# Supporting Information

# Synthesis and biological evaluation of novel of 1, 5-diaryl-1, 4-pentadien- 3-one derivatives containing phenolic ethers group

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## 1. General methods.

The melting points of the products were determined on a XT-4 binocular microscope (Beijing Tech Instrument Co., China) and were not corrected. The IR spectra were recorded on a Bruker VECTOR 22 spectrometer in KBr disk. $^{1}H$, $^{13}C$ and $^{31}P$ NMR (solvent $CDCl_3$ or $D_3CCOCD_3$ or DMSO-$d_6$) spectral analyses were performed on a JEOL-ECX 500 NMR spectrometer at room temperature using TMS as an internal standard. The following abbreviations were used to designate chemical shift multiplicities: s = singlet, d = doublet, t = triplet, m = multiplet, br = broad. All first-order splitting patterns were assigned on the basis of the appearance of the multiplet, Splitting patterns that could not be easily interpreted were designated as multiplet (m) or broad (br). Elemental analysis was performed on an Elementar Vario-III CHN analyzer. Analytical TLC was performed on silica gel $GF_{254}$. Column chromatographic purification was carried out using silica gel. Commercial reagents were used as received, unless otherwise indicated. Reactions were performed under a positive pressure of dry argon in oven-dried or flame-dried glassware equipped with a magnetic stir bar. Standard inert atmosphere techniques were used in handling all air and moisture sensitive reagents. DCM was freshly distilled from $CaH_2$.

## 2. Materials

High speed centrifuge 3-18K (SIGMA, American), Electronic analytical balance CP64(Sartorius, Germany), $CO_2$ incubator (SANYO, Japan), -20 °C, -80 °C ultra cold freezer (SANYO, Japan), 96 well plates ELIASA BIO-RAD680(BIO-RAD, American), PowerPac300 electrophresis apparatus(BIO-RAD, American), Gel imaging system(BIO-RAD, American), IX71SIF-3 fluorescence microscope (OLYPUS, Japan), Flow cytometer FACS-CALIBUR(BD, American).

RPMI 1640 culture media (GIBICO, American), Trypsin (SIGMA, American), 96 well plates (Corning Incorporated, American). The standard compounds Adriamycin (ADM, Zhejiang Hisun Pharmaceutical Co. Ltd, China) and Hydroxycamptothecin (HCPT, Wuhan Lishizhen Pharmaceutical Co. Ltd, China) were made for comparison for activity. PC3 cells, BGC-823 cells, Bcap-37 cells (Institute of Biochemistry and Cell Biology, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences, Shanghai).

**3. General Procedure for the Preparation of the Intermediates 3a-f**. To a solution of NaOH (13.25 mmol) in $H_2O$ (25 mL) was added with stirring a solution of substituted benzaldehyde (10 mmol) and 4-(2-hydroxyphenyl)-3-butene-2-ones or 4-(4-hydroxyphenyl) -3-butene-2-one **2** (10.0 mmol) in EtOH (50 mL) at 5-10 °C for 3 hours. The mixture immediately turned red and the stirring was continued for 7h at room temperature. Water (200mL) was added and the resulting purple solution was neutralized by gently bubbling $CO_2$ through it about 45 min. The resulting precipitate was filtered and washed with water, dried. The solid was purified by thin layer chromatography with silica gel (ethyl acetate/dichloromethane/petroleum ether, v:v:v = 2:1:1) to afford intermediates **3**.

Data for (1E, 4E)-1-(2,3-dichlorophenyl)-5-(4-hyoxylphenyl)-1,4-pentadien-3-one (**3a**). Yellow solid; yield, 51%; m.p. 183~185 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 3408, 1673, 1602, 1558, 1508, 1411, 1168, 981, 813; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.09 (d, *J*=16.0 Hz, 1H, Ar(OH)CH=), 7.71 (d, *J*=16.0 Hz, 1H, Ar(Cl)CH=), 7.61~6.84 (m, 7H, Ar-H), 6.99 (d, *J*=16.0 Hz, 1H, Ar(OH)C=CH), 6.96 (d, *J*=16.0 Hz, 1H, Ar(2Cl)C=CH); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.4, 161.0, 141.3, 136.9, 135.5, 133.0, 132.1, 131.3, 129.3, 128.8, 127.1, 125.8, 123.4, 116.5, 116.4.

(1E, 4E)-1-(2,3-dichlorophenyl)-5-(2-hyoxylphenyl)-1,4-pentadien-3-one (**3b)**. Yellow solid; yield, 58%; m.p. 122~124 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 3282, 1641, 1558, 1448, 1409, 1340, 1097, 985, 750; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 10.24 (s, 1H, OH), 7.99~6.82 (m, 7H, Ar-H), 7.97 (d, *J*=16.0 Hz, 1H, Ar(OH)CH=), 7.89 (d, *J*=16.0 Hz, 1H, Ar(2Cl)CH=), 740 (d, *J*=16.0 Hz, 1H, Ar(OH)C=CH), 7.27 (d, *J*=16.0 Hz, 1H, Ar(2Cl)C=CH); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.7, 158.0, 140.1, 137.1, 135.6, 133.0, 132.6, 132.3, 130.2, 129.7, 129.0, 127.4, 125.9, 121.6, 119.9, 116.9.

(1E, 4E)-1-(2-fluorophenyl)-5-(2-hyoxylphenyl)-1,4-pentadien-3-one (**3c**). Yellow solid; yield, 56%; m.p. 124~126 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 3413, 1639, 1566, 1458, 1346, 1251, 1111, 989, 759; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.20 (d, J=16.0 Hz, 1H, Ar(OH)CH=), 7.92~6.89 (m, 8H, Ar-H), 7.90 (d, *J*=16.0 Hz, 1H, Ar(F)CH=), 7.34 (d, *J*=16.0 Hz, 1H, Ar(OH)C=CH), 7.26 (d, *J*=16.0 Hz, 1H, Ar(F)C=CH); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 191.3, 156.8, 141.3, 136.4, 132.3, 132.1, 132.0, 129.6, 129.4, 125.7, 124.6, 123.0, 121.9, 120.5, 116.9, 116.4, 116.2.

(1E, 4E)-1-(2-fluorophenyl)-5-(4-hyoxylphenyl)-1,4-pentadien-3-one (**3d**). Yellow solid; yield, 53%, m.p. 135~137 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 3261, 1600, 1556, 1512, 1435, 1166, 1111, 993, 758; $^1H$ NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 7.84 (d, *J*=16.0 Hz, 1H, Ar(OH)CH=), 7.72 (d, *J*=15.5 Hz, 1H, Ar(F)CH=), 7.62~6.90 (m, 8H, Ar-H), 7.17 (d, *J*=16.0 Hz, 1H, Ar(OH)C=CH), 6.96 (d, *J*=15.5 Hz, 1H, Ar(F)C=CH); $^{13}C$ NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 189.6, 158.6, 144.3, 136.0, 131.9, 131.8, 130.7, 129.5, 127.9, 127.7, 127.2, 124.6, 122.9, 116.4, 116.2.

(1E, 4E)-1-(4-fluorophenyl)-5-(4-hyoxylphenyl)-1,4-pentadien-3-one (**3e**) Yellow solid; yield, 52%, m.p. 170~172 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 3153, 1641, 1566, 1508, 1286, 1193, 1155, 985, 825; $^1H$ NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 7.69 (d, *J*=16.0 Hz, 1H, Ar(OH)CH=), 7.68 (d, *J*=16.0 Hz, 1H, Ar(F)CH=), 7.60~6.80 (m, 8H, Ar-H), 7.26 (d, *J*=16.0 Hz, 1H, Ar(OH)C=CH), 7.06 (d, *J*=16.0 Hz, 1H, Ar(F)C=CH); $^{13}C$ NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.7, 160.6, 143.8, 141.2, 132.0, 131.3, 131.2, 131.1, 126.2, 126.1, 123.0, 116.6, 116.5, 116.4.

(1E, 4E)-1-(2-furanyl)-5-(2-hydroxyphenyl)-1, 4-pentadiene-3-one **(3f)**. Yellow solid; yield, 56.2%, m.p. 164~166 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 3130, 1634, 1558, 1478, 1324, 1147, 1130, 1017, 752. $^1H$ NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.06 (d, *J*=16.5 Hz, 1H, $H_2Fu$), 7.58~7.54 (m, 3H, $H_6$(Ar), ArCH=, FuCH=), 7.24 (t, *J*=12.0 Hz, 1H, $H_4$(Ar)), 7.16 (d, *J*=16.0 Hz, 1H, $H_4Fu$), 6.99~6.92 (m, 3H, $H_5$(Ar), ArC=CH, FuC=CH), 6.74 (d, *J*=5.5 Hz, 1H, $H_3$(Ar)), 6.41 (t, *J*=2.75 Hz, 1H, $H_3Fr$); $^{13}C$ NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 191.0, 156.9, 150.6, 146.0, 138.5, 132.8, 130.6, 128.4, 127.8, 121.4, 122.7, 121.9, 117.7, 116.9, 112.3.

**4. General Procedure for the Preparation of the Title Compounds 4**. RX (1.2 mmol) in 5 mL of acetone was added slowly with constant stirring to a 50 mL three necked round bottom flask containing the intermediates **2** (1.0 mmol) and anhydrous KI (0.0288 g, 0.174 mmol)) and anhydrous acetone (20 mL). The reaction mixture was refluxed for 2 h, then cooled down to room temperature. The solvent was removed under reduced pressure and the crude product was further purified by flash chromatography on silica gel using petroleum ether: acetone (2:1) to gave the pure products **4**.

Data for the title compound 4-**{**[5-(2, 3-dichlorophenyl)-3-one-1, 4-pentadieneyl]-phenoxy**}** ethyl acetate **(4A).** Yellow solid, 100~101 °C; yield: 67%; IR (KBr, , $cm^{-1}$): $\nu_{max}$

1749, 1668, 1618, 1602, 1585, 1571, 1510, 1452, 1425, 1340, 1313, 1286, 1207, 1184 ,1116, 1095, 1074, 987, 815, 785, 729, 590; $^{1}$H-NMR (500 MHz, $CDCl_3$) $\delta$: 8.07 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.70 (d, $J$=16.0 Hz, 1H,Ar(Cl)CH=), 7.60~6.96 (m, 7H, Ar-H), 7.02 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$) C=CH), 6.94 (d, $J$=16.0 Hz, 1H, ArC(2Cl)C=CH), 4.66 (s, 2H, -$CH_2$), 4.27 (q, $J$=7.2 Hz ,2H, -$COCH_2$) 1.29 (t, $J$=7.2 Hz, 3H, -$CH_3$); $^{13}$C-NMR (125 MHz, $CDCl_3$) $\delta$: 188.5, 168.5, 159.9, 143.6, 138.6, 135.6, 134.1, 133.4, 131.6, 130.3, 129.3, 128.4, 127.5, 125.9, 123.3, 115.2, 65.3, 61.6, 14.3; Anal. Calcd. for $C_{21}H_{18}C_2lO_4$: C, 62.24; H, 4.48; Found: C, 62.00; H, 4.53.

Data for the title compound 1-[4-(4-nitrobenzyloxyphenyl]-5-(4-fluorophenyl)-1, 4-pentadiene-3-one (**4B**). Yellow crystal, yield, 78%, m.p. 170~171 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 1666, 1618, 1606, 1516, 1348, 1263, 1186, 1101, 995, 817, 750; $^{1}$H NMR (500 MHz, $CDCl_3$) $\delta$: 7.82 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.69 (d, $J$=16.0 Hz, 1H, Ar(F)CH=), 8.26~6.99 (m, 12H, Ar-H), 7.15 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 6.95 (d, $J$=16.0 Hz, 1H, Ar(F)C=CH), 5.21 (s, 2H, -$OCH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.9, 160.1, 143.9, 143.1, 135.6, 131.9, 130.3, 129.4, 128.3, 127.9, 127.7, 124.6, 124.0, 123.7, 116.4, 116.2, 115.3, 68.7; Anal. Calcd. for $C_{24}H_{18}FNO_4$: C, 71.46; H, 4.50; N, 3.47; Found: C, 71.59; H, 4.57; N, 3.26.

Data for the title compound 1-[2-(2-nitrobenzyloxyphenyl]-5-(2-fluorophenyl)-1, 4-pentadiene-3-one (**4C**). Yellow crystal, yield, 71%, m.p. 144~146 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 1654, 1600, 1521, 1487, 1456, 1348, 1323, 1186, 985, 750, 578; $^{1}$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.13 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.74 (d, $J$=16.0 Hz, 1H, Ar(F)CH=), 7.61~6.98 (m, 12H, Ar-H), 7.64 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 7.16 (d, $J$=16.0 Hz, 1H, Ar(F)C=CH), 5.25 (s, 2H, -$OCH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 189.5, 162.6, 157.0, 147.5, 143.9, 138.4, 135.8, 132.0, 131.9, 129.6, 129.0, 127.8, 127.7, 126.4, 124.7, 124.1, 124.0, 121.8, 116.4, 116.2, 112.5, 69.2; Anal. Calcd. for $C_{24}H_{18}FNO_4$: C, 71.46; H, 4.50; N, 3.47; Found: C, 71.25; H, 4.30; N, 3.31.

Data for the title compound 1-[4-(4-nitrobenzyloxyphenyl]-5-(4-chlorophenyl)-1, 4-pentadiene-3-one (**4D**). Yellow crystal, yield, 74%, m.p. 158~160 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 3086, 2856, 1647, 1587, 1247, 1159, 1170, 983, 825; $^{1}$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.26 (d, $J$=8.6 Hz, 2H, $H_2$, $H_6$, Ar($NO_2$)), 7.69 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.63 (d,

*J*=16.0 Hz, 1H, Ar(Cl)CH=), 7.61 (d, *J*=8.6 Hz, 2H, $H_3$, $H_5Ar(NO_2)$), 7.58 (d, *J*=8.6 Hz, 2H, $H_3$, $H_5Ar(Cl)$), 7.53 (d, *J*=8.8 Hz, 2H, $H_2$, $H_6Ar(Cl)$), 7.37 (d, *J*=8.0 Hz, 2H, $H_3$, $H_5Ar(OCH_2)$), 7.03 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$) C=CH), 6.99 (d, *J*=8.8 Hz, 2H, $H_2$, $H_6Ar(OCH_2)$), 6.94 (d, *J*=16.0 Hz, 1H, Ar(Cl)C=CH), 5.21 (s, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.6, 160.1, 147.8, 143.8, 143.1, 141.6, 136.4, 133.4, 130.3, 129.6, 129.3, 128.3, 127.7, 125.9, 124.0, 123.8, 115.3, 68.8; Anal. calcd for $C_{24}H_{18}NClO$: C, 68.66; H, 4.32; N, 3.34; Found: C, 68.64; H, 4.32; N, 3.20.

Data for the title compound 1-[2-(4-mthylbenzyloxyphenyl]-5-(4-chlorophenyl)-1, 4-pentadiene-3-one (**4E**). Yellow crystal, yield, 78%, m.p. 215~217 °C; IR (KBr, cm$^{-1}$): $\nu_{max}$ 2920, 1651, 1612, 1489, 1089, 1012, 752; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.04 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.51 (d, *J*=16.0 Hz, 1H, Ar(Cl)CH=), 7.60~6.98 (m, 12H, Ar-H), 7.02 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$) C=CH), 6.96 (d, *J*=16.0 Hz, 1H, Ar(Cl)C=CH), 5.15 (s, 2H, -$CH_2$), 2.38 (s, 3H, -$CH_3$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 189.6, 158.1, 141.2, 139.4, 138.0, 136.2, 133.6, 133.5, 131.8, 130.0, 129.5, 129.4, 129.3, 129.2, 127.7, 127.5, 126.3, 126.1, 124.0, 121.2, 112.8, 70.6, 21.3; Anal. calcd for $C_{25}H_{21}ClO_2$: C, 77.21; H, 5.44; Found: C, 77.60; H, 5.70.

Data for the title compound 1-[4-(2-chlorobenzyloxyphenyl]-5-(4-chlorophenyl)-1, 4-pentadiene-3-one (**4F**). Yellow crystal, yield, 76%; m.p. 120~121 °C; IR (KBr, cm$^{-1}$): $\nu_{max}$ 1649, 1510, 1255, 1172, 983, 825; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 7.71 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.66 (d, *J*=16.0 Hz, 1H, Ar(Cl)CH=), 7.58~6.92 (m, 12H, Ar-H), 7.04 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 6.94 (d, *J*=16.0 Hz, 1H, Ar(Cl)C=CH), 5.21 (s, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.6, 160.6, 143.3, 141.4, 136.3, 134.1, 133.4, 132.7, 131.2, 130.3, 129.7, 129.5, 129.3, 128.8, 128.5, 127.9, 127.1, 125.9, 123.5, 67.3; Anal. calcd for $C_{24}H_{18}Cl_2O_2$: C, 70.43; H, 4.43; Found: C, 70.06; H, 4.84.

Data for the title compound 1-[4-(4-methylbenzyloxyphenyl]-5-(2, 3-dichlorophenyl)-1, 4-pentadiene-3-one (**4G**)**.** Yellow crystal, yield, 69%; m.p. 149~150 °C; IR (KBr, cm$^{-1}$): $\nu_{max}$ 1643, 1620, 1602, 1591, 1571, 1508, 1452, 1411, 1323, 1242, 1174, 1004, 979, 819, 796, 582, 520; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.07 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.71 (d, *J*=16.0 Hz, 1H,Ar(Cl)CH=), 7.60~6.98 (m, 11H, Ar-H), 7.02 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$) C=CH), 6.96 (d, *J*=16.0 Hz, 1H, Ar(2Cl)C=CH), 5.06 (s, 2H, -$CH_2$), 2.36 (s, 3H, -$CH_3$); $^{13}$C

NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.6, 161.1, 144.0, 138.5, 138.1, 135.7, 134.1, 133.3, 131.6, 130.4, 130.2, 129.5, 129.4, 127.7, 127.5, 125.9, 122.8, 115.4, 70.1, 21.3; Anal. Calcd. for $C_{25}H_{20}Cl_2O_2$: C, 70.93; H, 4.76; Found: C, 70.80; H, 4.56.

Data for the title compound 1-[2-(4-methylbenzyloxyphenyl]-5-(4-chlorophenyl)-1, 4-pentadiene-3-one (**4H**). Yellow crystal, yield, 78%; m.p. 215~217 °C; IR (KBr, $cm^{-1}$): νmax 2920, 1651, 1612, 1489, 1089, 1012, 752; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.04 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.51 (d, *J*=16.0 Hz, 1H, Ar(Cl)CH=), 7.60~6.98 (m, 12H, Ar-H), 7.02 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$) C=CH), 6.96 (d, *J*=16.0 Hz, 1H, Ar(Cl)C=CH), 5.15 (s, 2H, -$CH_2$), 2.38 (s, 3H, -$CH_3$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 189.6, 158.1, 141.2, 139.4, 138.0, 136.2, 133.6, 133.5, 131.8, 130.0, 129.5, 129.4, 129.3, 129.2, 127.7, 127.5, 126.3, 126.1, 124.0, 121.2, 112.8, 70.6, 21.3; Anal. calcd for $C_{25}H_{21}ClO_2$: C, 77.21; H, 5.44; Found: C, 77.60; H, 5.70.

Data for the title compound 1-[2-(benzyloxyphenyl]-5-(4-chlorophenyl)-1, 4- pentadiene -3-one (**4I**). Yellow crystal, yield, 79%, m.p. 108~110 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 1641, 1622, 1242, 1182, 983, 813; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.08 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.54 (d, *J*=16.0 Hz, 1H, Ar(Cl)CH=), 7.62 (d, *J*=8.5 Hz, 1H, H(Ar($OCH_2$))), 7.46~6.98 (m, 12H, Ar-H), 7.20 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$)C=CH ), 7.00 (d, *J*=16.0 Hz, 1H, Ar(Cl)C=CH), 5.19 (s, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 189.5, 157.9, 141.4, 139.2, 136.7, 136.2, 133.5, 131.9, 129.7, 129.5, 129.2, 128.8, 128.3, 127.5, 126.3, 126.1, 124.1, 121.3, 112.8, 70.6; Anal. calcd for $C_{24}H_{19}ClO_2$: C, 76.90; H, 5.11; Found: C, 76.67; H, 5.13.

Data for the title compound 1-[2-(benzyloxyphenyl]-5-(2, 3-dichlorophenyl)-1, 4-pentadiene-3-one (**4J**). Yellow crystal, yield, 71%, m.p. 151~152 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 1651, 1604, 1587, 1508, 1490, 1249, 1195, 1172, 1016, 983, 738, 694; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.07 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.71 (d, *J*=16.0 Hz, 1H, Ar(2Cl)CH=), 7.60~6.98 (m, 11H, Ar-H), 7.08 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 6.93 (d, *J*=16.0 Hz, 1H, Ar(2Cl)C=CH), 5.11 (s, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.6, 161.1, 143.9, 138.5, 136.4, 135.7, 134.1, 133.4, 131.6, 130.4, 129.3, 128.8, 128.3, 127.6, 127.5, 125.9, 122.8, 115.4, 70.2; Anal. Calcd. for $C_{24}H_{17}Cl_2O_2$: C, 70.46; H, 4.43; Found: C, 70.26; H, 4.28.

Data for the title compound 1-[2-(2-chlorobenzyloxyphenyl]-5-(2, 3-dichlorophenyl)-1, 4- pentadiene- 3-one (**4K**). Yellow crystal, yield, 73%, m.p. 117~119 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$

1670, 1649, 1616, 1570, 1508, 1409, 1240, 1176, 1089, 989, 748; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.09 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.72 (d, $J$=16.0 Hz, 1H, Ar(2Cl)CH=), 7.61~6.97 (m, 11H, Ar-H), 7.01 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 7.00 (d, $J$=16.0 Hz, 1H, Ar(2Cl)C=CH), 5.22 (s, 2H, -$OCH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.5, 160.7, 144.5, 143.9, 138.5, 135.7, 134.1, 133.4, 132.7, 131.5, 130.4, 130.2, 129.5, 129.3, 128.8, 127.8, 127.4, 127.1, 125.9, 124.5, 122.9, 67.3; Anal. Calcd. for $C_{24}H_{17}Cl_3O_2$: C, 64.96; H, 3.86; Found: C, 64.68; H, 4.06.

Data for the title compound 1-[2-(4-fluorobenzyloxyphenyl]-5-(4-chlorophenyl)-1, 4-pentadiene-3-one (**4L**). Yellow crystal, yield, 67%, m.p. 97~99 °C; IR (KBr, cm$^{-1}$): $\nu_{max}$ 1649, 1593, 1224, 1186, 983, 813; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.06 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.54 (d, $J$=16.0 Hz, 1H, Ar(Cl)CH=), 7.62 (d, $J$=8.5 Hz, 1H, H(Ar($OCH_2$))), 7.46~6.95 (m, 11H, Ar-H), 7.17 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH ), 7.05 (d, $J$=16.0 Hz, 1H, Ar(Cl)C=CH), 5.14 (s, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 189.3, 157.8, 141.4, 139.0, 133.4, 132.4, 131.9, 131.8, 131.5, 131.0, 129.6, 129.5, 129.4, 126.2, 126.1, 124.1, 121.4, 115.8, 112.8, 69.9; Anal. calcd for $C_{24}H_{18}ClFO_2$: C, 73.38; H, 4.62; Found: C, 73.12; H, 4.56.

Data for the title compound 1-[2-(4-fluorobenzyloxyphenyl]-5-(2, 3-dichlorophenyl)-1, 4- pentadiene-3-one (**4M**). Yellow crystal, yield, 80%, m.p. 162~164 °C; IR (KBr, cm$^{-1}$): $\nu_{max}$ 1649, 1600, 1514, 1450, 1328, 1261, 1176, 1157, 1093, 977, 815, 777, 576; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.08 (d, $J$=16.0 Hz, 1H, Ar(OCH)CH=), 7.72 (d, $J$=16.0 Hz, 1H, Ar(Cl)CH=), 7.61~6.98 (m, 12H, Ar-H), 7.08 (d, $J$=16.0 Hz, 1H, Ar(OCH)CCH=), 6.93 (d, $J$=16.0 Hz, 1H, ArC=CH), 5.07 (s, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.6, 160.8, 143.9, 138.5, 135.7, 134.1, 131.6, 130.4, 130.2, 129.5, 129.4, 129.3, 127.7, 127.5, 125.9, 122.9, 115.8, 115.6, 115.4, 69.5; Anal. Calcd. for $C_{24}H_{18}Cl_2FO_2$: C, 67.46; H, 4.01; Found: C, 67.23; H, 4.31.

Data for the title compound 1-[2-(4-nitrobenzyloxyphenyl]-5-(2, 3-dichlorophenyl)-1, 4- pentadiene-3-one (**4N**). Yellow crystal, yield, 71%, m.p. 162~164 °C; IR (KBr, cm$^{-1}$): $\nu_{max}$ 3074, 1668, 1641, 1519, 1344, 1238, 1151, 1018, 979, 750, 570; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.14 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 8.03 (d, $J$=16.0 Hz, 1H, Ar(2Cl)CH=), 8.24~6.90 (m, 12H, Ar-H), 7.17 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 6.96 (d, $J$=16.0 Hz, 1H,

Ar(2Cl)C=CH), 5.27 (s, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 189.1, 157.0, 147.7, 143.9, 138.9, 138.8, 135.5, 134.1, 133.2, 131.1, 131.7, 129.2, 129.1, 127.7, 127.5, 127.4., 125.9, 125.8, 124.0, 121.8, 112.6, 69.2; Anal. Calcd. for $C_{24}H_{18}ClNO_4$: C, 63.45; H, 3.77; N, 3.08; Found: C, 63.44; H, 3.62; N, 3.04.

Data for the title compound 1-[2-(2-chlorobenzyloxyphenyl]-5-(2-fluorophenyl)-1, 4-pentadiene-3-one (**4O**). Yellow crystal, yield, 70%, m.p. 93~95 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 3070, 1653, 1598, 1489, 1323, 1244, 1190, 1031, 975, 750, 580; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.19 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.80 (d, $J$=16.0 Hz, 1H, Ar(F)CH=), 7.67~6.98 (m, 12H, Ar-H), 7.24 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 7.16 (d, $J$=16.0 Hz, 1H, Ar(F)C=CH), 5.29 (s, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 189.3, 157.4, 138.8, 135.9, 134.3, 132.6, 131.9, 131.7, 129.6, 129.5, 129.2, 128.8, 127.8, 127.7, 127.2, 126.4., 124.5, 124.2, 123.1, 121.5, 116.4, 116.2, 112.9, 67.7; Anal. Calcd. for $C_{24}H_{18}ClFO_2$: C, 73.38; H, 4.62; Found: C, 73.55; H, 4.57.

Data for the title compound 1-[2-(4-fluorobenzyloxyphenyl]-5-(4-chlorophenyl)-1, 4-pentadiene-3-one (**4P**). Yellow crystal, yield, 69%, m.p. 159~161 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 1649, 1587, 1234, 1193, 983, 825; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 7.71 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.67 (d, $J$=16.0 Hz, 1H, Ar(Cl)CH=), 7.57 (d, $J$=8.5 Hz, 2H, $H_2$, $H_6$(Ar(Cl))), 7.54 (d, $J$=8.0 Hz, 2H, $H_2$, $H_6$(Ar($CH_2O$))), 7.42~7.40 (m, 2H, $H_2$, $H_6$, (Ar(F))), 7.38 (d, $J$=8.5 Hz, 2H, $H_3$, $H_5$(Ar(Cl))), 7.08 (m, 2H, $H_3$, $H_5$(Ar($OCH_2$))), 7.04 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH)), 6.99 (d, $J$=8.5 Hz, 2H, $H_3$, $H_5$Ar(F)), 6.94 (d, $J$=16.0 Hz, 1H, Ar(Cl)C=CH), 5.07 (s, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.6, 163.7, 161.7, 160.8, 143.4, 141.5, 136.3, 133.2, 132.1, 131.6, 129.6, 128.5, 127.8, 126.3, 123.7, 115.3, 69.5; Anal. calcd for $C_{24}H_{18}ClFO_2$: C, 73.38; H, 4.62; Found: C, 73.26; H, 4.94.

Data for the title compound 1-[2-(4-fluorobenzyloxyphenyl]-5-(4-chlorophenyl)-1, 4-pentadiene-3-one (**4Q**). Yellow crystal, yield, 74%, m.p. 170~171 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 2920, 1666, 1624, 1598, 1510, 1259, 1234, 1174, 1105, 985, 853, 511; $^1$H NMR (500 MHz, $CDCl_3$) $\delta$: 7.70 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.68 (d, $J$=16.0 Hz, 1H, Ar(F)CH=), 7.57~6.98 (m, 12H, Ar-H), 6.99 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 6.94 (d, $J$=16.0 Hz, 1H, Ar(F)C=CH), 5.29 (s, 2H, -$OCH_2$), 1.62 (s, 3H, -$CH_3$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.7, 161.0, 143.3, 141.6, 138.1, 133.3, 131.2, 130.3, 130.2, 129.4, 127.7, 127.6, 125.3,

123.4, 116.2, 116.1, 115.4, 70.1, 21.3; Anal. Calcd. for $C_{25}H_{21}FO_2$: C, 66.87; H, 4.49; Found: C, 66.44; H, 4.16.

Data for the title compound 1-[2-(4-fluorobenzyloxyphenyl]-5-(4-fluorophenyl)-1, 4-pentadiene-3-one (**4R**). Yellow crystal, yield, 76%, m.p. 120~121 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 1668, 1620, 1696, 1514, 1346, 1263 ,1224, 1186, 1099, 955, 748, 547; $^1H$ NMR (500 MHz, $CDCl_3$) $\delta$: 7.85 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.71 (d, $J$=16.0 Hz, 1H, Ar(F)CH=), 7.63~6.98 (m, 12H, Ar-H), 7.61 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 7.40 (d, $J$=16.0 Hz, 1H, Ar(F)C=CH), 5.07 (s, 2H, -$OCH_2$); $^{13}C$ NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.8, 163.5, 161.6, 143.3, 135.4, 131.6, 130.2, 129.4, 129.3, 127.9, 127.7, 124.4, 123.3, 116.3, 116.1, 115.7, 115.5, 115.2, 114.4, 69.4; Anal. Calcd. for $C_{24}H_{18}F_2O_2$: C, 76.58; H, 4.82; Found: C, 76.63; H, 5.09.

Data for the title compound 1-[2-benzyloxyphenyl]-5-(4-fluorophenyl)-1, 4- pentadiene-3-one (**4S**). Yellow crystal, yield, 73%, m.p. 138~140 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 1651, 1583, 1508,1452, 1413, 1249, 1193, 1018, 983, 833, 738; $^1H$ NMR (500 MHz, $CDCl_3$) $\delta$: 7.85 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.68 (d, $J$=16.0 Hz, 1H, Ar(F)CH=), 7.61~6.98 (m, 13H, Ar-H), 6.94 (d, $J$=16.0 Hz, 2H, Ar($OCH_2$)C=CH, Ar(F)C=CH), 5.10 (s, 2H, -$OCH_2$); $^{13}C$ NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.7, 160.9, 143.3, 141.6, 136.4, 131.2, 130.4, 130.3, 128.7, 128.3, 127.7, 127.5, 125.3, 123.4, 116.2, 116.1, 115.4, 70.2; Anal. Calcd. for $C_{24}H_{18}F_2O_2$: C, 76.58; H, 4.82; Found: C, 76.63; H, 5.09.

Data for the title compound Ethyl {4-[5-(4-chlorophenyl)-3-one-1,4-pentadiene]} phenyl carbonate (**4T**). Yellow crystal, yield, 71%, m.p. 134~135 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 1651, 1593, 1506, 1490, 1369, 1269, 1228 ,1192, 1012, 983, 835; $^1H$ NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 7.72 (d, $J$=16.0 Hz, 1H, Ar(OCH)CH=), 7.72 (d, $J$=16.0 Hz, 1H, Ar(Cl)CH=), 7.66~7.24 (m, 8H, Ar-H), 7.04 (d, $J$=16.0 Hz, 1H, Ar(OCH)CCH=), 7.01 (d, $J$=16.0 Hz, 1H, ArCCH=), 4.35 (q, $J$=6.8 Hz 2H, -$CH_2$), 1.40 (t, $J$=6.8 Hz, 3H, -$CH_3$); $^{13}C$ NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.5, 169.7, 153.2, 152.7, 142.3, 142.0, 136.5, 133.3, 132.6, 129.6, 129.3, 125.8, 125.6, 121.7, 65.2, 14.2. Anal. Calcd. for $C_{20}H_{17}ClO_3$: C, 70.49; H, 5.03; Found: C, 70.24; H, 5.01.

Data for the title compound Benzyl {4-[5-(4-chlorophenyl)-3-one-1,4-pentadiene]} phenyl carbonate (**4U**). Yellow crystal, yield, 81%, m.p. 120~121 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 2990, 1716, 1654, 1589, 1489, 1269, 1228, 1193, 1089, 983, 833; $^1H$ NMR (500 MHz, $CDCl_3$, ppm) $\delta$:

7.71 (d, *J*=15.5 Hz, 1H, Ar($OCH_2$)CH=, Ar(Cl)CH= ), *δ*: 7.68 (d, *J*=15.5 Hz, 1H, Ar(Cl)CH= ), 7.62~7.24 (m, 13H, Ar-H), 7.04 (d, *J*=15.5 Hz, 1H, Ar($OCH_2$) C=CH), 7.01 (d, *J*=15.5 Hz,1H,Ar(Cl)C=CH), 5.29 (s, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) *δ*: 188.5, 153.2, 152.6, 142.3, 142.0, 136.5, 134.6, 133.3, 132.7, 131.2, 129.6, 129.3, 129.0, 128.8, 128.7, 125.7, 125.6, 121.7, 70.7; Anal. Calcd. for $C_{25}H_{19}ClO_4$: C, 71.69; H, 4.57; Found: C,71.38; H, 4.61.

Data for the title compound 1-(4-propargyloxygenphenyl)-5-(4-chlorophenyl)-1,4-pentadiene-3-one (**4V**). Yellow crystal, yield, 79%, m.p. 141~143 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 3300, 1664, 1620, 1257, 1178, 981, 821; $^1$H NMR (500 MHz, $CDCl_3$, ppm) *δ*: 7.70 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.66 (d, *J*=16.0 Hz, 1H, Ar(Cl)CH=), 7.57 (d, *J*=8.6 Hz, 2H, $H_2$, $H_6$Ar(Cl)), 7.52 (d, *J*=8.0 Hz, 2H, $H_2$, $H_6$Ar($OCH_2$)), 7.37 (d, *J*=8.0 Hz, 2H, $H_3$, $H_5$Ar($OCH_2$)), 7.57 (d, *J*=8.8 Hz, 2H, $H_3$, $H_5$Ar(Cl)), 7.02 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$) C=CH), 6.93 (d, *J*=16.0 Hz, 1H, Ar(Cl)C=CH), 4.73 (s, 2H, -$CH_2$), 2.55 (s, 1H, -$CH_2$CCH); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) *δ*: 188.5, 159.6, 143.2, 141.5, 136.3, 133.5, 130.2, 129.6, 129.3, 128.3, 125.9, 123.7, 115.4, 78.0, 76.1, 55.9; Anal. calcd for $C_{20}H_{15}ClO_2$: C, 74.42; H, 4.68; Found: C, 74.50; H, 4.73.

Data for the title compound 1-(2-(4-fluorobenzyloxyphenyl)-5-(2-furyl)-1, 4-pentadiene-3-one (**4W**). Yellow crystal, yield, 78%, m.p. 101~103 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 3051, 1643, 1622, 1570, 1512, 1489, 1340, 1222, 1182, 981,738, 580; $^1$H NMR (500 MHz, $CDCl_3$) *δ*: 8.05 (d, *J*=16.0 Hz, 1H, Ar(OCH)CH=), 7.39 (d, *J*=16.0 Hz, 1H, FrCH=), 7.62~6.98 (m, 11H, Ar-H, Fr-H), 7.11 (d, *J*=16.0 Hz, 1H, Ar($OCH_2$)CCH=), 6.94 (d, *J*=16.0 Hz, 1H, FrCCH=), 5.14 (s, 2H, -$OCH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) *δ*: 189.2, 161.6, 157.6, 151.6, 144.9, 138.5, 131.7, 129.5, 129.4, 129.3, 129.1, 126.8, 123.0, 124.2, 121.4, 115.8, 115.6, 112.8, 112.7, 69.9; Anal. Calcd. for $C_{22}H_{17}FO_3$: C, 75.85; H, 4.92; Found: C, 75.58; H, 4.53.

Data for the title compound 1-(2-benzyloxyphenyl)-5-(2-furyl)-1, 4-pentadien-3-one (**4X**). Yellow crystal, yield, 81%, m.p. 83~85 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 3134, 3030, 1647, 1618, 1598, 1548, 1477, 1450, 1390, 1311, 1247, 1215, 1174, 1022, 972, 875, 771, 754, 729, 594; $^1$H NMR (500 MHz, $CDCl_3$) *δ*: 8.08 (d, *J*=16.0 Hz, 1H, Ar(OCH)CH=), 7.60 (dd, $J_1$=8.0 Hz, $J_2$=1.1 Hz, 1H, $H_4$(Fr)), 7.50 (d, *J*=10.9 Hz, 1H, $H_4$ Ar($CH_2$)), 7.49 (d, *J*=16.0 Hz, 1H, FrCH=), 7.41 (d, $J_1$=7.4 Hz, $J_2$=8.5 Hz, 2H, $H_3$, $H_5$Ar($CH_2$)), 7.37~7.31 (m, 3H, Ar-H), 7.15 (d, *J*=16.0 Hz, 1H, Ar(OCH)CCH=), 6.99 (d, *J*=7.45 Hz, 2H, $H_2$,$H_6$, Ar($CH_2$)), 6.97 (d, *J*=16.0 Hz, 1H, FrCCH=),

6.63 (d, $J$=3.4 Hz, 1H, $H_2$, Fr), 6.49 (d, $J_1$=3.4 Hz, $J_2$=1.8 Hz, 1H, $H_3$Fr), 5.19 (s, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 189.2, 157.8, 151.7, 144.9, 138.7, 136.7, 131.7, 129.6, 129.1, 128.8, 128.2, 127.4, 126.7, 124.2, 123.1, 121.2, 115.8, 112.8, 112.6, 70.5; Anal. Calcd. for $C_{22}H_{18}O_3$: C, 79.98; H, 5.49; Found: C, 79.93; H, 5.43.

Data for the title compound 1-(2-(4-methylbenzyloxyphenyl)-5-(2-furyl)-1, 4-pentadien-3-one (**4Y**). Yellow crystal, yield, 81%, m.p. 80~81 °C; IR (KBr, cm$^{-1}$): $\nu_{max}$ 3022, 1645, 1583, 1550, 1487, 1342, 1273, 1180, 1010, 935, 742; $^1$H NMR (500 MHz, $CDCl_3$) $\delta$: 8.05 (d, $J$=16.0 Hz, 1H, Ar(OCH)CH=), 7.32 (d, $J$=16.0 Hz, 1H, FrCH=), 7.59~6.49 (m., 11H, Ar-H, Fr-H), 7.15 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CCH=), 6.94 (d, $J$=16.0 Hz, 1H, FrCCH=), 5.14 (s, 2H, -$OCH_2$), 2.36 (s, 3H, -$CH_3$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 189.3, 158.0, 151.7, 144.8, 138.8, 137.9, 133.6, 131.6, 129.6, 129.4, 129.0, 127.5, 126.7, 124.2, 123.2, 121.1, 115.6, 112,8, 112.6, 70.5, 21.3; Anal. Calcd. for $C_{23}H_{20}O_2$: C, 80.21; H, 5.85; Found: C, 80.13; H, 6.03.

Data for the title compound 1-[4-(2-nitrobenzyloxyphenyl]-5-(4-chlorophenyl)-1, 4-pentadiene-3-one (**4Z**). Yellow crystal, yield, 68%, m.p. 131~132 °C; IR (KBr, cm$^{-1}$): $\nu_{max}$ 1647, 1600, 1587, 1539, 1510, 1489 , 1350, 1259, 1192, 1170, 1091, 1053, 1010, 983, 825, 732, 572, 489; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.26 (d, $J$=16.0 Hz, 1H, Ar(OCH)CH=), 7.69 (d, $J$=16.0 Hz, 1H, Ar(Cl)CH=), 8.19~6.98 (m, 12H, Ar-H), 7.03 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)), 6.94 (d, $J$=16.0 Hz, 1H, ArCCH=), 5.21 (s, 2H,- $CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.6, 160.1, 146.9, 143.1, 136.3, 134.2, 133.4, 133.3 , 130.3, 129.5, 129.3, 128.6, 128.5, 128.3, 125.9, 125.2, 123.8, 66.9; Anal. Calcd. for $C_{24}H_{18}ClNO_4$: C, 68.66; H, 4.32; N, 3.34; Found: C, 68.74; H, 4.45; N, 3.24.

Data for the title compound 1-[4-(4-iodobenzyloxyphenyl)-5-(4-chlorophenyl)-1,4-pentadiene-3-one (**4AA**). Yellow crystal, yield, 73%, m.p. 138~140 °C; IR (KBr, cm$^{-1}$): $\nu_{max}$ 1653, 1622, 1558, 1506, 1456, 1257, 1172, 1087, 1008, 987, 831; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 7.70 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.54 (d, $J$=16.0 Hz, 1H, Ar(Cl)CH=), 7.72~6.97 (m, 12H, Ar-H), 7.02 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 6.93 (d, $J$=16.0 Hz, 1H, Ar(Cl)C=CH), 5.53 (s, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.6, 160.6, 143.3, 141.5, 137.8, 136.3, 136.1, 133.4, 130.3, 129.5, 129.3, 127.9, 125.9, 123.5, 115.3, 93.8, 69.4; Anal. Calcd. for $C_{24}H_{18}ClIO_2$: C, 57.56; H, 3.62; Found: C, 57.28; H, 3.50.

Data for the title compound 1-(4-propyleneoxyphenyl)-5-(4-chlorophenyl)-1,4-pentadiene-3-one (**4AB**). Yellow crystal, yield, 77%, m.p. 126~127 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 1653, 1695, 1558, 1508, 1489, 1249, 1176, 1093, 1012, 979, 827; $^1H$ NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 7.69 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.64 (d, $J$=16.0 Hz, 1H, Ar(Cl)CH=), 7.55~6.97 (m, 12H, Ar-H), 7.02 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 6.92 (d, $J$=16.0 Hz, 1H, Ar(Cl)C=CH), 6.04 (m, 1H, -$CH_2$CH), 5.36 (dd, $J_1$=18.0 Hz, $J_2$=10.3 Hz, 2H, $CH_2$CH=$CH_2$), 4.56 (d, $J$=5.1 Hz., 2H, -$CH_2$); $^{13}C$ NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.6, 160.8, 143.4, 141.4, 136.3, 133.4, 132.7, 130.2, 129.5, 129.2, 127.5, 125.9, 123.3, 118.2, 115.9, 68.9; Anal. Calcd. for $C_{20}H_{17}ClO_2$: C, 73.96; H, 5.28; Found: C, 73.89; H, 5.18.

Data for the title compound 1-[4-(3-iodobenzyloxyphenyl)-5-(4-chlorophenyl)-1,4-pentadiene-3-one (**4AC**). Yellow crystal, yield, 78%, m.p. 139~141 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 1653, 1586, 1558, 1506, 1247, 1228, 1193, 1014, 983, 823, 777; $^1H$ NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 7.69 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.65 (d, $J$=16.0 Hz, 1H, Ar(Cl)CH=), 7.78~6.96 (m, 12H, Ar-H), 7.02 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 6.93 (d, $J$=16.0 Hz, 1H, Ar(Cl)C=CH), 5.03 (s, 2H, -$OCH_2$); $^{13}C$ NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.6, 160.6, 143.3, 141.4, 138.8, 137.3, 136.3, 133.4, 130.4, 130.3, 129.5, 129.3, 127.6, 126.6, 125.9, 123.6, 115.3, 94.6, 69.3; Anal. Calcd. for $C_{24}H_{18}ClIO$: C, 57.56; H, 3.62; Found: C, 57.21; H, 3.33.

Data for the title compound 1-[4-(4-iodobenzyloxyphenyl)-5-(2,3-dichlorophenyl)-1,4-pentadiene-3-one (**4AD**). Yellow crystal, yield, 79%, m.p. 144~146 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 1666, 1606, 1570,1514, 1409, 1267, 1186, 1095, 1031, 985, 773; $^1H$ NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.08 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.59 (d, $J$=16.0 Hz, 1H, Ar(2Cl)CH=), 7.78~6.92 (m, 11H, Ar-H), 7.24 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 6.99 (d, $J$=16.0 Hz, 1H, Ar(2Cl)C=CH), 5.05 (s, 2H, -$CH_2$); $^{13}C$ NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.5, 160.7, 143.8, 138.5, 137.8, 136.1, 135.7, 134.1, 133.4, 131.5, 130.4, 130.2, 129.3, 127.8, 127.4, 125.9, 122.9, 115,4, 93.8, 68.9; Anal. Calcd. for $C_{24}H_{17}Cl_2IO_2$: C, 53.86; H, 3.20; Found: C, 53.46; H, 3.66.

Data for the title compound 1-(4-propyleneoxyphenyl)-5-(2, 3-dichlorophenyl)-1,4-pentadiene-3-one (**4AE**). Yellow crystal, yield, 81%, m.p. 124~125 °C; IR (KBr, $cm^{-1}$): $\nu_{max}$ 1666, 1616, 1506, 1409, 1261, 1174, 1093, 1043, 985, 813, 779; $^1H$ NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.07 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.71 (d, $J$=16.0 Hz, 1H, Ar(2Cl)CH=), 7.72~6.97 (m, 12H, Ar-H), 6.99 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 6.96 (d, $J$=16.0 Hz, 1H, Ar(Cl)C=CH),

6.04 (m, 1H, -$CH_2CH$), 5.36 (dd, $J_1$=17.1 Hz, $J_2$=12.0 Hz, 2H, $CH_2CH=CH_2$), 4.57 (d, $J$=5.0 Hz, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.5, 160.9, 144.0, 138.4, 135.7, 134.1, 133.3, 132.7, 131.5, 130.3, 129.3, 127.4, 125.9, 122.8, 115.2, 115.3, 68.9; Anal. Calcd. for $C_{20}H_{16}Cl_2O_2$: C, 66.87; H, 4.49; Found: C, 66.44; H, 4.16.

Data for the title compound 1-[4-(3-iodobenzyloxyphenyl)-5-(2,3-dichlorophenyl)-1,4-pentadiene-3-one (**4AF**). Yellow crystal, yield, 69%, m.p. 117~119 °C; IR (KBr, cm$^{-1}$): $\nu_{max}$ 1653, 1600, 1558, 1506, 1419, 1249, 1172, 1091, 977, 815, 769; $^1$H NMR (500 MHz, $CDCl_3$, ppm) $\delta$: 8.07 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)CH=), 7.69 (d, $J$=16.0 Hz, 1H, Ar(2Cl)CH=), 7.78~6.92 (m, 11H, Ar-H), 7.11 (d, $J$=16.0 Hz, 1H, Ar($OCH_2$)C=CH), 6.95 (d, $J$=16.0 Hz, 1H, Ar(2Cl)C=CH), 5.02 (s, 2H, -$CH_2$); $^{13}$C NMR (125 MHz, $CDCl_3$, ppm) $\delta$: 188.4, 160.9, 143.8, 138.7, 138.5 137.3, 136.3, 135.6, 134.1, 133.4, 131.6, 130.5, 130.4, 129.3, 127.8, 127.5, 126.6, 125.9, 123.0, 115.3, 94.6, 69.1; Anal. Calcd. for $C_{24}H_{17}Cl_2IO_2$: C, 53.86; H, 3.20; Found: C, 53.86; H, 2.96.

## 5. Biological tests

**Cell culture.** PC3 cells, BGC-823 cells and Bcap-37 cells were cultured on RPM I1640 culture medium supplemented with 10% FBS at 37 °C in $CO_2$ incubator of 5% volume fraction.

**Dispense drug.** The title compounds **4A-4AF** whose relative molecular mass is 405 was screened from a series of curcumin derivatives synthesized by our group and then diluted with DMSO.

***In vitro* bioassay for antitumor activity by MTT method**.[1] After digesting the exponential phase of growth cells by trypsin, the cells were suspended in RPMI 1640 culture medium supplemented with 10% FBS. Then the cells ($2\times10^4$ /ml) were seeded on 96 well plates (100 μL/well). Culture medium was discarded after 24 h, and then added with different drug concentrations (200 μL/well). Culture medium was again discarded after 72h, and then added with MTT (0.5 mg/mL) to each well (100 μL/well). After 4 h, 100 μL 10% SDS was added into 96 well plates, then incubated for 10 h in order to dissolve the crystal. After taking out the cells and cooling to room temperature, OD values were measured at 595 nm to obtain the inhibition ratio. The control group was added to medium without the cells; the negative group was added to DMSO with the same volume of drug and the positive control was added to ADM with the same concentration of measured drug.

**Detection of cytotoxicity and apoptosis by AO/EB staining**. Six coverslips were first soaked in 75% alcohol for 6 h and then put into 6 well plates and dried by alcohol lamp; PC3 cell suspension (4 mL) was digested and mixed steadily in a centrifuge tube (15 mL). Then 800 μL cell suspensions to per coverslips, 6 well plates were put into incubator. Add 1200 μL RPMI1640 culture medium containing 10%FBS to each well after the cells, cultivate cells continuatively. Add test compounds to 6 well plates when the cells grow to 80%. The cells were observed after add drug. The cells can be stain when cells morphology changed, add 20 μL stains to glass slide, coverslips in 6 wells plate were covered the surface of stains. The cells were observed and photographed by fluorescence microscope.

**Detect apoptosis by Hoechst 33258 staining.**[2-3] The procedures of inoculating well plates and adding drugs are same with AO/EB staining. 0.5 mL Fixative solution was added into each well, cells were fixed for 10min. The wells were washed twice (3min/once) with 1*PBS after drain fixative solution. 0.5ml Hoechst 33258 staining solution was added into each well, the cells were stained for 5min on shaking table. Then the wells were washed twice (3min/once) with 1*PBS after staining. Later, coverslips having cells were covered the glass slide, the cells were detected by the violet ray of fluorescence microscope.

**Detect apoptosis by TUNEL colouration.**[4-5] The procedures of inoculating well plates and adding drugs are same with AO/EB staining. First, prepare related solution.

A: Biotin-labeled solution: TdT enzyme (10 μL) and Biotin-dUTP(240 μL) were mixed steadily for standby.

B: Streptavidin-HRP working solution: Streptavidin-HRP (5 μL) and Streptavidin-HRP diluent (245 μL) were mixed steadily for standby.

C: DAB chromogenic solution: DAB chromogenic solution A(200 μL) and DAB chromogenic solution B(200 μL) were mixed steadily for standby.

Second, the cells were washed once with 1*PBS, then the cells were fixed by immunostaining fixative solution for 40 min. The cells were washed once with 1*PBS, Immunostaining washing solution was added to the cells, Incubate the cells in iced bath for 2 min. Incubate cells in 0.3% $H_2O_2$ in Methanol after washed once with 1*PBS at room temperature for 20min. Then 50 μL Biotin-labeled solution was added into per well after wash three times with 1*PBS, the cells were incubated at 37 °C for 60 min. 200 μL Labeling

reaction stop buffer was added into per well after washed once with 1*PBS, the cells were incubated at room temperature for 10 min.The cells were washed three times with 1*PBS, the cells were incubated at room temperature for 30 min after added Streptavidin-HRP working solution (50 μL/well). Then the cells were washed three times with 1*PBS, the cells were incubated in dark at room temperature for 60 min after added DAB chromogenic solution(800 μL/well), then the cells were washed three times with 1*PBS. The cells were observed with fluorescence microscope. Brown cells were positive apoptotic cells with TUNEL method.

**Detect apoptosis by DNA Ladder.**[6-7] The exponential phase of growth PC3 cells were inoculated on Petri dish which diameter was 10 cm. The compounds were added into the cells for inducing apoptosis when the cells grow to 80%. Scraped the cells from culture plate and centrifuged at 2000 rpm for 2 min after 72 h. Discarded the supernatant and collected the cells, then DNA was extracted with DAN Extraction Kit. And then ran agarose gels electrophoresis with the products of DNA, used 2% agarose gel (involved 0.5 μg/mL EB) and added 8 μL samples, make the samples electrophoresis at 120 V pressure for 30min. The results were observed by gel imaging system after electrophoresis.

**Detect apoptosis by FCM.**[8-9] The compound **4A** induced apoptosis was added into the exponential phase of growth PC3 cells. Collected and accounted the cells, then suspended cells with PBS, 50-100 thousand suspensive cells were centrifuged at 1000 g for 5 min. Discarded supernatant and added 500 μL Binding Buffer, then the cells were suspended. Added 5 μL Annexin V-FITC and incubated for 15 min in dark at room temperature. Absorbance values of FITC and PI was detected by flow cytometry within 1 h at 530 nm and 585 nm respectively. Early apoptotic cells present Annexin+/PI-, late apoptotic and necrotic cells present Annexin+/PI+.

**Table S1** The results of *in vitro* antitumor activity of **4A-4AF** on three kind of tumor cells (Inhibition ratio (%))

| Compd. | PC3 | | BCap-37 | | BGC-83 | |
|---|---|---|---|---|---|---|
| | 1μM | 10μM | 1μM | 10μM | 1μM | 10μM |
| 4A | 2.1±23.5 | 87.7±3.0 | 7.6±2.6 | 85.6±0.8 | 6.8±2.3 | 81.4±0.5 |
| 4B | 34.1±14.9 | 45.1±16.7 | 31.7±3.1 | 41.1±0.9 | 24.2±2.5 | 31.4±0.6 |
| 4C | 32.2±16.6 | 39.9±7.4 | 32.5±3.0 | 40.8±1.8 | 24.8±2.4 | 31.2±1.5 |
| 4D | 4.0±5.6 | 9.0±10.5 | 5.7±1.5 | 5.1±0.7 | 4.9±1.3 | 4.4±0.6 |
| 4E | 0.0±11.0 | 2.1±13.8 | 0.4±0.3 | 6.1±1.1 | 0.4±0.3 | 5.3±0.9 |
| 4F | 16.2±13.0 | 19.7±9.0 | 19.8±1.2 | 18.9±2.7 | 16.4±1.0 | 15.6±2.3 |
| 4G | 4.0±7.8 | 17.6±8.6 | 6.8±1.0 | 18.9±1.0 | 5.8±0.8 | 16.2±0.9 |
| 4H | 14.2±8.9 | 44.3±4.9 | 13.6±1.6 | 43.6±2.3 | 11.3±1.3 | 36.2±2.0 |
| 4I | 30.4±11.1 | 33.6±15.0 | 31.2±3.0 | 32.2±2.6 | 23.8±2.4 | 24.6±2.1 |
| 4J | 5.4±20.7 | 53.7±10.1 | 5.6±0.7 | 51.0±3.0 | 15.9±2.5 | 58.8±2.3 |
| 4K | 1.3±2.8 | 54.4±12.7 | 6.7±4.8 | 50.4±2.2 | 13.3±3.2 | 61.2±1.8 |
| 4L | 13.2±20.9 | 67.3±10.5 | 10.4±4.0 | 68.8±2.7 | 25.3±2.2 | 61.0±2.4 |
| 4M | 36.9±15.3 | 75.1±5.8 | 39.5±2.4 | 70.8±1.8 | 43.2±2.5 | 76.4±2.8 |
| 4N | 4.8±18.8 | 20.6±16.4 | 6.9±5.7 | 26.7±2.6 | 5.7±4.7 | 21.8±2.2 |
| 4O | 3.3±5.5 | 54.1±3.1 | 8.7±3.3 | 57.2±1.5 | 7.1±2.7 | 46.8±1.3 |
| 4P | 2.6±11.5 | 23.8±7.8 | 9.5±4.0 | 30.8±2.9 | 7.8±3.2 | 25.2±2.4 |
| 4Q | 11.1±15.0 | 30.6±9.0 | 6.8±4.3 | 28.1±2.2 | 6.5±4.1 | 27.2±2.1 |
| 4R | 1.6±10.0 | 32.1±1.4 | 6.6±2.0 | 25.2±5.0 | 6.4±1.9 | 24.3±4.8 |
| 4S | 7.1±7.3 | 33.1±12.4 | 1.6±2.8 | 27.1±2.0 | 1.5±2.7 | 26.2±1.9 |
| 4T | 3.0±8.8 | 66.9±9.3 | 0.2±0.8 | 65.5±0.9 | 0.2±0.7 | 56.2±0.8 |
| 4U | 11.0±8.4 | 72.4±8.4 | 13.7±1.5 | 54.5±0.7 | 12.3±1.4 | 48.9±0.6 |
| 4V | 23.2±7.2 | 41.8±4.8 | 24.9±2.0 | 42.8±1.2 | 20.7±1.7 | 35.5±1.0 |
| 4W | 40.3±14.4 | 80.2±7.7 | 40.4±8.9 | 79.5±1.5 | 45.8±3.1 | 80.8±1.3 |
| 4X | 8.1±15.7 | 69.9±6.7 | 4.5±3.4 | 70.9±1.8 | 16.0±4.9 | 71.2±1.8 |
| 4Y | 42.8±8.0 | 74.8±8.0 | 44.1±7.2 | 81.0±4.0 | 43.1±5.2 | 70.1±4.0 |
| 4Z | 22.4±1.9 | 36.1±3.4 | - | - | - | - |
| 4AA | 16.9±1.1 | 29.1±3.2 | - | - | - | - |
| 4AB | 47.1±9.1 | 66.6±8.7 | - | - | - | - |
| 4AC | 24.8±3.1 | 27.1±5.5 | - | - | - | - |
| 4AD | 26.0±7.1 | 63.6±4.9 | - | - | - | - |
| 4AE | 20.3±4.6 | 72.3±8.1 | - | - | - | - |
| 4AF | 3.8±2.0 | 69.6±7.7 | - | - | - | - |
| ADM | 88.2±1.5 | 94.7±1.9 | 84.2±0.9 | 93.1±0.9 | 90.7±0.6 | 95.9±1.1 |
| HCPT | 17.1±2.9 | 37.0±2.2 | 8.8±1.7 | 33.5±1.6 | 7.3±3.8 | 26.5±1.5 |

**Table S2** The results of *in vitro* antitumor activity ($IC_{50}$) of **4A** and **4Y**

| Compd. Cell | Inhibition ratio(%) | | | | | | $IC_{50}$ values μmol/L |
|---|---|---|---|---|---|---|---|
| | 1 μmol/L | 2 μmol/L | 4 μmol/L | 6 μmol/L | 8 μmol/L | 10 μmol/L | |
| **4A** PC3 | 5.8±4.4 | 17.7±2.3 | 26.3±1.5 | 39.5±1.6 | 61.3±4.0 | 87.6±1.4 | 7.1±0.5 |
| 4A BGC-823 | 11.3±1.6 | 18.9±0.9 | 25.1±1.1 | 38.8±1.4 | 54.8±0.7 | 82.6±0.8 | 7.3±0.1 |
| **4A** Bcap-37 | 8.5±2.6 | 19.6±3.1 | 26.2±2.6 | 39.4±0.7 | 59.4±2.3 | 83.7±1.8 | 7.2±0.1 |
| **4Y** PC3 | 34.6±9.1 | | | 38.9±7.3 | 54.6±4.3 | 83.3±2.1 | 8.0±0.3 |
| **4Y** BGC-823 | 27.0±1.6 | | | 33.3±2.6 | 47.2±1.3 | 81.3±2.3 | 8.6±0.3 |
| **4Y** Bcap-37 | 37.1±2.0 | | | 42.4±1.3 | 63.3±2.0 | 82.7±2.6 | 6.6±0.2 |

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