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Synthesis, Characterization and Bioactivity of Propranolol and it's Derivatives

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ABSTRACT

Herein, the conventional method used for β-blocker synthesis is initiated by refluxing biphenyl-2-ol (**1**) with an epoxy ring (**2**) in the presence of K_2CO_3 to obtain 2-[(biphenyl-2-yloxy)methyl]oxirane (**3**). Compound (**3**) was then reacted with 99% isopropylamine (**4**) and various substituted phenols (**6a-i**) to form 1-(biphenyl-2-yloxy)-3-(propan-2-ylamino)propan-2-ol (**5**) and 1-(2,6-dimethyl-/4-methoxy-/4-chloro-3-hydroxy-/2,6-dimethoxy-/3,4-dimethyl-/4-amine-/4-bromo/3,4-dinitro-/2,4-dihydroxyphenoxy)-3-(biphenyl-2-yloxy)-propan-2-ols (**7a-i**), respectively. The synthesized compounds were analyzed by ^{1}H NMR and FTIR spectroscopy to determine their structure and also evaluated for their antifungal activity against *Rhizoctonia solani* and *Aspergillus niger* using the food poison technique. From the activity data, it was found that compound 1-(biphenyl-2-yloxy)-3-(propan-2-ylamino)-propan-2-ol (**5**) was most active against both the fungi *Rhizoctonia solani* and *Aspergillus niger*. The antibacterial activity was also determined against *Bacillus* species by zone of inhibition method. The compounds (**5**, **7a-i**) were also evaluated for its herbicidal activity.

KEYWORDS

Propranolol, β-Blockers, Antifungal activity, Herbicidal activity, Antibacterial activity.

INTRODUCTION

Propranolol is widely used as an inhibitor in the field of medicine [1] to treat angina, hypertension, glaucoma, pectoris-obesity and other cardiovascular diseases [2]. Oral propranolol is an effective, safe and fast-acting drug for the treatment of child-hood hemangiomas and can be monitored on an outpatient basis [3]. Heterocyclic compounds containing oxygen, nitrogen and sulfur are the building blocks used for the synthesis of various compounds with medicinal or biological properties [4,5]. In present study, a novel multistep methodology for the synthesis of propranolol and its related compounds was employed, which is very efficient and offers interesting results [6].

In first step, biphenyl-2-ol was refluxed with epichlorhydrin then the formed compound was further treated with isopropylamine to yield propranolol (**5**). Compound **3** was also treated with substituted phenols to give compounds **7a-i**. These compounds are important constituents of dyes, copolymers, antioxidants, ligands and bases [7].

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EXPERIMENTAL

The melting point was checked on board the electrical equipment for the Gensen melting point. The homogeneity of the compounds was monitored regularly on silica gel G TLC plates using ethyl acetate:hexane (3:7) as eluent. FTIR spectra were recorded on the Perkin-Elmer FTIR spectrophotometer in KBr and frequencies were recorded in cm^{-1}. ^1H NMR spectra were recorded on a Bruker Avance II 400F (400 MHz) ^1H NMR spectrophotometer in $CDCl_3$ or DMSO-d_6 using tetramethylsilane (TMS) as an internal reference.

Biological activities

Herbicidal activity: A solution of 50 g/mL, 100 g/mL and 150 g/mL of the test compound in DMSO was prepared. The agar powder (5 g) was put in boiling distilled water (1 L) until it dissolved and then cooled to 40-50 ºC. A solution (2 mL) containing the test compounds and the melting agar (18 mL) was mixed and this mixture was added to a 4.5 cm diameter petri dish. The agar plate without test compound was used as an untreated control. The seeds of *Raphanus sativus* L. (radish) were deposited on the surface of the agar plate. The Petridish were covered with glass lids and the culture conditions were maintained alternately for 7 days at 25 ± 1 ºC and 12 h in the light and 12 h in the dark. Seven days later, the root and shoot lengths of *Raphanus sativus* L. were measured. The rate of growth inhibition bound to the untreated control was determined by a given formula:

$$\text{Inhibition (\%)} = \frac{C - T}{C} \times 100$$

wher, C = mycelia development in control dish; T = mycelia development in treated dish.

Antibacterial activity: The *Bacillus* strain was grown in the lab on Luria-Bertani medium. Antibacterial activity was tested using the zone inhibition method [8]. Concentrations of 50, 100, 150 and 200 µg/mL synthesized compounds were prepared from the stock solution by taking the appropriate amount and diluted with DMSO. The DMSO solvent was used as a negative control. The 10 mm diameter circular paper discs were made from Whatman's No. 1 filter paper. The discs were placed in a Petri plate and autoclaved at 15 lbs pressure for 20 min [9]. Two paper discs were used for each concentration of the synthesized compounds. The excess solution absorbed by the paper discs was removed by holding them vertically with sterile forceps. These soaked discs were aseptically transferred to Petri plates containing media and a bacterial suspension was smeared on the surface. The Petri plates were kept overnight in an incubator at 25 ± 2 ºC and then examined for the zone of inhibition at these different concentrations of compounds. The experiment was performed in triplicate and the activity was determined based on the zone of inhibition (in mm).

Antifungal activity: The synthesized compounds **5**, **7a-i** were evaluated for their antifungal activity against *Rhizoctonia solani* and *Aspergillus niger*, respectively [10,11]. The fungal species were grown in the laboratory on Potato dextrose agar (PDA) media. The antifungal activity was determined by the food poisoning technique method. The required amount of synthetic compound dissolved in 1 mL of DMSO was aseptically introduced into a 99 mL aliquot of sterile potato dextrose agar which was cooled to 45 ºC after brief stirring. Each batch of media was poured into Petri dishes and allowed to solidify. DMSO was used as a negative control. Each plate was inoculated centrally with 5 mm pieces of mycelium from the periphery of the 2-3 day old fungal colony. The inoculated Petri dishes were incubated in the dark at 25 ± 2 ºC for 48-72 h and the colony diameter was measured periodically until the control plates were almost completely covered by fungal growth. All observations were made in triplicate. The degree of growth inhibition was calculated from the mean differences between the treatments and the control as a percentage (eqn. 2):

$$\text{Inhibition (\%)} = \frac{C - T}{C} \times 100$$

where C = mycelia growth in control dish, T = mycelia growth in treated dish.

Statistical analysis: The experiment was performed in triplicate for each treatment and the mean value was recorded and expressed as mean ± SD

Multistep method for the synthesis of propranolol and its related compounds

Synthesis of 1-(biphenyl-2-yloxy)-3-(propan-2-ylamino)propan-2-ol (5) and 1-(2,6-dimethyl-/4-methoxy-/4-chloro-3-hydroxy-/2,6-dimethoxy-/3,4-dimethyl-/4-amine-/4-bromo-/3,4-dinitro-/2,4-dihydroxyphenoxy)-3-(biphenyl-2-yloxy)propan-2-ols (7a-i): Biphenyl-2-ol (**1**) was refluxed on an oil bath with epichlorohydrin (**2**) [12] in the presence of anhydrous K_2CO_3 to get 2-[(biphenyl-2-yloxy)-methyl]oxirane (**3**) [13]. Compound **3** was then reacted with 99% isopropyl-amine (**4**) and various substituted phenols (**6a-i**) to formed 1-(biphenyl-2-yloxy)-3-(propan-2-ylamino)propan-2-ol (**5**) and 1-(2,6-dimethyl-/4-methoxy-/4-chloro-3-hydroxy-/2,6-dimethoxy-/3,4-dimethyl-/4-amine-/4-bromo-/3,4-dinitro-/2,4-dihydroxyphenoxy)-3-(biphenyl-2-yloxy)propan-2-ols (**7a-i**), respectively [14]. The physico-chemical parameters of the synthesized compounds are given in Table-1.

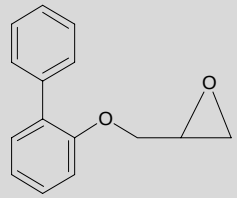
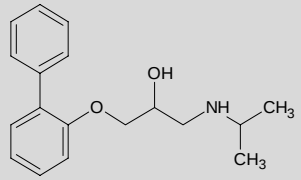
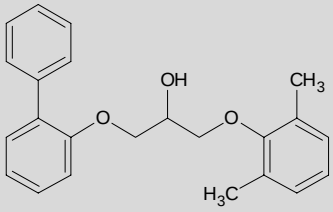
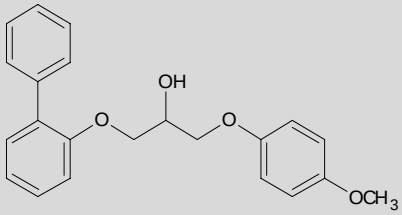
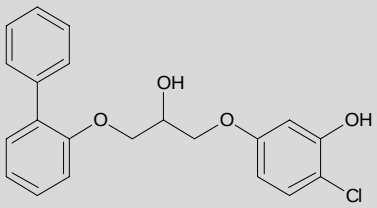
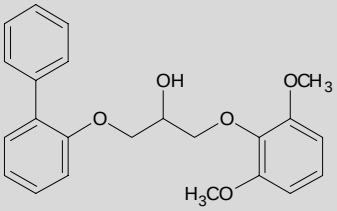
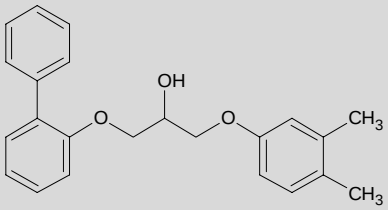
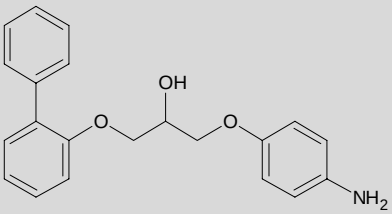
2-[(Biphenyl-2-yloxy)methyl]oxirane (3): IR (KBr, ν_{max}, cm^{-1}): 3520 (OH), 3410 (NH), 1550.0 (C=C, arom.), 1400.0 (C-CH_3). Elemental anal. calcd. (found) % of $C_{15}H_{13}O_2$: C, 80.07 (80.05); H, 5.74 (5.72).

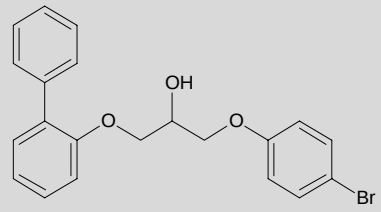
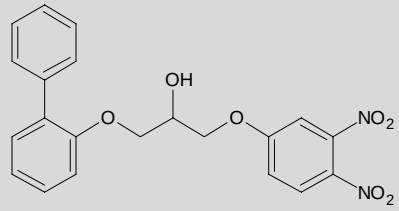
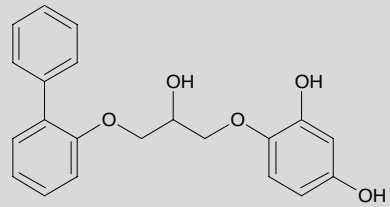
1-(Biphenyl-2-yloxy)-3-(propan-2-ylamino)propan-2-ol (5): IR (KBr, ν_{max}, cm^{-1}): 3482 (OH), 3362 (NH), 1592 (C=C, arom.), 1446.0 (C-CH_3), 1112 (C-O-C); ^1H NMR ($CDCl_3$): δ 2.59 (s, 3H, CH_3), 3.24 (m, 1H, CH). Elemental anal. calcd. (found) % of $C_{18}H_{23}NO_2$: C, 75.79 (75.83), H, 8.10 (8.07), N, 5.66 (4.91).

1-(2,6-Dimethylphenoxy)-3-(biphenyl-2-yloxy)propan-2-ol (7a): IR (KBr, ν_{max}, cm^{-1}): 3530.0 (OH), 1550 (C=C, arom.), 1400.0 (C-CH_3), 1105 (C-O-C); ^1H NMR ($CDCl_3$): δ 3.12 (s, 6H, $2CH_3$), 3.42 (m, 1H, CH), 7.35 (dd, Ar-H). Elemental anal. calcd. (found) % of $C_{23}H_{24}O_3$: C, 79.34 (79.31); H, 6.92 (6.89).

1-(4-Methoxyphenoxy)-3-(biphenyl-2-yloxy)propan-2-ol (7b): IR (KBr, ν_{max}, cm^{-1}): 3547 (OH), 1550 (C=C, arom.), 1220 (OCH_3), 1106.0 (C-O-C); ^1H NMR ($CDCl_3$): δ 3.45 (s, 3H, OCH_3), 3.49 (m, 1H, CH), 6.2-7.89 (m, 5H, Ar-H). Elemental anal. calcd. (found) % of $C_{22}H_{22}O_4$: C, 75.43 (75.46); H, 6.29 (6.28).

TABLE-1
PHYSICAL AND ANALYTICAL DATA OF 1-(SUBSTITUTEDPHENOXY)-3-(BIPHENYL-2-YLOXY)PROPAN-2-OLS **(3, 5, 7a-i)**

Compd. No.	R_1	R_2	R_3	R_4	m.f.	Structure	Yield (%)	m.p. (°C)
3	–	–	–	–	$C_{15}H_{13}O_2$		85	Viscous mass
5	–	–	–	–	$C_{18}H_{23}NO_2$		71	93-95 °C (Lit. 95 °C) [Ref. 15]
7a	CH_3	H	H	CH_3	$C_{23}H_{24}O_3$		78	Viscous mass
7b	H	H	OCH_3	H	$C_{22}H_{22}O_4$		76	Viscous mass
7c	H	OH	Cl	H	$C_{21}H_{19}O_4Cl$		78	Viscous mass
7d	OCH_3	H	H	OCH_3	$C_{23}H_{24}O_5$		74	Viscous mass
7e	H	CH_3	CH_3	H	$C_{23}H_{24}O_3$		82	Viscous mass
7f	H	H	NH_2	H	$C_{21}H_{21}NO_3$		78	Viscous mass

7g	H	H	Br	H	$C_{21}H_{19}O_3Br$		70	Viscous mass
7h	H	NO_2	NO_2	H	$C_{21}H_{20}N_2O_7$		79	Viscous mass
7i	OH	H	OH	H	$C_{21}H_{20}O_4$		81	Viscous mass

1-(4-Chloro-3-hydroxyphenoxy)-3-(biphenyl-2-yloxy)-propan-2-ol (7c): IR (KBr, ν_{max}, cm^{-1}): 3553 (OH); 1550 (C=C arom.), 1092 (C-O-C), 817 (C-Cl); ^{1}H NMR ($CDCl_3$): δ 3.50 (m, 1H, CH), 6.35-7.89 (m, 5H, Ar-H). Elemental anal. calcd. (found) % of $C_{21}H_{19}O_4Cl$: C, 68.01 (68.11), H, 5.17 (5.14).

1-(2,6-Dimethoxyphenoxy)-3-(biphenyl-2-yloxy)-propan-2-ol (7d): IR (KBr, ν_{max}, cm^{-1}): 3550 (OH), 1550 (C=C, arom.), 1220 (OCH_3), 1112 (C-O-C); ^{1}H NMR ($CDCl_3$): δ 3.45 (s, 6H, OCH_3), 3.59 (m, 1H, CH), 6.35-7.91 (m, 5H, Ar-H). Elemental anal. calcd. (found) % of $C_{23}H_{24}O_5$: C, 72.65 (72.63), H, 6.33 (6.32).

1-(3,4-Dimethylphenoxy)-3-(biphenyl-2-yloxy)propan-2-ol (7e): IR (KBr, ν_{max}, cm^{-1}): 3540 (OH), 1550 (C=C, arom), 1400 (C-CH_3), 1110 (C-O-C); ^{1}H NMR ($CDCl_3$): δ 2.71 (s, 6H, CH_3), 3.42 (m, 1H, CH), 6.12-7.51 (m, 5H, Ar-H). Elemental anal. calcd. (found) % of $C_{23}H_{24}O_3$: C, 79.33 (79.31), H, 6.92 (6.90).

1-(4-Aminophenoxy)-3-(biphenyl-2-yloxy)propan-2-ol (7f): IR (KBr, ν_{max}, cm^{-1}): 3540 (OH), 3420 (NH), 1550 (C=C, arom.), 1112.0 (C-O-C); ^{1}H NMR ($CDCl_3$): δ 3.84 (m, 1H, CH), 5.03 (s, 2H, NH), 6.42-7.69 (m, 5H, Ar-H). Elemental anal. calcd. (found) % of $C_{21}H_{21}O_3N$: C, 75.24 (75.22); H, 6.28 (6.27); N, 4.21 (4.18).

1-(4-Bromophenoxy)-3-(biphenyl-2-yloxy)propan-2-ol (7g): IR (KBr, ν_{max}, cm^{-1}): 3550 (OH); 1598 (C=C, arom.), 1110 (C-O-C), 650 (C-Br). ^{1}H NMR ($CDCl_3$): δ 3.94 (m, 1H, CH), 6.51-7.89 (m, 5H, Ar -H). Elemental anal. calcd. (found) % of $C_{21}H_{19}O_3Br$: C, 63.19 (63.16); H, 4.79 (4.76).

1-(3,4-Dinitrophenoxy)-3-(biphenyl-2-yloxy)propan-2-ol (7h): IR (KBr, ν_{max}, cm^{-1}): 3520 (OH); 1598 (C=C, arom.), 1570 (NO_2), 1115 (C-O-C); ^{1}H NMR ($CDCl_3$): δ 4.32 (m, 1H, CH), 6.87-8.00 (m, 5H, Ar-H). Elemental anal. calcd. (found) % of $C_{21}H_{20}O_7N_2$: C, 61.20 (61.17); H, 4.87 (4.85); N, 6.83 (6.80).

1-(2,4-Dihydroxyphenoxy)-3-(biphenyl-2-yloxy)-propan-2-ol (7i): IR (KBr, ν_{max}, cm^{-1}): 3540.0 (OH); 1597.0 (C=C, arom.); 1118 (C-O-C); ^{1}H NMR ($CDCl_3$): δ 2.91 (m, 1H, CH), 4.15 (broad, 2H, OH), 6.13-7.21 (m, 5H, Ar -H). Elemental anal. calcd. (found) % of $C_{21}H_{20}O_4$: C, 75.59 (75.57); H, 5.98 (5.95).

Antifungal activity: All the synthesized compounds (**5**, **7a-i**) were evaluated for their antifungal activity against two fungal strains *viz. Rhizoctonia solani* and *Aspergillus niger* by the method of food poisoned technique method. DMSO was used as negative control against fungal strains.

Antibacterial activity: All the synthesized compounds (**5**, **7a-i**) were screened for their *in vitro* antibacterial activity against *Bacillus* species by the zone of inhibition method using DMSO as a negative control.

Herbicidal activity: All the synthesized compounds (**5**, **7a-i**) were also screened for herbicidal activity against *Raphanus sativus* L. at various concentrations *viz.* 200, 150, 100 and 50 µg/mL [16]. All the synthesized compounds were diluted to 1000 µg/mL concentration as a stock solution. Herbicidal activities of compounds were evaluated against *Raphanus sativus* L. by inhibitory effect of compounds on the growth of weed roots and shoots.

RESULTS AND DISCUSSION

Synthesis of 1-(biphenyl-2-yloxy)-3-(propan-2-yl-amino)propan-2-ol (6) and 1-(2,6-dimethyl-/4-methoxy-/4-chloro-3-hydroxy-/2,6-dimethoxy-/3,4-dimethyl-/4-amine-/4-bromo-/3,4-dinitro-/2,4-dihydroxyphenoxy)-3-(biphenyl-2-yloxy)propan-2-ols (7a-i): Condensation of biphenyl-2-ol (**1**) with epichlorohydrin (**2**) in the presence of anhydrous K_2CO_3 was refluxed on oil bath. The excess epichlorohydrin was evaporated to obtained 2-[(biphenyl-2-yloxy)methyl]oxirane (**3**) by conventional method. The progress of the reaction was monitored by TLC and the reaction was found to be completed. Compound (**3**) was further refluxed with 99% isopropylamine (**4**) on the water bath. The reaction completion was checked by TLC. The excess of isopropylamine was evaporated to dryness

in vacuum. The remainder found was extracted between 2 N HCl and ether. The HCl layer was neutrallized with 1 N NaOH.

The formed product was filtered and recrystallized from ethyl acetate to afford a crystalline solid, m.p. 93-95 ºC in 71% yield compound **5**, respectively. ^{1}H NMR spectrum of compound **5** in $CDCl_3$ displayed a doublet at δ 2.59 ppm integrating for three protons for methyl functionality. A characteristic multiplet appeared at δ 3.24 ppm for one proton of CH. The compound showed IR absorption peak at 3482, 3362 and 1592 cm^{-1} indicated the presence of OH, NH and C=C aromatic respectively. Based on the above data, compound was assigned as 1-(biphenyl-2-yloxy)-3-(propan-2-ylamino)propan-2-ol.

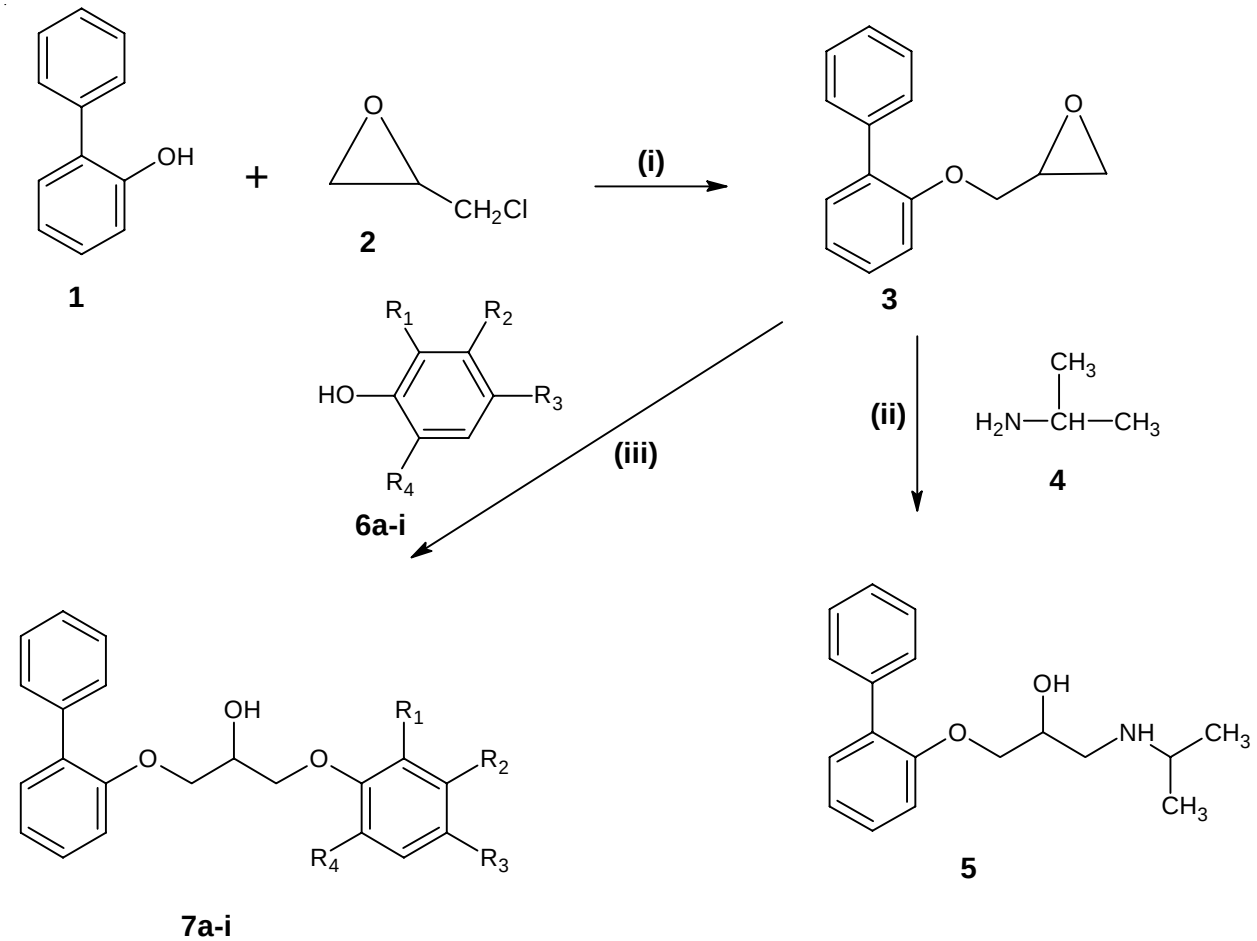
Compound **3** was then reacted with 2,6-dimethyl phenol (**6a**), 4-methoxy phenol (**6b**), 4-chloro-2-hydroxy phenol (**6c**), 2,6-dimethoxy phenol (**6d**), 3,4-dimethyl phenol (**6e**), 4-amine phenol (**6f**), 4-bromo phenol (**6g**), 3,4-dinitro phenol (**6h**) and 2,4-dihydroxy phenol (**6i**) in presence of ethanol and NaOH as catalyst refluxed on water bath for 8 h (**Scheme-I**). Herein, the formation of 2,6-dimethyl phenoxy)-3-(biphenyl-2-yloxy)-propan-2-ol (**7a**) was chosen. In this reaction, a mixture of 2-[(biphenyl-2-yloxy)methyl]oxirane (**3**) and 2,6-dimethyl phenol (**6a**) was refluxed on water bath for 8 h in presence of ethanol and sodium hydroxide. The reaction completion was checked by TLC. The extra solvent was separated and add ice water. The product was filtered, dried and recrystallized by ethyl acetate to afford a crystalline solid, m.p. viscous mass in 78% yield respectively.

^{1}H NMR spectrum of compound **7a** in $CDCl_3$ displayed a singlet at δ 3.12 ppm integrating for six protons for methyl functionality. A characteristic multiplet appeared at δ 3.42 ppm for one proton of CH. The compound showed IR absorptions at 3530, 1400 and 1550 cm^{-1} indicated the presence of OH, C-CH_3 and C=C aromatic, respectively. Based on the above data the compound was assigned 2,6-dimethylphenoxy)-3-(biphenyl-2-yloxy)propan-2-ol (**7a**). The other compounds **7b-i** were also synthesized and characterized by similar method.

Antifungal activity: The results given in Table-2 showed that compound 1-(biphenyl-2-yloxy)-3-(propan-2-ylamino)-propan-2-ol (**5**) was most active against both the tested fungi *Rhizoctonia solani* and *Aspergillus niger* with EC_{50} value 48.00 and 52.91 µg/mL, while other compounds showed the least toxicity against both the tested fungi.

Antibacterial activity: The results of the antibacterial activity of the synthesized compounds are shown in Table-3. Compound **7c** showed the highest toxicity. It is found that chlorine and methyl substituents at different positions in a series of compounds showed the highest antibacterial activity.

Herbicidal activity: Herbicidal activities of the synthesized compounds were evaluated against *Raphanus sativus* L. by inhibitory effect of compounds on the growth of weed roots and shoots. Compound 2,6-dimethoxyphenoxy)-3-(biphenyl-2-yloxy)propan-2-ol (**7d**) showed highest growth inhibition in both roots and shoots of *Raphanus sativus* L. at all the tested concentrations (Table-4), whereas compound 2,4-dihydroxy-



Scheme-I: Reagents and reaction conditions: (i) Anhydrous K_2CO_3, reflux, (ii) Methanol, reflux, (iii) Ethanol, NaOH, reflux

TABLE-2
FUNGI TOXICITY OF 1-(BIPHENYL-2-YLOXY)-3-(PROPAN-2-YLAMINO)PROPAN-2-OL (**5**) AND 1-(2,6-DIMETHYL-/4-METHOXY-/4-CHLORO-3-HYDROXY-/2,6-DIMETHOXY-/3,4-DIMETHYL-/4-AMINE-/4-BROMO-/3,4-DINITRO-/2,4-DIHYDROXYPHENOXY)-3-(BIPHENYL-2-YLOXY)PROPAN-2-OLS (**7a-i**)

Compd. No.	Growth inhibition (%)								*Rhizoctonia solani*	*Aspergillus niger*
	Rhizoctonia solani				*Aspergillus niger*					
	50 µg/mL	100 µg/mL	150 µg/mL	200 µg/mL	50 µg/mL	100 µg/mL	150 µg/mL	200 µg/mL	EC_{50} (µg/mL)	EC_{50} (µg/mL)
5	38.57	47.14	54.28	62.85	48.62	72.35	75.32	79.63	48.00	52.91
7a	35.68	49.37	59.48	69.32	43.64	50.37	58.23	69.72	103.12	97.65
7b	44.28	52.83	61.15	67.37	33.49	46.56	57.39	66.32	83.45	115.88
7c	44.28	49.05	59.54	67.32	37.32	45.58	57.47	66.42	104.53	118.59
7d	–	–	–	–	33.45	37.52	45.24	54.87	–	174.72
7e	47.14	57.14	67.15	72.14	35.68	49.37	59.48	69.32	64.30	103.12
7f	32.85	45.71	56.77	66.25	–	–	–	–	119.39	–
7g	32.85	48.57	60.00	70.00	32.47	40.32	49.73	60.03	106.34	151.31
7h	–	–	–	–	–	–	–	–	–	–
7i	39.97	48.23	55.78	63.54	33.56	43.00	57.65	68.32	111.72	123.90

– = No growth inhibition

TABLE-3
ANTIBACTERIAL ACTIVITY OF 1-(BIPHENYL-2-YLOXY)-3-(PROPAN-2-YLAMINO)PROPAN-2-OL (**5**) AND 1-(2,6-DIMETHYL-/4-METHOXY-/4-CHLORO-3-HYDROXY-/2,6-DIMETHOXY-/3,4-DIMETHYL-/4-AMINE-/4-BROMO-/3,4-DINITRO-/2,4-DIHYDROXYPHENOXY)-3-(BIPHENYL-2-YLOXY)PROPAN-2-OLS (**7a-i**)

Compd. No.	Zone inhibition (mm)			
	Bacillus species			
	50 µg/mL	100 µg/mL	150 µg/mL	200 µg/mL
5	–	–	8.50	15.00
7a	13.00	29.50	36.00	45.50
7b	–	–	–	–
7c	3.50	8.00	13.50	20.00
7d	–	–	9.00	16.00
7e	11.50	26.00	35.50	49.00
7f	–	–	–	–
7g	–	–	12.00	43.00
7h	4.00	7.50	10.00	15.50
7i	–	–	–	–

– = No growth inhibition

phenoxy)-3-(biphenyl-2-yloxy)propan-2-ol (**7h**) showed the minimum toxicity in this series. The growth inhibition may be attributed to substitution of methoxy and nitro groups on phenyl ring.

Conclusion

An alternative multistep reaction for the synthesis of propranolol and its compounds has been developed compared to the previous report. This route is easy, inexpensive and mild conditions can be used. All synthesized compounds (**5**, **7a-i**) were fully analyzed *via* NMR and FTIR spectral analysis. The bioefficacy of the synthesized compounds were also evaluated in relation to herbicidal activity against *Raphanus sativus* L. (radish) seeds, antibacterial activity against *Bacillus* species and antifungal activity against *R. solani* and *A. niger*.

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TABLE-4
HERBICIDAL ACTIVITY OF 1-(BIPHENYL-2-YLOXY)-3-(PROPAN-2-YLAMINO)PROPAN-2-OL (**5**) AND 1-(2,6-DIMETHYL-/4-METHOXY-/4-CHLORO-3-HYDROXY-/2,6-DIMETHOXY-/3,4-DIMETHYL-/4-AMINO-/4-BROMO-/3,4-DINITRO-/2,4-DIHYDROXYPHENOXY)-3-(BIPHENYL-2-YLOXY)PROPAN-2-OLS (**7a-i**)

Compd. No.	Inhibition (%)							
	Root				Shoot			
	50 (µg/mL)	100 (µg/mL)	150 (µg/mL)	200 (µg/mL)	50 (µg/mL)	100 (µg/mL)	150 (µg/mL)	200 (µg/mL)
5	50.06	57.70	69.54	75.00	50.00	56.45	66.05	73.30
7a	54.78	60.00	70.56	77.54	54.98	57.73	68.90	74.37
7b	58.63	65.74	74.00	80.53	56.05	62.06	73.26	76.59
7c	63.89	69.07	76.48	88.00	61.93	65.07	74.57	84.58
7d	68.90	75.96	80.72	90.45	64.17	73.00	77.46	87.56
7e	64.06	71.54	78.46	89.54	62.00	67.43	75.00	83.41
7f	61.13	68.79	76.13	84.05	58.04	64.60	71.04	78.74
7g	59.63	66.03	79.02	87.90	54.31	61.00	63.30	81.03
7h	53.07	58.80	65.90	71.03	52.87	54.06	63.32	67.46
7i	63.75	69.48	74.35	80.00	61.05	65.50	73.78	78.56

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