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Preparation of Polyfunctioneled 1,2-Benzylated Derivatives from *O*-Salycilique Aldehyde and *B*-Ketoesters

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Abstract

1, 2 Polyfunctionalized benzene derivatives have been important structural units present in certain molecules used in a wide range of applications (pharmaceutical, biological, cosmetic, etc.). In this work, the synthesis of 1 and 2 polyfunctionalized benzene derivatives has been proceeded from largely available and cheap reagents namely: β-keto-ester salicylic aldehydes and alkyl halides. The inspiring obtained results emphasized on the interesting strategy implemented for the synthesis of such molecules. The NMR spectroscopic analysis was used to identify the structure of different isolated products in the form of a single stereoisomer designed as E-configuration.

In fact, the following seven condensation products were obtained:

1-(E)-methyl 2-(3-(2-(allyloxy) phenyl) acryloyl) pent-4-enoate

2-(E)-methyl 5-(2-(allyloxy) phenyl)-3-oxo-2-(prop-2-ynyl) pent-4-enoate

3-(E)-methyl 2-(3-(2-(but-3-enyloxy) phenyl) acryloyl) pent-4-enoate

4-(E)-methyl 5-(2-(but-3-enyloxy) phenyl)-3-oxo-2-(prop-2-ynyl)pent-4-enoate

5-(E)-methyl 2-(3-(2-(pent-4-enyloxy) phenyl) acryloyl) pent-4-enoate

6-(E)-methyl 3-oxo-5-(2-(pent-4-enyloxy) phenyl)-2-(prop-2-ynyl)pent-4-enoate

7-(E)-methyl 2-(3-(2-(prop-2-ynyloxy) phenyl) acryloyl) pent-4-enoate. In addition to their possible activity, they have several functional positions within their structures, giving them a high synthetic and reactivity potential. Many reaction-types such as addition, cyclization by metathesis, can be carried out leading to more complex compounds that can be better valorized.

Keywords: Polyfunctioneled, 1,2-Benzylated, Derivatives, O-Salycilique, Aldehyde, B-Ketoesters.

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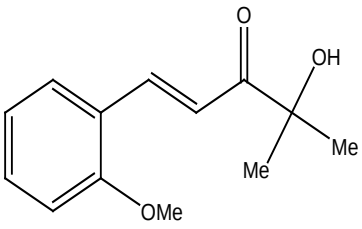
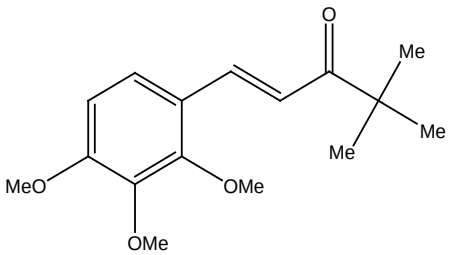
Introduction

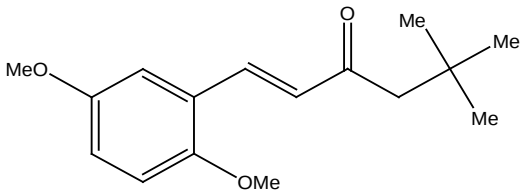
Many structures of Polyfunctionalized benzene derivatives types 1 and 2 have been used in different important products such as pharmaceuticals, cosmetics, phytosanitary products…. etc. Among these, the following compounds can be cited (King, 1968; Nasipuri, 1976; Lee and Ku, 1999, Funaki *et al*, 1981):



(*E*)-4-hydroxy-1-(2-methoxyphenyl)-4-methylpent-1-en-3-one herbicide product[1]



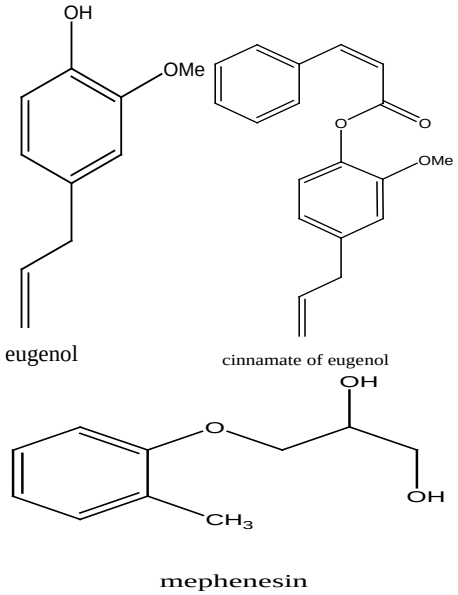
(*E*)-4,4-dimethyl-1-(2,3,4-trimethoxyphenyl)pent-1-en-3-one cosmetic product [2]



(*E*)-1-(2,5-dimethoxyphenyl)-5,5-dimethylhex-1-en-3-one
pharmaceutical product
action on the central nervous system[4]

Fig. 1: Examples of 1,2 type poly-functionalized benzene derivatives

Moreover, several other compounds of this type as can be seen in the example below possess biological activities and therapeutic applications. For instance, compounds derived from eugenol are used as dental dressing for their antiseptic properties (Wang *et al*, 1995; Wang and Hong, 1995; Carey and Sundberg; 1977). And, compounds with relaxant properties, such as mephenesin, are used against muscle contraction (spasticity) (Funaki *et al*, 1981).



eugenol
cinnamate of eugenol
mephenesin

Fig. 2: examples of polyfunctionalized benzene bioactive derivatives

In this work, it has been focused on the preparation of similar structure derivatives from two cheap and available compounds: the β-ketoesters and salicylic aldehyde. Moreover, the access to these compounds includes simple reactions of alkylation which take place under mild conditions. The strategy betrothed to access to these compounds would have three major steps:

- Alkylation of β-ketoesters by allylic and propargylic unsaturated chains:
- *O*-alkylation of salicylic aldehyde by alkylating agents (allyl and propargyl bromide, 4-bromo but 1-ene, 5-bromopent-1-ene).
- Condensation of alkylated β-ketoesters on salicylic aldehyde alkyls.

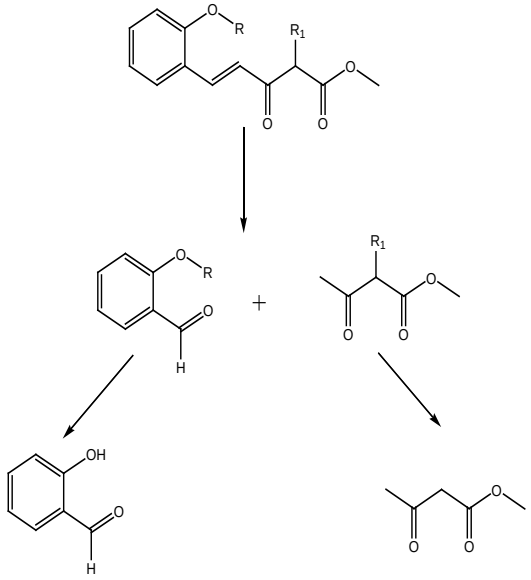


Fig. 3: 1,2-poly functionalized benzene derivative from a β-ketoester and salicylic aldehyde

Other structurally related compounds also have a similar activity such as cresoxy lactic acid (Pearson, 1963; Ho, 1977)**.**

Only a little literature has been reported about the synthetic pathway of ortho disubstituted phenolic derivatives, among which the following is the way of preparation of 1, 2-polyfunctionalized benzene compounds:

The (1Z) -1- (2-methoxyphenyl) -4,4-dimethyl-2- (1H-1,2,4-triazol-1-yl) pent-1-en-3-one which is obtained by the condensation in basic medium of 3,3-dimethyl-1-(1H-1,2,4-triazol-1-yl) butan-2-one on 2-methoxybenzaldehyde.

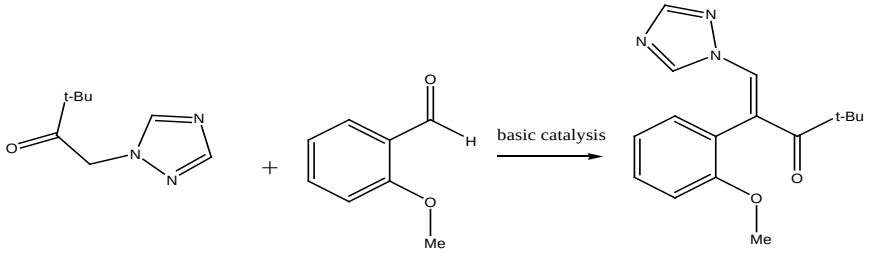


Fig. 4: Condensation of 3,3-dimethyl-1-(1H-1,2,4-triazol-1-yl) butan-2-one on 2-methoxybenzaldehyde

Results and Discussion

General β-keto esters alkylation diagram:

The alkylation of *β*-keto esters was carried out via an alkyl halide in the presence of potassium carbonate (K_2CO_3) and acetone. It consists in alkylating the β-ketoester into α carbonyl (Arnaud, 1977, Zemmermann, 1983, Christoffers, 1999)**.**

These steps can be schematized as follows:

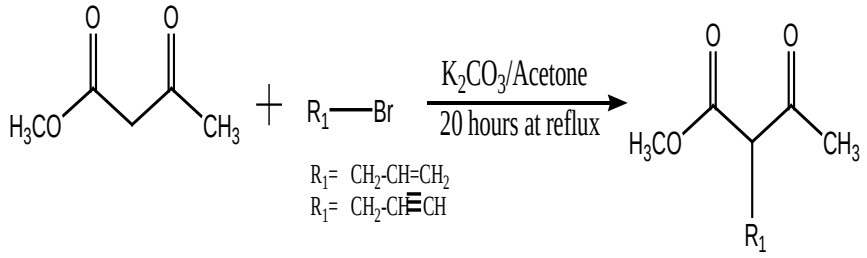
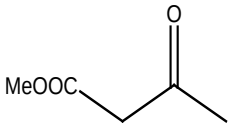
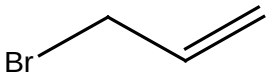
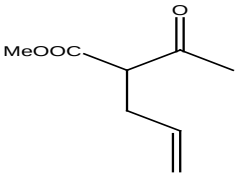
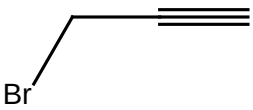
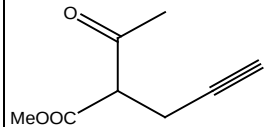


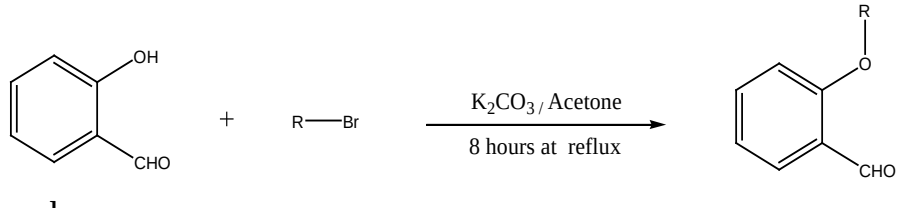
Fig. 5: alkylation of β-ketoesters

Table 1: products of the alkylation of β-ketoesters

The substrate		Conditions	Products	Yield
 a		K_2CO_3, Acetone,4eq 20 Hours at reflux	 a_1	**63%**
			 a_2	**65%**

Alkylation of ortho-salicylic aldehyde
General diagram:

With ortho-salicylic aldehyde, the use of K_2CO_3 in refluxing acetone in the presence of the alkylating agents: allyl bromide, propargyl bromide, 4-bromobut-1-ene (homo-allylic bromide) and 5-bromo pent-1-enne, provided access to the desired *O*-alkylation products. The results obtained from *O*-alkylation have been shown in **Table 2**



R= CH_2-CH=CH_2
R= CH_2-CH ≡CH
R= CH_2CH_2CH=CH_2
R= $CH_2CH_2CH_2CH$=CH_2

b_1 R= CH_2-CH=CH_2
b_2 R= CH_2-CH≡CH
b_3 R= CH_2CH_2CH=CH_2
b_4 R= $CH_2CH_2CH_2CH$=CH_2

Fig. 6: alkylation of ortho-salicylic aldehyde

Table 2: *O*-Alkylation of Salicylic Aldehyde

The substrate	Halide R-Br	Conditions	Products	Yield
b	Br	K_2CO_3,Acetone,4eq 8 Hours at reflux	**b₁**	60%
	Br		**b₂**	50%
	Br		**b₃**	69%
	Br		**b₄**	61%

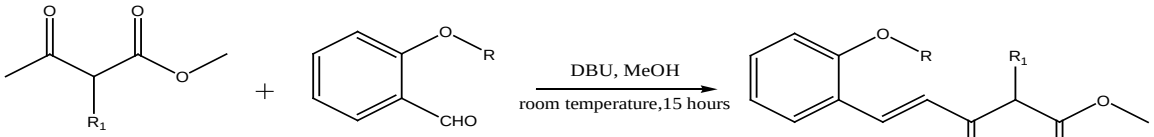
Condensation

Condensation involves reacting a *C*-alkylated β-ketoester with an *O*-alkylated orthosalicylic aldehyde under reaction conditions including DBU in anhydrous MeOH at room temperature for about 15 hours. These conditions were chosen based on what was reported by Charonnet (Charonnet *et al*, 2001).

This study showed that the β-ketoesters and the β-ketoamides reacted with the benzaldehyde as an electrophile in the presence of DBU in methanol, giving good yields compared to the other experiments conducted under different conditions in the presence of K_2CO_3, MeOH, MeONa · MeOH, NaH / THF, DBU · THF, DBU · toluene, DBU, MeOH.

Condensation of C-alkylated β-ketoester on O-alkylated orthosalicylic aldehydes:

The reactions performed according to the previously described conditions have been summarized in the following general diagram:

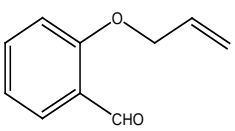
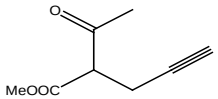
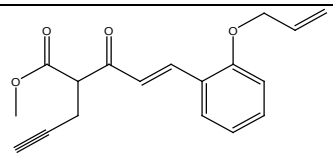
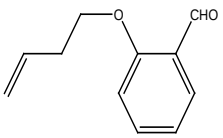
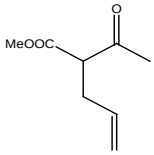
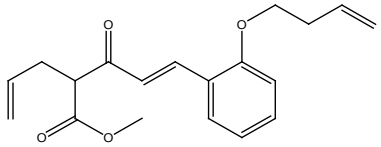
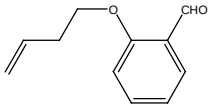
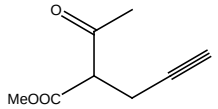
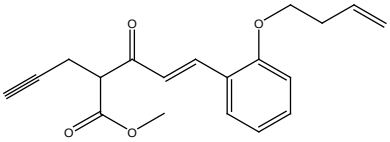
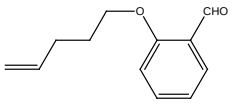
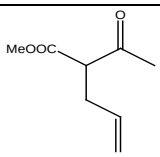
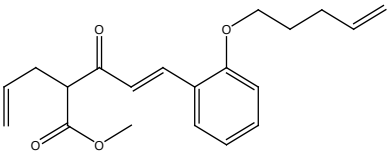
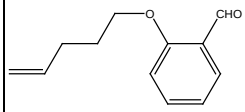
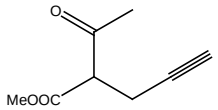
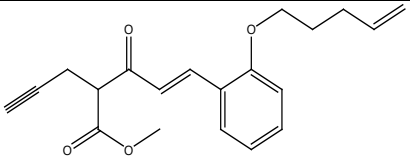
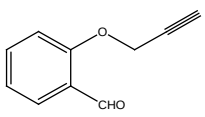
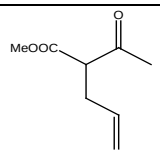
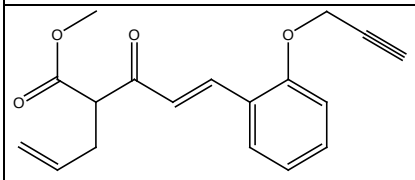


a₁: R_1= CH_2-CH=CH_2 **b₁** R= CH_2-CH=CH_2
a₂ : R_1= CH_2-CH≡CH **b₂** R= CH_2-CH≡ CH
b₃ R= CH_2CH_2CH=CH_2
b₄ R= $CH_2CH_2CH_2CH$=CH_2

Fig. 7: Condensation of *C*-alkylated β-ketoester on *O*-alkylated orthosalicylic aldehyde

Table 3: Products of Condensation of α-allyl and α-propargyl β-ketoester on *O*-alkylated ortho-salicylic aldehyde

The substrate	*B*-ketoester	*Conditions*	*Products*	*Yield*
b₁	a₁	***DBU MeOH Room Temperature For 15 hours***	**1**	***60%***

 **b1**	 a_2	***DBU , MeOH*** ***Room temperature 15 hours***	 **2**	***54%***
 **b3**	 a_1		 **3**	***64%***
 **b3**	 a_2		 **4**	***43%***
 **b4**	 a_1		 **5**	***58%***
 **b4**	 a_2		 **6**	***51%***
 **b2**	 a_1		 **7**	***63%***

The above table highlights the results obtained during the condensation of *C*-alkylated *β*-keto-esters on *O*-alkylated ortho-salicylic aldehydes.

The inspection of this table has shown that the non-optimized yields of the condensation were between 43% and 64%.

All the structures of the condensation products were confirmed by IR, ^{1}H and ^{13}C NMR spectroscopic analysis. The results were acceptable in comparison with what has been stated in the literature (Charonnet *et al*, 2001, Aissaoui, et al, 2012; Belaud-Rotureau et al 2010).

In fact, during the preparation of ethyl (E) -5- (2-furyl) -2-methyl-3-oxopent-4-enoate c, instead of obtaining the desired product **c**, a mixture of two non-separable products namely:1- (furan-2-yl) -pent-1-en-3-one **d** and 1,5- (di-furan-2-yl) -4-methyl-penta-1,4-dien-3 -one **f** was obtained - under the same operating conditions (but at a higher temperature and a longer time).

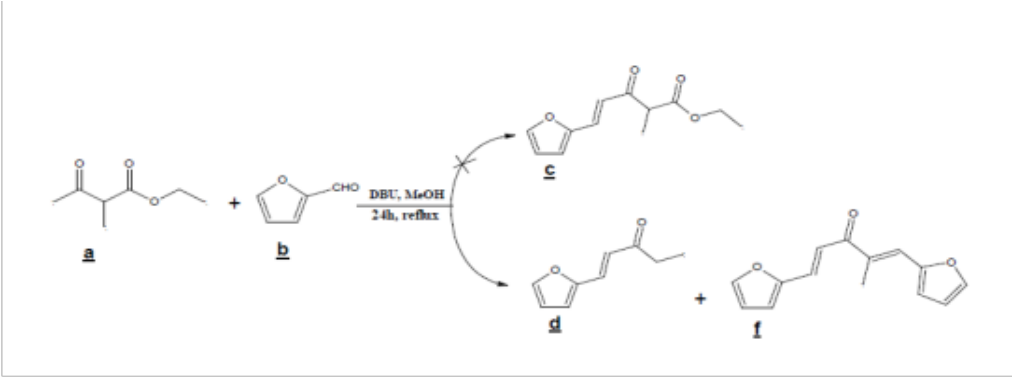


Fig. 8: synthesis pathway of ethyl (E) -5- (2-furyl) -2-methyl-3-oxopent-4-enoate

The authors explained the synthesis of compound **d** as a major compound by a g-aldolization / dehydration sequence, followed by the saponification / decarboxylation of the starting substrate ester function. Compounds **a** and **b** again underwent an aldolization / dehydration on the enolisable position to provide the product **f**.

These literature reports have highlighted the interest of the results obtained during the condensation, since only the desired aldolization product has been isolated.

Proposed mechanism:

According to the literature, a reversible aldolization or aldolization - retroaldolization process can be considered in a first step (Baucherel *et al*, 2000, Watanabe and Ishikawa, 1999)

The proposed mechanism in a first step, generated the unstable α-aldol **A** which would undergo a retro-aldolization to give kinetically and thermodynamically disadvantaged enolate **B**.

The later reacted with the aldehyde to give a more stable g-aldol **C** which after dehydration provided the α-substituted conjugated β-ketoesters (Charonnet *et al*, 2001, Langer *et al*, 2000).

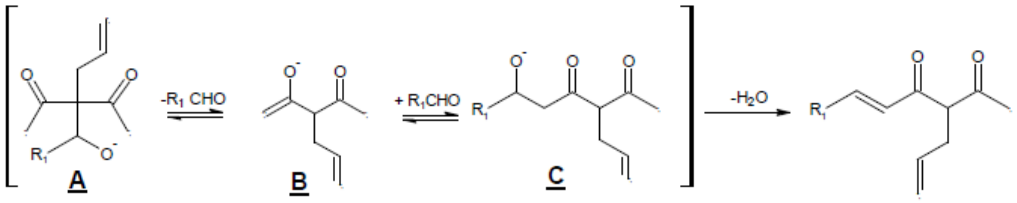


Fig. 9: proposed mechanism: the unstable α-aldol A undergoes a retro-aldolization to give enolate B

On the other hand, it should be pointed out that there were only obtained products corresponding to a single orientation of the C-alkylation reaction (Benetti *et al* 1995).

This region-selectivity can be explained by Pearson's theory, involving the notions of "hard-center- soft center" 1, 3-dicarbonyl derivatives and electrophiles.

This principle named H.S.A.B. follows a simple rule: "a soft acid prefers to bond with a soft base, and a hard acid prefers to bind with a hard base" (Pearson, 1963).

Concerning the sites of attack of this study's products, the tearing of the hydrogen with the DBU which has been a hard base was done on hydrogen of the harder terminal carbon.

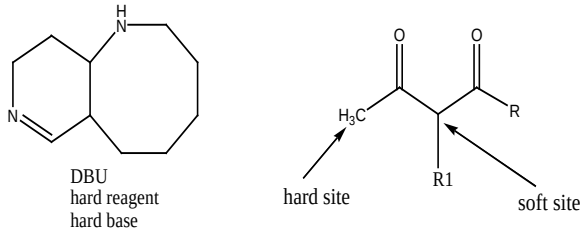


Fig. 10: "hard-soft" character of the 1,3-dicarbonyl

The "hard-soft" character of the 1,3-dicarbonyl compounds differed according to the substituent electronic nature at the carbonyl function α-position. Indeed, the *β*-diketones substituted by a weakly donor alkyl group would generate the highly stabilized anions which constituted a "soft" center.

Similarly, *β*-ketoesters which carried an alkoxy group whose electron donor character was a little more marked, gave slightly less stabilized anions but retained a relatively "soft" character.

The stability of the corresponding anions was directly related to the relative acidity of the protons which decreased progressively as we moved from a *β*-diketone to a *β*-ketoester.

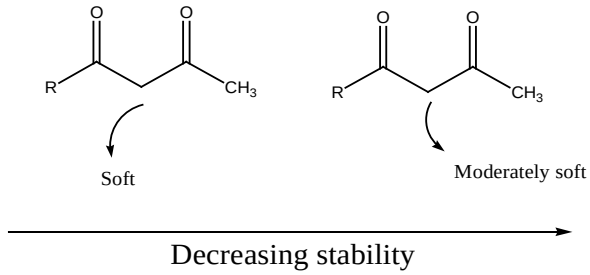


Fig. 11: decreasing stability of the corresponding anions

Experimental

Solvents:

The solvents were distilled on specific desiccants under an argon atmosphere before being used: Acetone on potassium carbonate, Methanol on magnesium.

Reagents:

DBU: 1,8-diazabicyclo [5.4.0] undec -7- en, Methyl 3-oxobutanoate,The penta-2,4 dione, Ortho-salicylic aldehyde, Allyl bromide, Propargyl bromide,4-bromo but-1-ene (homo-allylic bromide).5-Bromo pent-1-ene.

Analytical and preparative chromatography:

Thin layer chromatography (TLC) was carried out on "Merck" silica plates 60F254, and revealed by the universal developer (p-anisaldehyde (5mL), ethanol (90mL), sulfuric acid (5mL), acetic acid (30 drops), iodine or ultraviolet lamp. Flash chromatography on silica gel was performed on silica "Merck" 230-400 Mesh. The eluent used was ethyl ether / petroleum ether.

Spectroscopic data:

The infrared spectra were recorded on a Perkin-Elmer 1600 Fourier transform spectrophotometer; the absorption frequencies were expressed in cm^{-1}.

The ^{1}H, ^{13}C NMR spectra were recorded on the "Brucker" AC200 and AC300 MHz apparatus, and carried out at the ambient temperature in deuterated chloroform. The chemical shifts were given in a part per million (ppm).The abbreviations for the multiplicities: s, d, t, m, dd, respectively represented a singlet, a doublet, a triplet, a multiplet and a doublet duplicate.

Operating modes and spectroscopic data

a. General procedure for alkylation of *β*-ketoesters:

In a 250 mL bicol on mounted refrigerant, provided with magnetic stirring and placed under an argon atmosphere, 40mmol (1eq) of *B*-ketoesters was introduced. In 60 mL of anhydrous acetone, 160 mmol (4 eq) of potassium carbonate (K_2CO_3) was added. After 15 minutes stirring at room temperature, 52 mmol (1.3eq) of allyl bromide (propargyl bromide) was added in 60 mL of anhydrous acetone with a dropping funnel. After refluxing for 20 hours, following the reaction by thin layer chromatography (TLC), the reaction medium was filtered, and the solvent was evaporated under the reduced pressure. The obtained crude product was purified by chromatography on silica gel (E / Ep: 1/12).

Methyl 2-acetylpent-4-enoate: R_f = 0.76 (Eluent: E / Ep: 1/1) .yield = 63%,^{1}H NMR (300 MHz, CDCl3) δ: 2.06 (s, 3H). 2.40 (m, 2H). 3.41 (t, jcb = 5Hz, 1H). 3.54 (s, 3H). 4.92 (dd, *j* = 15 Hz, *j* = 1.2 Hz, 1H). 5.40 (dd, *j* = 10Hz, *j* = 1.2 Hz, 1H). 5.50-5.70 (m, 1H).^{13} C NMR, C1: 29.32, C2: 32.41, C3: 52.54, C4: 59.14, C5: 117.57, C6: 134.6, C7: 169.93, C8: 202.51; IR cm^{-1} (KBr): υ C = O: 1723, υ C = C: 1646, υ C-O: 1249

Methyl 2-acetylpent-4-ynoate: Rf = 0.65 (Eluent: E / Ep: 1/1) .yeild = 65%; ^{1}H NMR: 2.14 (s, 3H) ., 2.90 (dd, *jbc* = 4.4Hz, d = 1.8Hz, 2H) ., 3.39 (t, *jcb* = 4.8Hz, 1H) . 3.71 (s, 3H))., 2 (t, *jeb* = 1.8 Hz, 1H).^{13} C NMR C1: 23.0 C2: 16.5 C3: 54.0 C4: 64.0 C5: 74.0 C6: 80.0C7: 171 C8: 202 ,IR cm-1 (KBr): υC = O: 1715.86, υ C: 2121.80, υC-O: 1279.06, υ C H: 3287.57

b. General procedure for *O*-alkylation of ortho-salicylic aldehyde:

O-alkylation of the orthosalicylic aldehyde with allyl bromide, propargyl bromide, 4-bromo-1-ene, 5-bromo pent-1-en was carried out under the same operating conditions, used for the alkylation of β-ketoester, and the obtained crude product was purified by chromatography on silica gel (E / Ep: 1/4).

2- (allyloxy) benzaldehyde

Rf = 0.51 (Eluent: E / Ep: 1/1) .yield = 60% ,^{1}H NMR: 4.59 (d, *j* = 5Hz, 2H) . 6.27 (ddq, *j* = 12.2Hz, *j* = 10.5Hz, *j* = 5Hz, 1H) . 5.43 (dd, *j* = 12.2Hz, *j* = 1.6Hz, 1H) .H: 5.76 (dd, *j* = 10.5Hz, *j* = 1.4Hz, 1H) ., 6.89-7.24 (m, 4H) . 8.48 (s, 1H). ^{13} C NMR C1: 117.37 C7: 150.35.C9: 70.01.C10: 209.80.C2-C6, C8: 132.83, 123.65, 119.53, 121.89, 114.10, 121.85. IR cm^{-1} (KBr): υ C = O: 1707.18, υ C = 1649.33, υC-O: 1233.74, υ = CH: 2974.67.

2- (prop-2-ynyloxy) benzaldehyde

Rf = 0.24 (Eluent: E / Ep: 1/1) yield = 50%,^{1}H NMR: 2.65 (s, 1H) ., 4.71 (s, 1H) ., 6.96-7.52 (m, 4H) ., 8.50 (s, 1H).^{13} C NMR C1: 50.52C2: 75.86.C3: 78.46.C9: 153.38.C10: 209.07.C4-C8: 111.61, 121.48, 126.34, 127.99, 131.86. IR cm^{-1} (KBr): υC = O: 1704.29-1638.24,υ C: 2213, υ C H: 3279.86-2840, υC-O: 1768.

2- (but-3-enyloxy) benzaldehyde

Rf = 0.35 (Eluent: E / Ep: 1/1) .yield = 69% ^{1}H NMR: 3.05 (m, 2H) ., 4.16 (t, *J* = 4.8Hz, 2H) ., 5.80 (d, *j* = 9Hz, 1H) ., 5.78 (d, *j*= 17Hz) , 1H) ., 6.57 (m, 1H) ., 7.4- 8.5 (m, 4H) ., 8.57 (s, 1H).;^{13} C NMR C1: 34 .C2: 67.09. C3: 117.66.C10: 200.69.C11:

209.80.C4-C9: 112.46,120.64, 121.85,129.20,134.96, 140.47. IR cm^{-1} (KBr): υC = O: 1731.39, υC = C: 1642.09, υC-O: 1252.54, υ = CH: 2923.56.

2- (pent-4-enyloxy) benzaldehyde

Rf = 0.46 (Eluent: E / Ep: 1/1) .yeild= 61%; ^{1}H NMR: 3.95 (t, 2H) ., 1.87 (m, 2H) .; 5.80 (q, 2H) ., 4.85 (dd, 1H). Hd: 5.75 (m, 1H) ., 4.78 (dd, 1H)., 7.06-7.67 (m, 4H) .; 8.50 (s, 1H).^{13} C NMR C1: 29.37 .C2: 30.41.C3: 69.75.C4: 115.47.C11: 157.91.C12: 199.22.C5-C10: 115.55, 120.68, 123.39,131.80, 137.74, 139.16. IR cm^{-1} (KBr): υC = O: 1709.59, υC = C: 1664.27,υC-O: 1240.97, υ = CH: 2939.

c. General Procedure of Condensation of B-Ketoesters and C-Alkylates on O-Alkylated Orthosalicylic Aldehyde Derivatives

In a 25 mL bicol with magnetic stirring and under an argon atmosphere, 3 mmol (1 eq) alkyl-substituted ketoesters or b-diketones placed in 8 mL of anhydrous MeOH, 3mmol (1eq) DBU was added. Then, the alkyl derivative of the ortho-salicylic aldehyde corresponding to 3mmol (1eq) was put in 2mL of anhydrous MeOH using a syringe. Stirred at room temperature, the progress of the reaction was monitored by TLC. The solvent was evaporated under the reduced pressure. The oily residue was taken with 20 mL of a 1N hydrochloric acid solution, after the extraction with diethyl ether (3 x 20 mL). The organic phases were then washed with a saturated solution of NaCl (2 x 20mL), and then washed with distilled water (2 x 20mL). After drying over magnesium sulfate and filtration, the solvent was evaporated under the reduced pressure, the products were purified by chromatography on silica gel (E / Ep: 1/8).

Methyl (4E) -2-allyl-5- [2- (allyloxy) phenyl] -3-oxopent-4-enoate

Rf = 0.66 (Eluent: E / Ep: 1/1) as a beige solid (560mg,yield = 60%) : mp.130-1301°C.^{1} H NMR: 2.47 (s, 3H) . 2.91 (t, *J* = 4Hz, 1H). 3.24 (d, *J* = 4Hz, 2H) . 6.2-6.5 (m, 2H) . 5.65 (dd, *J* = 16Hz, 2H) . 5.80 (dd, *j* = 12Hz, 2H) .Hf: 7.05 (d, *j* = 12Hz, 1H) . 8.16 (d, g = 12Hz, 1H).7.17-7.83 (m, 4H) . 4.88 (d, *J* = 4.4Hz, 2H).^{13} C NMR: 27.83 .C2: 53.20.C3: 59.81.C4: 70.003.C5 - C12: 113.45, 118.33.118.55.120.04, 121.85, 124.40, 128.50, 129.18.C13 -C15: 133.75, 135.07, 139.71.C16: 158.15.C17: 172.80.C18: 200.00.IR cm^{-1} (KBr): υC = O: 1738.76, υC = C: 1661.37, υC-O: 1234.22, υ = CH: 2924.52. ($[M+H]^+$) : $C_{18}H_{20}O_4$ = 300.34 found 300.35

Methyl (4E) -2-allyl-3-oxo-5- [2- (prop-2-ynyloxy) phenyl] pent-4-enoate

Rf = 0.66 (Eluent: E / Ep: 1/1) . as a yellow solid (470 mg,yield = 54%): mp. 139-140°C .^{1}H NMR: 2.48 (s, 3H) . 2.89 (t, *J* = 4Hz, 1H) .Hc: 3.22 (d, *J* = 4Hz, 2H) . 2.64 (s, 1H) . 5.75 (dd, *J* = 16Hz, 1H). 5.90 (dd, *J* = 12Hz, 1H) . 6.99 (d, *J* = 12Hz, 1H) .Hg: 8.22 (d, *J* = 12Hz, 1H) .Hh-Hk: 7.04-7.83 (m, 4H) . 4.90 (d, *J* = 4.4Hz, 2H) ., 6.25-6.49 (m, 1H).^{13} C NMR C l: 20.81.C2: 63.28.C3: 53.07.C4: 79.41.C5: 71.60.C6 - C12: 121.97, 116.67, 133.82, 128.67, 132.67, 124.53, 129.24.C13: 113.5.C14 -C15: 156.16, 139.59.C16: 170.61.C17: 199.87.C18: 201.57. IR cm^{-1} (KBr): υC = O: 1735.62, υ C: 2203, υ C H: 2926.45, υ C-O: 1604.48, υ C = C: 1683. ($[M+H]^+$) : $C_{18}H_{18}O_4$ = 298.33 found 298.33

Methyl (4E) -2-allyl-5- [2- (but-3-enyloxy) phenyl] -3-oxopent-4-enoate

Rf = 0.82 (Eluent: E / Ep: 1/1) as a white solid (600mg, yield = 64%) : mp.141-142°C.^{1}H NMR: 3.70 (s, 3H) . 3.40 (t, *J* = 4Hz, 1H) . 2.60 (d, *J* = 4Hz, 2H) . 5.5-6.(2H) . 5.05 (dd, *J* = 16Hz, 2H). 5.25 (dd, *J* = 12Hz, 2H) . 6.71 (d 1H): 7.44 (d, *J*= 12Hz, 1H) . 6.98-7.23 (m, 4H) 4.00 (d, *J* = 4Hz, 2H). 2.1 (m, 2H).^{13} C NMR C1: 27.65.C2: 53.03.C3: 59.68.C4: 64.06 C5-C12: 117.08, 112.83.119.88.129.48, 128.03, 121.04.119.18 .C14 -C16: 134.75, 140.60, 132.42.C13: 32.85.C17 : 156.82.C18: 72.66.C19: 203.25. IR cm^{-1} (KBr): υ C = O: 1715.37, υ C = C: 1644.02, υ C-O: 1226.51, υ = CH: 2929.34. ($[M+H]^+$) :$C_{19}H_{22}O_4$ = 314.37 found $C_{19}H_{22}O_4$ = 314.39

Methyl (4E) -5- [2- (but-3-enyloxy) phenyl] -3-oxo-2-prop-2-ynylpent-4-enoate

Rf = 0.76 (Eluent: E / Ep: 1/1) . as a white solid (400mg,yield = 43%): mp 144-145°C.1H NMR: 2.41 (s, 3H) . 2.98 (t, *J* = 3.6Hz, 1H) . 2.67 (d, *J* = 3.6Hz, 2H). 2.2 (s, 1H) . 5.00 (dd, *J* = 15Hz, *J*= 1.8, 1H) . 5.15 (dd, *J* = 12.2Hz, *J* = 1.8Hz, 1H) 6.65 (d, *J* = 16.4Hz, 1H) . 7.81 (d, *J* = 16.4Hz, 1H) . 6.75-7.94 (m, 4H).Hl: 4.14 (t, *J* = 6.6Hz, 2H) . 2.05-2.10 (m, 2H) . 5.70-5.90 (m, 1H).^{13} C NMR C1: 19.95.C2: 62.42.C3: 52.23.C4: 72.21.C5: 67.62 C6 - C12: 117.43, 112.29.120.96, 123.47, 127.72, 128.70, 118.31.C13: 33.79C14: 80.49C15 -C16: 131.93, 139.29C17: 157.72.C18: 172.91.C19: 199.57. IR cm^{-1} (KBr): υ C = O: 1724.05, CC: 2213, υ CH: 2951.52, υ C- O: 1604.48, υ C = C: 1652.9. ($[M+H]^+$) : $C_{19}H_{20}O_4$ = 312.36 found $C_{19}H_{22}O_4$ = 312.35

Methyl (4E) -2-allyl-3-oxo-5- [2- (pent-4-enyloxy) phenyl] pent-4-enoate

Rf = 0.65 (Eluent: E / Ep: 1/1) as a white solid (500mg, yield = 58%): mp.145-146.^{1}H NMR: 2.70 (s, 3H) 2.40 (t, *J* = 6Hz, 1H) . 2.80 (d, *J* = 6Hz, 2H) . 5.1-5.9 (m, 2H). 4.95 (dd, *J*= 2H) 5.25 (dd, *J* = 12Hz, 2H) . 6.81 (d, *J* = 16Hz, 1H). 7.94 (d, *J* = 16Hz, 1H).6.98-7.53 (m, 4H) . 4.09 (t, *J* = 4Hz, 2H).1.90-2.1 (m, 4H).^{13}C NMR C1: 26.25.C2: 53.00, C3: 58.08.C4: 71.36 C7: 28.60.C8: 30.49 C5.6.9 - C14: 115.88, 121.83, 123.88, 127.48, 127.93, 128.04.128.78.126.33.C15 : 158.00. C16-C18: 137.75, 140.20, 132.18, C19: 172.96, C20: 202.15, 13 19 18 18 .IR cm-1 (KBr): υC = O: 1736.58, υC = C: 1662.34, υC-O: 1235.18, υ = CH: 2942.84.($[M+H]^+$) : $C_{20}H_{24}O_4$ = 328.40 found $C_{19}H_{22}O_4$ = 328.39

Methyl (4E) -3-oxo-5- [2- (pent-4-enyloxy) phenyl] -2-prop-2-ynylpent-4-enoate

R_f = 0.76 (Eluent: E / Ep: 1/1) as a yellow solid (400mg, yield = 51%): mp .130-131°C ^{1}H RMN : 2.20 (s, 3H). 2.65 (t, *J*= 6Hz, 1H) . 3.00 (d, *J* = 6Hz, 2H) . 1.22 (s, 1H) . 5.7-5.9 (m, 1H) . 5.01 (dd, *J* = 16Hz, 1H) .He ': 5.15 (dd, *jeo* = 12Hz, 1H) .Hf: 6.71 (d, *J* = 16Hz, 1H) .Hg: 7.90 (d, *J* = 16Hz, 1H) .6.89-7.60 (m, 4H) .H1: 4.00 (t, *J* = 8Hz, 2H) . 1.90-2.1 (m, 4H) . ^{13}C RMN C1: 22.18, C2: 53.51, C3: 62.69, C4: 72.45, C5: 43.29, C7: 30.59, C8: 27.46, C14: 112.53, 115.79, 121.06, 121.11, 123.73, 127.93, 128.77, C15: 80.76, C16: 158.08, C17, C18: 139.22, 132.16.C19:

173.09.C20: 200.99.13 19 18 IR cm^{-1} (KBr): υC = 0: 1732.73, CC: 2223, υ CH: 2933.20, υC-O: 1591.98, υC = C: 1644.9.($[M+H]^+$) : $C_{20}H_{22}O_4$ = 326.38 faund $C_{19}H_{22}O_4$ = 326.37

Methyl (4E) -2-allyl-3-oxo-5 - [2- (prop-2-ynyloxy) phenyl] pent-4-enoate

Rf = 0.71 (Eluent: E / Ep: 1/1) as a yellow solid (600mg , yeild = 63%) : mp. 133-134.^{1}H NR (: 1.24 (s, 3H) . 2.22 (t, *J* = 2.4Hz, 1H) .Hc: 2.63 (d, *J* = 2.4Hz, 2H) . 5.0-5.2 (m, 1H) . 6.00 (dd, *J*= 2.2Hz, *J* = 18Hz, 1H) . 5.75 (dd, *J* = 2.2Hz, *J* = 12Hz, 2H) . 6.89 (d, *J*= 16Hz, 1H) . 7.98 (d, *J* = 16Hz, 1H) . 7.01-7.59 (m, 4H) . 4.73 (d, *J* = 4Hz, 2H) . 2.38 (s, 1H) .RMN ^{13}C: C1 : 28.13.C2: 53.21.C3: 59.81.C4: 56.68.C5 , C14: 76.38.77.83.C6 - C12: 113.95, 118.39,119.85,120.14, 121.05, 123.50,128.50, 129.18.C13, C15: 132.75, 134.57.C16: 157.55.C17: 173.60.C18: 201.00.18 13.IR cm^{-1} (KBr) : υC = O: 1710.07, υ C-C: 2118.91, υ CH: 2853.66, υ C-O: 1597.74, υ C=C: 1666.20.($[M+H]^+$) : $C_{18}H_{18}O_4$ = 298.33 found $C_{19}H_{22}O_4$ = 298.31

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