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Synthesis and study of the fungicidal activity of substituted 1-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-1*H*-imidazoles, 1-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-1*H*-1,2,4-triazoles and 4-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-4*H*-1,2,4-triazoles

V.S. Talismanov[1], S.V. Popkov[2], S.S. Zykova[3], O.G. Karmanova[1]

[1]*Moscow Institute of Physics and Technology*
9, Institutskiy per., Dolgoprudny, Moscow Region, 141701, Russian Federation

[2]*D. Mendeleev University of Chemical Technology of Russia*
9, Miusskaya sq., Moscow, 125047, Russian Federation

[3]*Perm Penal Service Institute*
125, Karpinskii street, Perm, 614012, Russian Federation

Abstract

In vitro tests of substituted 1-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-1*H*-imidazoles, 1-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-1*H*-1,2,4-triazoles and 4-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-4*H*-1,2,4-triazoles showed high fungicidal activity against six common fungal phytopathogens: *Sclerotinia sclerotiorum*, *Fusarium oxysporum*, *Fusarium moniliforme*, *Bipolaris sorokiniana*, *Rhizoctonia solani* and *Venturia inaequalis*. The target compounds were derived by cyclization of substituted benzylphenylketones or dibenzylketones with 3-chloro-1,2-propanediol followed by alkylation of the derived 4-chloromethyl-1,3-dioxolanes of sodium salts of imidazole or 1,2,4-triazole.

Keywords: alkylation, 1,3-dioxolane, gradient flash chromatography, imidazole, fungicidal activity, ketalization, ketals, 1,2,4-triazole.

INTRODUCTION

The overwhelming majority of systemic fungicides and antimycotics used are 1-substituted 1,2,4-triazoles and imidazoles [1-3]. The mechanism of action of azole fungicides and antimycotics is well studied: these preparations inhibit the biosynthesis of ergosterol (a component of the cell membrane of many fungi) at the stage of oxidative demethylation of lanosterol, which involves P-450 cytochrome oxidase. Azole fungicides inhibit cytochrome oxidase, forming a donor-acceptor bond between the nitrogen atom of the heterocycle and the heme iron atom in the catalytic site [4]. Azole preparations are systemic, have low consumption rates, are low in toxicity, have a wide range of action, and surpass other classes of fungicides on these parameters. The foregoing stimulaed the search for new effective fungicides and antimycotics in the series of substituted 1,2,4-triazoles and imidazoles.

The earlier synthesized 2,2-disubstituted 1-[(1,3-dioxolan-4-yl)methyl]-1*H*-imidazoles and 1-[(1,3-dioxolan-4-yl)methyl]-1*H*-1,2,4-triazoles demonstrated a wide range of biological activities: antimycobacterial [5], growth-regulating [6,7], antiradical [8], antibacterial [9], cytotoxic [10], as well as pronounced fungicidal [11-20] and antimycotic [19, 20].

In the syntheses of substituted 1-[(1,3-dioxolan-4-yl)methyl]-1*H*-1,2,4-triazoles by alkylation of the 1,2,4-triazole sodium salt with substituted 4-chloromethyl-1,3-dioxolanes, minor alkylation by-products were also prepared: 4-[(1,3-dioxolan-4-yl)methyl]-4*H*-1,2,4-triazoles. We studied and compared the fungicidal activities of 1-[(1,3-dioxolan-4-yl)methyl]-1*H*-1,2,4-triazoles and 4-[(1,3-dioxolan-4-yl)methyl]-4*H*-1,2,4-triazoles.

MATERIALS AND METHODS

^{1}H NMR spectra were recorded on Bruker AM-300 instrument (300.13 MHz). IR spectra were recorded on a Specord M-80 instrument (Nujol). The course of reaction was monitored and the purity of the compounds was checked by TLC (Silufol UV-254).

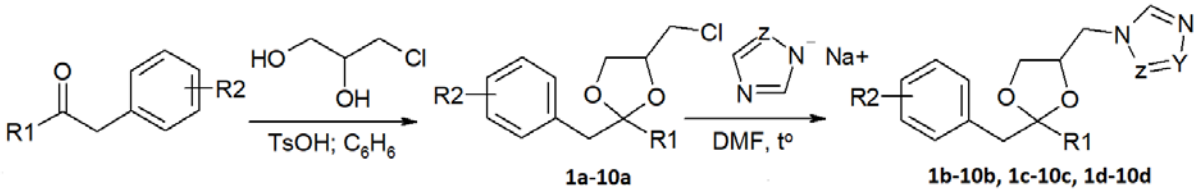
The target compounds were tested for fungicidal activity *in vitro* according to the procedure of [21] on six common fungal phytopathogens: *Sclerotinia sclerotiorum (S.s.)* – causative agent of white rot, *Fusarium oxysporum (F.o.)*, *Fusarium moniliforme (F.m.)* – causative agent of Fusarium wilt, *Bipolaris sorokiniana (B.s.)* – causative agent of helminthosporium root rot, *Rhizoctonia solani (R.s.)* – causative agent of brown rot – Rhizoctonia rot and *Venturia inaequalis (V.i.)* – causative agent of apple scab. Effect of compounds on the radial growth of mycelium was studied at a concentration of 30 mg/l. Solutions of the test substances were prepared in acetone, their aliquots were added to the molten sterile potato-sucrose agar, and the resulting media were poured into aseptic conditions in Petri dishes, in which case a final concentration of acetone in all media, including test medium, did not exceed 1%. Pieces of fungus mycelium were placed on the consolidated nutrient medium, thermostated in the dark at 25±0.5°C, and the radial growth was measured after 72 h. The experiment was repeated three times. The percent of mycelial growth inhibition (I) was calculated by Abbott:

$$I = \frac{D_c - D_t}{D_c} \cdot 100\,\%$$

D_c – is the diameter of the fungus colonies in the test medium (control), D_t – is the diameter of the fungal colonies in the medium with the test substance.

As the reference substances, the well-known 1,2,4-triazole fungicide triadimefon and 1,3-dioxolane-containing fungicide spiroxamine were used.

We synthesized the target compounds according to **Scheme 1**. Intermediate substituted 4-chloromethyl-1,3-dioxolanes **1a–10a** were obtained with 65–99% yields by condensation of ketones with 3-chloro-1,2-propanediol in benzene catalyzed by *p*-toluenesulfonic acid with azeotropic removal of water. The target compounds **1b-10b** were derived with 15–89% yields by alkylation of sodium salts of imidazole with substituted 4-chloromethyl-1,3-dioxolanes **1a–10a** with boiling in DMF for 8 h. The target compounds were purified from the by-products of azole's alkylation using gradient flash chromatography.



Scheme 1.

Alkylation of the sodium salt of 1,2,4-triazole with 4-chloromethyl-1,3-dioxolanes **1a–10a** derived the mixtures of 1-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-1*H*-1,2,4-triazoles **1c-10c** and 4-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-4*H*-1,2,4-triazoles **1d-10d**, which were separated from each other and from polyalkylation and blending products by gradient flash chromatography as well.

Sodium salts of imidazole and 1,2,4-triazole were prepared in quantitative yield by the reaction of sodium isopropylate with azoles in isopropanol [22].

Compounds **1a-10a, 1b-10b** and **1c-10c** were synthesized earlier and described in [5, 8, 20].

Procedure for purification and separation of 1,2,4-triazole alkylation products by gradient flash chromatography.

4.0 g of the technical product of alkylation of the sodium salt of 1,2,4-triazole with substituted 4-chloromethyl-1,3-dioxolane **4a,** consisting of products **4c** and **4d**, as well as the products of asphaltization and polyalkylation, were dissolved in 15 ml of 7:3 hexane-acetone mixture and applied to the chromatographic column. The column was a 70 mm diameter glass filter filled with 90 g of Acros 35/70 silica gel. Gradient elution was carried out with a mixture of hexane-acetone: 100 ml (10:1), 100 ml (10:3), 100 ml (7:3). Fractions with R_f = 0.62 (in a chloroform-methanol (10:1) system) were collected, combined, and the solvent was evaporated in vacuum; 2.08 g (51 %) of the 1-({2-(4-chlorophenyl)-2-[(4-chlorophenyl)methyl]-1,3-dioxolan-4-yl}methyl)-1*H*-1,2,4-triazole **(4c)** were derived.

A filter with silica gel containing the other isomer was dried from the previous eluent and eluted with 200 ml of a chloroform-methanol (10:1) system, collecting fractions with R_f = 0.15 (in a chloroform-methanol (10:1) system), fractions were combined and the solvent was evaporated in vacuum; 1.15 g (26%) of the **4-({2-(4-chlorophenyl)-2-[(4-chlorophenyl)methyl]-1,3-dioxolan-4-yl}methyl)-4*H*-1,2,4-triazole (4d)** were derived, m.p. 150-151°C. NMR^{1}H ($CDCl_3$, δ, ppm, *J*/Hz): 3.05 (s, 2H, *n*-ClPh$\underline{CH_2}$); 3.55-3.79 (m, 2H, CH_2O); 3.84-4.04 (m, 2H, CH_2N); 4.29 (q, 1H, CHO, ^3J=5.4); 6.97, 6.99 (both d, по 1H, $C^{2,6}H$, $C_6H_4ClCH_2$, ^3J=8.1); 7.13-7.33 (m, 6H, $C^{2,6}H$, C_6H_4Cl, $C^{3,5}H$, $C_6H_4ClCH_2$, $C^{3,5}H$, C_6H_4Cl); 8.06 (s, 0.5H; CH triaz.); 8.55 (s, 1.5H; CH triaz.). IR (Nujol, ν/sm^{-1}): 1279 (β CH triaz.); 1245, 1172, 1084 (COCOC); 784 (C-Cl).

Similar procedure was used to isolate substituted 4-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-4*H*-1,2,4-triazoles **1d-3d, 5d-10d**:

4-[(2-benzyl-2-phenyl-1,3-dioxolan-4-yl)methyl]-4*H*-1,2,4-triazole (1d), yield 22%, semisolid. NMR^{1}H ($CDCl_3$, δ, ppm, *J*/Hz): 2.08 (s, 2H, $PhCH_2\underline{CH_2}$); 2.54 (s, 2H, Ph $\underline{CH_2}CH_2$); 3.46 (d, 0.3H, CH_2O, ^3J=7,1); 3.61−3.85 (m, 0.70H, CH_2O); 4.08−4,76 (m, 4H, CH_2O + CHO + CH_2N); 7.39−7.58 (m, 4H aryl.); 7.58−7.72 (m, 2H, aryl.); 7.83−8.06 (m, 4H, aryl.); 8.50 (s, 1H, CH triaz.). IR (Nujol, ν/sm^{-1}): 1288 (β CH triaz.); 1245, 1220, 1195, 1175, 1078, (COCOC).

4-({2-[(4-chlorophenyl)methyl]-2-(4-methylphenyl)-1,3-dioxolan-4-yl}methyl)-4*H*-1,2,4-triazole oxalate (2d), yield 4%, m.p. 219-225 (decomp.). NMR^{1}H (DMSO-d_6, δ, ppm, *J*/Hz): 2.27 (d, 3H CH_3); 3.09 (s, 2H, *n*-ClPh$\underline{CH_2}$); 3.46-3.73 (m, 2H, CH_2O); 3.97-4.14 (m, 2H, CH_2N); 4.56 (q, 1H, CHO, ^3J=8.1); 7.01 (d.d, 2H, $C^{3,5}H$, $C_6H_4CH_3$, ^3J=8.6, ^2J=9.0); 7.09 (d.d, 2H, $C^{2,6}H$, *n*-ClPhCH_2, ^3J=8.2, ^2J=9.0); 7.13-7.25 (m, 4H, $C^{2,6}H$, $C_6H_4CH_3$, $C^{3,5}H$, *n*-ClPhCH_2); 8.04 (s, 0.71H; CH triaz.); 8.54 (s, 1.29H; CH triaz.). IR (Nujol, ν/sm^{-1}): 1280 (β CH triaz.); 1245, 1220, 1190, 1170, 1085 (COCOC);784 (C-Cl).

4-({2-[(4-chlorophenyl)methyl]-2-(4-fluorophenyl)-1,3-dioxolan-4-yl}methyl)-4*H*-1,2,4-triazole oxalate (3d), yield 9%, m.p. 209-215 (decomp.). NMR^{1}H (DMSO-d_6, δ, ppm, *J*/Hz): 3.10 (s, 2H, $\underline{CH_2}$Ar); 3.52 (d.d, 0.36H; CH_2O, ^3J=6.1, ^2J=8.6); 3.71 (d, 1.36H, CH_2O, ^3J=6.1); 3.83−4.03 (m, 1H, CH_2O + CH_2N); 4.07−4.37 (m, 2.36H, CH_2O+CHO+CHN); 7.02 (d, 2H, $C^{2,6}H$ 4-ClBz; ^3J=7.3); 7.06−7.17 (m, 2H; $C^{2,6}H$ 4-FPh); 7.17−7.37 (m, 4H; $C^{3,5}H$ 4-ClBz; $C^{3,5}H$ 4-FPh); 8.04 (s, 0.64H; CH triaz.); 8.54 (s, 1.36H; CH triaz.). IR (Nujol, ν/sm^{-1}): 1280 (β CH triaz.); 1245, 1190, 1160, 1080, (COCOC), 792 (C-Cl).

4-({2-(4-bromophenyl)-2-[(4-chlorophenyl)methyl]-1,3-dioxolan-4-yl}methyl)-4*H*-1,2,4-triazole oxalate (5d), yield 10%, m.p. 141-145 (decomp.). NMR^{1}H (DMSO-d_6, δ, ppm, *J*/Hz): 3.09 (s, 2H, $\underline{CH_2}$Ar); 3.51 (d.d, 0.4H^B, CH_2O, ^3J=7.2, ^2J=8.8); 3.63-3.79 (m, 1.6H, CH_2O+CH_2N); 3.86-4.05 (m, 2H, CH_2N+CHO); 4.08-4.37 (m, 1H, CHO); 7.02 (d, 2H, $C^{2,6}$ C_6H_4Cl, ^3J=8.2); 7.14 (d, 2H, $C^{2,6}$ C_6H_4Br, ^3J=8.8); 7.23 (d, 2H, $C^{3,5}$ C_6H_4Cl, ^3J=8.2); 7.47 (d, 2H, $C^{3,5}$ C_6H_4Br, ^3J=8.8); 8.43 (s, 0.8H, CH triaz.); 8.55 (s, 1.2H, CH triaz.). IR (Nujol, ν/sm^{-1}): 1279 (β CH triaz.); 1240, 1192, 1175, 1085 (COCOC); 782 (C-Cl).

4-({2-[(4-chlorophenyl)methyl]-2-[4-(hexylsulfanyl)phenyl]-1,3-dioxolan-4-yl}methyl)-4*H*-1,2,4-triazole (6d), yield 9%, m.p. 68-70°C. NMR^{1}H ($CDCl_3$, δ, ppm, *J*/Hz): 0.85 (t, 3H, CH_3, ^3J=5.9); 1.19-1.31 (m, 4H, $\underline{CH_2}\underline{CH_2}CH_3$); 1.32-1.45 (m, 2H, $\underline{CH_2}CH_2CH_2CH_3$); 1.54 (q, 2H, $\underline{CH_2}CH_2CH_2CH_2CH_3$, ^3J=7.4); 2.92 (t, 2H, SCH_2, ^3J=6.6); 3.10 (s, 1H, $\underline{CH_2}$Ar); 3.70 (d, 1H, CH_2O, ^3J=5.9); 3.95 (d.d, 1H, CH_2O, ^3J=7.4, ^2J=14.7); 4.04-4.43 (m, 3H, CH_2N+CHO); 7.04 (d, 2H, $C^{2,6}H$, $PhCH_2$, ^3J=8.1); 7.11-7.38(m, 6H aryl.); 8.35(s, 1H, CH triaz.); 8.47(s, 1H, CHtriaz.). IR (Nujol, ν/sm^{-1}): 1274 (β CH triaz.); 1245, 1220, 1195, 1170, 1082 (COCOC) 782 (CCl); 688 (CS).

4-[(2,2-dibenzyl-1,3-dioxolan-4-yl)methyl]-4*H*-1,2,4-triazole oxalate (7d), yield 5%, m.p. 203-208 (decomp.). NMR^{1}H (DMSO-d_6, δ, ppm, *J*/Hz): 2.73-2.89 (m, 4H, $(\underline{CH_2}Ph)_2$); 3.48 (d.d, 1H, CH_2O, ^3J=8.0, ^2J=8.7); 3.70 (d.d, 1H, CH_2O, ^3J=6.6, ^2J=8.7); 3.91 (d, 1H, CH_2N, ^3J=7.2); 4.07 (d, 1H, CH_2N, ^3J=7.2); 4.37 (q, 1H, CHO, ^3J=5.3); 7.10-7.33 (m, 10H aryl.); 8.33 (s, 1H, CH triaz.); 8.43 (s, 1H, CH triaz.). IR (Nujol, ν/sm^{-1}): 1270 (β CH triaz.); 1245, 1220, 1195, 1130, 1085 (COCOC).

4-({2-benzyl-2-[(4-chlorophenyl)methyl]-1,3-dioxolan-4-yl}methyl)-4*H*-1,2,4-triazole oxalate (8d), yield 8%, m.p. 85-87°C, (decomp.). NMR^{1}H (DMSO-d_6, δ, ppm, *J*/Hz): 2.50 (s, 2H, $\underline{CH_2}$Ph); 2.83 (s, 2H, CH_2PhCl); 3.30-3.42 (m, 2H, CH_2O); 3.77-4.09 (m, 3H, CH_2N+CHO); 7.11-7.40 (m, 9H, aryl.); 8.32 (s, 1H, CH triaz.); 8.42 (s, 1H, CH triaz.). IR (Nujol, ν/sm^{-1}): 1272 (β CH triaz.); 1240, 1221, 1190, 1136, 1080 (COCOC).

4-({2-[(4-chlorophenyl)methyl]-2-[(4-fluorophenyl)methyl]-1,3-dioxolan-4-yl}methyl)-4*H*-1,2,4-triazole (9d), yield 12%, m.p. 238-245°C, (decomp.). NMR^{1}H (DMSO-d_6, δ, ppm, *J*/Hz): 2.84 (s, 2H, $CH_2C_6H_4F$); 3.72 (s, 2H,

$CH_2C_6H_4Cl$); 3.97-4.09 (m, 4H, CH_2O+CH_2N); 4.16-4.30 (m, 1H, CHO); 6.99-7.42 (m, 8H, aryl.); 7.94 (s, 1H, CH triaz.); 8.40 (s, 1H, CH triaz.). IR (Nujol, ν/sm^{-1}): 1274 (β CH triaz.); 1245, 1220, 1205, 1146, 1085 (COCOC); 788 (C-Cl).

4-({2,2-bis[(4-chlorophenyl)methyl]-1,3-dioxolan-4-yl}methyl)-4*H*-1,2,4-triazole (10d), yield 7%, semisolid. NMR^{1}H ($CDCl_3$, δ, ppm, *J*/Hz): 3.73 (c, 4H, $(\underline{CH_2}Ar)_2$); 3.90-4.15 (m, 3H, CH_2O+CH_2N); 4.15-4.35 (m, 2H, CH_2N+CHO); 7.30 (d, 4H, $C^{3,5}$; $C^{3',5'}$H, 4-ClBz, ^3J=8.5); 7.37 (d, 4H, $C^{2,6}$H, $C^{2',6'}$H, 4ClBz, ^3J=8.5); 8.32 (s, 1.8H, CH triaz.); 8.44 (s, 0.2H, CH triaz.). IR (Nujol, ν/sm^{-1}): 1274 (β CH triaz.); 1245, 1220, 1200, 1146, 1088, (COCOC); 788 (C-Cl).

To analyze the relationship of the structure of synthesized compounds with their fungicidal activity, logPow of synthesized compounds was calculated [23]. The calculated lipophilicity index corresponded to the values determined experimentally [24] for the studied series of compounds.

The structure of synthesized compounds is given in **Table 1**.

RESULTS AND DISCUSSION

The content of the products of 1-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-1*H*-1,2,4-triazoles **1c-10c** in the technical product of alkylation of 1,2,4-triazole was 57 to 94%, while the content of the products of 4-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-4*H*-1,2,4-triazoles **1d-10d** was 5–26%.

Table 1. Structure of substituted 1-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-1*H*-imidazoles, 1-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-1*H*-1,2,4-triazoles and 4-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-4*H*-1,2,4-triazoles

№	R1	R2	X	Z	№	R1	R2	X	Z
1b	C_6H_5	H	CH	CH	**6b**	4-($C_6H_{13}S$)C_6H_4	Cl	CH	CH
1c	C_6H_5	H	N	CH	**6c**	4-($C_6H_{13}S$)C_6H_4	Cl	N	CH
1d	C_6H_5	H	CH	N	**6d**	4-($C_6H_{13}S$)C_6H_4	Cl	CH	N
2c	4-$CH_3C_6H_4$	Cl	CH	CH	**7b**	$CH_2C_6H_5$	H	CH	CH
2b	4-$CH_3C_6H_4$	Cl	N	CH	**7c**	$CH_2C_6H_5$	H	N	CH
2d	4-$CH_3C_6H_4$	Cl	CH	N	**7d**	$CH_2C_6H_5$	H	CH	N
3b	4-FC_6H_4	Cl	CH	CH	**8b**	$CH_2C_6H_5$	Cl	CH	CH
3c	4-FC_6H_4	Cl	N	CH	**8c**	$CH_2C_6H_5$	Cl	N	CH
3d	4-FC_6H_4	Cl	CH	N	**8d**	$CH_2C_6H_5$	Cl	CH	N
4b	4-ClC_6H_4	Cl	CH	CH	**9b**	$CH_2C_6H_4F$	Cl	CH	CH
4c	4-ClC_6H_4	Cl	N	CH	**9c**	$CH_2C_6H_4F$	Cl	N	CH
4d	4-ClC_6H_4	Cl	CH	N	**9d**	$CH_2C_6H_4F$	Cl	CH	N
4b	4-BrC_6H_4	Cl	CH	CH	**10b**	$CH_2C_6H_4Cl$	Cl	CH	CH
5c	4-BrC_6H_4	Cl	N	CH	**10c**	$CH_2C_6H_4Cl$	Cl	N	CH
5d	4-BrC_6H_4	Cl	CH	N	**10d**	$CH_2C_6H_4Cl$	Cl	CH	N

Table 2. Inhibition (I) of mycelial growth of phytopathogenic fungi under the action of test compounds.

Compound	I, %						$logP_{ow}$
	V.i.	*R.s.*	*F.o.*	*F.m.*	*B.s.*	*S.s.*	
1b	30	53	29	45	16	10	3.90±0,57
1c	42	67	38	51	16	14	3.25±0,69
1d	16	27	13	28	5	3	3.25±0,69
2b	54	99	72	89	-	66	4.96±0,58
2c	65	96	79	74	79	57	4.30±0,70
2d	15	35	25	53	44	17	4.30±0,69
3b	64	90	79	83	67	72	4.55±0,64
3c	54	73	73	81	80	43	3.90±0,75
3d	14	27	22	30	0	12	3.89±0,73
4b	63	100	85	88	95	74	5.09±0,59
4c	68	83	75	70	71	53	4.44±0,70
4d	31	66	68	62	72	33	4.44±0,70
5b	50	87	79	81	71	69	5.27±0,64
5c	38	72	70	72	60	36	4.62±0,75
5d	16	53	43	53	49	20	4.61±0,73
6b	32	46	28	61	49	22	7.64±0,61
6c	14	22	34	44	34	15	6.99±0,72
6d	21	47	32	65	16	9	6.98±0,71
7b	45	44	46	70	72	45	3.66±0,42
7c	26	43	21	48	41	20	3.01±0,57
7d	19	21	15	35	23	20	3.01±0,64
8b	62	65	69	83	84	44	4.26±0,43
8c	45	44	47	60	60	25	3.61±0,48
8d	23	24	18	41	32	21	3.60±0,64
9b	48	80	60	78	78	58	4.31±0,51
9c	52	67	69	70	70	48	3.66±0,64
9d	21	25	22	38	35	21	3.66±0,67
10b	16	18	31	44	27	17	4.85±0,44
10c	48	81	52	63	64	37	4.20±0,59
10d	20	28	8	35	2	8	4.20±0,65
triadimefon	58	40	82	89	54	57	
spiroxamine	81	70	16	59	70	59	

The target compounds were tested for fungicidal activity on six phytopathogenic fungi. The test results are shown in **Table 2.** Analysis of the results of fungicidal activity showed that displacement of the aryl fragment to one methylene group from the 1,3-dioxolane ring does not increase the activity in comparison with the diaryl derivatives described earlier [11], while the benzylphenyl derivatives show a fungitoxicity higher than the dibenzyl derivatives**.** The compounds with logP values in the range of 3.5–5.5 and with halogen atoms, both in the aryl and benzyl rings, exhibited the highest fungitoxicity. When replacing the 4-halogenaryl substituent with 4-hexylthiophenyl in compound **6b, 6c, 6d**, the fungicidal activity decreased.

Fungitoxicity of minor 4-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-4*H*-1,2,4-triazoles **1d-10d** had lower values than that of isomers of 1-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-1*H*-1,2,4-triazoles **1c-10c**.

CONCLUSIONS

In general, substituted 1-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-1*H*-imidazoles, 1-[(2-benzyl-1,3-dioxolan-4-yl)methyl]-1*H*-1,2,4-triazoles showed fungicidal activity exceeding the activity of the reference substances (triadimefon and spiroxamine). Therefore, the search for new fungitoxic compounds of this series is promising.

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