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·研究论文·

2-杂环基-1,3,4-噁二嗪酮类化合物的合成及其除草活性

潘玲玲[1], 沈晓霞[2], 曹 瑾[2], 陈 亮[2], 沈 宙[2], 袁莉萍*[2], 张一宾[2]

(1. 华东理工大学 药学院,上海 200237;2. 上海市农药研究所,上海 200032)

摘 要:以取代杂环羧酸为起始原料,在1,3,4-噁二嗪-5-酮的2-位上分别引入呋喃环、吡啶环及氯代噻吩环,合成了31个未见报道的2-杂环基-1,3,4-噁二嗪酮化合物,其化学结构经核磁共振氢谱和元素分析确证。初步的生物活性测定结果表明,该类化合物具有良好的除草活性,如在质量浓度200 mg/L时,化合物**E14**、**E16**、**E20**、**E21**对马唐*Digitaria sanguinalis*的抑制率大于90%,化合物**E06**、**E07**、**E10**、**E14**、**E16**、**E20**对苋菜*Ambrosia tricolor*的抑制率也大于90%。

关键词:1,3,4-噁二嗪-5-酮;有机合成;除草活性
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Synthesis and herbicidal activity of 2-heterocyclic-1,3,4-oxadiazine-5-ones

PAN Ling-ling[1], SHEN Xiao-xia[2], CAO Jin[2], CHEN Liang[2], SHEN Zhou[2], YUAN Li-ping*[2], ZHANG Yi-bin[2]

(1. *Pharmaceutical Institute, East China University of Science and Technology, Shanghai* 200237, *China*; 2. *Shanghai Pesticide Research Institute, Shanghai* 200032, *China*)

Abstract: Thirty one novel compounds of 2-heterocyclic-1,3,4-oxadiazine-5-one derivatives were synthesized through the starting material substituted heterocyclic carboxylic acid. The structure of all compounds was confirmed by ^{1}H NMR and elemental analysis. The preliminary assays showed that some compounds exhibited significant herbicidal activity. The inhibition rate of **E14**, **E16**, **E20** and **E21** to the *Digitaria sanguinalis* and **E06**, **E07**, **E10**, **E14**, **E16** and **E20** to the *Ambrosia tricolor* reached 90% at the mass concentration of 200 mg/L.

Key words: 1,3,4-oxadiazine-5-one; synthesis; herbicidal activity

杂环类农药的开发已成为当今世界新农药研发的热点之一,而其中'ó 二嗪(oxadiazine)杂环化合物的研究开发亦引起了人们广泛的兴趣[1],如茚虫威(indoxacarb)具有结构新颖,作用机制独特,用量低,几乎对所有鳞翅目害虫有效,而对人类、环境、作物和非靶标生物安全等特点,是替代有机磷杀虫剂的理想品种之一[2]。笔者所在的研究小组对此类结构的化合物开展过一定研究,已发现2-取代苯基-

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作者简介:潘玲玲(1987-),女,浙江人,硕士研究生,**E-mail**:panlingling198767@163.com;* **通讯作者**(Author for correspondence):袁莉萍(1964-),女,上海人,教授级高级工程师,主要从事新农药创制研究工作,**电话**:021-64644052,**E-mail**:ylp2354@126.com

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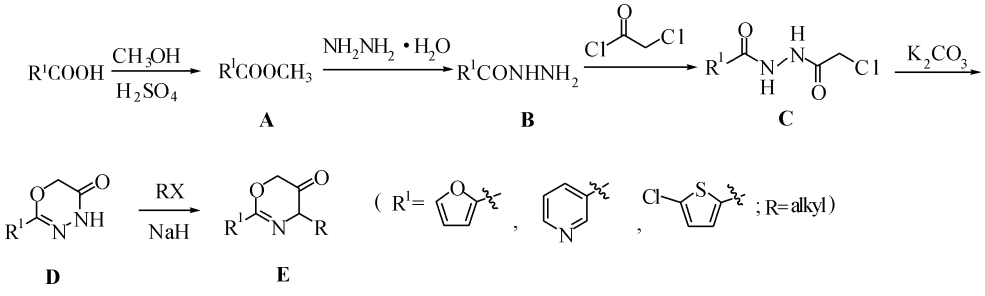
1,3,4-'ó 二嗪酮化合物[3]具有一定的杀菌活性,而2-取代苯乙烯基1,3,4-'ó 二嗪酮化合物[4]具有一定的杀虫活性。在前期研究工作的基础上,将杂环基团(2-呋喃基、3-吡啶基、5-氯-2-噻吩基)引入至1,3,4-'ó 二嗪酮环的2-位,并在4-位引入烷基。以杂环羧酸为原料,采用 **Scheme 1** 的合成路线,合成了一系列未见文献报道的2-杂环基-1,3,4-'ó 二嗪-5-酮的衍生物,并对其进行了杀虫、抗菌和除草的室内生物活性测定。结果发现此类化合物具有良好的除草活性,特别对马唐 *Digitaria sanguinalis* 和苋菜 *Ambrosia tricolor* Linn. 有较高的活性。



Scheme 1

1 实验部分

1.1 仪器与试剂

Bruker A 300 型核磁共振仪(以四甲基硅烷为内标,氘代氯仿为溶剂);Carloerba EA 元素分析仪;WRS 21A 型数字熔点仪(熔点未经校正);试剂为化学纯或分析纯。

1.2 化合物的合成

1.2.1 中间体 **A**、**B**、**C** 和 **D** 的制备 分别参照文献[5-8]的方法进行。

1.2.2 目标化合物 **E** 的制备 以化合物 **E01** 的合成为例。参照文献[9]的方法进行。冰水浴冷却下,先将氢化钠0.09 g(质量分数60%,2.25 mmol)加入到100 mL三口烧瓶中,再加入 *N*,*N*-二甲基甲酰胺(DMF) 10 mL及2-(2-呋喃基)-4-氢-1,3,4-'ó 二嗪-5-酮(**D01**) 0.33 g(2.00 mmol),搅拌15 min后加入碘甲烷0.45 g(3.17 mmol),反应液继续在0 ℃下搅拌4 h。向反应体系中加入二氯甲烷50 mL和水100 mL,分出有机相并用水洗至中性,经无水硫酸钠干燥,脱溶得粗品。经硅胶柱层析(洗脱剂 $V_{石油醚}:V_{乙酸乙酯}=4:1$)分离提纯,得浅黄色固体0.17 g,收率47.2%。以不同卤代烃代替碘甲烷,用类似方法合成了其余27个目标化合物。

1.3 除草活性测定

按照《国家南方农药创制中心上海基地生测标准程序》——平皿法测定化合物在200 mg/L下对马唐 *Digitaria sanguinalis*、苋菜 *Ambrosia tricolor* Linn. 的除草活性。

1.3.1 药液的配制 将100 mg供试原药溶解于5 mL *N*,*N*-二甲基甲酰胺(DMF)中,加入0.25 mL表面活性剂OP-10,用水稀释至100 mL,得质量浓度为1 000 mg/L的母液。试验时再用水依次稀释成不同浓度的供试药液。以不加原药者为空白对照。

1.3.2 测试方法 取马唐和苋菜种子各5粒置入垫有滤纸的平皿中,加入待测药液10~15 mL,每处理设3个重复,并设空白对照;将处理好的种子置于光照培养箱内,在温度28~30 ℃、相对湿度70%~80%、光照周期为L/D = 16 h/8 h的条件下培养。7 d后调查结果。从株高、根长和生长相态3方面进行比较,根长度、相态与对照差异大的抑制率高,反之则低。

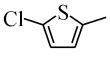
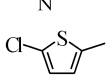
2 结果与讨论

2.1 化合物的合成

目标化合物的理化数据及元素分析数据见表1,核磁(^{1}H NMR)数据见表2。对于目标化合物的合成,也有文献报道先将中间体 **A** 与取代肼反应,然后再与氯乙酰氯反应最终环合得到目标物[10]。但商品化的烷基取代肼品种很少,且不易得到,若采用该合成方法只能获得数量很少的目标物。本文报道的方法是先将中间体 **A** 与水合肼反应,接着再与氯乙酰氯反应,经环合得到中间体 **D**,**D** 再与各种卤代烃反应最终得到目标化合物。由于商品化的卤代烃品种很多,原料易得,故可得到数量众多的目标化合物,有利于进行构效关系分析。

表 1 中间体 D 及目标化合物 E 的理化数据及元素分析数据

Table 1 Physical and elemental analytical data of compounds **D** and **E**

化合物 Compd.	R^1	R	熔点 m. p. /℃ or n_D^{31}	收率 Yield/%	元素分析(计算值)/% Elemental analysis(Calcd.)/%		
					C	N	H
D01		H	148.3 ~ 150.0	16.90	50.55(50.61)	16.78(16.86)	3.68(3.64)
D02		H	196.4 ~ 197.2	32.50	54.11(54.24)	23.81(23.72)	3.92(3.98)
D03		H	190.4 ~ 192.0	31.50	38.73(38.81)	12.85(12.93)	2.37(2.33)
E01		CH_3	114.4 ~ 115.4	47.20	53.29(53.33)	15.73(15.55)	4.59(4.48)
E02		C_2H_5	64.2 ~ 64.9	50.30	55.60(55.67)	14.45(14.43)	5.23(5.19)
E03		n-C_3H_7	45.2 ~ 45.4	52.40	57.62(57.69)	13.57(13.45)	5.73(5.81)
E04		i-C_3H_7	45.3 ~ 46.3	69.80	57.74(57.69)	13.48(13.45)	5.85(5.81)
E05		$CH_2CH=CH_2$	65.3 ~ 65.6	46.00	58.16(58.25)	13.66(13.59)	4.92(4.89)
E06		n-C_4H_9	41.8 ~ 42.5	56.80	59.52(59.45)	12.46(12.60)	6.32(6.37)
E07		sec-C_4H_9	33.3 ~ 33.8	57.00	59.56(59.45)	12.71(12.60)	6.28(6.35)
E08		i-C_4H_9	84.1 ~ 84.5	41.80	59.43(59.45)	12.61(12.60)	6.38(6.35)
E09		$CH_2CH_2CH=CH_2$	48.7 ~ 49.2	43.76	60.03(59.99)	12.60(12.72)	5.57(5.49)
E10		i-C_5H_{11}	46.5 ~ 47.0	56.00	61.13(61.00)	11.73(11.86)	6.88(6.83)
E11		CH_3	145.4 ~ 146.9	46.90	56.50(56.54)	22.06(21.98)	4.66(4.74)
E12		C_2H_5	76.8 ~ 77.1	48.60	58.45(58.53)	20.34(20.48)	5.44(5.40)
E13		n-C_3H_7	68.5 ~ 69.0	51.60	60.31(60.26)	19.28(19.17)	5.89(5.98)
E14		i-C_3H_7	84.2 ~ 85.2	60.00	60.23(60.26)	19.11(19.17)	6.01(5.98)
E15		$CH_2CH=CH_2$	56.7 ~ 57.5	59.10	60.89(60.82)	19.32(19.34)	5.17(5.10)
E16		n-C_4H_9	56.5 ~ 57.4	59.00	61.71(61.79)	18.08(18.01)	6.41(6.48)
E17		sec-C_4H_9	60.6 ~ 61.0	46.20	61.68(61.79)	18.10(18.01)	6.39(6.48)
E18		i-C_4H_9	76.6 ~ 77.1	42.30	61.83(61.79)	17.97(18.01)	6.56(6.48)
E19		i-C_5H_{11}	83.7 ~ 84.8	75.00	63.02(63.14)	17.03(16.99)	6.85(6.93)
E20		CH_3	112.2 ~ 112.8	69.30	41.78(41.65)	12.02(12.14)	3.09(3.06)

续表 1(Continued table 1)

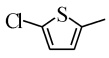
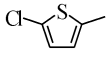
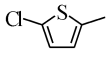
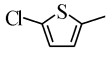
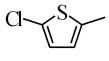
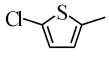
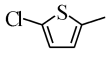
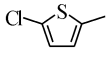
化合物 Compd.	R^1	R	熔点 m. p. /℃ or n_D^{31}	收率 Yield/%	元素分析(计算值)/% Elemental analysis(Calcd.)/%		
					C	N	H
E21		C_2H_5	76.0 ~ 76.8	72.70	44.29(44.18)	11.31(11.45)	3.63(3.71)
E22		*n*-C_3H_7	66.6 ~ 67.4	66.90	46.30(46.42)	10.92(10.83)	4.21(4.29)
E23		*i*-C_3H_7	84.9 ~ 85.4	58.70	46.53(46.42)	10.75(10.83)	4.26(4.29)
E24		$CH_2CH=CH_2$	78.8 ~ 79.5	63.60	46.64(46.79)	10.97(10.91)	3.45(3.53)
E25		*n*-C_4H_9	n 31*D* = 1.6572	70.90	48.37(48.44)	10.35(10.27)	4.73(4.80)
E26		*sec*-C_4H_9	n 31*D* = 1.6585	64.30	48.52(48.44)	10.18(10.27)	4.85(4.80)
E27		*i*-C_4H_9	99.5 ~ 100.0	66.70	48.49(48.44)	10.21(10.27)	4.88(4.80)
E28		*i*-C_5H_{11}	75.2 ~ 76.8	58.20	50.12(50.26)	9.90(9.77)	5.18(5.27)

表 2 化合物 D 和 E 的核磁共振氢谱数据

Table 2 ^{1}H NMR data of compounds **D** and **E**

化合物 Compd.	^{1}H NMR ($CDCl_3$/TMS), δ
D01	4.74(s,2H,OCH_2),6.49 ~ 6.50(m,1H,furanylH-4),6.87(d,1H,*J* = 2.70 Hz,furanylH-3),7.53(d,1H,furanyl H-5,*J* = 1.75 Hz),8.59(s,1H,NH)
D02	4.82(s,2H,OCH_2),7.48 ~ 7.52(m,1H,pyridinylH-5),8.11(d,1H,*J* = 8.10 Hz,pyridinylH-4),8.67(d,1H,*J* = 3.30 Hz,pyridinylH-6),8.93(s,1H,pyridinylH-2),11.24(s,1H,NH)
D03	4.76(s,2H,OCH_2),6.89(d,1H,*J* = 3.90 Hz,thiophenylH-3),7.26(d,1H,*J* = 3.90 Hz,thiophenylH-4),8.32(s,1H,NH)
E01	3.40(s,3H,CH_3),4.68(s,2H,OCH_2),6.48 ~ 6.49(m,1H,furanylH-4),6.85(d,1H,*J* = 3.00 Hz,furanylH-3),7.53(d,1H,*J* = 1.80 Hz,furanylH-5)
E02	1.28(t,3H,*J* = 7.20 Hz,CH_3),3.80 ~ 3.87(m,2H,N − CH_2),4.66(s,2H,OCH_2),6.47 − 6.49(m,1H,furanylH-4),6.84(d,1H,*J* = 3.00 Hz,furanylH-3),7.53(d,1H,*J* = 1.80 Hz,furanylH-5)
E03	0.91(t,3H,*J* = 7.30 Hz,CH_3),1.69 ~ 1.76(m,2H,CH_2),3.72(t,3H,*J* = 7.35 Hz,N − CH_2),4.64(s,2H,OCH_2),6.47 ~ 6.49(m,1H,furanylH-4),6.84(d,1H,*J* = 3.60 Hz,furanylH-3),7.50(d,1H,*J* = 1.75 Hz,furanylH-5)
E04	1.29(d,6H,*J* = 6.90 Hz,CH_3),4.64(s,2H,OCH_2),4.86 ~ 4.95(m,1H,CH),6.47 ~ 6.49(m,1H,furanylH-4),6.84(d,1H,*J* = 3.70 Hz,furanylH-3),7.52(d,1H,*J* = 1.80 Hz,furanylH-5)
E05	4.38(d,2H,*J* = 5.70 Hz,CH_2),4.69(s,2H,OCH_2),5.21 ~ 5.32(m,2H, = CH_2),5.86 ~ 5.95(m,1H, = CH),6.46 ~ 6.48(m,1H,furanylH-4),6.84(d,1H,*J* = 3.70 Hz,furanylH-3),7.51(d,1H,*J* = 1.80 Hz,furanylH-5)
E06	0.95(t,3H,*J* = 7.20 Hz,CH_3),1.32 ~ 1.40(m,2H,CH_2),1.65 ~ 1.73(m,2H,CH_2),3.78(t,2H,*J* = 7.35 Hz,N − CH_2),4.67(s,2H,OCH_2),6.49 ~ 6.50(m,1H,furanylH-4),6.85(d,1H,*J* = 3.30 Hz,furanylH-3),7.54(d,1H,*J* = 1.80 Hz,furanylH-5)
E07	0.86(t,3H,*J* = 7.30 Hz,CH_3),1.27(d,3H,*J* = 7.10 Hz,CH_3),1.54 ~ 1.85(m,2H,CH_2),4.62 ~ 4.71(m,1H,CH),4.66(s,2H,OCH_2),6.47 ~ 6.48(m,1H,furanylH-4),6.84(d,1H,*J* = 3.30 Hz,furanylH-3),7.53(d,1H,*J* = 1.90 Hz,furanylH-5)
E08	0.95(d,6H,*J* = 5.10 Hz,CH_3),2.19 ~ 2.21(m,1H,CH),3.61(d,2H,*J* = 6.30 Hz,N − CH_2),4.69(s,2H,OCH_2),6.49 ~ 6.51(m,1H,furanylH-4),6.87(d,1H,*J* = 3.40 Hz,furanylH-3),7.54(d,1H,*J* = 1.70 Hz,furanylH-5)

续表 2(Continued table 2)

化合物 Compd.	^{1}H NMR ($CDCl_3$/TMS), δ
E09	2.44 ~ 2.51(m,2H,CH_2),3.85(t,J = 7.20 Hz,2H,N − CH_2),4.65(s,2H,OCH_2),5.02 ~ 5.13(m,2H, = CH_2),5.74 ~ 5.83(m,1H, = CH),6.48 − 6.49(m,1H,furanylH-4),6.84(d,1H,J = 3.30 Hz,furanylH-3),7.53(d,1H,J = 1.80 Hz,furanylH-5)
E10	0.93(d,6H,J = 6.00 Hz,CH_3),1.58 − 1.62(m,3H,CH and CH_2),3.78(t,2H,J = 7.20 Hz,N − CH_2),4.65(s,2H,OCH_2),6.47 ~ 6.49(m,1H,furanylH-4),6.84(d,1H,J = 3.00 Hz,furanylH-3),7.52(t,1H,J = 1.80 Hz,furanylH-5)
E11	3.40(s,3H,CH_3),4.76(s,2H,OCH_2),7.34 ~ 7.38(m,1H,pyridinylH-5),8.15(d,1H,J = 8.10 Hz,pyridinylH-4),8.67(d,1H,J = 3.30 Hz,pyridinylH-6),9.06(s,1H,pyridinylH-2)
E12	1.30(t,3H,J = 7.20 Hz,CH_3),3.81 ~ 3.88(m,2H,CH_2),4.74(s,2H,OCH_2),7.34 ~ 7.38(m,1H,pyridinylH-5),8.15(d,1H,J = 8.10 Hz,pyridinylH-4),8.67(d,1H,J = 3.30 Hz,pyridinylH-6),9.08(s,1H,pyridinylH-2)
E13	0.95(t,3H,J = 7.3 5Hz,CH_3),1.72 ~ 1.79(m,2H,CH_2),3.75(t,2H,J = 7.20 Hz,N − CH_2),4.75(s,2H,OCH_2),7.35 ~ 7.38(m,1H,pyridinylH-5),8.15(d,1H,J = 8.10 Hz,pyridinylH-4),8.66(d,1H,J = 3.00 Hz,pyridinylH-6),9.07(s,1H,pyridinlylH-2)
E14	1.30(d,6H,J = 6.60 Hz,CH_3),4.75(s,2H,OCH_2),4.91 ~ 5.00(m,1H,CH),7.38 ~ 7.42(m,1H,pyridinylH-5),8.18(d,1H,J = 8.10 Hz,pyridinylH-4),8.68(d,1H,J = 4.80 Hz,pyridinylH-6),9.11(s,1H,pyridinylH-2)
E15	4.41(d,2H,J = 6.00 Hz,CH_2),4.80(s,2H,OCH_2),5.26 ~ 5.36(m,2H, = CH_2),5.90 ~ 5.99(m,1H, = CH),7.36 ~ 7.40(m,1H,pyridinylH-5),8.15(d,1H,J = 8.10 Hz,pyridinylH-4),8.68(d,1H,J = 3.60 Hz,pyridinylH-6),9.08(s,1H,pyridinylH-2)
E16	0.96(t,3H,J = 7.35 Hz,CH_3),1.35 ~ 1.43(m,2H,CH_2),1.67 ~ 1.74(m,2H,CH_2),3.80(t,2H,J = 7.05 Hz,N − CH_2),4.75(s,2H,OCH_2),7.35 ~ 7.39(m,1H,pyridinylH-5),8.15(d,1H,J = 8.10 Hz,pyridinylH-4),8.67(d,1H,J = 3.30 Hz,pyridinylH-6),9.08(s,1H,pyridinylH-2)
E17	0.90(t,3H,J = 7.50 Hz,CH_3),1.29(d,3H,J = 6.60 Hz,CH_3),1.57 ~ 1.86(m,2H,CH_2),4,67 ~ 4.78(m,1H,CH),4.78(s,2H,OCH_2),7.45 ~ 7.49(m,1H,pyridinylH-5),8.25(d,1H,J = 8.10 Hz,pyridinylH-4),8.70(d,1H,J = 4.50 Hz,pyridinylH-6),9.12(s,1H,pyridinylH-2)
E18	0.98(d,6H,J = 5.70 Hz,CH_3),1.59 ~ 1.68(m,1H,CH),3.81(d,2H,J = 7.50 Hz,N − CH_2),4.75(s,2H,OCH_2),7.36 ~ 7.40(m,1H,pyridinylH-5),8.16(d,1H,J = 8.10 Hz,pyridinylH-4),8.69(d,1H,J = 4.80 Hz,pyridinylH-6),9.09(s,1H,pyridinylH-2)
E19	0.97(d,6H,J = 5.70 Hz,CH_3),1.59 ~ 1.68(m,3H,CH and CH_2),3.82(t,2H,J = 6.90 Hz,N − CH_2),4.75(s,2H,OCH_2),7.36 ~ 7.40(m,1H,pyridinylH-5),8.16(d,1H,J = 8.10 Hz,pyridinylH-4),8.69(d,1H,J = 4.80 Hz,pyridinylH-6),9.09(s,1H,pyridinylH-2)
E20	3.35(s,3H,CH_3),4.69(s,2H,OCH_2),6.87(d,1H,J = 3.90 Hz,thiophenylH-3),7.24(d,1H,J = 3.90 Hz,thiophenylH-4)
E21	1.30(t,3H,J = 7.20 Hz,CH_3),3.78 ~ 3.85(m,2H,CH_2),4.70(s,2H,OCH_2),6.89(d,1H,J = 3.90 Hz,thiophenylH-3),7.26(d,1H,J = 3.90 Hz,thiophenylH-4)
E22	0.93(t,3H,J = 7.35 Hz,CH_3),1.67 ~ 1.74(m,2H,CH_2),3.67(t,2H,J = 7.05 Hz,CH_2),4.66(s,2H,OCH_2),6.84(d,1H,J = 3.90 Hz,thiophenylH-3),7.20(d,1H,J = 3.90Hz,thiophenylH-4)
E23	1.30(d,6H,J = 6.60 Hz,CH_3),4.71(s,2H,OCH_2),4.91 ~ 4.96(m,1H,CH),6.91(d,1H,J = 3.90 Hz,thiophenylH-3),7.27(d,1H,J = 3.90 Hz,thiophenylH-4)
E24	4.33(d,2H,J = 5.70Hz,CH_2),4.70(s,2H,OCH_2),5.22 ~ 5.32(m,2H, = CH_2),5.85 ~ 5.94(m,1H, = CH),6.86(d,1H,J = 3.90 Hz,thiophenylH-3),7.23(d,1H,J = 4.20Hz,thiophenylH-4)
E25	0.93(t,3H,J = 7.35Hz,CH_3),1.33 ~ 1.35(m,2H,CH_2),1.62 ~ 1.67(m,2H,CH_2),3.65(t,2H,J = 7.20Hz,CH_2),4.64(s,2H,OCH_2),6.84(d,1H,J = 3.90 Hz,thiophenylH-3),7.20(d,1H,J = 3.90 Hz,thiophenylH-4)
E26	0.87(t,3H,J = 7.35 Hz,CH_3),1.24(d,3H,J = 6.60 Hz,CH_3),1.53 ~ 1.77(m,2H,CH_2),4.60 ~ 4.68(m,3H,CH and OCH_2),6.87(d,1H,J = 3.90 Hz,thiophenylH-3),7.22(d,1H,J = 3.90 Hz,thiophenylH-4)
E27	0.94(d,6H,J = 6.60 Hz,CH_3),2.11 ~ 2.16(m,1H,CH),3.55(d,2H,J = 7.20 Hz,CH_2),4.68(s,2H,OCH_2),6.87(d,1H,J = 3.90 Hz,thiophenylH-3),7.22(d,1H,J = 3.90 Hz,thiophenylH-4)
E28	0.95(d,6H,J = 6.30 Hz,CH_3),1.56 ~ 1.63(m,3H,CH and CH_2),3.75(t,2H,J = 7.05 Hz,CH_2),4.67(s,2H,OCH_2),6.87(d,1H,J = 3.90 Hz,thiophenylH-3),7.22(d,1H,J = 3.90 Hz,thiophenylH-4)

2.2 除草活性

测定结果见表3。可以看出,部分化合物对马唐和苋菜具有明显的除草活性。与课题组曾经研究过的2-位上为取代苯基和取代苯乙烯基的化合物比较,可以发现,2-位上取代基不同,表现出的生物活性不同:如为取代苯基时,化合物具有一定的杀菌活性[3];为取代苯乙烯基时,表现出一定的杀虫活性[4];而本文报道的2-位上为杂环基时,化合物表现出的则是除草活性。除草活性的大小则与4-位的取代基**R**有一定关系:当**R**为H时,化合物均无活性;当R为烯丙基时,化合物的活性均小于90%;而当R为供电子基团时,化合物活性均大于90%。此类化合物深入的结构-活性关系值得进一步研究。

表3 部分化合物在200 mg/L下的除草活性(抑制率/%) *

Table 3 Herbicidal activity of some compounds at 200 mg/L (Inhibition rate/%) *

化合物 Compd.	株高/根长 Shoot/Root		化合物 Compd.	株高/根长 Shoot/Root	
	马唐 *Digitaria sanguinalis*	苋菜 *Ambrosia tricolor*		马唐 *Digitaria sanguinalis*	苋菜 *Ambrosia tricolor*
E02	40/40	65/65	**E15**	45/30	75/75
E03	50/50	75/75	**E16**	90/90	90/90
E04	20/20	70/70	**E17**	50/50	75/75
E05	20/20	75/75	**E18**	75/75	75/75
E06	75/75	90/90	**E19**	70/70	75/75
E07	30/30	90/90	**E20**	95/95	90/90
E08	20/20	75/75	**E21**	90/90	85/85
E09	35/25	75/75	**E22**	70/70	60/60
E10	25/20	90/90	**E23**	10/15	70/70
E12	55/65	65/65	**E24**	70/70	70/78
E13	50/60	70/75	**E25**	65/65	30/30
E14	90/90	90/90	**E26**	5/5	60/60

* 未列出化合物在测试浓度下均无活性。* There is no activity for the unlisted compounds at the tested concentration.

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