8.3, C_6H_4); 7.44 (2H, d, *J* = 8.1, C_6H_4); 7.50 (2H, d, *J* = 8.3, C_6H_4); 7.60 (1H, br. s, H-5)
4c	1.90 (3H, d, *J* = 1.0, CH_3); 2.40 (3H, s, CH_3); 2.41 (3H, s, CH_3); 3.31 (1H, dd, *J* = 12.0, *J* = 15.7, C<u>H</u>$_2$–CH); 3.56 (1H, dd, *J* = 3.7, *J* = 15.7, C<u>H</u>$_2$–CH); 4.64 (1H, dd, *J* = 3.7, *J* = 12.0, C<u>H</u>–CH_2); 6.91 (2H, d, *J* = 8.6, C_6H_4); 7.16 (2H, d, *J* = 8.6, C_6H_4); 7.17 (2H, d, *J* = 8.1, C_6H_4); 7.21 (2H, d, *J* = 8.3, C_6H_4); 7.44 (2H, d, *J* = 8.1, C_6H_4); 7.50 (2H, d, *J* = 8.3, C_6H_4); 7.60 (1H, br. s, H-5)
4d	1.87 (3H, d, *J* = 0.8, CH_3); 2.37 (3H, s, CH_3); 2.38 (3H, s, CH_3); 3.31 (1H, dd, *J* = 12.0, *J* = 15.3, C<u>H</u>$_2$–CH); 3.55 (1H, dd, *J* = 3.8, *J* = 15.3, C<u>H</u>$_2$–CH); 3.73 (3H, s, OCH_3); 4.59 (1H, dd, *J* = 3.8, *J* = 12.0, C<u>H</u>–CH_2); 6.57-7.55 (12H, m, arom.); 7.56 (1H, br. кв, *J* = 0.8, H-5)
4e	1.88 (3H, d, *J* = 1.0, CH_3); 2.33 (3H, s, CH_3); 2.35 (3H, s, CH_3); 3.44 (1H, dd, *J* = 10.2, *J* = 15.4, C<u>H</u>$_2$–CH); 3.63 (1H, dd, *J* = 3.9, *J* = 15.4, C<u>H</u>$_2$–CH); 4.44 (1H, d, *J* = 11.7, C<u>H</u>$_2$–O); 4.69 (1H, d, *J* = 11.7, CH_2–O); 5.49 (1H, dd, *J* = 3.9, *J* = 10.2, C<u>H</u>–CH_2); 6.54 (1H, d, *J* = 8.1, C_6H_4); 6.87 (1H, t, *J* = 7.6, C_6H_5); 7.01 (2H, d, *J* = 8.3, C_6H_4); 7.05 (2H, d, *J* = 8.3, C_6H_4); 7.13 (1H, m, C_6H_4); 7.20 (2H, m, C_6H_5); 7.30 (6H, m, arom.); 7.49 (2H, d, *J* = 8.3, C_6H_4); 7.57 (1H, br. s, H-5)

* Compounds **3a-d** were isolated as mixtures of diastereomers.

In the presence of an excess of tosylhydrazine the β-tosyl ketones that are formed then react with participation of the epoxy ketone fragment, leading to the adducts **4a-e**. This fact is confirmed by the isolation of the pyrazole **4a** when compound **3a** is heated with tosylhydrazine, whereas the pyrazole **2a** does not change under such conditions. In view of the possibility that *p*-toluenesulfinic acid is formed during the decomposition of tosylhydrazine an alternative path for the formation of the pyrazoles **4a-e** with the addition of *p*-toluenesulfinic acid at the multiple bond of the styrylpyrazoles **2a-e** when they are heated together was considered. The negative result of this experiment indicated that the precursors of the β-aryl-β-ethylpyrazoles **4a-e** are the β-tosylepoxy ketones **3a-e**.

Thus, the reaction of 2-cinnamoyl-2-methyloxiranes with tosylhydrazine, unlike the reaction with phenylhydrazine, is complicated by the concurrent formation of β-tosylepoxy ketones as a result of decomposition of the intermediate hydrazino alcohols and addition of *p*-toluenesulfinic acid.

EXPERIMENTAL

The chemical reagents used in the work were of pure, analytical, and chemically pure grades. The solvents were prepared and purified by traditional methods [9]. The ^{1}H NMR spectra were obtained on a Tesla BS-567A spectrometer (100 MHz) and a Bruker Avance-400 spectrometer (400 MHz) in deuterochloroform with HMDS as internal standard (δ 0.05 ppm). The mass spectra were obtained on a Shimadzu QP-5000 instrument (70-eV ionizing electrons). The IR spectra were obtained on a Specord IR-75 spectrophotometer in

tablets with potassium bromide. The reaction was monitored by TLC on Silufol plates (Kieselgel 60 F_{254}). The eluants were 1:1-5:1 mixtures of diethyl ether and hexane, and the developer was iodine vapor or 4% potassium permanganate solution. Silicagel L 40/100 was use to isolate the individual substances by column chromatography. The initial unsaturated epoxy ketones **1a-e** were obtained by the method in [10] by condensation of the respective acyloxiranes and aromatic aldehydes in methanol in the presence of a 15% methanol solution of sodium hydroxide. The physicochemical characteristics and spectral characteristics of the synthesized compounds are given in Tables 1-3.

3-[(*E*)-2-Arylvinyl]-4-methyl-1-tosyl-1H-pyrazoles (2a-c) and 3-Aryl-1-(2-methyloxiran-2-yl)-3-tosylpropan-1-ones (3a-c). A sample of the 3-aryl-1-(2-methyloxiran-2-yl)prop-2-en-1-one **1a-c** (5 mmol) was dissolved in isopropyl alcohol (20 ml), and acetic acid (0.3 ml) and tosylhydrazine were added (6.5 mmol). The reaction mixture was boiled with a reflux condenser for 3-6 h, while the reaction was monitored by chromatography. It was then cooled, and the pyrazole **2a-c** was filtered off. The remaining part of the reaction mixture was chromatographed on silica gel with linear gradient elution with petroleum and diethyl ethers and then with diethyl ether and ethanol as eluants. As a result the pyrazoles **2a-c** and tosyl ketones **3a-c** were isolated. Mass spectrum of styrylpyrazole **2a**, *m*/*z* (I_{rel}, %): 338 [M^+] (8), 183 [M^+-Ts] (100), 168 (12), 156 (38), 143 (14), 128 (28), 115 (20), 91 (45), 77 (13), 65 (31), 51 (12), 39 (18).

4-Methyl-3-[(*E*)-2-(4-methoxyphenyl)vinyl]-1-tosyl-1H-pyrazole (2d) and 1-(2-Methyloxiran-2-yl)-3-(4-methoxyphenyl)-3-tosylpropan-1-one (3d). We dissolved 1-(2-methyloxiran-2-yl)-3-(4-methoxyphenyl)-prop-2-en-1-one (**1d**) (0.3 g, 1.38 mmol) in isopropyl alcohol (15 ml) and added acetic acid (0.2 ml) and tosylhydrazine (0.28 g, 1.52 mmol). The reaction mixture was boiled with a reflux condenser for 5 h, and the solvent was evaporated. The residue was diluted with water, neutralized with sodium carbonate solution, and extracted with diethyl ether (3 × 5 ml). The combined fractions were dried over anhydrous sodium sulfate. After partial evaporation of the solvent the tosyl ketone **3d** (0.1 g) was filtered off. The remaining part of the reaction mixture was submitted to chromatographic separation as described above, and the pyrazole **2d** and also compound **3d** were isolated.

3-[(*E*)-2-(2-Benzyloxyphenyl)vinyl]-4-methyl-1-tosyl-1H-pyrazole (2e), 1-(2-Methyloxiran-2-yl)-3-(4-methoxyphenyl)-3-tosylpropan-1-one (3e), and 3-[2-(Benzyloxyphenyl)-2-tosylethyl]-4-methyl-1-tosyl-1H-pyrazole (4e). We dissolved 3-(4-benzyloxyphenyl)-1-(2-methyloxiran-2-yl)prop-2-en-1-one (**1e**) (1 g, 3.4 mmol) in isopropyl alcohol (20 ml) and added acetic acid (0.3 ml) and tosylhydrazine (0.85 g, 4.6 mmol). The reaction mixture was boiled for 3 h, after which the solvent was partly evaporated. After cooling 0.21 g of a mixture of pyrazoles **2e** and **4e** was isolated. The tosyl ketone **3e** and the pyrazole **2e** were isolated by chromatography.

Boiling of the Tosylhydrazine in Isopropyl Alcohol.We dissolved tosylhydrazine (1.0 g, 5.4 mmol) in isopropyl alcohol (20 ml) and added acetic acid (0.3 ml). The mixture was boiled with a reflux condenser for 5 h, and the process was monitored by TLC. After 1 h the formation of *p*-toluenesulfinic acid was detected by chromatography. The eluant was 1:4 diethyl ether–ethanol. According to data from the PMR spectrum, the ratio of tosylhydrazine to *p*-toluenesulfinic acid after 5 h was 65:10.

3-(2-Phenyl-2-tosylethyl)-4-methyl-1-tosyl-1H-pyrazole (4a). We dissolved 1-(2-methyloxiran-2-yl)-3-tosyl-3-phenylpropan-1-one (**3a**) (0.03 g, 0.09 mmol) in isopropyl alcohol (3 ml) and added acetic acid (0.005 ml) and tosylhydrazine (0.017 g, 0.09 mmol). The mixture was boiled with a reflux condenser for 12.5 h. The formation of the pyrazole **4a** (30%) was detected by means of the PMR spectrum.

1-(2-Methyloxiran-2-yl)-3-tosyl-3-phenylpropan-1-one (3a). To a solution of 1-(2-methyloxiran-2-yl)-3-phenylprop-2-en-1-one (**1a**) (0.55 g, 3 mmol) in isopropyl alcohol (15 ml) we added acetic acid (0.25 ml) and *p*-toluenesulfinic acid (0.5 g, 3.2 mmol). The reaction mixture was boiled with a reflux condenser for 5 h and cooled, and 0.41 g of the β-tosyl ketone **3a** was filtered off.

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