



# Chemical design and bioefficacy screening of new insect growth regulators as potential insecticidal agents against *Spodoptera littoralis* (Boisd.)

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## ARTICLE INFO

### Article history:

Received 21 September 2019

Received in revised form 3 November 2019

Accepted 6 November 2019

### Keywords:

*Spodoptera littoralis*(Boisd)

Fenoxycarb

Toxicity

Insect growth regulators

## ABSTRACT

The **13** new compounds were chemically synthesized and their spectroscopic analysis was done to determine their chemical structure. All the compounds were screened for their insecticidal potential against *Spodoptera littoralis* (Boisd.). Among the tested compounds, the compound **13** was found to be the most potent. It displayed one fold more activity than a reported insect growth regulator, fenoxycarb. The other target compounds demonstrated weak to strong toxicological activities against *Spodoptera littoralis* (Boisd.).

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## 1. Introduction

*Spodoptera littoralis* (Boisd.) is considered one of key insect that reason incredible harm to cotton plants and other different plants in Egypt [1,2] the instar larvae of this insect can feed on about ninety economically plant kind belonging to 40 families. To battle the insect growth, producers utilize prepared organic insecticides [3] and some biorational operators, for example, *Bacillus thuringiensis* is Berliner, however the accomplished control isn't successful enough because high ability to create opposition toward of the majority of conventional compounds. Consequently, researchers and producers are looking for elective materials that are viable against this insect, safe to people, natural well disposed, and good inside focused bug the board (IPM) practices [4]. The elective control strategies that is promising as a potential instrument in *S. littoralis* safe administration projects is the utilization of biorational control specialists, for example, synthetic insect growth regulators (IGRs) and those dependent on normally inferred product [5,6]. IGRs are professed to be more secure for valuable creatures than customary items, and they have been effectively utilized in IPM programs against many tree and little fruit insects [7]. There is a need for different insecticides having different modes of action. We found while searching at the desired and synthesis of juvenile hormone analogs [8,9] of pests to be

evaluate against the *S. littoralis* (Boisd.).The prepared compounds displayed a variable level of action activity against this pests, and a number of them were most dynamic activity than the normally juvenile hormones [10–13]. Considering that the pests, after treatment with JHAs, were less defenseless to characteristic contaminations with the *S. littoralis* than normal non treated insects [14]. Shockingly, they demonstrated a changeful level of activity, some of them being very active in inhibiting cell expansion of this pests [15]. Toward the start, the well-known insect growth regulator fenoxycarb was utilized as standard control since it carried on as an exceedingly active operator against larvae of *S. littoralis* [10]. Be that as it may, some adjusted chemical structures have the 4-phenoxyan carbamate were observed to be more active than fenoxycarb in investigations against *S. littoralis* cells [16]. The mode of action of these compounds have been studied and there is evidence that there is a restrain sterol biosynthesis inside the cells [17].

## 2. Materials and methods

Estimating of the MP. for all prepared target compounds was completed on a Fisher-John mechanical technique. By utilizing a Vario EL C, H, N, S analyzer, basic examinations (C, H, N, and S) were elucidated. On a Pye-Unicam SP3-100 spectrophotometer IR spectra were gotten by utilizing the KBr disc technique. <sup>1</sup>H NMR and <sup>13</sup>C NMR spectra were estimated on Bruker 400 MHz spectrometers utilizing tetramethylsilane (TMS) as a source of perspective and concoction movements were accounted for as

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ppm. By utilizing a Jeol JMS-400 mass spectra were completed. Fenoxycarb juvenile hormone analogues as an insect growth regulators insecticide was buy from Sigma-Aldrich. The numbers of *S. littoralis* insects were gathered from cotton leave worm, fields of Assiut University. Toxic activity of the thirteen compounds comparing with fenoxycarb as reported insecticide was tested against the instar larvae of *S. littoralis*.

### 3. Result and Discussion

#### 3.1. Chemistry

As following our project in prepared and toxicity evaluate the biological activity of juvenile hormones analogues, here in thirteen tested compounds where shown in (Fig. 1) to determined their toxicity as insecticides. The thirteen compounds, namely, *N*-[4-(oxiran-2-ylmethoxy)phenyl]benzamide **1**, ethyl[4-(oxiran-2-ylmethoxy)phenyl]carbamate **2**, 2-chloro-*N*-[4-(oxiran-2-ylmethoxy)phenyl]acetamide **3**, *N*-[4-(oxiran-2-ylmethoxy)phenyl]furan-2-carboxamide **4**, 4-(furan-2-carboxamido)-2,6-bis(phenylcarbonyl)phenyl phenylcarbamate **5**, *N*-{4-[2-hydroxy-3-(piperidine-1-yl)propoxy]phenyl}benzamide **6**, *N*-{4-[2-hydroxy-3-(morpholin-4-yl)propoxy]phenyl}benzamide **7**, Ethyl(3,5-bis(phenylcarbonyl)oxy)phenyl carbamate **8**, 2-chloro-*N*-[4-[2-hydroxy-3-(piperidin-1-yl)propoxy]phenyl]acetamide **9**, 2-chloro-*N*-[4-[2-hydroxy-3-(morpholin-4-yl)propoxy]phenyl]acetamide **10**, *N*-[4-[2-hydroxy-3-(piperidin-1-yl)propoxy]phenyl]furan-2-carboxamide **11**, *N*-[4-[2-hydroxy-3-(morpholin-4-yl)propoxy]phenyl]furan-2-carboxamide **12** and *N*-[4-(2-hydroxynaphthoxypropoxy)phenyl]benzamide **13**.

#### 3.2. Experimental

A Fisher-Johns instruments were practiced to register the melting points of every prepared compounds. Infra-red and elemental analyses (C, H, N, and S) were achieved through a Pye Unicam SP3-100 spectro-photometer utilizing the KBr disk strategy and a Vario EL C, H, N, S analyzer, separately. A Bruker 400 MHz spectrometer was utilized to measure DEPT 135 spectra and the <sup>1</sup>H and <sup>13</sup>C NMR spectra within the TMS as an interior standard. Reaction headway and perfection of the prepared sections were checked by thin layer chromatography.

**General procedure of synthetic oxirane ring (1-4)** By reaction of 4-hydroxyphenyl acetamide derivatives (0.04 mol) with epichlorohydrin (0.12 mol) in presence of sodium hydroxide 25 % in

water was stirred in ice bath for 4 h, compounds (**1-4**) were prepared, The formed precipitate was filtered off and recrystallized from methanol.

#### 3.3. *N*-[4-(oxiran-2-ylmethoxy)phenyl]benzamide (**1**)

Pale red crystals. Yield: 83 %; MP: 102–104 °C. IR (ν) (KBr) cm<sup>-1</sup>: 3328 (NH), 3050, 3027 (C–H<sub>Aromatic</sub>), 2922, 2827 (C–H aliphatic). <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>): δ 10.11 (s, 1H, NH), 6.19 – 7.99 (m, 9H Ar-H), 4.33 (s, 1H, CH), 3.8 (m, 2H, CH<sub>2</sub>), 2.8 (s, 1H, CH), 2.7 (s, 1H, CH). <sup>13</sup>C NMR (DMSO-*d*<sub>6</sub>): δ 165.61, 155.02, 135.54, 13307, 132.66, 131.82, 128.80, 128.00, 122.44, 69.60, 50.22, 40.69. DEPT 135: δ 131.80, 128.78, 127.99, 122.49, 122.47, 115.01, 114.91, 69.63(CH<sub>2</sub>), 44.24(CH<sub>2</sub>). Elemental analysis calculated for C<sub>16</sub>H<sub>15</sub>NO<sub>3</sub> (%) Calcd. /found; C: 71.36/71.34, H: 5.61/5.60, N: 5.20/5.21.

#### 3.4. Ethyl [4-(oxiran-2-ylmethoxy)phenyl]carbamate (**2**)

White crystals. Yield: 90%; MP: 86–89 °C. IR (ν) (KBr) cm<sup>-1</sup>: 3322 (NH), 3059, 3018 (C–H<sub>Aromatic</sub>), 2901, 2880 (C–H aliphatic) 1710 (C=O). <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>): δ 9.35 (s, 1H, NH), 7.36 – 7.38 (s, 2H Ar-H), 6.80 – 6.90 (s, 2H Ar-H), 4.27 (s, 1H, CH), 4.26 (s, 2H, CH<sub>2</sub>), 3.95 (s, 1H, CH), 3.31 (s, 1H, CH), 2.83 (s, 1H, CH), 2.84 (s, 1H, CH), 1.3 (s, 3H, CH<sub>3</sub>). <sup>13</sup>C NMR (DMSO-*d*<sub>6</sub>): δ 157.01, 153.31, 149.92, 136.04, 119.12, 89.22, 39.44, 38.14, 28.22, 27.69. Elemental analysis calculated for C<sub>12</sub>H<sub>15</sub>NO<sub>4</sub> (%) Calcd. /found; C: 60.75/60.74, H: 6.37/6.35, N: 5.90/5.89.

#### 3.5. 2-Chloro-*N*-[4-(oxiran-2-ylmethoxy)phenyl]acetamide (**3**)

White crystals. Yield: 72%; MP: 146–148 °C. IR (ν) (KBr) cm<sup>-1</sup>: 3267 (NH), 3093 (C–H<sub>Aromatic</sub>), 2920 (C–H aliphatic), 1660 (C=O). <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>): δ 10.10 (s, 1H, NH), 7.50 – 7.52 (s, 2H Ar-H), 6.93 – 6.95 (s, 2H Ar-H), 4.30 (s, 1H, CH), 4.27 (s, 2H, CH<sub>2</sub>), 3.85 (s, 1H, CH), 3.31 (s, 1H, CH), 2.85 (s, 1H, CH), 2.82 (s, 1H, CH). <sup>13</sup>C NMR (DMSO-*d*<sub>6</sub>): δ 158.02, 153.41, 143.12, 133.59, 126.12, 117.03, 38.14, 27.22, 28.01. Elemental analysis calculated for C<sub>11</sub>H<sub>12</sub>ClNO<sub>3</sub> (%) Calcd. /found; C: 54.67/54.55, H: 5.00/4.98, N: 5.80/5.78.

#### 3.6. *N*-[4-(oxiran-2-ylmethoxy)phenyl]furan-2-carboxamide (**4**)

Brown powder. Yield: 69 %; MP: 166–168 °C. IR (ν) (KBr) cm<sup>-1</sup>: 3346 (NH), 3185 (C–H<sub>Aromatic</sub>), 2941 (C–H aliphatic), 1661 (C=O). <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>): δ 10.03 (s, 1H, NH), 6.69 – 7.90 (m, 7H Ar-H), 4.32 (s, 1H, CH), 3.33 (s, 1H, CH), 3.29 (s, 2H, CH<sub>2</sub>), 2.85 (s, 1H, CH), 2.71 (s, 1H, CH). <sup>13</sup>C NMR (DMSO-*d*<sub>6</sub>): δ 158.43, 156.31, 143.44, 131.59, 129.63, 127.22, 126.12, 120.17, 117.03, 114.33, 38.13,

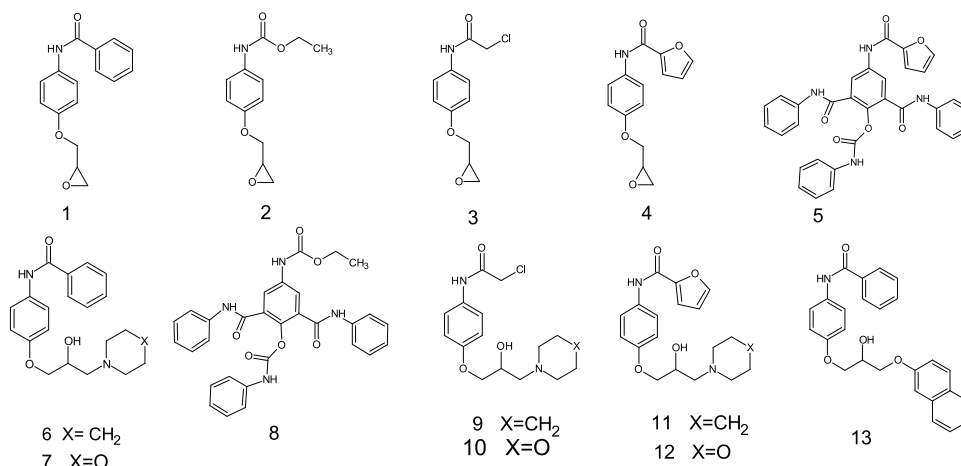


Fig. 1. Purposed compounds that tested against *S. littoralis*.

28.201. Elemental analysis calculated for  $C_{14}H_{13}NO_4$  (%) Calcd. / found; C: 64.86/64.88, H: 5.05/5.505, N: 5.40/5.39.

**General procedure of synthetic compounds (5, 8)** via reaction of 4-hydroxyphenyl acetamide derivatives (0.09 mmol) with phenyl isocyanate (0.02 mmol) and two drops of triethylamine as catalyst in 30 ml 1,4-dioxane, the reaction mixture was refluxed for 5 h, the formed precipitate was filtered off and recrystallized from methanol.

### 3.7. 4-(Furan-2-carboxamido)-2,6-bis(phenylcarbamoyl)phenylphenylcarbamate (5)

White powder. Yield: 70%; MP: 143–146 °C. IR ( $\nu$ ) (KBr)  $cm^{-1}$ : 3288 (2NH), 3138 (C–H<sub>Aromatic</sub>), 1716, 1648 (C=O). <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>):  $\delta$  10.22 (s, 1H, NH), 10.14 (s, 1H, NH), 8.61 (s, 2H, 2NH), 6.71–7.93 (m, 20H Ar-H). <sup>13</sup>C NMR (DMSO-*d*<sub>6</sub>):  $\delta$  156.43, 153.31, 150.44, 130.01, 127.32, 127.19, 119.63, 118.22, 118.02, 112.92. Elemental analysis calculated for  $C_{32}H_{24}N_4O_6$  (%) Calcd. / found; C: 68.56/68.49, H: 4.32/4.30, N: 9.99/9.98.

**General procedure of synthetic compounds (6–13)** A mixture of oxirane ring derivatives (compounds 1–4) (1 mmol), the nucleophilic reagent added (piperidine, morpholine, 2-naphthol) (3 mmol), add drops of triethylamine in ethanol was stirred and refluxed at ambient temperature for 5 h to give a precipitate which filtered off and recrystallized from 1,4-Dioxane.

### 3.8. N-{4-[2-hydroxy-3-(piperidin-4-yl)propoxy]phenyl}-benzamide (6)

White powder. Yield: 62%; MP: 155–158 °C. IR ( $\nu$ ) (KBr)  $cm^{-1}$ : 3496, 3395 (NH, OH), 3055 (C–H<sub>Aromatic</sub>), 2924 (C–H aliphatic), 1627 (C=O). <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>):  $\delta$  10.11 (s, 1H, NH), 7.50–7.97 (m, 9H Ar-H), 5.52 (s, 1H, OH), 4.00 (m, 3H, CH), 3.8 (m, 9H, 4CH<sub>2</sub>+CH), 2.2 (s, 1H, CH), 1.4 (s, 2CH, CH<sub>2</sub>). <sup>13</sup>C NMR (DMSO-*d*<sub>6</sub>):  $\delta$  158.03, 155.32, 140.44, 136.01, 128.39, 127.19, 118.22, 118.02, 112.9, 77.20, 56.15, 39.22, 31.13, 29.15, 28.32. Elemental analysis calculated for  $C_{21}H_{26}N_2O_3$  (%) Calcd. / found; C: 71.16/71.09, H: 7.39/7.40, N: 7.90/7.89.

### 3.9. N-{4-[2-hydroxy-3-(morpholin-4-yl)propoxy]phenyl}-benzamide (7)

White powder. Yield: 73 %; MP: 205–208 °C. IR ( $\nu$ ) (KBr)  $cm^{-1}$ : 3277 (OH), 3115 (C–H<sub>Aromatic</sub>), 2903 (C–H aliphatic), 1689 (C=O). <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>):  $\delta$  10.11 (s, 1H, NH), 7.50–7.97 (m, 9H Ar-H), 5.52 (s, 1H, OH), 4.00 (m, 3H, CH), 3.8 (m, 8H, 4CH<sub>2</sub>), 1.4 (s, 2CH, CH<sub>2</sub>). <sup>13</sup>C NMR (DMSO-*d*<sub>6</sub>):  $\delta$  157.03, 145.70, 137.15, 127.39, 127.19, 119.55, 118.15, 111.09, 81.20, 75.15, 35.22, 33.13, 27.15, 27.32.

Elemental analysis calculated for  $C_{20}H_{24}N_2O_4$  (%) Calcd. / found; C: 67.40/67.38, H: 6.74/6.72, N: 7.86/7.88.

### 3.10. Ethyl(3,5-bis(phenylcarbamoyl)-4-((phenylcarbamoyl)oxy)phenyl)carbamate (8)

White crystals. Yield: 83 %; MP: 186–189 °C. IR ( $\nu$ ) (KBr)  $cm^{-1}$ : 3326 (NH), 3194, 3132 (C–H<sub>Aromatic</sub>), 2978 (C–H aliphatic), 1733, 1694, 1645 (C=O). <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>):  $\delta$  10.13 (s, 1H, NH), 9.63 (s, 1H, NH), 8.64 (s, 1H, NH), 6.96–7.56 (s, 17H Ar-H), 4.18 (s, 2H, CH<sub>2</sub>), 1.3 (s, 3H, CH<sub>3</sub>). <sup>13</sup>C NMR (DMSO-*d*<sub>6</sub>):  $\delta$  157.32, 157.03, 156.70, 147.15, 140.89, 139.25, 137.25, 130.00, 123.23, 122.23, 121.58, 119.68, 119.05, 117.23, 116.35, 59.93, 12.3. Elemental analysis calculated for  $C_{30}H_{26}N_4O_6$  (%) Calcd. / found; C: 66.91/66.90, H: 4.87/4.88, N: 10.40/10.38.

### 3.11. 2-Chloro-N-{4-[2-hydroxy-3-(piperidin-1-yl)propoxy]phenyl}acetamide (9)

Brown powder. Yield: 44 %; MP: 158–160 °C. IR ( $\nu$ ) (KBr)  $cm^{-1}$ : 3267 (NH), 3093 (C–H<sub>Aromatic</sub>), 2920 (C–H aliphatic), 1658 (C=O). <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>):  $\delta$  10.10 (s, 1H, NH), 7.50–7.52 (m, 4H Ar-H), 4.30 (s, 1H, OH), 4.27 (s, 1H, CH), 3.85 (m, 4H, 2CH<sub>2</sub>), 2.85 (8, 8H, 4CH<sub>2</sub>), 1.82 (s, 4H, 2CH<sub>2</sub>). <sup>13</sup>C NMR (DMSO-*d*<sub>6</sub>):  $\delta$  157.20, 134.81, 129.69, 127.21, 126.77, 123.92, 119.2, 107.25, 71.78, 55.32, 26.19, 24.64. Elemental analysis calculated for  $C_{16}H_{23}ClN_2O_3$  (%) Calcd. / found; C: 58.80/58.78, H: 7.09/7.07, N: 8.57/8.55.

### 3.12. 2-Chloro-N-{4-[2-hydroxy-3-(morpholin-4-yl)propoxy]phenyl}acetamide (10)

White powder. Yield: 72 %; MP: 146–148 °C. IR ( $\nu$ ) (KBr)  $cm^{-1}$ : 3267 (NH), 3093 (C–H<sub>Aromatic</sub>), 2920 (C–H aliphatic), 1660 (C=O). <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>):  $\delta$  10.13 (s, 1H, NH), 7.98 (s, 2H Ar-H), 7.82 (s, 2H Ar-H), 4.90 (s, 1H, OH), 3.29 (s, 1H, CH), 3.85 (s, 2H, CH<sub>2</sub>), 3.12 (s, 2H, CH<sub>2</sub>), 2.20 (m, 8H, 4CH<sub>2</sub>), 1.82 (s, 2H, CH<sub>2</sub>). <sup>13</sup>C NMR (DMSO-*d*<sub>6</sub>):  $\delta$  157.40, 139.69, 127.71, 127.17, 119.2, 107.25, 71.78, 67.25, 55.02, 25.29, 23.44. Elemental analysis calculated for  $C_{15}H_{21}ClN_2O_4$  (%) Calcd. / found; C: 54.79/54.77, H: 6.44/7.41, N: 8.52/8.50.

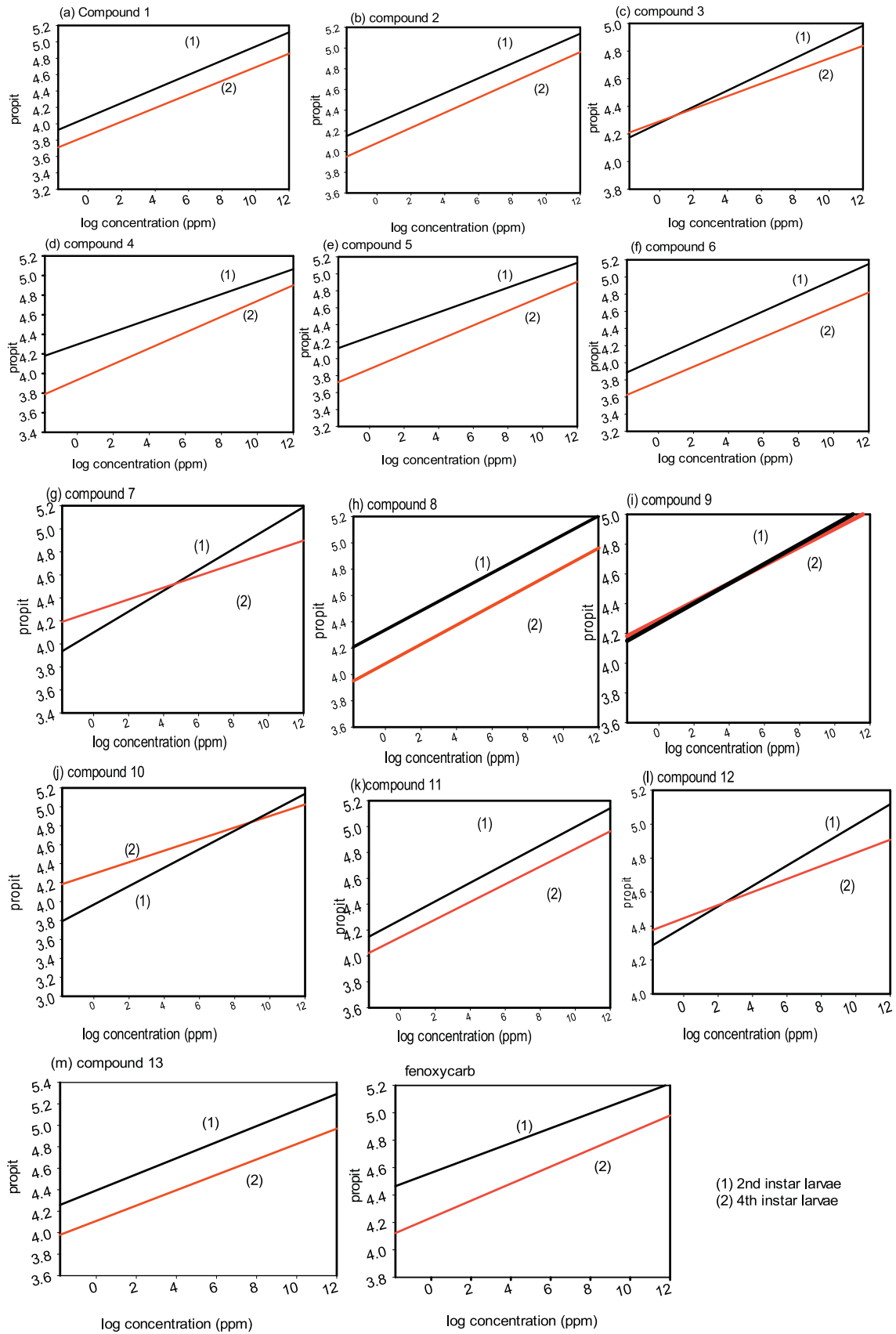
### 3.13. N-{4-[2-Hydroxy-3-(piperidin-1-yl)propoxy]phenyl}furan-2-carboxamide (11)

Yellow crystals. Yield: 63 %; MP: 196–198 °C. IR ( $\nu$ ) (KBr)  $cm^{-1}$ : 3326 (NH), 3178, (C–H<sub>Aromatic</sub>), 2925 (C–H aliphatic), 1694, (C=O). <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>):  $\delta$  10.01 (s, 1H, NH), 6.98–7.90 (s, 7H

**Table 1**

Insecticidal activity of compounds 1–13 and juvenile hormone analogue fenoxycarb against the larvae of *S. littoralis* (Boisd.), after 72 h of treatments.

2 <sup>nd</sup> instar larvae				4 <sup>th</sup> instar larvae			
Comp.	LC <sub>50</sub> (ppm)	slope	Toxic ratio	LC <sub>50</sub> (ppm)	slope	Toxic ratio	
fenoxycarb	5.943	0.298 ± 0.0808	0.684	59.914	0.225 ± 0.0870	0.954	
1	26.546	0.246 ± 0.0805	0.153	145.369	0.301 ± 0.0991	0.393	
2	12.505	0.246 ± 0.0793	0.325	67.908	0.297 ± 0.0893	0.840	
3	57.622	0.246 ± 0.0791	0.070	254.471	0.225 ± 0.0820	0.224	
4	25.414	0.233 ± 0.0756	0.159	128.376	0.297 ± 0.0978	0.445	
5	15.720	0.196 ± 0.0858	0.258	81.406	0.231 ± 0.0880	0.702	
6	20.478	0.239 ± 0.0796	0.198	91.360	0.341 ± 0.0987	0.625	
7	21.424	0.209 ± 0.0756	0.191	113.203	0.293 ± 0.0966	0.505	
8	8.032	0.262 ± 0.0793	0.506	67.670	0.266 ± 0.0912	0.844	
9	37.445	0.213 ± 0.0794	0.108	148.565	0.302 ± 0.0986	0.384	
10	37.495	0.221 ± 0.0794	0.108	152.260	0.239 ± 0.0985	0.375	
11	13.885	0.261 ± 0.0802	0.292	68.670	0.260 ± 0.0912	0.832	
12	14.106	0.218 ± 0.0776	0.288	77.624	0.202 ± 0.0793	0.742	
13	4.066	0.196 ± 0.0756	1	57.170	0.264 ± 0.0905	1	



**Fig. 2.** Compounds 1–13 and reference juvenile hormone analogue fenoxycarb as insecticidal activities against the 2<sup>nd</sup> and 4<sup>th</sup> instar larvae of *S. littoralis* after 72 h of treatment.

Ar-H), 4.72 (s, 1H, OH), 3.9 (m, 3H, CH + CH<sub>2</sub>), 2.4 (s, 2H, CH<sub>2</sub>), 2.3 (s, 2H, CH<sub>2</sub>), 1.4 (m, 8H, 4CH<sub>2</sub>). <sup>13</sup>C NMR (DMSO-d<sub>6</sub>): δ 157.33, 150.03, 159.70, 149.15, 147.89, 146.25, 140.25, 128.63, 128.23, 127.23, 52.36, 44.99, 28.98, 18.23, 16.35. Elemental analysis calculated for C<sub>19</sub>H<sub>24</sub>N<sub>2</sub>O<sub>4</sub> (%) Calcd. /found; C: 66.26/66.23, H: 7.02/7.00, N: 8.13/8.15.

### 3.14. N-[4-[2-Hydroxy-3-(morpholin-4-yl)propoxy]phenyl]furan-2-carboxamide (**12**)

White powder. Yield: 26 %; MP: 218–220 °C. IR (ν) (KBr) cm<sup>-1</sup>: 3326 (NH), 3302 (OH), 3078, (C–H<sub>Aromatic</sub>), 2909 (C–H<sub>aliphatic</sub>), 1653, (C=O). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>): δ 10.10 (s, 1H, NH), 6.90 – 7.63 (s, 7H Ar-H), 4.72 (s, 1H, OH), 3.72 (s, 1H, CH), 2.5 (m, 4H, 2CH<sub>2</sub>), 1.3 (m, 8H, 4CH<sub>2</sub>). <sup>13</sup>C NMR (DMSO-d<sub>6</sub>): δ 157.83, 159.70, 148.15, 148.89, 128.85, 128.65, 128.01, 172.93, 127.23, 52.36, 48.23, 38.98, 17.23, 16.33. Elemental analysis calculated for C<sub>18</sub>H<sub>22</sub>N<sub>2</sub>O<sub>5</sub> (%) Calcd. /found; C: 62.42/62.40, H: 6.40/6.38, N: 8.09/8.09.

### 3.15. N-[4-(2-Hydroxy-3-naphthoxypropoxy)phenyl]benzamide (**13**)

White crystals. Yield: 81 %; MP: 220–222 °C. IR (ν) (KBr) cm<sup>-1</sup>: 3330 (NH), 3051 (C–H<sub>Aromatic</sub>), 2922 (C–H<sub>aliphatic</sub>), 1645 (C=O). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>): δ 10.13 (s, 1H, NH), 6.96 – 7.98 (s, 16H Ar-H), 4.33 (s, 1H, OH), 4.1 (m, 5H, CH). <sup>13</sup>C NMR (DMSO-d<sub>6</sub>): δ 166.39, 157.16, 154.75, 148.39, 139.68, 134.78, 129.74, 128.95, 127.96, 127.12, 126.82, 123.99, 119.25, 111.15, 111.27, 107.10, 107.59, 67.16, 61.33. Elemental analysis calculated for C<sub>30</sub>H<sub>26</sub>N<sub>4</sub>O<sub>6</sub> (%) Calcd. /found; C: 66.91/66.90, H: 4.87/4.88, N: 10.40/10.38. Elemental analysis calculated for C<sub>26</sub>H<sub>23</sub>NO<sub>4</sub> (%) Calcd. /found; C: 75.53/75.50, H: 6.61/6.63, N: 3.39/3.40.

## 4. Laboratory bioassay

The method that measure toxicity of the target compounds was tested by leaf dipping bioassay [18]. Results of research facility screening to discover the suitable concentrations of the objective target compounds which are deformation in the insect to kill half 50 % LC<sub>50</sub> of instar larvae were proclaimed here. Five concentrations of arrangement of each synthesized compound in addition to 0.1 % Triton X-100 as a surfactant were used. The number of ten 2nd instar larvae and 4th instar larvae of insects, nearly have the same size, plates (9 cm. distance across) of castor bean leaves in which dunked in the objective treatment concentrations for 10 s then left to dry and offered to larvae, which starved for 4–6 treatment was reproduced multiple times (10 larvae for each). Control was dunked in distilled water only. The larvae were permitted to benefit from treated plates for 48 h., then transferred to the untreated ones. Mortality percentages were recorded after 72 h. for all insecticides. Mortality was redressed by Abbott's formula [19]. The doses mortality relapse lines were statistically investigated by probit analysis [20]. Toxicity Index and Relative Potency determined by Sun equations [21]:

$$\text{Toxicity ratio} = \frac{LC_{50} \text{ or } LC_{90} \text{ of the most efficient compound} \times 100}{LC_{50} \text{ or } LC_{90} \text{ of the other compound}}$$

Slope esteems and middle deadly focused concentrations LC<sub>50</sub> of the title target compounds were determined through a Probit relapse investigation program and recorded in (ppm) [20]. Were inundated for 10 s in each concentration multiple times (3 times). Pests which treated were leaved to dry at room temperature for about half hour. Control clumps of utilized pests were likewise used. The insecticidal action trial of each compound was reshaped multiple times (2 time) and the gotten data were rectified by Abbott's equation [19]. By utilizing a modernized probit relapse investigation program, middle deadly fixations (LC<sub>50</sub>) and incline

estimations of objective target compounds were figured and revealed as (ppm) [20].

## 5. Insecticidal activity

The objective tested compounds have been used for insecticidal activity as explained beneath:

### 5.1. Toxicological activity of compounds against 2<sup>nd</sup> instar larvae

As shown in (Table 1) target compounds were tested of their activity as insecticides in which shown beneath. Thirteen previously mentioned compounds displayed strong to weak toxic action against the 2<sup>nd</sup> instar larvae in light of the fact that various of them were active than fenoxycarb after 72 h. of the test with LC<sub>50</sub> qualities differ from 4.066 ppm for 2nd instar larvae, while fenoxycarb LC<sub>50</sub> was 5.943 ppm for 2nd instar larvae. For example, LC<sub>50</sub> values of compounds **1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12** and **13** were 26.546, 12.505, 57.622, 25.414, 15.720, 20.478, 21.424, 8.032, 37.445, 37.495, 13.885, 14.106 and 4.066 ppm, respectively in a specific order, and LC<sub>50</sub> of fenoxycarb was 5.943 ppm. From outcomes in over, the toxicity of compound **13** against the *S. littoralis* larvae 4.066 ppm after 72 h of the test on the grounds that LC<sub>50</sub> estimation of reported fenoxycarb was 5.943 ppm.

### 5.2. Toxicological activity of compounds against 4<sup>th</sup> instar larvae

As shown in (Table 1) target compounds were tested for their activity as insecticides and this is shown beneath. Thirteen previously mentioned compounds displayed strong to weak toxic action against the 4<sup>th</sup> instar larvae in light of the fact that various them were active than fenoxycarb after 72 hs of the treatment in which LC<sub>50</sub> values changed from 57.170–254.471 ppm, while fenoxycarb LC<sub>50</sub> was 59.914 ppm. Compounds **1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12** and **13** gave a high toxicity with LC<sub>50</sub> values of 145.369, 67.908, 254.471, 128.376, 81.406, 91.360, 113.203, 67.670, 148.565, 152.260, 68.670, 68.670 and 57.170 ppm. Comparing with fenoxycarb compound **13** shown that the highest toxicity while compounds **8, 11, 12** and **5** give a very good activity in which LC<sub>50</sub> values are 67.670, 68.670, 68.670 and 81.406 ppm, respectively.

## 6. Structure-activity relationship

As a resumption of our search, the structure-activity relationships were accounted for here as indicated by the poisonous activity peaks in Table 1 underneath and (Fig. 2) too. It is demonstrated that the 4-aminophenol derivatives **13** is progressively active against of *S. littoralis* than different compounds that prepared. The large activity related with compounds **8** and **5** might be because of the closeness of the carbamate and fuoryl group moiety independently in their chemically structure and the general qualities of the synthesized compounds.

## 7. Conclusion

A chain of 4-alkyloxyphenyl amide derivatives which are analogues to fenoxycarb juvenile hormone in which contain phenoxy group were chemically synthesized. The toxic activity of the tested target compounds was assessed against 2nd and 4th instar larvae demonstrated that some of the synthesized target compounds have great toxicological activity, though some of them uncovered sensible aphicidal activity. Particularly, compound **13** was the most toxic action since it surpassed the aphicidal activity of a reference juvenile hormone analogue fenoxycarb. The activity concerning compound **13** might be because of the presence of the ethers group joined to the aminophenol in its atomic structure. Our



examination showed that the new aminophenol analogues containing ethers group moiety could successfully control of *S. littoralis*. These results are lively and gainful for additional work on the improvement of new and strong insecticides.

### Declaration of Competing Interest

We are declared that there is no conflict of interest including any financial, personal or other relationships with other people or organizations within five years of beginning the submitted our paper that could inappropriately influence, or be perceived to influence, our work

### Acknowledgements

This work was financially supported by the plant protection institute, agriculture research center of Egypt, and chemistry department, Sohag University.

### Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.btre.2019.e00394>.

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