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Article

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Metal-free Brønsted Acid-Catalyzed Rearrangement of δ-Hydroxyalkynones to 2,3-Dihydro-4*H*-pyran-4-ones: Total Synthesis of Obolactone and a Catechol Pyran Isolated from *Plectranthus sylvestris*

Sachin P. Gholap, Dashrath Jangid and Rodney A. Fernandes*

Department of Chemistry, Indian Institute of Technology Bombay, Powai, Mumbai 400076, Maharashtra, India

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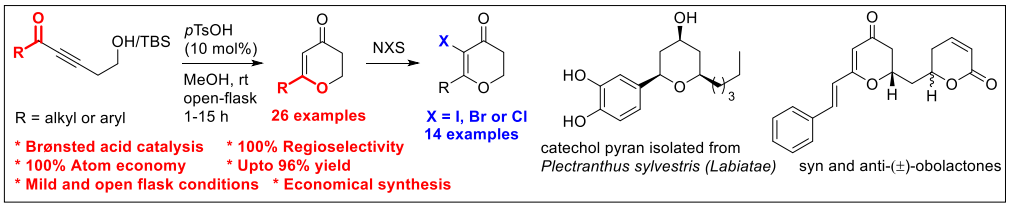
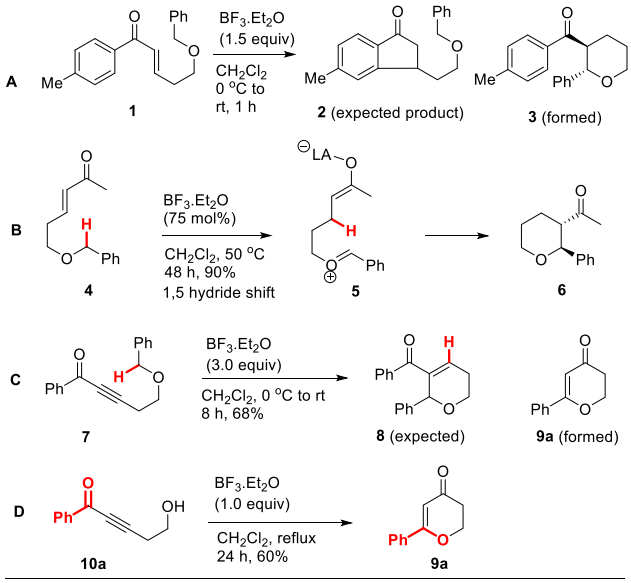


ABSTRACT: A metal-free, Brønsted acid, *p*TsOH-catalyzed intramolecular rearrangement of δ-hydroxyalkynones to substituted 2,3-dihydro-4*H*-pyran-4-ones has been developed. The rearrangement occurs with high regioselectivity under mild and open-air conditions. The scope of work has been illustrated by synthesizing an array of aliphatic and aromatic substituted 2,3-dihydro-4*H*-pyran-4-ones in upto 96% yield, 100% atom economy and complete regioselectivity. Some of the dihydropyranones are utilized for vinylic halogenations and to complete the total synthesis of bioactive natural products, obolactone and a catechol pyran isolated from *Plectranthus sylvestris (Labiatae).*

INTRODUCTION

The dihydropyranone skeleton shows wide range of pharmaceutical and bioactive properties.[1] It is present in various bioactive natural products such as obolactone (anti-trypanosomal activity),[2a] heplialone,[2b] diospongin (potent inhibitory activities on bone resorption),[2c,d] neopeltolide (potent inhibitor of the in vitro proliferation of A-549 human lung adenocarcinoma),[2e] lyngbyaloside-B,[2f] stegobiol,[2g] monensin (polyether antibiotics),[2h] exiguolide,[2i] etc. A few methods are reported in the literature for the synthesis of dihydropyranones;[3] some of them have concerns like vigorous reaction conditions, limited substrate scope, lengthy synthesis of starting materials as well as the use of costly reagents. This report of a simple and cost-effective method toward the synthesis of dihydropyranones is a serendipitous discovery. In the Nazarov cyclization of compound **1** to get indanone **2**, we obtained the pyran **3** (Scheme 1A). A search for the mechanistic rationale for such a reaction, led us to the report by Sames *et al.*,[4] where in (*E*)-6-(benzyloxy)hex-3-en-2-one **4** was converted into 2-phenyl-3-acetyl tetrahydro-2*H*-pyran **6** by the action of $BF_3{\cdot}Et_2O$ (75 mol%) in 90% yield and 15:1 ratio for *trans*:*cis*-isomers (Scheme 1B). This reaction proceeds via a 1,5-hydride shift creating an oxocarbenium ion that is attacked by the enolate **5** formed in-situ, leading to 2,3-disubstituted tetrahydropyran **6**. On similar lines, we expected that alkyne compound **7** would lead to 2-phenyl-3-benzoyl 5,6-dihydro-2*H*-pyran **8**, by an identical hydride shift. However this reaction led to 6-phenyl 2,3-dihydro-4*H*-pyran-4-one **9a**. The excess Lewis acid (3.0 equiv) caused debenzylation and subsequent cyclization involving the alkyne. Similar to

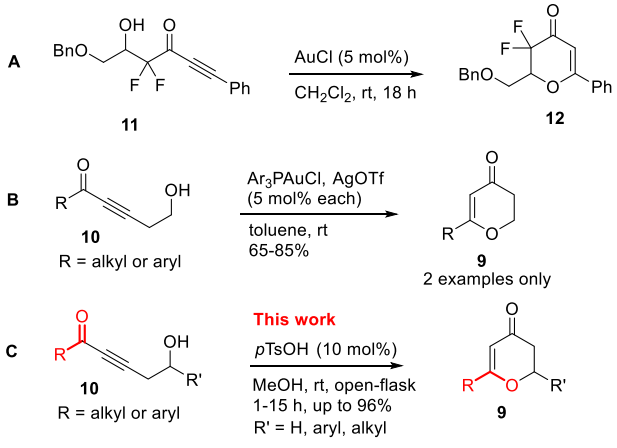
Scheme 1. Approaches to substituted pyrans and dihydropyranones



compound **7**, the alkyne compound **10a** with a free hydroxyl group, also delivered **9a** (indicating debenzylation in the earlier case) and required only one equivalent of Lewis acid. While 6-substituted pyran-4-ones have been synthesized before by different strategies,[3] the methods having closer substrate resemblance were that of Gouverneur[3d] and Akai[3f] (only 2 examples), which were based on gold catalysis (Scheme 2A and 2B, respectively). Considering that the Lewis acid-based approach would be simple and economical, we ventured to study the scope and limitations of

this reaction and its validation in total synthesis. It was indeed found that the reaction could be catalyzed more efficiently and metal-free, by the Brønsted acid, *p*-toluenesulphonic acid (*p*TsOH, 10 mol%) with complete regioselectivity and 100% atom economy under mild and open-air conditions (Scheme 2C).

Scheme 2. Catalytic synthesis of dihydropyranones

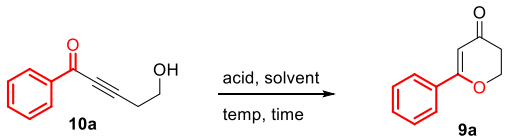


RESULTS AND DISCUSSION

The rearrangement reaction was optimized using substrate **10a** as model compound using various Lewis and Brønsted acids in different solvents and temperature. The reaction of **10a** with $BF_3{\cdot}OEt_2$ (1.0 equiv) in CH_2Cl_2 at 50 °C delivered **9a** in 60% yield in 24 h, while *p*TsOH under the same conditions was found to be better, giving **9a** in 75% yield in a shorter time of 5 h (Table 1, entries 1 and 2 respectively). Other Lewis acids like $AlCl_3$, $FeCl_3$ or $TiCl_4$ gave poor yields (entries 3-5). Protic acids such as HCl, H_2SO_4 or HBr did not prove better (entries 6-8). Other Brønsted acids like AcOH or its halogenated analogues did not work well for this reaction (entries 9-11). Triflic acid (TfOH) and $Cu(OTf)_2$ also did not appear to be better (entries 12-14). Other sulphonic acids such as methanesulfonic acid (MsOH), benzenesulfonic acid (PhsOH) or camphorsulfonic acid (CSA) were not superior in giving **9a** (entries 15-17). In fact, the reaction with CSA yielded only trace amounts of the product. Thus, *p*TsOH was taken further for optimization. The reaction at room temperature with *p*TsOH was sluggish and delivered **9a** in 15% yield after 24 h. Several solvents were then investigated for *p*TsOH-based reactions (entries 19-24). The reaction in MeOH improved the yield of **9a** to 95% and was completed in just 3.5 h at room temperature (entry 19), indicating the influence of the protic solvent. Change in *p*TsOH concentration (entries 25-27) indicated that the reaction worked equally well with 10 mol% (entry 26) at the expense of time, while further decrease resulted in a lower yield of **9a** (entry 27).

With the optimized conditions, the scope and limitations of different δ-hydroxyalkynones cyclization catalyzed by *p*TsOH (10 mol%) was studied. As shown in Scheme 3, the cyclization of various aryl and alkyl substituted δ-hydroxyalkynones **10a-z** delivered the 6-substituted 2,3-dihydro-4*H*-pyran-4-ones or 2,6-substituted 2,3-dihydro-4*H*-pyran-4-ones **9a-z** in good to excellent yields under open-air conditions. The substrates with aryl group bearing

Table 1. Optimizations of reaction conditions[a]



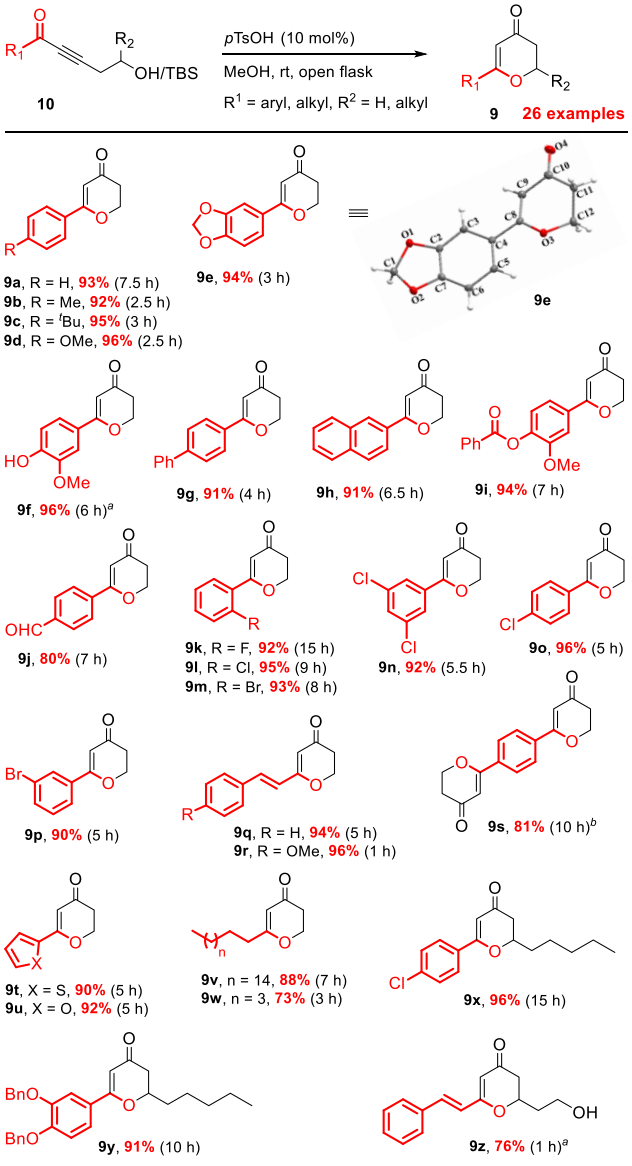
Entry	Acid (equiv)	Solvent	Temp. °C	Time h	Yield %[b]
1	$BF_3{\cdot}OEt_2$ (1)	CH_2Cl_2	reflux	24	60
2	*p*TsOH (1)	CH_2Cl_2	reflux	5	75
3	$AlCl_3$ (1)	CH_2Cl_2	reflux	30	12
4	$FeCl_3$ (1)	CH_2Cl_2	reflux	30	40
5	$TiCl_4$ (1)	CH_2Cl_2	reflux	24	34
6	HCl (1)	CH_2Cl_2	reflux	16	40
7	H_2SO_4 (1)	CH_2Cl_2	reflux	16	42
8	HBr (1)	CH_2Cl_2	reflux	16	36
9	AcOH (1)	CH_2Cl_2	reflux	24	40
10	F_3CCO_2H (1)	CH_2Cl_2	reflux	30	12
11	Cl_3CCO_2H (1)	CH_2Cl_2	reflux	24	trace
12	TfOH (1)	CH_2Cl_2	reflux	30	trace
13	$Cu(OTf)_2$ (1)	CH_2Cl_2	rt	24	20
14	$Cu(OTf)_2$ (1)	CH_2Cl_2	reflux	36	51
15	MsOH (1)	CH_2Cl_2	reflux	16	62
16	PhsOH	CH_2Cl_2	reflux	16	66
17	CSA (1)	CH_2Cl_2	reflux	24	trace
18	*p*TsOH (1)	CH_2Cl_2	rt	24	15
19	*p*TsOH (1)	MeOH	rt	3.5	95
20	*p*TsOH (1)	EtOH	rt	50	60
21	*p*TsOH (1)	*t*BuOH	rt	40	50
22	*p*TsOH (1)	THF	70	30	10
23	*p*TsOH (1)	Toluene	rt	40	40
24	*p*TsOH (1)	DMF	rt	24	NR
25	*p*TsOH (0.5)	MeOH	rt	5	94
26	*p*TsOH (0.1)	MeOH	rt	7.5	93
27	*p*TsOH (0.05)	MeOH	rt	15	81

[a]Reaction conditions: **10a** (0.5 mmol), acid (0.05–1.0 equiv), solvent, rt–70 °C, 3.5–50 h. [b]Isolated yield. NR = No reaction, rt = room temperature

substituents like Me, *t*Bu, OMe, -OCH_2O-, OH or Ph (**10a-h**) were successfully converted into the corresponding pyranones **9a-h** in 80–91% yields.[5] The δ-hydroxyalkynone **10f** had TBS groups on the phenolic and primary alcohol groups, which were desilylated followed by cyclization to afford **9f** in excellent yield of 96%. Also compounds with electron withdrawing and halo groups **10i-p** were well-tolerated, providing the pyranones **9i-p** in 80–96% yields. The benzoyl group in **9i** remained intact; like-wise, the formyl group in **9j** did not undergo acetal formation under the *p*TsOH conditions in MeOH solvent. The sensitive styryl systems **10q** and **10r** also provided the corresponding pyranones **9q** (94%) and **9r** (96%) in excellent yields. The symmetric *bis*-δ-hydroxyalkynone **10s** delivered the *bis*-pyranone **9s** with *p*TsOH (20 mol%) in a 10 h reaction in 81% yield. The cyclization also worked well for heteroaryls

based on thiophene **10t** and furan **10u** to provide the dihydropyranones **9t** and **9u** in good yields (90 and 92% respectively). With successful results on aromatic substrates, we moved our attention to the synthesis of alkyl substituted dihydropyranones. The substrates **10v** and **10w** worked as expected to give **9v** and **9w** in good yields of 88% and 73%. We also investigated the synthesis of 2,6-disubstituted dihydropyranones. Toward this endeavour, the secondary δ-hydroxyalkynones **10x-z** worked efficiently to give the 2,6-disubstituted dihydropyranones **9x-z** in good to excellent yields of 76-96%. In the latter case, **10z** had the primary OH protected as a OTBS derivative, which was desilylated during the reaction. This proved advantageous in total synthesis (see Scheme 7 later).

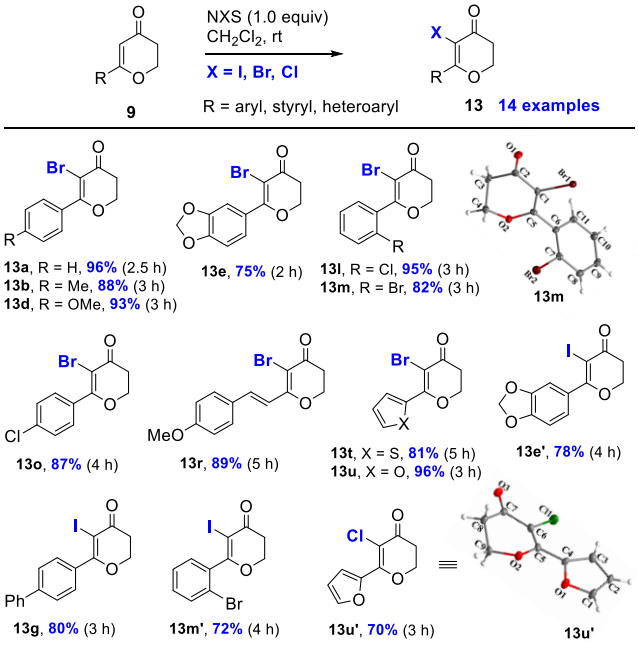
Scheme 3. Substrate scope for synthesis of 6-substituted or 2,6-disubstituted 4*H*-pyran-4-ones



Reaction conditions: Alkynone **10** (1.0 mmol), *p*TsOH (10 mol%), MeOH, rt, open-flask. [a]Corresponding OTBS substrate was used. [b]*p*TsOH (20 mol% used)

Vinyl halides are precursors for various cross coupling reactions.[6] Hence we considered the conversion of some of the synthesized dihydropyranones **9** to the vinyl halo compounds by regioselective halogenation.[3d] The treatment of dihydropyranones **9a**, **9b**, **9d**, **9e**, **9l**, **9m**, **9o**, **9r**, **9t** and **9u** with NBS in CH_2Cl_2, provided the corresponding vinyl bromo compounds **13a**, **13b**, **13d**, **13e, 13l**, **13m**, **13o**, **13r**, **13t** and **13u** respectively in good to excellent yields (75–96%) without effecting aryl halogenation/s (Scheme 4).[5] The styryl **13r,** thiophenyl **13t** and furanyl **13u** pyranones were obtained by regioselective bromination in good yields, remarkably without affecting the styryl or heteroaryl groups. Similarly **13e′**, the biphenyl compound **13g** and **13m′** were obtained as vinyl iodides in good yields of 72-80%. Also the chlorination of **9u** gave compound **13u′** in 70% yield.[5]

Scheme 4. Regioselective halogenation of 6-substituted 4*H*-pyran-4-ones



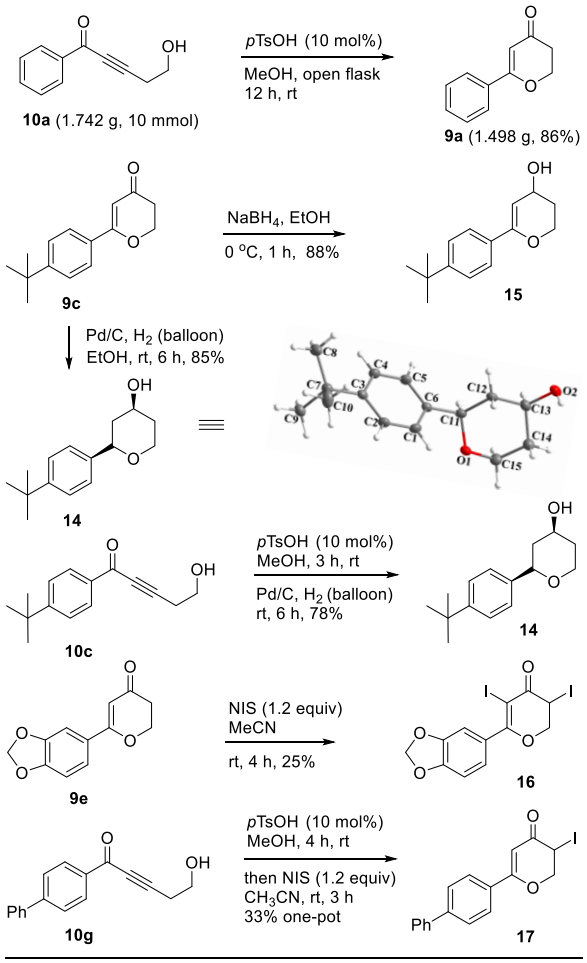
Reaction conditions: Pyranone **9** (0.25 mmol), NXS (1.0 equiv), CH_2Cl_2, rt

Further, a gram scale reaction of **10a** (1.742 g, 10 mmol) gave **9a** (1.498 g, 86%) in a 12 h reaction with the same loading of *p*TsOH (10 mol%, Scheme 5), indicating scope for scale up of reaction. Next, the functionalization of some of the pyranones was executed. Dihydropyranone **9c** upon catalytic hydrogenation with Pd/C provided exclusively *cis*-tetrahydropyran **14** (X-ray)[5] in 85% yield. The $NaBH_4$ reduction of **9c** gave 3,4-dihydro-*2H*-pyran-4-ol **15** in 88% yield. A one pot rearrangement of **10c** followed by hydrogenation gave **14** in 78% yield. Selective iodination of **9e** with NIS in the presence of *p*TsOH furnished diiodo compound **16** in 25% yield. The aryl ring was not affected in this case. However, the one pot rearrangement followed by iodination under latter conditions gave the other regioseselective α-iodo compound **17** in 33% yield. Thus this demonstrates the various avenues available for structural modification of synthesized dihydropyranones and these could be used for further derivatizations.

The application of a synthetic methodology to streamline the synthesis of natural products is an important validation

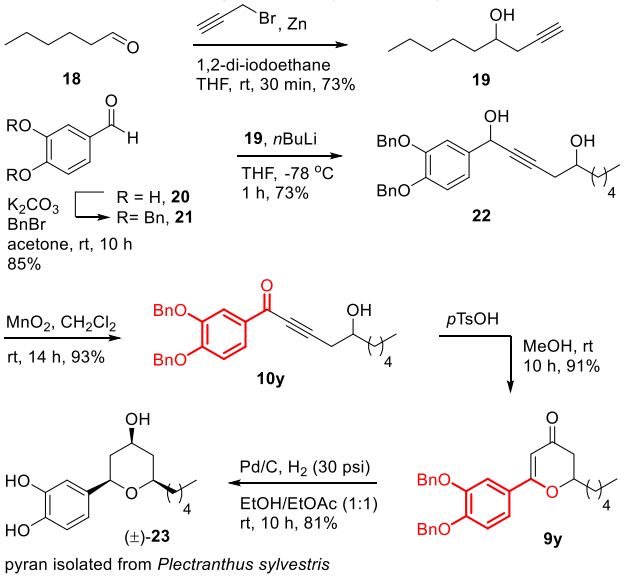
of its synthetic potential and usefulness. The developed rearrangement was also utilized in the total synthesis of a catechol pyran molecule **23** isolated from *Plectranthus sylvestris* (*Labiatae*) by Juch and Rüedi[7] (Scheme 6). It shows potent antioxidant and anti-imflammatory activities.[7] The first total synthesis of **23** along with its acetate analogue was reported by Willis and co-workers using asymmetric Prins cyclization as a key step.[8] Alkyne **19** was prepared from hexanal **18** and propargyl bromide by using Zn and 1,2-diiodoethane (Scheme 6). This was added to aldehyde **21** (prepared from commercially available **20**) to give alkynediol **22** in 73% yield. Selective benzylic oxidation of **22** using MnO_2 produced the key intermediate **10y** that was subjected to present rearrangement catalyzed by *p*TsOH (10 mol%) in MeOH to furnish efficiently dihydropyranone **9y** (Scheme 3) in 91% yield. Finally the catalytic hydrogenation of the double bond and debenzylation (81%) successfully completed the total synthesis of catechol pyran **23** (single diastereomer, 42.5% overall yield from **20**).

Scheme 5. Functionalization of dihydropyranones

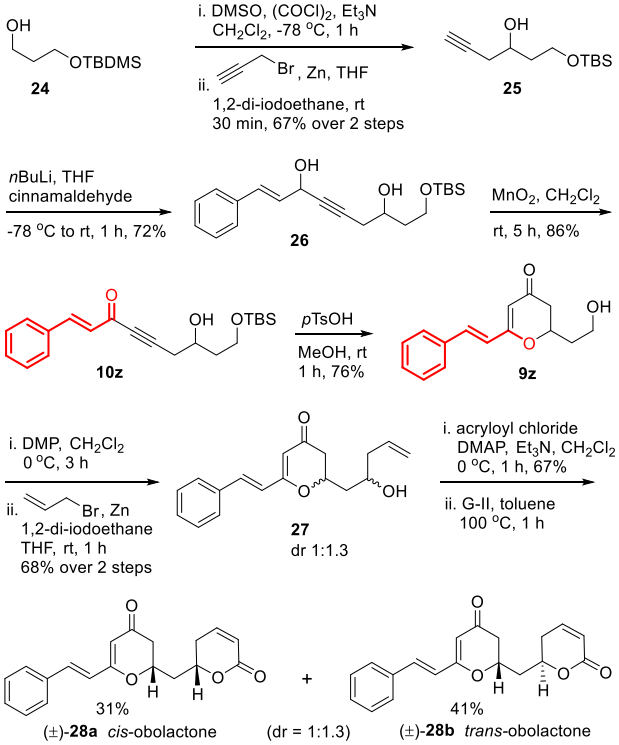


Further, the total synthesis of both diastereomers of (±)-obolactone **28** employing the rearrangement reported herein as the key step was undertaken (Scheme 7). Guéritte and co-workers isolated (*R,R*)-obolactone from the dried ground trunk bark of *Cryptocarya obovata*,[1b] a tropical plant of cinnamon family, which displayed medium cytotoxicity on human nasopharyngeal carcinoma KB cells (56% inhibition at 10 μg mL^{-1} for ethanolic extract of fruit and 23% for extract from trunk bark). It was extracted in EtOH and

Scheme 6. Total synthesis of catechol pyran 23 isolated from *Plectranthus sylvestris (Labiatae)*



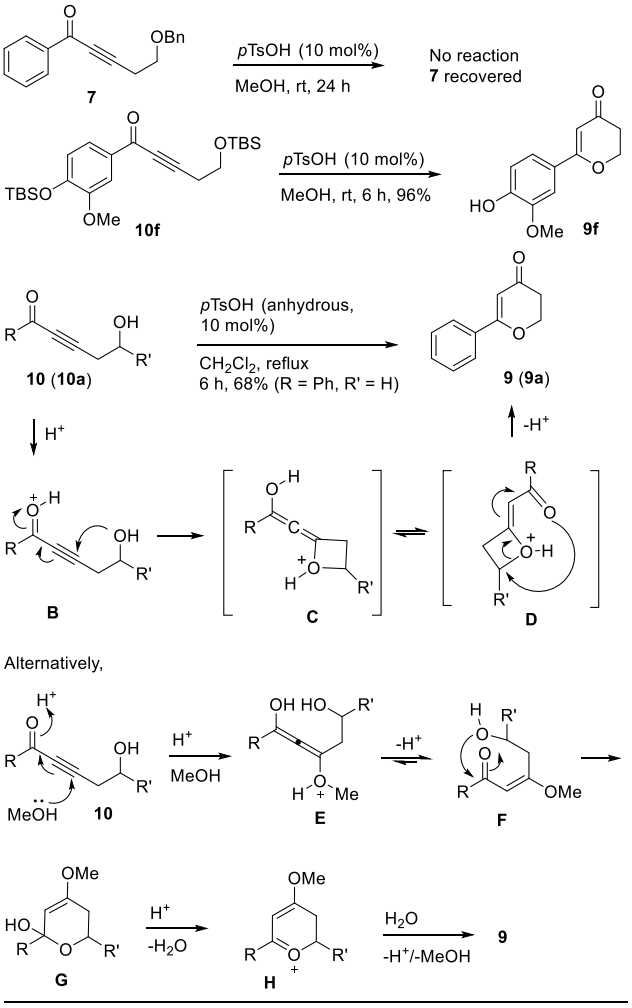
Scheme 7. Total synthesis of *syn*/*anti*-(±)-obolactones 28a and 28b



purified by silica gel column chromatography.[1b,2a] There are few reports on the total synthesis of obolactone.[9] Our synthesis commenced from 3-(*tert*-butyldimethylsilyloxy) propan-1- ol **24**, which on Swern oxidation followed by propargylation gave alkyne **25** in 67% yield. The latter on addition to cinnamaldehyde using *n*BuLi provided the diol **26** in 72% yield. This on selective allylic oxidation by MnO_2 gave the

desired alkynone **10z** in 86% yield. Further the *p*TsOH-catalyzed rearrangement delivered efficiently the dihydropyranone **9z** in 76% yield with desilylation occurring in the same reaction (Scheme 3). Dess–Martin periodinane (DMP) oxidation of **9z** to aldehyde and in situ Barbier allylation gave **27** as a mixture of diastereomers in 68% yield (dr = 1:1.3, syn/anti). Esterification of alcohol **27** with acryloyl chloride (67%) and ring closing metathesis delivered the easily separable two diastereomers of (±)-obolactone, **28a** (31%) and **28b** (41%).

Scheme 8. Proposed reaction mechanism



To obtain insights into the reaction mechanism, when the reaction of alkynone **7** was carried out using *p*TsOH, it did not yield the desired dihydropyranone **9a**, unlike the case when excess $BF_3{\cdot}OEt_2$ was used, which effected debenzylation and subsequent rearrangement (Schemes 1 and 8). However, the free hydroxy-containing compound **10a** and the TBS-protected compound **10f**, both delivered the dihydropyranones **10a** and **9f** respectively, indicating the requirement of free hydroxyl for this rearrangement (the silyl group is deprotected during the reaction as discussed above). With this understanding, we propose the initial protonation of carbonyl oxygen of **10** to **B** followed by conjugate addition by hydroxyl group leading to intermediate oxetane **C**, which tautomerizes to **D** (Scheme 8). Such conjugate addition to alkynes has been proposed for 3- and 5-membered rings.[3i,10] Further nucleophilic attack by the carbonyl oxygen at the δ-position results in rearranged compound, that on deprotonation gives the dihydropyranones **9**. This mechanism is supported by the fact that a reaction under anhydrous conditions (freshly dried *p*TsOH) in dry CH_2Cl_2 at reflux delivered the product **9a** in 68% yield (against the 75% yield obtained under the wet *p*TsOH and open flask conditions, entry 2, Table 1, in 5 h). Secondly, the reaction with $BF_3.OEt_2/CH_2Cl_2$ (entry 1, Table 1) gave 60% yield of rearranged product **9a** in 24 h. Since the yield of reaction was influenced by MeOH solvent, the participation by moisture (H_2O) and/or MeOH cannot be rulled out for an alternative alkyne hydration/methanol addition mechanism (Scheme 8). Addition of MeOH to **10** would give **E**, which tautomerizes to ketone **F**. Intramolecular hemiacetal formation to **G** followed by dehydration to **H** and further hydrolysis would give **9**.

CONCLUSION

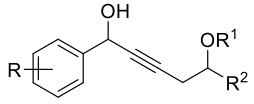
In summary, we have developed a simple, metal-free and cost-effective *p*TsOH-catalyzed intramolecular rearrangement of δ-hydroxyalkynones to substituted 2,3-dihydro-4*H*-pyran-4-ones. The rearrangement occurs regioselectively under mild and open-air conditions. The scope has been illustrated by synthesizing several mono- and disubstituted-2,3-dihydro-4*H*-pyran-4-ones in up to 96% yield with 100% atom economy. A regioselective and chemoselective vinylic halogenation has also been achieved on the synthesized dihydropyranones. Further application of this rearrangement in the total synthesis of *syn*/*anti*-(±)-obolactones and a catechol pyran isolated from *Plectranthus sylvestris* (*Labiatae*) has been demonstrated.

EXPERIMENTAL SECTION

General Information. Solvents were dried by standard methods. Thin-layer chromatography was performed on EM 250 Kieselgel 60 F254 silica gel plates. The spots were visualized by staining with $KMnO_4$ or under a UV lamp. ^1H and ^{13}C NMR were recorded with a spectrometer operating at 500 or 400 and 125 or 100 MHz for proton and carbon nuclei respectively. The chemical shifts are based on the TMS peak at δ = 0.00 pm for proton NMR and the $CDCl_3$ peak at δ = 77.00 ppm (t) in carbon NMR. IR spectra were obtained on an FT–IR spectrometer, and samples were prepared by evaporation from $CHCl_3$ on CsBr plates. High-resolution mass spectra (HRMS) were obtained using positive electrospray ionization by the TOF method. δ-Hydroxyalkynones **10** were prepared from aldehydes in 2 steps.

General procedure for alkynylation of aldehydes. To a solution of homopropargylic alcohol, (but-3-yn-1-yloxy)(*tert*-butyl)dimethylsilane or non-1-yn-4-ol (5.0 mmol, 1.0 equiv) in dry THF (20 mL) cooled to –78 °C was added *n*-BuLi (1.6 M in hexane, 6.30 mL, 10.0 mmol, 2.0 equiv) dropwise. The reaction was stirred for 30 min and aldehyde (5.0 mmol, 1.0 equiv) in THF (10 mL) was added in one portion. The mixture was allowed to warm to 0 °C

over 1 h and then quenched by addition of sat. aqueous solution of NH_4Cl (30 mL). The two layers were separated and the aqueous layer was extracted with EtOAc (3 × 30 mL). The combined organic layers were washed with water (40 mL), brine, dried ($MgSO_4$), filtered and concentrated. The residue was purified by silica gel column chromatography using petroleum ether/EtOAc (7:3 to 1:1) as eluent to afford the desired diol **29a-x**. The characterization data for all the diols is given below. Compound **29i** was not prepared. The corresponding *δ*-hydroxyalkynone **10i** was prepared from **10f** (procedure given separately). For compound **29f**, *n*-BuLi (1.6 M in hexane, 3.2 mL, 5.0 mmol, 1.0 equiv) was used.



29 R^1 = H, TBS; R^2 = H, alkyl

*1-Phenylpent-2-yne-1,5-diol (**29a**):*[3f] Yellow oil (608 mg, 69%). ^{1}H NMR (500 MHz, $CDCl_3$): *δ* = 2.51 (td, *J* = 6.2, 2.0 Hz, 2H), 2.55 (br s, 2H, *OH*), 3.73 (t, *J* = 6.2 Hz, 2H), 5.44 (t, *J* = 2.0 Hz, 1H), 7.29–7.39 (m, 3H), 7.51–7.53 (m, 2H) ppm. ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): *δ* = 23.1, 60.8, 64.6, 81.9, 84.1, 126.6, 128.3, 128.6, 140.9 ppm. IR ($CHCl_3$): υ_{max} = 3614, 3411, 3019, 2976, 2926, 1602, 1522, 1494, 1476, 1450, 1423, 1390, 1123, 1044, 1027, 928, 876, 848, 669 cm^{-1}.

*1-p-Tolylpent-2-yne-1,5-diol (**29b**):* Yellow solid (618 mg, 65%), M.p. 84–86 °C. ^{1}H NMR (400 MHz, $CDCl_3$): *δ* = 2.35 (s, 3H), 2.53 (td, *J* = 6.1, 2.1 Hz, 2H), 3.75 (t, *J* = 6.1 Hz, 2H), 5.42 (s, 1H), 7.18 (d, *J* = 7.8 Hz, 2H), 7.41 (d, *J* = 8.1 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): *δ* = 21.1, 23.2, 60.9, 64.5, 82.2, 83.8, 126.5, 129.3, 138.1, 138.2 ppm. IR ($CHCl_3$): υ_{max} = 3684, 3620, 3434, 3019, 2976, 2927, 2240, 1638, 1604, 1519, 1476, 1422, 1046, 928, 669 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{12}H_{14}O_2Na$ 213.0886; Found 213.0887.

*1-(4-tert-Butylphenyl)pent-2-yne-1,5-diol (**29c**):* Yellow semi-solid (801.5 mg, 69%). ^{1}H NMR (500 MHz, $CDCl_3$): *δ* = 1.32 (s, 9H), 2.52 (td, *J* = 6.0, 1.5 Hz, 2H), 3.74 (t, *J* = 6.1 Hz, 2H), 5.42 (s, 1H), 7.39 (d, *J* = 8.3 Hz, 2H), 7.46 (d, *J* = 8.3 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): *δ* = 23.2, 31.3, 34.6, 60.9, 64.4, 82.1, 83.9, 125.5, 126.3, 138.0, 151.4 ppm. IR ($CHCl_3$): υ_{max} = 3353, 2960, 2905, 2871, 2227, 1661, 1613, 1510, 1412, 1364, 1269, 1203, 1107, 1045, 946, 842, 775, 758, 698, 576 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{15}H_{20}O_2Na$ 255.1356; Found 255.1353.

*1-(4-Methoxyphenyl)pent-2-yne-1,5-diol (**29d**):* Yellow oil (660 mg, 64%). ^{1}H NMR (500 MHz, $CDCl_3$): *δ* = 2.47 (td, *J* = 6.2, 1.9 Hz, 2H), 3.69 (t, *J* = 6.2 Hz, 2H), 3.78 (s, 3H), 5.39 (s, 1H), 6.86 (d, *J* = 8.7 Hz, 2H), 7.42 (d, *J* = 8.7 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): *δ* = 23.0, 55.2, 60.7, 64.0, 82.0, 84.0, 113.8, 128.0, 133.2, 159.4 ppm. IR ($CHCl_3$): υ_{max} = 3439, 3005, 2955, 2935, 2838, 2240, 2208, 1608, 1512, 1463, 1422, 1303, 1253, 1172, 1108, 1032, 846, 690 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{12}H_{14}O_3Na$ 229.0835; Found 229.0833.

*1-(Benzo[d][1,3]dioxol-5-yl)pent-2-yne-1,5-diol (**29e**):* Yellow solid (837 mg, 76%), M.p. 94–96 °C. ^{1}H NMR (500 MHz, $CDCl_3$): *δ* = 2.53 (td, *J* = 6.5, 1.7 Hz, 2H), 3.74 (t, *J* = 6.1 Hz, 2H), 5.35 (s, 1H), 5.95 (s, 2H), 6.78 (d, *J* = 7.9 Hz, 1H), 6.98 (dd, *J* = 6.9, 1.7 Hz, 1H), 7.04 (d, *J* = 1.7 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): *δ* = 23.2, 60.9, 64.5, 81.9, 83.9, 101.2, 107.3, 108.1, 120.2, 135.0, 147.6, 147.8 ppm. IR ($CHCl_3$): υ_{max} = 3426, 2924, 2857, 2225, 1652, 1503, 1489, 1444, 1280, 1258, 1038, 930, 765 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{12}H_{12}O_4Na$ 243.0628, Found 243.0629.

*5-(tert-Butyldimethylsilyloxy)-1-[4-(tert-butyldimethylsilyloxy)-3-methoxyphenyl]pent-2-yn-1-ol (**29f**):* Yellow oil (1.375 g, 61%). ^{1}H NMR (400 MHz, $CDCl_3$): *δ* = 0.06 (s, 6H), 0.15 (s, 6H), 0.89 (s, 9H), 0.99 (s, 9H), 2.50 (td, *J* = 7.1, 2.0 Hz, 2H), 3.75 (t, *J* = 7.1 Hz, 2H), 3.81 (s, 3H), 5.37 (s, 1H), 6.81 (d, *J* = 8.1 Hz, 1H), 6.98 (dd, *J* = 8.1, 2.0 Hz, 1H), 7.04 (d, *J* = 2.0 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): *δ* = –5.3, –4.7, 18.3, 18.4, 23.2, 25.7, 25.9, 55.4, 61.8, 64.7, 81.2, 84.2, 110.7, 119.1, 120.6, 134.5, 145.1, 150.9 ppm. IR ($CHCl_3$): υ_{max} = 3403, 2959, 2931, 2858, 2230, 1593, 1513, 1464, 1420, 1292, 1258, 1224, 1124, 1034, 898, 839, 792 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{22}H_{42}O_4Si_2Na$ 449.2514; Found 449.2514.

*1-(Biphenyl-4-yl)pent-2-yne-1,5-diol (**29g**):* Pale yellow solid (883 mg, 70%), M.p. 80–82 °C. ^{1}H NMR (400 MHz, $CDCl_3$): *δ* = 2.00 (br s, 2H, *OH*), 2.57 (td, *J* = 6.1, 1.9 Hz, 2H), 3.38 (t, *J* = 6.1 Hz, 2H), 5.51 (s, 1H), 7.34–7.38 (m, 1H), 7.42–7.46 (m, 2H), 7.58–7.60 (m, 6H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): *δ* = 23.2, 61.0, 64.5, 82.0, 84.1, 127.0, 127.1, 127.4, 127.43, 128.8, 139.9, 140.6, 141.3 ppm. IR ($CHCl_3$): υ_{max} = 3429, 3031, 2920, 2240, 2206, 1641, 1603, 1487, 1406, 1277, 1179, 1114, 1039, 858, 749, 698 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + H]$^+$ Calcd for $C_{17}H_{17}O_2$ 253.1223; Found 253.1219.

*1-(Naphthalen-2-yl)pent-2-yne-1,5-diol (**29h**):* White solid (746.7 mg, 66%), M.p. 100–102 °C. ^{1}H NMR (500 MHz, $CDCl_3$): *δ* = 2.55 (td, *J* = 6.0, 1.9 Hz, 2H), 3.75 (t, *J* = 6.1 Hz, 2H), 6.12 (s, 1H), 7.45–7.56 (m, 3H), 7.82–7.84 (m, 2H), 7.88 (d, *J* = 8.6 Hz, 1H), 8.29 (d, *J* = 8.4 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): *δ* = 23.2, 61.9, 62.9, 81.8, 84.7, 123.8, 124.4, 125.2, 125.9, 126.4, 128.8, 129.3, 130.4, 134.0, 135.9 ppm. IR ($CHCl_3$): υ_{max} = 3367, 3049, 2922, 2857, 2231, 1596, 1510, 1415, 1395, 1256, 1232, 1166, 1135, 1048, 1015, 992, 863, 779, 632 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{15}H_{14}O_2Na$ 249.0886; Found 249.0886.

*4-(1,5-Dihydroxypent-2-ynyl)benzaldehyde (**29j**):* Yellow semi-solid (653.5 mg, 64%). ^{1}H NMR (400 MHz, $CDCl_3$): *δ* = 2.49 (td, *J* = 6.0, 2.0 Hz, 2H), 3.23 (br s, 2H, *OH*), 3.73 (t, *J* = 6.0 Hz, 2H), 5.49 (s, 1H), 7.67 (d, *J* = 8.1 Hz, 2H), 7.85 (d, *J* = 8.1 Hz, 2H), 9.98 (s, 1H) ppm. ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): *δ* = 22.9, 60.7, 63.9, 81.2, 84.9, 127.0, 130.0, 135.9, 147.5, 192.1 ppm. IR ($CHCl_3$): υ_{max} = 3418, 2925, 2854, 2237, 2203, 1702, 1646, 1608, 1418, 1267, 1207, 1102, 1046, 824, 761, 516 cm^{-1}. HRMS and CH analysis is not available, as the compound decomposes.

*1-(2-Fluorophenyl)pent-2-yne-1,5-diol (**29k**):* Pale yellow oil (709 mg, 73%). ^{1}H NMR (400 MHz, $CDCl_3$): *δ* = 2.53 (td, *J*

= 6.1, 2.0 Hz, 2H), 3.76 (t, *J* = 6.1 Hz, 2H), 5.74 (d, *J* = 2.0 Hz, 1H), 7.04–7.09 (m, 1H), 7.17 (td, *J* = 7.5, 1.1 Hz, 1H), 7.29–7.34 (m, 1H), 7.64 (td, *J* = 7.6, 1.7 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 23.2, 59.2 (d, *J* = 5.4 Hz), 60.9, 80.9, 84.0, 115.6 (d, *J* = 21.7 Hz), 124.4 (d, *J* = 3.6 Hz), 128.2 (d, *J* = 3.6 Hz), 130.1 (d, *J* = 8.2 Hz), 160.1 (d, *J* = 248.1 Hz) ppm. IR ($CHCl_3$): υ_{max} = 3418, 2922, 2239, 2205, 1644, 1407, 1266, 1049, 964, 857, 768, 710 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{11}H_{11}O_2FNa$ 217.0635; Found 217.0637.

*1-(2-Chlorophenyl)pent-2-yne-1,5-diol (**29l**):* Pale yellow oil (747.8 mg, 71%). ^1H NMR (500 MHz, $CDCl_3$): δ = 2.46–2.50 (m, 2H), 3.45 (br s, 2H, *OH*), 3.71 (t, *J* = 5.8 Hz, 2H), 5.78 (s, 1H), 7.23–7.30 (m, 2H), 7.34 (d, *J* = 7.8 Hz, 1H), 7.74 (d, *J* = 7.5 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 23.0, 60.7, 61.6, 80.7, 84.2, 127.2, 128.1, 129.4, 129.6, 132.5, 138.2 ppm. IR ($CHCl_3$): υ_{max} = 3364, 2928, 2228, 1597, 1577, 1472, 1444, 1330, 1270, 1194, 1136, 1054, 1040, 950, 754 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{11}H_{11}O_2ClNa$ 233.0340; Found 233.0339.

*1-(2-Bromophenyl)pent-2-yne-1,5-diol (**29m**):* Pale yellow oil (931 mg, 73%). ^1H NMR (500 MHz, $CDCl_3$): δ = 2.52 (t, *J* = 5.9 Hz, 2H), 2.57 (br s, 2H, *OH*), 3.74 (t, *J* = 6.0 Hz, 2H), 5.77 (s, 1H), 7.16–7.20 (m, 1H), 7.35 (t, *J* = 7.2 Hz, 1H), 7.54 (d, *J* = 7.9 Hz, 1H), 7.76 (dd, *J* = 7.7, 1.3 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 23.2, 60.8, 64.1, 80.9, 84.3, 122.5, 127.9, 128.4, 129.8, 132.9, 139.8 ppm. IR ($CHCl_3$): υ_{max} = 3387, 2891, 2231, 1591, 1570, 1469, 1442, 1326, 1266, 1194, 1136, 1046, 949, 847, 742 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{11}H_{11}O_2BrNa$ 276.9835; Found 276.9835.

*1-(3,5-Dichlorophenyl)pent-2-yne-1,5-diol (**29n**):* Pale yellow oil (695 mg, 62%). ^1H NMR (500 MHz, $CDCl_3$): δ = 2.49 (t, *J* = 5.7 Hz, 2H), 3.71 (t, *J* = 5.7 Hz, 2H), 4.50 (br s, 2H, *OH*), 5.34 (s, 1H), 7.27 (t, *J* = 1.5 Hz, 1H), 7.36 (d, *J* = 1.3 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 22.7, 60.5, 62.9, 80.5, 85.0, 124.9, 128.0, 134.9, 144.1 ppm. IR ($CHCl_3$): υ_{max} = 3362, 2942, 2888, 2223, 1588, 1572, 1434, 1265, 1197, 1137, 1042, 863, 802, 740, 768, 705 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{11}H_{10}O_2Cl_2Na$ 266.9950; Found 266.9950.

*1-(4-Chlorophenyl)pent-2-yne-1,5-diol (**29o**):* Pale yellow solid (568.8 mg, 54%), M.p. 84–84 °C. ^1H NMR (500 MHz, $CDCl_3$): δ = 2.47 (td, *J* = 5.9, 1.7 Hz, 2H), 3.69 (t, *J* = 6.0 Hz, 2H), 3.94 (br s, 2H, *OH*), 5.37 (s, 1H), 7.29–7.31 (m, 2H), 7.41 (d, *J* = 8.4 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 22.9, 60.7, 63.7, 81.5, 84.5, 127.9, 128.6, 128.7, 131.4, 133.9, 139.4 ppm. IR ($CHCl_3$): υ_{max} = 3372, 3018, 2945, 2889, 2280, 2227, 1596, 1489, 1411, 1327, 1220, 1132, 1090, 1040, 1015, 943, 845, 669 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{11}H_{11}O_2ClNa$ 233.0340; Found 233.0338.

*1-(3-Bromophenyl)pent-2-yne-1,5-diol (**29p**):* Pale yellow semi-solid (880 mg, 69%). ^1H NMR (500 MHz, $CDCl_3$): δ = 2.51 (td, *J* = 6.0, 2.0 Hz, 2H), 3.73 (t, *J* = 6.1 Hz, 2H), 5.39 (s, 1H), 7.22 (t, *J* = 7.9 Hz, 1H), 7.43 (dd, *J* = 7.8, 2.1 Hz, 2H), 7.67 (t, *J* = 1.7 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 23.0, 60.8, 63.7, 81.3, 84.7, 122.5, 125.2, 129.6, 130.1, 131.2, 143.1 ppm. IR ($CHCl_3$): υ_{max} = 3449, 2921, 2851, 2214, 1645, 1568, 1464, 1423, 1281, 1253, 1120, 1067, 751, 669 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{11}H_{12}O_2Br$ 255.0015; Found 255.0013.

*(E)-7-Phenyl-hept-6-en-3-yne-1,5-diol (**29q**):* Yellow oil (435 mg, 43%). ^1H NMR (500 MHz, $CDCl_3$): δ = 2.52–2.56 (m, 2H), 3.74–3.77 (m, 2H), 5.05 (d, *J* = 6.0 Hz, 1H), 6.29 (dd, *J* = 15.8, 6.0 Hz, 1H), 6.74 (d, *J* = 15.8 Hz, 1H), 7.24–7.27 (m, 1H), 7.31–7.33 (m, 2H), 7.40 (d, *J* = 7.3 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 23.1, 60.9, 63.0, 81.1, 83.9, 126.8, 128.1, 128.4, 128.6, 131.7, 136.1 ppm. IR ($CHCl_3$): υ_{max} = 3444, 3063, 3016, 2923, 2872, 2220, 1628, 1601, 1493, 1452, 1419, 1389, 1333, 1096, 958, 910, 849, 700, 668 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{13}H_{15}O_2$ 203.1067; Found 203.1071.

*(E)-7-(4-Methoxyphenyl)hept-6-en-3-yne-1,5-diol (**29r**):* Yellow oil (557.5 mg, 48%). ^1H NMR (500 MHz, $CDCl_3$): δ = 2.50 (t, *J* = 6.1 Hz, 2H), 3.73 (t, *J* = 5.9 Hz, 2H), 3.77 (s, 3H), 5.00 (d, *J* = 6.0 Hz, 1H), 6.14 (dd, *J* = 15.7, 6.0 Hz, 1H), 6.64 (d, *J* = 15.7 Hz, 1H), 6.82 (d, *J* = 8.6 Hz, 2H), 7.30 (d, *J* = 8.6 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 23.0, 55.2, 60.7, 62.9, 81.2, 83.8, 113.9, 126.3, 127.9, 128.8, 131.1, 159.4 ppm. IR ($CHCl_3$): υ_{max} = 3684, 3619, 3451, 3019, 2976, 1605, 1512, 1476, 1423, 1034, 926, 669, 627 cm^{-1}; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{14}H_{16}O_3Na$ 255.0992; Found 255.0990.

*1,1'-(1,4-Phenylene)bis(pent-2-yne-1,5-diol) (**29s**):* Pale yellow semi-solid (481 mg, 35%). ^1H NMR (400 MHz, Acetone-d_6+$CDCl_3$): δ = 2.40–2.44 (m, 4H), 3.64 (t, *J* = 6.5 Hz, 4H), 4.03 (br s, 2H, *OH*), 4.90 (br s, 2H, *OH*), 5.38 (s, 2H), 7.46 (s, 4H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, Acetone d_6+$CDCl_3$): δ = 23.5, 61.2, 64.1, 82.6, 83.7, 127.0, 142.3 ppm. IR ($CHCl_3$): υ_{max} = 3430, 2931, 2225, 1653, 1481, 1331, 1247, 1220, 1137, 1077, 1012, 864, 758 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{16}H_{18}O_4Na$ 297.1097; Found 297.1099.

*1-(Thiophen-2-yl)pent-2-yne-1,5-diol (**29t**):* Yellow oil (401 mg, 44%). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.52 (td, *J* = 6.0, 1.9 Hz, 2H), 3.74 (t, *J* = 6.0 Hz, 2H), 5.64 (s, 1H), 6.96 (dd, *J* = 5.1, 3.5 Hz, 1H), 7.14 (d, *J* = 3.5 Hz, 1H), 7.28 (dd, *J* = 5.1, 1.2 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 23.0, 60.2, 60.8, 81.4, 83.7, 125.4, 125.8, 126.8, 145.0 ppm. IR ($CHCl_3$): υ_{max} = 3378, 2925, 2234, 1652, 1435, 1411, 1293, 1229, 1115, 1050, 911, 853, 733, 706, 650 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_9H_{10}O_2SNa$ 205.0294; Found 205.0292.

*1-(Furan-2-yl)pent-2-yne-1,5-diol (**29u**):* Pale yellow oil (440.3 mg, 53%). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.52 (td, *J* = 6.1, 1.5 Hz, 2H), 2.55–2.68 (br s, 1H, *OH*), 3.74 (t, *J* = 6.1 Hz, 2H), 5.45 (s, 1H), 6.33–6.34 (m, 1H), 6.43 (d, *J* = 3.2 Hz, 1H), 7.38–7.40 (m, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 23.0, 58.1, 60.8, 79.5, 83.5, 107.5, 110.4, 142.9, 153.3 ppm. IR ($CHCl_3$): υ_{max} = 3442, 2926, 2340, 1651, 1464, 1369, 1179, 1019, 949, 744 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_9H_{11}O_3$ 167.0703; Found 167.0709.

*Docos-3-yne-1,5-diol (**29v**):* White solid (863.3 mg, 51%), M.p. 66–68 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 0.88 (t, *J* = 6.6 Hz, 3H), 1.25–1.43 (m, 30H), 1.61–1.71 (m, 2H), 1.86 (br s, 2H, *OH*), 2.47 (t, *J* = 6.1 Hz, 2H), 3.72 (t, *J* = 6.1 Hz, 2H), 4.36 (t, *J* = 6.5 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 14.1, 22.7, 23.1, 25.2, 29.3, 29.4, 29.5, 29.6, 29.64, 29.7, 31.9,

38.0, 61.0, 62.6, 81.8, 83.4 ppm. IR ($CHCl_3$): υ_{max} = 3684, 3611, 3462, 3020, 2985, 2928, 2855, 2254, 1603, 1522, 1477, 1466, 1446, 1427, 1375, 1249, 1096, 1046, 910, 669, 650 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{22}H_{42}O_2Na$ 361.3077; Found 361.3072.

*Undec-3-yne-1,5-diol (**29w**):* Yellow oil (534.4 mg, 58%). ^1H NMR (400 MHz, $CDCl_3$): δ = 0.88 (t, *J* = 6.6 Hz, 3H), 1.23–1.43 (m, 8H), 1.63–1.70 (m, 2H), 2.47 (td, *J* = 6.0, 1.8 Hz, 2H), 2.54 (br s, 2H, *OH*), 3.71 (t, *J* = 6.1 Hz, 2H), 4.34 (t, *J* = 6.5 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 14.0, 22.5, 23.0, 25.2, 28.9, 31.7, 38.0, 60.9, 62.5, 81.9, 83.3 ppm. IR ($CHCl_3$): υ_{max} = 3683, 3609, 3401, 3019, 2930, 2859, 2220, 1602, 1522, 1467, 1423, 1331, 1046, 928, 909, 876, 848, 669, 627 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{11}H_{20}O_2Na$ 207.1356; Found 207.1356.

*1-(4-Chlorophenyl)dec-2-yne-1,5-diol (**29x**):* Pale yellow semi-solid (856.4 mg, 61%). ^1H NMR (400 MHz, $CDCl_3$): δ = 0.88 (t, *J* = 6.9 Hz, 3H), 1.27–1.51 (m, 8H), 2.30–2.36 (m, 1H), 2.44–2.50 (m, 1H), 3.70–3.76 (m, 1H), 5.37–5.39 (m, 1H), 7.30 (d, *J* = 8.4 Hz, 2H), 7.43 (d, *J* = 8.4 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 14.0, 22.5, 25.3, 27.4, 31.7, 36.2, 63.7, 70.1, 82.1, 84.1, 128.0, 128.6, 133.9, 139.6 ppm. IR ($CHCl_3$): υ_{max} = 3427, 2955, 2931, 2859, 2238, 2204, 1647, 1587, 1570, 1457, 1401, 1263, 1171, 1107, 1091, 1014, 916, 846, 792, 747, 677 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{16}H_{21}O_2ClNa$ 303.1122; Found 303.1122.

General procedure for synthesis of *δ*-hydroxyalkynones 10. To a stirred solution of diol **29** (1.25 mmol, 1.0 equiv) in dry CH_2Cl_2 (30 mL) was added activated MnO_2 (1.63 g, 18.75 mmol, 15.0 equiv). The resulting mixture was stirred overnight at room temperature and then filtered through celite pad and the pad washed with EtOAc (2 × 40 mL). The combined organic filtrates were directly concentrated under reduced pressure. Purification of the residue by column chromatography on silica gel using petroleum ether/EtOAc (7:3 to 3:2) as eluent gave the *δ*-hydroxyalkynones **10**. For **10i** prepared from **10f**, a separate preparation procedure is given. For **10y** and **10z**, see total synthesis part later.

*5-Hydroxy-1-phenylpent-2-yn-1-one (**10a**):* Pale yellow semi-solid (150.2 mg, 69%). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.67 (br s, 1H, *OH*), 2.75 (t, *J* = 6.3 Hz, 2H), 3.91 (t, *J* = 6.2 Hz, 2H), 7.41–7.48 (m, 2H), 7.56–7.62 (m, 1H), 8.11–8.17 (m, 2H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 23.5, 60.2, 80.6, 93.7, 128.5, 129.6, 134.1, 136.5, 178.3 ppm. IR ($CHCl_3$): υ_{max} = 3427, 3064, 3016, 2928, 2892, 2238, 2207, 1709, 1642, 1598, 1581, 1450, 1399, 1360, 1314, 1176, 1052, 963, 917, 858, 703, 667 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + K]^+$ Calcd for $C_{11}H_{10}O_2K$ 213.0312; Found 213.0312.

*5-Hydroxy-1-p-tolylpent-2-yn-1-one (**10b**):* Pale yellow semi-solid (211.7 mg, 90%). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.42 (s, 3H), 2.76 (t, *J* = 6.2 Hz, 2H), 3.90 (t, *J* = 6.3 Hz, 2H), 7.26 (d, *J* = 8.0 Hz, 2H), 8.02 (d, *J* = 8.2 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 21.8, 23.5, 60.2, 80.7, 93.1, 129.2, 129.8, 134.2, 145.3, 178.0 ppm. IR ($CHCl_3$): υ_{max} = 3682, 3616, 3429, 3019, 2974, 2926, 2891, 2240, 2206, 1636, 1603, 1572, 1521, 1411, 1323, 1310, 1273, 1178, 1112, 1048, 958, 928, 835, 699 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{12}H_{12}O_2Na$ 211.0730; Found 211.0729.

*1-(4-tert-Butylphenyl)-5-hydroxypent-2-yn-1-one (**10c**):* Yellow semi-solid (253.3 mg, 88%). ^1H NMR (400 MHz, $CDCl_3$): δ = 1.34 (s, 9H), 2.77 (t, *J* = 6.3 Hz, 2H), 3.90 (t, *J* = 6.2 Hz, 2H), 7.49 (d, *J* = 8.5 Hz, 2H), 8.06 (d, *J* = 8.5 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 23.5, 31.0, 35.2, 60.3, 80.8, 93.0, 125.5, 129.6, 134.1, 158.2, 178.0 ppm. IR ($CHCl_3$): υ_{max} = 3428, 3017, 2966, 2211, 1639, 1605, 1566, 1464, 1410, 1365, 1316, 1272, 1241, 1189, 1120, 1103, 1052, 964, 921, 852, 697 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{15}H_{19}O_2$ 231.1380; Found 231.1380.

*5-Hydroxy-1-(4-methoxyphenyl)pent-2-yn-1-one (**10d**):* Yellow solid (188.9 mg, 74%), M.p. 102–104 °C. ^1H NMR (500 MHz, $CDCl_3$): δ = 2.76 (t, *J* = 6.2Hz, 2H), 3.88–3.91 (m, 5H), 6.94 (d, *J* = 8.8 Hz, 2H), 8.12 (d, *J* = 8.7 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 23.5, 55.6, 60.4, 80.7, 92.2, 113.8, 130.0, 132.0, 164.5, 176.8 ppm. IR ($CHCl_3$): υ_{max} = 3418, 2922, 2849, 2239, 2205, 1631, 1597, 1572, 1510, 1322, 1260, 1169, 1113, 1048, 1029, 846, 689 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{12}H_{13}O_3$ 205.0859; Found 205.0859.

*1-(Benzo[d][1,3]dioxol-5-yl)-5-hydroxypent-2-yn-1-one (**10e**):* White solid (245.5 mg, 90%), M.p. 74–76 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 1.88 (br s, 1H, *OH*), 2.75 (t, *J* = 6.2 Hz, 2H), 3.89 (t, *J* = 6.2 Hz, 2H), 6.07 (s, 2H), 6.87 (d, *J* = 8.2 Hz, 1H), 7.54 (t, *J* = 1.6 Hz, 1H), 7.80 (dd, *J* = 8.1, 1.7 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 23.5, 60.3, 80.6, 92.3, 102.1, 108.0, 108.4, 127.3, 131.8, 148.2, 152.9, 176.2 ppm. IR ($CHCl_3$): υ_{max} = 3414, 2908, 2216, 1633, 1598, 1504, 1488, 1446, 1361, 1281, 1263, 1159, 1117, 1077, 1038, 976, 933, 911, 879, 831, 806, 748, 717, 677 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{12}H_{10}O_4Na$ 241.0471; Found 241.0472.

*5-(tert-Butyldimethylsilyloxy)-1-[4-(tert-butyldimethylsilyloxy)-3-methoxyphenyl]pent-2-yn-1-ol (**10f**):* Colorless oil (493.6 g, 88%). ^1H NMR (400 MHz, $CDCl_3$): δ = 0.09 (s, 6H), 0.19 (s, 6H), 0.91 (s, 9H), 1.00 (s, 9H), 2.69 (t, *J* = 6.9 Hz, 2H), 3.86 (t, *J* = 6.9 Hz, 2H), 3.86 (s, 3H), 6.88 (d, *J* = 8.2 Hz, 1H), 7.59 (d, *J* = 2.0 Hz, 1H), 7.76 (dd, *J* = 8.2, 2.0 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = –5.3, –4.6, 18.3, 18.5, 23.6, 25.6, 25.8, 55.5, 61.0, 80.3, 92.6, 111.1, 120.3, 125.6, 131.2, 151.0, 151.1, 176.9 ppm. IR ($CHCl_3$): υ_{max} = 2954, 2930, 2886, 2858, 2227, 1641, 1591, 1509, 1471, 1417, 1291, 1256, 1220, 1179, 1110, 1036, 896, 838, 811, 784 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{24}H_{40}O_4Si_2Na$ 471.2357; Found 471.2359.

*1-(Biphenyl-4-yl)-5-hydroxypent-2-yn-1-one (**10g**):* Brown white solid (278.5 mg, 89%), M.p. 80–82 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 2.38 (br s, 1H, *OH*), 2.80 (t, *J* = 6.2 Hz, 2H), 3.93 (t, *J* = 6.2 Hz, 2H), 7.39–7.43 (m, 1H), 7.45–7.49 (m, 2H), 7.62 (d, *J* = 7.7 Hz, 2H), 7.69 (d, *J* = 8.2 Hz, 2H), 8.20 (d, *J* = 8.3 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 23.6, 60.3, 80.8, 93.4, 127.2, 127.3, 128.4, 129.0, 130.2, 135.4, 139.7, 146.8, 177.8 ppm. IR ($CHCl_3$): υ_{max} = 3298, 2926, 2241, 2207, 1639, 1604, 1404, 1283, 1269, 1045, 852, 736, 693 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{17}H_{15}O_2$ 251.1067; Found 251.1067.

5-Hydroxy-1-(naphthalen-2-yl)pent-2-yn-1-one ***(10h)****:* Yellow oil (238.3 mg, 85%). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.77 (t, *J* = 6.2 Hz, 2H), 3.92 (t, *J* = 6.2 Hz, 2H), 7.48–7.54 (m, 2H), 7.61–7.64 (m, 1H), 7.85 (d, *J* = 8.1 Hz, 1H), 8.02 (d, *J* = 7.7 Hz, 1H), 8.54 (d, *J* = 7.3 Hz, 1H), 9.15 (d, *J* = 8.7 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 23.5, 60.2, 82.1, 92.3, 124.4, 125.8, 126.6, 128.5, 128.9, 130.6, 132.3, 133.7, 135.0, 135.1, 180.0 ppm. IR ($CHCl_3$): υ_{max} = 3412, 2922, 2886, 2215, 1635, 1590, 1509, 1459, 1436, 1326, 1280, 1239, 1195, 1137, 1051, 945, 909, 875, 813, 777, 670, 631 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + H]$^+$ Calcd for $C_{15}H_{13}O_2$ 225.0910; Found 225.0914.

4-(5-Hydroxypent-2-ynoyl)benzaldehyde ***(10j)****:* Yellow semi-solid (202.2 mg, 80%). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.12 (br s, 1H, *OH*), 2.81 (t, *J* = 6.2 Hz, 2H), 3.93 (t, *J* = 6.2 Hz, 2H), 7.98 (d, *J* = 8.3 Hz, 2H), 8.29 (d, *J* = 8.1 Hz, 2H), 10.12 (s, 1H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 23.6, 60.2, 80.6, 94.9, 129.7, 130.1, 139.6, 140.6, 177.1, 191.6 ppm. IR ($CHCl_3$): υ_{max} = 3431, 2925, 2854, 2237, 2205, 1704, 1645, 1464, 1410, 1383, 1266, 1203, 1105, 1044, 830, 761 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + H]$^+$ Calcd for $C_{12}H_{11}O_3$ 203.0708; Found 203.0705.

1-(2-Fluorophenyl)-5-hydroxypent-2-yn-1-one ***(10k)****:* Pale yellow oil (206.6 g, 86%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.37 (br s, 1H, *OH*), 2.74 (t, *J* = 6.2 Hz, 2H), 3.87 (t, *J* = 6.2 Hz, 2H), 7.11–7.15 (m, 1H), 7.21–7.25 (m, 1H), 7.53–7.58 (m, 1H), 8.03 (td, *J* = 7.7, 1.8 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ = 23.6, 60.1, 82.2, 93.6, 117.0 (d, *J* = 21.9 Hz), 124.2 (d, *J* = 4.0 Hz), 125.3 (d, *J* = 7.4 Hz), 132.0, 135.6 (d, *J* = 9.3 Hz), 162.1 (d, *J* = 262.0 Hz), 174.4 ppm. ^{19}F NMR (471 MHz, $CDCl_3$): δ = –111.72. IR ($CHCl_3$): υ_{max} = 3449, 2925, 2213, 1652, 1609, 1485, 1455, 1405, 1296, 1252, 1049, 963, 754 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + Na]$^+$ Calcd for $C_{11}H_9O_2FNa$ 215.0479; Found 215.0479.

1-(2-Chlorophenyl)-5-hydroxypent-2-yn-1-one ***(10l)****:* Pale yellow oil (224.3 mg, 86%). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.21–2.37 (br s, 1H, *OH*), 2.73 (t, *J* = 6.2 Hz, 2H), 3.86 (t, *J* = 6.2 Hz, 2H), 7.34–7.37 (m, 1H), 7.43–7.45 (m, 2H), 8.01 (d, *J* = 7.9 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 23.6, 60.1, 82.0, 94.5, 126.7, 131.5, 132.8, 133.4, 135.3, 176.9 ppm. IR ($CHCl_3$): υ_{max} = 3413, 2890, 2213, 1651, 1587, 1468, 1436, 1296, 1245, 1057, 964, 918, 862, 742 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + Na]$^+$ Calcd for $C_{11}H_9O_2ClNa$ 231.0183; Found 231.0187.

1-(2-Bromophenyl)-5-hydroxypent-2-yn-1-one ***(10m)****:* Pale yellow oil (275.2 mg, 87%). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.72 (t, *J* = 6.1 Hz, 2H), 3.85 (t, *J* = 6.2 Hz, 2H), 7.31–7.34 (m, 1H), 7.39 (t, *J* = 7.4 Hz, 1H), 7.63 (d, *J* = 7.8 Hz, 1H), 8.00 (d, *J* = 7.5 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 23.5, 59.9, 81.5, 95.0, 121.0, 127.3, 133.1, 133.4, 134.9, 136.8, 177.6 ppm. IR ($CHCl_3$): υ_{max} = 3421, 2929, 2210, 1651, 1586, 1464, 1431, 1294, 1245, 1050, 963, 916, 860, 740 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + Na]$^+$ Calcd for $C_{11}H_9O_2BrNa$ 274.9678; Found 274.9675.

1-(3,5-dichlorophenyl)-5-hydroxypent-2-yn-1-one ***(10n)****:* Pale yellow oil (255.2 mg, 84%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.79 (t, *J* = 6.2 Hz, 2H), 3.92 (t, *J* = 6.2 Hz, 2H), 7.57 (t, *J* = 1.9 Hz, 1H), 7.97 (d, *J* = 1.9 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ = 23.5, 60.1, 79.9, 95.3, 127.8, 133.7, 135.6, 138.9, 175.3 ppm. IR ($CHCl_3$): υ_{max} = 3404, 3081, 2212, 1653, 1566, 1430, 1396, 1259, 1100, 1050, 985, 874, 805 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + H]$^+$ Calcd for $C_{11}H_9O_2Cl_2$ 242.9974; Found 242.9977.

1-(4-Chlorophenyl)-5-hydroxypent-2-yn-1-one ***(10o)****:*[11] Yellow semi-solid (253 mg, 97%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.75 (t, *J* = 6.2 Hz, 2H), 3.89 (t, *J* = 6.2 Hz, 2H), 7.41 (d, *J* = 8.5 Hz, 2H), 8.03 (d, *J* = 8.6 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ = 23.5, 60.1, 80.3, 94.5, 128.9, 130.9, 134.8, 140.8, 177.0 ppm. IR ($CHCl_3$): υ_{max} = 3683, 3616, 3433, 3019, 2975, 2892, 2239, 2206, 1644, 1587, 1570, 1402, 1265, 1091, 1048, 846, 669 cm^{-1}. LRMS (ESI-TOF) *m/*z: [M + H]$^+$ Calcd for $C_{11}H_{10}O_2Cl$ 209.0369; Found 209.0401.

1-(3-Bromophenyl)-5-hydroxypent-2-yn-1-one ***(10p)****:* Yellow oil (246.8 mg, 78%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.79 (t, *J* = 6.2 Hz, 2H), 3.92 (t, *J* = 6.2 Hz, 2H), 7.36 (t, *J* = 7.8 Hz, 1H), 7.71–7.74 (m, 1H), 8.06 (dt, *J* = 7.8, 1.3 Hz, 1H), 8.25 (t, *J* = 1.7 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ = 23.5, 60.2, 80.3, 94.4, 122.8, 128.1, 130.2, 132.4, 136.9, 138.2, 176.6 ppm. IR ($CHCl_3$): υ_{max} = 3433, 3019, 2927, 2212, 1644, 1568, 1473, 1424, 1252, 1048, 669 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + Na]$^+$ Calcd for $C_{11}H_9O_2BrNa$ 274.9678; Found 274.9677.

(E)-7-Hydroxy-1-phenylhept-1-en-4-yn-3-one ***(10q)****:* Yellow oil (200.2 mg, 80%). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.73 (t, *J* = 6.2 Hz, 2H), 3.88 (t, *J* = 6.2 Hz, 2H), 6.75 (d, *J* = 16.0 Hz, 1H), 7.38–7.42 (m, 3H), 7.54–7.56 (m, 2H), 7.83 (d, *J* = 16.1 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 23.4, 60.2, 80.3, 92.0, 128.2, 128.6, 129.0, 131.1, 133.9, 148.9, 178.6 ppm. IR ($CHCl_3$): υ_{max} = 3445, 2923, 2854, 2216, 1633, 1496, 1450, 1330, 1269, 1179, 1048, 1048, 977, 765, 702, 679 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + Na]$^+$ Calcd for $C_{13}H_{12}O_2Na$ 223.0730; Found 223.0738.

(E)-7-Hydroxy-1-(4-methoxyphenyl)hept-1-en-4-yn-3-one ***(10r)****:* Brown solid (258.4 mg, 89%), M.p. 118–120 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.74 (t, *J* = 6.2 Hz, 2H), 3.85 (s, 3H), 3.88 (t, *J* = 6.2 Hz, 2H), 6.67 (d, *J* = 15.9 Hz, 1H), 6.93 (d, *J* = 8.8 Hz, 2H), 7.53 (d, *J* = 8.6 Hz, 2H), 7.80 (d, *J* = 15.9 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 23.5, 55.5, 60.4, 77.2, 80.5, 114.5, 126.2, 126.7, 130.5, 148.7, 162.2, 178.4 ppm. IR ($CHCl_3$): υ_{max} = 3683, 3619, 3019, 1654, 1624, 1603, 1577, 1511, 1464, 1421, 1033, 928, 669 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + H]$^+$ Calcd for $C_{14}H_{15}O_3$ 231.1016; Found 231.1017.

1,1'-(1,4-Phenylene)bis(5-hydroxypent-2-yn-1-one) ***(10s)****:* Pale yellow solid (300.7 mg, 89%), M.p. 78–80 °C. ^{1}H NMR (500 MHz, $CDCl_3$+Acetone-d_6): δ = 2.76 (t, *J* = 6.3 Hz, 4H), 2.93 (br s, 2H, *OH*), 3.84 (t, *J* = 6.3 Hz, 4H), 8.23 (s, 4H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$+Acetone-d_6): δ = 23.8, 60.1, 80.3, 96.2, 129.9, 140.8, 177.2 ppm. IR ($CHCl_3$): υ_{max} = 3404, 2916, 2239, 2205, 1649, 1638, 1570, 1497, 1408, 1321, 1263, 1106, 1045, 964, 917, 868, 854, 760, 709, 668 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + H]$^+$ Calcd for $C_{16}H_{15}O_4$ 271.0965; Found 271.0967.

5-Hydroxy-1-(thiophen-2-yl)pent-2-yn-1-one ***(10t)****:* Yellow semi-solid (178 mg, 79%). ^{1}H NMR (500 MHz, $CDCl_3$): δ =

2.15 (br s, 1H, *OH*), 2.75 (t, *J* = 6.2 Hz, 2H), 3.89 (t, *J* = 6.2 Hz, 2H), 7.14 (dd, *J* = 4.9, 3.9 Hz, 1H), 7.69 (dd, *J* = 4.9, 1.1 Hz, 1H), 7.82 (d, *J* = 3.8, 1.1 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 23.5, 60.2, 80.3, 91.8, 128.3, 135.3, 135.4, 144.6, 169.9 ppm. IR ($CHCl_3$): υ_{max} = 3685, 3617, 3019, 2976, 2926, 2253, 2235, 1621, 1515, 1474, 1411, 1385, 1360, 1297, 1282, 1258, 1102, 1044, 912, 844, 669, 651 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + K]^+$ Calcd for $C_9H_8O_2SK$ 218.9877; Found 218.9873.

*1-(furan-2-yl)-5-hydroxypent-2-yn-1-one (**10u**):* Pale yellow oil (164.2 mg, 80%). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.67 (t, *J* = 6.3 Hz, 2H), 3.33 (br s, 1H, *OH*), 3.82 (t, *J* = 6.3 Hz, 2H), 6.50 (dd, *J* = 3.6, 1.7 Hz, 1H), 7.32 (dd, *J* = 3.6, 0.8 Hz, 1H), 7.60 (dd, *J* = 1.7, 0.8 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 23.3, 59.8, 79.6, 92.9, 112.6, 121.6, 148.1, 152.7, 164.9 ppm. IR ($CHCl_3$): υ_{max} = 3417, 2891, 2214, 1631, 1565, 1462, 1396, 1307, 1230, 1172, 1125, 1054, 1021, 973, 921, 885, 832, 745, 592 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_9H_8O_3Na$ 187.0366; Found 187.0366.

*1-Hydroxydocos-3-yn-5-one (**10v**):* White semi-solid (307.1 mg, 73%). ^1H NMR (400 MHz, $CDCl_3$): δ = 0.87 (t, *J* = 6.6 Hz, 3H), 1.22–1.29 (m, 28H), 1.60–1.67 (m, 2H), 2.37 (br s, 1H, *OH*), 2.53 (t, *J* = 7.5 Hz, 2H), 2.62 (t, *J* = 6.3 Hz, 2H), 3.79 (t, *J* = 6.3 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 14.1, 22.7, 23.2, 24.0, 28.9, 29.3, 29.32, 29.4, 29.56, 29.6, 29.7, 31.9, 45.4, 60.2, 81.9, 90.6, 188.5 ppm. IR ($CHCl_3$): υ_{max} = 3419, 2918, 2851, 2216, 1673, 1467, 1403, 1374, 1164, 1048, 759 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + K]^+$ Calcd for $C_{22}H_{40}O_2K$ 375.2660; Found 375.2658.

*1-Hydroxyundec-3-yn-5-one (**10w**):* Yellow oil (149.7 mg, 65%). ^1H NMR (400 MHz, $CDCl_3$): δ = 0.87 (t, *J* = 6.8 Hz, 3H), 1.24–1.33 (m, 6H), 1.60–1.67 (m, 2H), 2.53 (t, *J* = 7.5 Hz, 2H), 2.62 (t, *J* = 6.3 Hz, 2H), 3.79 (t, *J* = 6.3 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 14.0, 22.5, 23.3, 24.0, 28.6, 31.5, 45.5, 60.2, 82.0, 90.6, 188.6 ppm. IR ($CHCl_3$): υ_{max} = 3685, 3620, 3019, 2928, 2216, 1666, 1522, 1423, 1046, 928, 909, 849, 669, 626 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{11}H_{18}O_2Na$ 205.1199; Found 205.1199.

*1-(4-Chlorophenyl)-5-hydroxydec-2-yn-1-one (**10x**):* Pale yellow oil (296.2 mg, 85%). ^1H NMR (500 MHz, $CDCl_3$): δ = 0.90 (t, *J* = 6.7 Hz, 3H), 1.29–1.42 (m, 5H), 1.46–1.51 (m, 1H), 1.60–1.64 (m, 2H), 1.95 (br s, 1H, *OH*), 2.64 (dd, *J* = 17.2, 6.6 Hz, 1H), 2.73 (dd, *J* = 17.2, 4.8 Hz, 1H), 3.91–3.96 (m, 1H), 7.44 (d, *J* = 8.4 Hz, 2H), 8.07 (d, *J* = 8.4 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 14.0, 22.5, 25.2, 28.1, 31.6, 36.7, 69.7, 80.9, 93.8, 128.9, 130.9, 135.1, 140.7, 176.7 ppm. IR ($CHCl_3$): υ_{max} = 3437, 2930, 2858, 2238, 2204, 1649, 1587, 1568, 1486, 1467, 1401, 1264, 1171, 1091, 1014, 916, 846, 791, 748, 763, 677 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{16}H_{19}O_2ClNa$ 301.0966; Found 301.0963.

*4-(5-Hydroxypent-2-ynoyl)-2-methoxyphenyl benzoate (**10i**):*[12] To a stirred solution of bis-silyl ether **10f** (449 mg, 1.0 mmol, 1.0 equiv) in dry DMF (3 mL) was added sodium hydride (36 mg, 1.5 mmol, 1.5 equiv) at room temperature and then benzoyl chloride (0.116 mL, 1.0 mmol, 1.0 equiv) was added. After 30 min, the reaction was quenched with water (1 mL) and diluted with EtOAc (10 mL). The organic layer was separated, washed with water (3 × 5 mL), dried (Na_2SO_4) and concentrated. The residue was diluted with THF (10 mL) and HCl (2 N, 3 mL) was added and stirred for 15 min at room temperature. The reaction mixture was extracted with EtOAc (2 × 10 mL). The organic layers were washed with water (3 × 5 mL), dried (Na_2SO_4) and concentrated. The residue was purified by silica gel column chromatography using petroleum ether/EtOAc (3:2) as eluent to give **10i** (207.6 mg, 64%) as yellow oil. ^1H NMR (400 MHz, $CDCl_3$): δ = 2.75 (t, *J* = 6.2 Hz, 2H), 3.85 (s, 3H), 3.88 (t, *J* = 6.2 Hz, 2H), 7.24 (d, *J* = 2.6 Hz, 1H), 7.49 (t, *J* = 7.7 Hz, 2H), 7.61–7.64 (m, 1H), 7.72 (d, *J* = 1.8 Hz, 1H), 7.84 (dd, *J* = 8.2, 1.9 Hz, 1H), 8.17–8.19 (m, 2H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 23.5, 56.1, 60.2, 80.5, 93.6, 111.9, 123.1, 124.1, 128.6, 128.9, 130.4, 133.8, 135.4, 145.1, 151.6, 164.1, 177.0 ppm. IR ($CHCl_3$): υ_{max} = 3452, 2925, 2954, 2223, 1744, 1644, 1598, 1504, 1464, 1452, 1414, 1283, 1260, 1200, 1172, 1123, 1104, 1078, 1057, 1024, 881, 788, 746, 706 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{19}H_{16}O_5Na$ 347.0890; Found 347.0899.

General procedure for synthesis of 2,3-dihydro-4*H*-pyran-4-ones 9. To a solution of δ-hydroxyalkynone **10** (1.0 mmol, 1.0 equiv) in MeOH (0.4 mL) was added *p*TsOH (17.2 mg, 0.1 mmol, 10 mol%) at room temperature. The reaction mixture was stirred at room temperature till the TLC showed total consumption of starting material. Methanol was then evaporated under reduced pressure and the residue purified by column chromatography on silica gel using hexanes/EtOAc (7:3) as eluent to give 2,3-dihydro-4*H*-pyran-4-ones **9**. For **9y** and **9z**, see in total synthesis part later.

*6-Phenyl-2H-pyran-4(3H)-one (**9a**):* Reaction time = 7.5 h, white solid (162 mg, 93%), M.p. 54–56 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 2.66 (t, *J* = 6.6 Hz, 2H), 4.67 (t, *J* = 6.6 Hz, 2H), 6.03 (s, 1H), 7.41–7.51 (m, 3H), 7.33 (d, *J* = 7.2 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 36.0, 68.2, 102.4, 126.5, 128.7, 131.7, 132.6, 170.6, 192.7 ppm. IR ($CHCl_3$): υ_{max} = 3058, 2884, 1651, 1591, 1569, 1492, 1463, 1448, 1395, 1353, 1296, 1251, 1233, 1189, 1100, 1078, 1056, 1029, 983, 888, 820, 773, 688 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{11}H_{10}O_2Na$ 197.0573; Found 197.0578.

*6-p-Tolyl-2H-pyran-4(3H)-one (**9b**):* Reaction time = 2.5 h, yellow solid (173.2 mg, 92%), M.p. 68–70 °C. ^1H NMR (500 MHz, $CDCl_3$): δ = 2.40 (s, 3H), 2.65 (t, *J* = 6.6 Hz, 2H), 4.65 (t, *J* = 6.7 Hz, 2H), 6.00 (s, 1H), 7.24 (d, *J* = 8.1 Hz, 2H), 7.63 (d, *J* = 8.2 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 21.5, 35.9, 68.1, 101.8, 126.5, 129.4, 129.7, 142.4, 170.9, 192.8 ppm. IR ($CHCl_3$): υ_{max} = 3019, 2977, 2927, 1656, 1595, 1567, 1520, 1477, 1421, 1355, 1046, 983, 929, 669 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{12}H_{12}O_2Na$ 211.0730; Found 211.0728.

*6-(4-tert-Butylphenyl)-2H-pyran-4(3H)-one (**9c**):* Reaction time = 3 h, brown white solid (219 mg, 95%), M.p. 100–102 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 1.32 (s, 9H), 2.64 (t, *J* = 6.7 Hz, 2H), 4.64 (t, *J* = 6.7 Hz, 2H), 6.01 (s, 1H), 7.44 (d, *J* = 8.7 Hz, 2H), 7.67 (d, *J* = 8.6 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 31.1, 35.0, 36.0, 68.1, 101.9, 125.6, 126.3, 129.7, 155.4, 170.7, 192.8 ppm. IR ($CHCl_3$): υ_{max} = 2963, 2867, 1652, 1591, 1558, 1515, 1462, 1416, 1348, 1234, 1075, 982,

888, 844, 757 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{15}H_{19}O_2$ 231.1380; Found 231.1377.

*6-(4-Methoxyphenyl)-2H-pyran-4(3H)-one (**9d**):* Reaction time = 2.5 h, brown solid (196 mg, 96%), M.p. 62–64 °C. ^1H NMR (500 MHz, $CDCl_3$): δ = 2.64 (t, *J* = 6.7 Hz, 2H), 3.86 (s, 3H), 4.63 (t, *J* = 6.8 Hz, 2H), 5.98 (s, 1H), 6.93 (d, *J* = 8.9 Hz, 2H), 7.69 (d, *J* = 8.9 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 35.9, 55.4, 68.1, 101.0, 114.1, 124.8, 128.3, 162.5, 170.6, 192.6 ppm. IR ($CHCl_3$): υmax = 2943, 2864, 2830, 1654, 1454, 1219, 1032, 771, 671 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{12}H_{12}O_3Na$ 227.0679; Found 227.0682.

*6-(Benzo[d][1,3]dioxol-5-yl)-2H-pyran-4(3H)-one (**9e**):* Reaction time = 3 h, yellow solid (205 mg, 94%), M.p. 104–106 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 2.64 (t, *J* = 6.8 Hz, 2H), 4.63 (t, *J* = 6.8 Hz, 2H), 5.92 (s, 1H), 6.04 (s, 2H), 6.85 (d, *J* = 8.3 Hz, 1H), 7.17 (d, *J* = 1.8 Hz, 1H), 7.31 (dd, *J* = 8.3, 1.9 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 35.9, 68.1, 101.5, 101.8, 106.6, 108.4, 121.8, 126.6, 148.1, 150.7, 170.2, 192.5 ppm. IR ($CHCl_3$): υ_{max} = 2918, 1651, 1622, 1578, 1502, 1463, 1449, 1335, 1320, 1261, 1234, 1192, 1108, 1074, 1037, 983, 931, 812, 764 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{12}H_{10}O_4Na$ 241.0471; Found 241.0471. See end of SI for X-ray structure.

*6-(4-Hydroxy-3-methoxyphenyl)-2H-pyran-4(3H)-one (**9f**):* Reaction time = 6 h, white solid (216.2 g, 96%), M.p. 118–120 °C. ^1H NMR (500 MHz, $CDCl_3$): δ = 2.67 (t, *J* = 6.8 Hz, 2H), 3.94 (s, 3H), 4.65 (t, *J* = 6.7 Hz, 2H), 6.03 (s, 1H), 6.96 (d, *J* = 8.5 Hz, 1H), 7.23 (d, *J* = 2.0 Hz, 1H), 7.34 (dd, *J* = 8.4, 2.0 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 35.8, 56.0, 68.0, 101.0, 108.8, 114.7, 121.0, 124.4, 146.6, 149.3, 170.9, 192.7 ppm. IR ($CHCl_3$): υ_{max} = 3401, 2926, 2854, 1645, 1574, 1512, 1464, 1430, 1400, 1360, 1290, 1237, 1130, 1079, 1031, 986, 890, 821, 772 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{12}H_{12}O_4Na$ 243.0628; Found 243.0627.

*6-(Biphenyl-4-yl)-2H-pyran-4(3H)-one (**9g**):* Reaction time = 4 h, yellow solid (228 mg, 91%), M.p. 174–176 °C. ^1H NMR (500 MHz, $CDCl_3$): δ = 2.68 (t, *J* = 6.5 Hz, 2H), 4.69 (t, *J* = 6.4 Hz, 2H), 6.08 (s, 1H), 7.39 (tt, *J* = 7.3, 1.1 Hz, 1H), 7.45–7.48 (m, 2H), 7.62–7.63 (m, 2H), 7.67 (d, *J* = 8.3 Hz, 2H), 7.81 (d, *J* = 8.4 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 36.1, 68.3, 102.3, 127.0, 127.1, 127.3, 128.1, 128.9, 131.4, 139.8, 144.4, 170.2, 192.6 ppm. IR ($CHCl_3$): υ_{max} = 3020, 2924, 1657, 1594, 1486, 1466, 1408, 1335, 1158, 1073, 1051, 1031, 985, 688, 671 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + K]^+$ Calcd for $C_{17}H_{14}O_2K$ 289.0625; Found 289.0629.

*6-(Naphthalen-2-yl)-2H-pyran-4(3H)-one (**9h**):* Reaction time = 6.5 h, brown solid (204 mg, 91%), M.p. 84–86 °C. ^1H NMR (500 MHz, $CDCl_3$): δ = 2.77 (t, *J* = 6.7 Hz, 2H), 4.78 (t, *J* = 6.7 Hz, 2H), 5.86 (s, 1H), 7.47–7.58 (m, 3H), 7.65 (dd, *J* = 7.1, 0.8 Hz, 1H), 7.88–7.91 (m, 1H), 7.95 (d, *J* = 8.3 Hz, 1H), 8.11–8.14 (m, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 36.0, 68.5, 107.9, 124.9, 125.0, 126.3, 127.1, 127.4, 128.6, 130.3, 131.4, 131.7, 133.7, 173.0, 192.3 ppm. IR ($CHCl_3$): υ_{max} = 3016, 2925, 1665, 1597, 1386, 1353, 1334, 1224, 1191, 1070, 1032, 983, 888, 804, 774, 756, 672 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C15H_{13}O_2$ 225.0910; Found 225.0915.

*2-Methoxy-4-(4-oxo-3,4-dihydro-2H-pyran-6-yl)phenyl benzoate (**9i**):* Reaction time = 7 h, pale yellow semi-solid (304 mg, 94%). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.67 (t, *J* = 6.7 Hz, 2H), 3.86 (s, 3H), 4.68 (t, *J* = 6.6 Hz, 2H), 6.03 (s, 1H), 7.22 (d, *J* = 8.2 Hz, 1H), 7.37 (d, *J* = 2.0 Hz, 1H), 7.40 (dd, *J* = 8.3, 2.0 Hz, 1H), 7.50–7.53 (m, 2H), 7.63–7.67 (m, 1H), 8.20–8.23 (m, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 35.9, 56.0, 68.3, 102.5, 110.4, 119.5, 123.2, 128.5, 129.0, 130.3, 131.4, 133.7, 142.8, 151.5, 164.3, 169.7, 192.5 ppm. IR ($CHCl_3$): υ_{max} = 2929, 1742, 1601, 1508, 1464, 1452, 1418, 1290, 1262, 1200, 1171, 1125, 794 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{19}H_{16}O_5Na$ 347.0890; Found 347.0890.

*4-(4-Oxo-3,4-dihydro-2H-pyran-6-yl)benzaldehyde (**9j**):* Reaction time = 7 h, yellow solid (162 mg, 80%), M.p. 96–98 °C. ^1H NMR (500 MHz, $CDCl_3$): δ = 2.69 (t, *J* = 6.7 Hz, 2H), 4.70 (t, *J* = 6.7 Hz, 2H), 6.09 (s, 1H), 7.89 (d, *J* = 8.3 Hz, 2H), 7.94 (d, *J* = 8.3 Hz, 2H), 10.07 (s, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 36.0, 68.5, 104.1, 127.0, 129.8, 138.07, 138.1, 168.6, 191.4, 192.4 ppm. IR ($CHCl_3$): υ_{max} = 2916, 2847, 1701, 1663, 1593, 1565, 1463, 1424, 1397, 1351, 1294, 1243, 1210, 1171, 1112, 1076, 983, 890, 827 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{12}H_{11}O_3$ 203.0703; Found 203.0699.

*6-(2-Fluorophenyl)-2H-pyran-4(3H)-one (**9k**):* Reaction time = 15 h, pale yellow oil (177 mg, 92%). ^1H NMR (500 MHz, $CDCl_3$): δ = 2.66 (t, *J* = 6.7 Hz, 2H), 4.64 (t, *J* = 6.7 Hz, 2H), 6.10 (s, 1H), 7.10–7.17 (m, 1H), 7.20 (t, *J* = 7.4 Hz, 1H), 7.40–7.45 (m, 1H), 7.70 (td, *J* = 7.7, 1.4 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 36.0, 68.2, 107.5 (d, *J* = 11.7 Hz), 116.6 (d, *J* = 22.9 Hz), 121.1 (d, *J* = 9.9 Hz), 124.2 (d, *J* = 3.7 Hz), 129.1, 132.7 (d, *J* = 9.2 Hz), 160.7 (d, *J* = 255.3 Hz), 165.8 (d, *J* = 3.6 Hz), 192.6 ppm. IR ($CHCl_3$): υ_{max} = 2924, 2854, 1725, 1651, 1609, 1485, 1455, 1357, 1296, 1274, 1251, 1227, 1053, 755, 668 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{11}H_9O_2FNa$ 215.0479; Found 215.0479.

*6-(2-Chlorophenyl)-2H-pyran-4(3H)-one (**9l**):* Reaction time = 9 h, Pale yellow oil (198.2 mg, 95%). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.67 (t, *J* = 6.7 Hz, 2H), 4.65 (t, *J* = 6.7 Hz, 2H), 5.74 (s, 1H), 7.27–7.39 (m, 2H), 7.40–7.47 (m, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 35.9, 68.5, 107.8, 126.8, 130.2, 130.5, 131.5, 132.7, 133.0, 170.4, 192.2 ppm. IR ($CHCl_3$): υ_{max} = 3064, 2989, 2928, 2884, 1668, 1607, 1586, 1460, 1438, 1395, 1350, 1251, 1223, 1186, 1127, 1082, 1043, 1067, 982, 889, 849, 826, 788, 762, 731, 715, 682, 657 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{11}H_9O_2ClNa$ 231.0183; Found 231.0186.

*6-(2-Bromophenyl)-2H-pyran-4(3H)-one (**9m**):* Reaction time = 8 h, yellow semi-solid (235.4 mg, 93%). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.67 (t, *J* = 6.6 Hz, 2H), 4.68 (t, *J* = 6.6 Hz, 2H), 5.69 (s, 1H), 7.27–7.43 (m, 3H), 7.64 (d, *J* = 7.9 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 36.0, 68.7, 107.6, 121.7, 127.4, 130.4, 131.7, 133.7, 135.2, 177.8, 192.3 ppm. IR ($CHCl_3$): υ_{max} = 3063, 3007, 2927, 2882, 1669, 1605, 1582, 1459, 1435, 1394, 1348, 1322, 1251, 1223, 1186, 1119, 1078, 1040, 1027, 995, 982, 889, 867, 847, 825, 787, 727, 697, 667, 649 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{11}H_9O_2BrNa$ 274.9678; Found 274.9676

6-(3,5-Dichlorophenyl)-2H-pyran-4(3H)-one ***(9n)****:* Reaction time = 5.5 h, brown solid (224 mg, 92%), M.p. 82–84 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.67 (t, J = 6.6 Hz, 2H), 4.67 (t, J = 6.6 Hz, 2H), 5.97 (s, 1H), 7.46 (s, 1H), 7.59 (d, J = 1.0 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 36.0, 68.5, 103.6, 124.8, 131.2, 135.5, 135.7, 167.4, 192.1 ppm. IR ($CHCl_3$): υ_{max} = 3083, 2922, 2854, 1673, 1599, 1583, 1562, 1463, 1440, 1420, 1391, 1345, 1241, 1188, 1122, 1080, 1016, 981, 885, 860, 801, 758 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + H]$^+$ Calcd for $C_{11}H_9O_2Cl_2$ 242.9974; Found 242.9977.

6-(4-Chlorophenyl)-2H-pyran-4(3H)-one ***(9o)****:* Reaction time = 5 h, white solid (200.3 mg, 96%), M.p. 76–78 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.66 (t, J = 6.8 Hz, 2H), 4.66 (t, J = 6.8 Hz, 2H), 5.99 (s, 1H), 7.41 (d, J = 8.7 Hz, 2H), 7.66 (d, J = 8.7, 2.2 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ = 35.9, 68.3, 102.5, 127.8, 129.0, 131.1, 137.9, 169.3, 192.5 ppm. IR ($CHCl_3$): υ_{max} = 2939, 2864, 2844, 1663, 1599, 1454, 1412, 1133, 1093, 1052, 1033, 771 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + Na]$^+$ Calcd for $C_{11}H_9O_2ClNa$ 231.0183; Found 231.0181.

6-(3-Bromophenyl)-2H-pyran-4(3H)-one ***(9p)****:* Reaction time = 5 h, yellow oil (228 mg, 90%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.66 (t, J = 6.7 Hz, 2H), 4.66 (t, J = 6.8 Hz, 2H), 5.98 (s, 1H), 7.30 (t, J = 7.9 Hz, 1H), 7.59–7.64 (m, 2H), 7.88 (t, J = 1.7 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 36.0, 68.4, 103.0, 122.9, 125.0, 129.5, 130.2, 134.5, 134.7, 168.8, 192.4 ppm. IR ($CHCl_3$): υ_{max} = 2938, 2829, 2523, 1655, 1560, 1411, 1033, 771 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + Na]$^+$ Calcd for $C_{11}H_9O_2BrNa$ 274.9678; Found 274.9677.

(E)-6-Styryl-2H-pyran-4(3H)-one ***(9q)****:* Reaction time = 5 h, yellow solid (188.2 mg, 94%), M.p. 104–106 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.63 (t, J = 6.7 Hz, 2H), 4.58 (t, J = 6.7 Hz, 2H), 5.55 (s, 1H), 6.74 (d, J = 15.9 Hz, 1H), 7.35–7.40 (m, 4H), 7.49–7.51 (m, 2H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 36.1, 67.9, 106.4, 121.4, 127.7, 128.9, 129.7, 135.1, 137.4, 168.8, 192.7 ppm. IR ($CHCl_3$): υ_{max} = 2918, 2849, 1653, 1625, 1579, 1565, 1464, 1449, 1404, 1463, 1329, 1241, 1190, 1124, 1075, 1038, 1011, 984, 817, 737, 695 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + Na]$^+$ Calcd for $C_{13}H_{12}O_2Na$ 223.0730; Found 223.0728.

(E)-6-(4-Methoxystyryl)-2H-pyran-4(3H)-one ***(9r)****:* Reaction time = 1 h, brown solid (221 mg, 96%), M.p. 118–120 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.62 (t, J = 6.5 Hz, 2H), 3.84 (s, 3H), 4.56 (t, J = 6.5 Hz, 2H), 5.51 (s, 1H), 6.41 (d, J = 15.8 Hz, 1H), 6.90 (d, J = 8.5 Hz, 2H), 7.32 (d, J = 15.8 Hz, 1H), 7.45 (d, J = 8.5 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 36.1, 55.4, 67.9, 105.8, 114.1, 119.1, 127.9, 129.3, 137.2, 161.0, 169.3, 192.7 ppm. IR ($CHCl_3$): υ_{max} = 3019, 2975, 2935, 1653, 1625, 1603, 1577, 1564, 1511, 1464, 1421, 1361, 1174, 1075, 1033, 983, 970, 928, 669 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + Na]$^+$ Calcd for $C_{14}H_{14}O_3Na$ 253.0835; Found 253.0837.

6,6'-(1,4-phenylene)bis(2H-pyran-4(3H)-one) ***(9s)****:* Reaction time = 10 h, yellow semi-solid (219 mg, 81%). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.68 (t, J = 6.7 Hz, 4H), 4.68 (t, J = 6.8 Hz, 4H), 6.08 (s, 2H), 7.79 (s, 4H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 35.9, 68.3, 103.2, 126.7, 135.4, 169.2, 192.7 ppm. IR ($CHCl_3$): υ_{max} = 2945, 2922, 2850, 1660, 1588, 1507, 1462, 1412, 1346, 1283, 1263, 1238, 1189, 1122, 1078, 1051, 1017, 985, 886, 852, 842, 780, 670, 537 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + Na]$^+$ Calcd for $C_{16}H_{14}O_4Na$ 293.0784; Found 293.0785.

6-(Thiophen-2-yl)-2H-pyran-4(3H)-one ***(9t)****:* Reaction time = 5 h, yellow semi-solid (162.2 mg, 90%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.64 (t, J = 6.7 Hz, 2H), 4.63 (t, J = 6.7 Hz, 2H), 5.93 (s, 1H), 7.11 (dd, J = 5.0, 3.9 Hz, 1H), 7.51–7.54 (m, 2H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 36.1, 68.4, 101.3, 128.2, 128.7, 130.5, 136.4, 165.6, 192.0 ppm. IR ($CHCl_3$): υ_{max} = 2925, 2851, 1658, 1581, 1463, 1422, 1398, 1366, 1344, 1229, 1186, 1072, 1039, 984, 885, 859, 821, 754, 715, 667 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + H]$^+$ Calcd for $C_9H_9O_2S$ 181.0318; Found 181.0320.

6-(Furan-2-yl0)-2H-pyran-4(3H)-one ***(9u)****:* Reaction time = 5 h, brown solid (151 mg, 92%), Mp = 84–86 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.63 (t, J = 6.7 Hz, 2H), 4.59 (t, J = 6.7 Hz, 2H), 5.94 (s, 1H), 6.51 (dd, J = 3.4, 1.7 Hz, 1H), 6.90 (d, J = 3.4 Hz, 1H), 7.53 (d, J = 1.0 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 36.2, 68.3, 100.9, 112.3, 113.6, 145.6, 147.2, 161.4, 191.8 ppm. IR ($CHCl_3$): υ_{max} = 3123, 3105, 2970, 1647, 1617, 1540, 1472, 1425, 1357, 1269, 1255, 1228, 1186, 1089, 1062, 1001, 984, 923, 882, 825, 814, 664, 596 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + Na]$^+$ Calcd for $C_9H_8O_3Na$ 187.0366; Found 187.0365.

6-Heptadecyl-2H-pyran-4(3H)-one ***(9v)****:* Reaction time = 7 h, white solid (296.2 mg, 88%), Mp = 38–40 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 0.86 (t, J = 6.9 Hz, 3H), 1.24–1.27 (m, 28H), 1.53 (quin, J = 7.4 Hz, 2H), 2.21 (t, J = 7.6 Hz, 2H), 2.50 (t, J = 6.8 Hz, 2H), 4.43 (t, J = 6.8 Hz, 2H), 5.32 (s, 1H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 14.1, 22.7, 26.3, 29.1, 29.3, 29.4, 29.5, 29.6, 29.64, 29.66, 29.7, 31.9, 34.8, 35.7, 67.9, 104.5, 178.2, 192.4 ppm. IR ($CHCl_3$): υ_{max} = 2925, 2853, 1668, 1606, 1465, 1403, 1360, 1252, 1232, 1195, 1156, 1071, 1033, 983, 875, 821, 722, 666 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + Na]$^+$ Calcd for $C_{22}H_{40}O_2Na$ 359.2921; Found 359.2915.

6-Hexyl-2H-pyran-4(3H)-one ***(9w)****:* Reaction time = 3 h, yellow oil (133 g, 73%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.88 (t, J = 6.2 Hz, 3H), 1.25–1.29 (m, 6H), 1.51–1.60 (m, 2H), 2.23 (t, J = 7.5 Hz, 2H), 2.51 (t, J = 6.8 Hz, 2H), 4.44 (t, J = 6.8 Hz, 2H), 5.33 (s, 1H) ppm. ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ = 14.0, 22.5, 26.3, 28.7, 31.4, 34.8, 35.7, 67.9, 104.5, 178.2, 192.4 ppm. IR ($CHCl_3$): υ_{max} = 3012, 2957, 2927, 2856, 1666, 1604, 1464, 1403, 1362, 1252, 1232, 1197, 1159, 1071, 1035, 984, 822, 666 cm^{-1}. HRMS (ESI-TOF) *m/*z: [M + Na]$^+$ Calcd for $C_{11}H_{18}O_2Na$ 205.1199; Found 205.1196.

6-(4-Chlorophenyl)-2-pentyl-2H-pyran-4(3H)-one ***(9x)****:* Reaction time = 15 h, pale yellow semi-solid (267.6 mg, 96%). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 0.92 (t, J = 7.0 Hz, 3H), 1.33–1.40 (m, 4H), 1.47–1.53 (m, 1H), 1.57–1.62 (m, 1H), 1.72–1.89 (m, 1H), 1.91–1.98 (m, 1H), 2.47–2.58 (m, 2H), 4.50–4.56 (m, 1H), 5.95 (s, 1H), 7.39 (d, J = 8.6 Hz, 2H), 7.65 (t, J = 8.6 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 13.9, 22.5, 24.7, 31.5, 34.4, 41.3, 79.7, 102.1, 127.7, 128.9, 131.3, 137.7, 169.0, 193.3 ppm. IR ($CHCl_3$): υ_{max} = 2955, 2931, 2860, 1663, 1600, 1564, 1489, 1467, 1409, 1380, 1334, 1299, 1276, 1092, 1052, 908, 840 cm^{-1}. HRMS (ESI-

TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{16}H_{19}O_2ClNa$ 301.0966; Found 301.0968.

General procedure for selective halogenation. To a stirred solution of dihydropyranones **9** (0.25 mmol, 1.0 equiv) in CH_2Cl_2 (3 mL) was added NBS, NIS or NCS (1.0 equiv) portion wise at room temperature. The reaction mixture was stirred at same temperature till the TLC showed complete consumption of staring material. The solvent was evaporated at reduced pressure and the residue was purified by silica gel column chromatography using petroleum ether/EtOAc (9:1 to 7:3) as eluent to give the vinyl halide compounds **13**.

*5-Bromo-6-phenyl-2H-pyran-4(3H)-one (**13a**):* Reaction time = 2.5 h, brown solid (60.7 mg, 96%), M.p. 152–154 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.90 (t, *J* = 6.7 Hz, 2H), 4.67 (t, *J* = 6.7 Hz, 2H), 7.43–7.51 (m, 3H), 7.73 (d, *J* = 7.3 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 36.5, 68.1, 100.8, 128.0, 129.5, 131.4, 133.3, 169.6, 185.7 ppm. IR ($CHCl_3$): υ_{max} = 2917, 1661, 1577, 1547, 1486, 1329, 1252, 1234, 1098, 1080, 1003, 835, 767, 700 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{11}H_9O_2BrNa$ 274.9678; Found 274.9683.

*5-Bromo-6-p-tolyl-2H-pyran-4(3H)-one (**13b**):* Reaction time = 3 h, yellow solid (58.8 mg, 88%), M.p. 122–124 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.41 (s, 3H), 2.87 (t, *J* = 6.7 Hz, 2H), 4.64 (t, *J* = 6.7 Hz, 2H), 7.24 (d, *J* = 7.9 Hz, 2H), 7.65 (d, *J* = 8.0 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 21.6, 36.5, 67.9, 100.4, 128.7, 129.5, 130.4, 142.1, 169.7, 185.7 ppm. IR ($CHCl_3$): υ_{max} = 2927, 2850, 1666, 1607, 1548, 1501, 1460, 1383, 1383, 1326, 1307, 1234, 1185, 1094, 1004, 913, 832, 762 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{12}H_{11}O_2BrNa$ 288.9835; Found 288.9836.

*5-Bromo-6-(4-methoxyphenyl)-2H-pyran-4(3H)-one (**13d**):* Reaction time = 3 h, pale yellow solid (65.8 mg, 93%), M.p. 130–132 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.87 (t, *J* = 6.7 Hz, 2H), 3.86 (s, 3H), 4.63 (t, *J* = 6.7 Hz, 2H), 6.93 (d, *J* = 8.8 Hz, 2H), 7.76 (d, *J* = 8.8 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 36.6, 55.4, 67.6, 99.8, 113.4, 125.3, 131.7, 162.1, 169.2, 185.8 ppm. IR ($CHCl_3$): υ_{max} = 2925, 2854, 1661, 1607, 1578, 1546, 1504, 1466, 1386, 1336, 1259, 1175, 1098, 1025, 1002, 835, 783, 688 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{12}H_{11}O_3BrNa$ 304.9784; Found 304.9789.

*6-(Benzo[d][1,3]dioxol-5-yl)-5-bromo-2H-pyran-4(3H)-one (**13e**):* Reaction time = 2 h, white solid (55.7 mg, 75%), M.p. 74–76 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.86 (t, *J* = 6.6 Hz, 2H), 4.62 (t, *J* = 6.7 Hz, 2H), 6.03 (s, 2H), 6.85 (d, *J* = 8.2 Hz, 1H), 7.23 (d, *J* = 1.7 Hz, 1H), 7.34 (dd, *J* = 8.2, 1.7 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 36.5, 67.7, 100.0, 101.7, 107.9, 109.8, 125.1, 126.7, 147.2, 150.2, 168.8, 185.7 ppm. IR ($CHCl_3$): υ_{max} = 2925, 1668, 1622, 1556, 1481, 1256, 1225, 1036, 794 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{12}H_9O_4BrNa$ 318.9576; Found 318.9569.

*5-Bromo-6-(2-chlorophenyl)-2H-pyran-4(3H)-one (**13l**):* Reaction time = 3 h, white solid (68.3 mg, 95%), M.p. 128–130 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.93 (t, *J* = 6.7 Hz, 2H), 4.70 (t, *J* = 6.7 Hz, 2H), 7.33–7.44 (m, 3H), 7.45–7.50 (m, 1H) ppm. ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ = 36.6, 68.8, 103.5, 126.7, 129.9, 130.0, 131.6, 132.5, 133.3, 168.8, 185.2 ppm. IR ($CHCl_3$): υ_{max} = 3018, 2928, 1682, 1603, 1574, 1459, 1383, 1330, 1252, 1188, 1103, 1008, 827, 668 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + H]$^+$ Calcd for $C_{11}H_9O_2ClBr$ 286.9469; Found 286.9460.

*5-Bromo-6-(2-bromophenyl)-2H-pyran-4(3H)-one (**13m**):* Reaction time = 3 h, white solid (68.1 mg, 82%), M.p. 140–142 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.39 (t, *J* = 6.7 Hz, 2H), 4.72 (t, *J* = 6.7 Hz, 2H), 7.31–7.43 (m, 3H), 7.66 (d, *J* = 7.9 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ = 36.6, 68.9, 103.3, 121.5, 127.4, 130.0, 131.6, 133.1, 135.4, 169.8, 185.3 ppm. IR ($CHCl_3$): υ_{max} = 3017, 2928, 1681, 1599, 1571, 1458, 1384, 1330, 1253, 1187, 1101, 1167, 1007, 913, 826, 668, 520 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{11}H_8O_2Br_2Na$ 352.8783; Found 352.8775. For X-ray structure, see end of SI.

*5-Bromo-6-(4-chlorophenyl)-2H-pyran-4(3H)-one (**13o**):* Reaction time = 4 h, pale yellow solid (62.5 mg, 87%), M.p. 124–126 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.90 (t, *J* = 6.7 Hz, 2H), 4.67 (t, *J* = 6.7 Hz, 2H), 7.42 (d, *J* = 8.6 Hz, 2H), 7.70 (d, *J* = 8.8 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 36.5, 68.1, 101.0, 128.4, 131.0, 131.6, 137.6, 168.2, 185.5 ppm. IR ($CHCl_3$): υ_{max} = 2924, 2850, 1661, 1593, 1570, 1543, 1480, 1401, 1319, 1252, 1231, 1098, 1003, 971, 837, 764 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + H]$^+$ Calcd for $C_{11}H_9O_2BrCl$ 286.9469; Found 286.9469.

*(E)-5-Bromo-6-(4-methoxystyryl)-2H-pyran-4(3H)-one (**13r**):* Reaction time = 5 h, yellow solid (68.8 mg, 89%), M.p. 152–154 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.83 (t, *J* = 6.6 Hz, 2H), 3.85 (s, 3H), 4.57 (t, *J* = 6.6 Hz, 2H), 6.92 (dt, *J* = 8.8, 2.2 Hz, 2H), 7.15 (d, *J* = 15.8 Hz, 1H), 7.42 (d, *J* = 15.8 Hz, 1H), 7.52 (dt, *J* = 8.8, 2.2 Hz, 2H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 36.8, 55.4, 67.4, 102.3, 114.5, 117.6, 127.8, 129.9, 140.2, 161.5, 166.0, 185.2 ppm. IR ($CHCl_3$): υ_{max} = 2922, 2853, 1663, 1619, 1602, 1534, 1508, 1469, 1393, 1298, 1274, 1256, 1173, 1080, 1024, 1002, 965, 818, 627 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{14}H_{13}O_3BrNa$ 330.9940; Found 330.9943.

*5-Bromo-6-(thiophen-2-yl)-2H-pyran-4(3H)-one (**13t**):* Reaction time = 5 h, pale yellow solid (52.5 mg, 81%), M.p. 106–108 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.87 (t, *J* = 6.6 Hz, 2H), 4.63 (t, *J* = 6.6 Hz, 2H), 7.17 (d, *J* = 4.5 Hz, 1H), 7.66 (d, *J* = 5.0 Hz, 1H), 8.13 (d, *J* = 3.9 Hz, 1H) ppm. ^{13}C{^{1}H} NMR (125 MHz, $CDCl_3$): δ = 36.6, 68.0, 99.6, 127.7, 132.6, 133.9, 135.2, 162.3, 185.4 ppm. IR ($CHCl_3$): υ_{max} = 3075, 3009, 2927, 2854, 1663, 1548, 1507, 1488, 1459, 1407, 1390, 1362, 1308, 1260, 1237, 1175, 1098, 1083, 1067, 1047, 1006, 906, 867, 856, 798, 723, 697, 686 cm^{-1}. HRMS (ESI-TOF) *m/z*: [M + H]$^+$ Calcd for $C_9H_8O_2SBr$ 258.9423; Found 258.9422.

*5-Bromo-6-(furan-2-yl)-2H-pyran-4(3H)-one (**13u**):* Reaction time = 3 h, brown solid (58.3 mg, 96%), M.p. 74–76 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.86 (t, *J* = 6.7 Hz, 2H), 4.64 (t, *J* = 6.5 Hz, 2H), 6.51–6.58 (m, 1H), 7.55 (dd, *J* = 3.7, 0.7 Hz, 1H), 7.65–7.67 (m, 1H) ppm. ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ = 36.7, 68.0, 98.5, 112.4, 119.9, 145.96, 146.02, 158.4, 185.2 ppm. IR ($CHCl_3$): υ_{max} = 3148, 3009, 2926, 1668, 1574, 1539, 1472, 1401, 1379, 1327, 1316, 1246, 1228,

1192, 1159, 1109, 1087, 1003, 929, 904, 886, 854, 801, 705, 665, 594, 547 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_9H_7O_3BrNa$ 264.9471; Found 264.9470.

*6-(Benzo[d][1,3]dioxol-5-yl)-5-iodo-2H-pyran-4(3H)-one (**13e**):* Reaction time = 4 h, white semi-solid (67.1 mg, 78%). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.90 (t, *J* = 6.6 Hz, 2H), 4.64 (t, *J* = 6.7 Hz, 2H), 6.05 (s, 2H), 6.86 (d, *J* = 8.2 Hz, 1H), 7.17 (d, *J* = 1.8 Hz, 1H), 7.28 (dd, *J* = 8.2, 1.8 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 35.8, 68.0, 76.9, 101.8, 107.8, 110.1, 125.3, 128.8, 147.2, 150.2, 171.7, 187.1 ppm. IR ($CHCl_3$): υ_{max} = 2924, 2853, 1742, 1652, 1501, 1466, 1376, 1302, 1256, 1098, 1019, 966, 849 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{12}H_9O_4INa$ 366.9443; Found 366.9448.

*6-(Biphenyl-4-yl)-5-iodo-2H-pyran-4(3H)-one (**13g**):* Reaction time = 3 h, white solid (75.2 mg, 80%), M.p. 126–128 °C. ^1H NMR (500 MHz, $CDCl_3$): δ = 2.95 (t, *J* = 6.7 Hz, 2H), 4.70 (t, *J* = 6.7 Hz, 2H), 7.40 (t, *J* = 7.3 Hz, 1H), 7.47 (t, *J* = 7.6 Hz, 2H), 7.62–7.68 (m, 4H), 7.79 (d, *J* = 8.3 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 35.8, 68.3, 126.6, 127.2, 128.1, 128.9, 130.2, 134.04, 139.9, 144.2, 172.1, 187.1 ppm. IR ($CHCl_3$): υ_{max} = 2928, 2854, 1666, 1603, 1563, 1546, 1485, 1404, 1319, 1306, 1252, 1092, 992, 844, 767, 746, 694 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{17}H_{14}IO_2$ 377.0033; Found 377.0029.

*6-(2-Bromophenyl)-5-iodo-2H-pyran-4(3H)-one (**13m**):* Reaction time = 4 h, yellow white solid (68.2 mg, 72%), M.p. 108–110 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 2.29 (t, *J* = 6.7 Hz, 2H), 4.73 (t, *J* = 6.7 Hz, 2H), 7.30–7.44 (m, 3H), 7.65 (d, *J* = 8.1 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 35.7, 69.1, 80.8, 121.4, 127.4, 130.0, 131.5, 133.0, 137.7, 172.6, 186.6 ppm. IR ($CHCl_3$): υ_{max} = 3011, 2924, 1675, 1596, 1562, 1457, 1437, 1381, 1315, 1251, 1226, 1185, 1096, 1065, 1026, 995, 862, 822, 725, 704, 654, 561 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{11}H_8O_2BrINa$ 400.8645; Found 400.8634.

*5-Chloro-6-(furan-2-yl)-2H-pyran-4(3H)-one (**13u**):* Reaction time = 3 h, yellow solid (34.8 mg, 70%), M.p. 74–76 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 2.81 (t, *J* = 6.7 Hz, 2H), 4.63 (t, *J* = 6.7 Hz, 2H), 6.60 (dd, *J* = 3.6, 1.7 Hz, 1H), 7.44–7.48 (m, 1H), 7.63–7.66 (m, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 36.5, 68.0, 108.5, 112.6, 119.7, 145.2, 146.0, 157.2, 185.2 ppm. IR ($CHCl_3$): υ_{max} = 3152, 3126, 2893, 1662, 1592, 1574, 1538, 1469, 1406, 1381, 1334, 1250, 1229, 1193, 1160, 1119, 1087, 1070, 1027, 1017, 932, 911, 886, 866, 835, 805, 709, 667, 588 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_9H_7O_3ClNa$ 220.9976; Found 220.9972.

*2-(4-tert-Butylphenyl)tetrahydro-2H-pyran-4-ol (**14**):* To a solution of compound **10c** (50 mg, 0.217 mmol) in EtOH (3 mL) was added 10% Pd/C (2 mg) and the mixture hydrogenated for 6 h with hydrogen balloon. The reaction mixture was then concentrated under reduced pressure. The residue was purified by silica gel column chromatography with petroleum ether/EtOAc (7:3) as eluent to give **14** (43.2 mg, 85%) as white solid. M.p. 118–120 °C. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.31 (s, 9H), 1.55–1.58 (m, 2H), 1.95–198 (m, 1H), 2.17–2.21 (m, 1H), 3.55–3.60 (m, 1H), 3.91–3.97 (m, 1H), 4.16 (dd, *J* = 11.8, 4.9 Hz, 1H), 4.30 (d, *J* = 11.3 Hz, 1H), 7.28 (d, *J* = 8.1 Hz, 2H), 7.37 (d, *J* = 8.4 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 31.3, 34.5, 35.5, 42.9, 66.3, 68.5, 78.2, 125.3, 125.7, 138.7, 150.6 ppm. IR ($CHCl_3$): υ_{max} = 3433, 2961, 2867, 1514, 1461, 1417, 1370, 1132, 1063, 983, 881, 830, 667, 598 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{15}H_{22}O_2Na$ 257.1512; Found 257.1511. For X-ray structure, see end of SI.

*6-(4-tert-Butylphenyl)-3,4-dihydro-2H-pyran-4-ol (**15**):* To a solution of compound **10c** (50 mg, 0.217 mmol) in EtOH (3 mL) was added $NaBH_4$ (8 mg, 0.217 mmol, 1.0 equiv) at 0 °C and the mixture stirred for 1 h. The reaction was quenched with one drop of water and the mixture was concentrated under reduced pressure. The residue was purified by silica gel column chromatography with petroleum ether/EtOAc (4:1) as eluent to give **15** (44.4 mg, 88%) as colorless oil. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.32 (s, 9H), 1.92–2.01 (m, 2H), 4.13 (td, *J* = 11.2, 2.1 Hz, 1H), 4.29–4.35 (m, 2H), 5.49 (d, *J* = 4.8 Hz, 1H), 7.37 (d, *J* = 8.4 Hz, 2H), 7.53 (d, *J* = 8.4 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 29.7, 31.2, 34.6, 60.5, 62.4, 98.4, 124.8, 125.1, 132.3, 151.9, 154.5 ppm. IR ($CHCl_3$): υ_{max} = 3488, 2961, 2828, 2861, 1676, 1605, 1446, 1408, 1361, 1274, 1190, 1109, 1010, 910, 839, 734, 648 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + K]^+$ Calcd for $C_{15}H_{20}O_2K$ 271.1095; Found 271.1096.

*6-(Benzo[d][1,3]dioxol-5-yl)-3,5-diiodo-2,3-dihydro-4H-pyran-4-one (**16**):* To a stirred solution of compound **9e** (67 mg, 0.307 mmol) in CH_3CN (1 mL) was added *p*TsOH (5.4 mg, 0.031 mmol, 10 mol%) and NIS (83.2 mg, 0.37 mmol, 1.2 equiv) at room temperature. The reaction mixture was stirred at room temperature for 4 h. The solvent was evaporated at reduced pressure and the residue was purified by silica gel column chromatography using petroleum ether/EtOAc (4:1) as eluent to give **16** (36.1 mg, 25%) as brown semisolid. ^1H NMR (400 MHz, $CDCl_3$): δ = 4.51 (dd, *J* = 12.9, 3.2 Hz, 1H), 4.60 (dd, *J* = 13.0, 3.8 Hz, 1H), 4.93–4.95 (m, 1H), 6.06 (s, 2H), 6.87 (d, *J* = 8.2 Hz, 1H), 7.21 (d, *J* = 1.6 Hz, 1H), 7.33 (dd, *J* = 8.2, 1.6 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 19.4, 73.4, 77.2, 101.9, 107.9, 110.1, 125.6, 128.1, 147.3, 150.6, 171.1, 183.3 ppm. IR ($CHCl_3$): υ_{max} = 2930, 1676, 1597, 1563, 1457, 1435, 1381, 1315, 1252, 1225, 1185, 1096, 1024, 996, 823 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{12}H_8O_4I_2Na$ 492.8404; Found 492.8406.

*6-(Biphenyl-4-yl)-3-iodo-2H-pyran-4(3H)-one (**17**):* To a stirred solution of alcohol **10g** (80 mg, 0.320 mmol) in MeOH (1 mL) was added *p*TsOH (5.5 mg, 0.032 mmol, 10 mol%) at room temperature. The reaction mixture was stirred at room temperature for 4 h. Methanol was evaporated under reduced pressure and the residue dissolved in CH_3CN (3.0 mL). To this was added NIS (86.4 mg, 0.384 mmol, 1.2 equiv) portion wise at room temperature. The reaction mixture was stirred at same temperature for 3 h. The solvent was evaporated at reduced pressure and the residue was purified by silica gel column chromatography using petroleum ether/EtOAc (7:3) as eluent to give **17** (39.7 mg, 33%) as brown solid. M.p. 134–136 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 4.58 (dd, *J* = 12.7, 3.3 Hz, 1H), 4.70 (t, *J* = 12.7, 4.1 Hz, 1H), 4.76–4.78 (m, 1H), 6.11 (d, *J* = 1.0 Hz, 1H), 7.40 (tt,

J = 7.3, 2.3 Hz, 1H), 7.46–7.50 (m, 2H), 7.61–7.64 (m, 2H), 7.69 (dt, *J* = 8.6, 1.9 Hz, 2H), 7.85 (dt, *J* = 8.6, 1.9 Hz, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 22.3, 74.2, 99.4, 127.15, 127.2, 127.4, 128.2, 129.0, 130.5, 139.7, 145.0, 169.6, 187.8 ppm. IR ($CHCl_3$): υ_{max} = 2918, 2847, 1651, 1591, 1408, 1349, 1339, 1232, 1092, 1075, 1032, 848, 824, 693 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{17}H_{14}O_2I$ 377.0033; Found 377.0032.

*Non-1-yn-4-ol (**19**):*[13] A mixture of zinc powder (1.816 g, 27.8 mmol, 5.0 equiv), 1,2-diiodoethane (1.567 g, 5.56 mmol, 1.0 equiv), aldehyde **18** (0.556 g, 5.56 mmol, 1.0 equiv) and 3-bromo-1-propyne (0.632 mL, 8.34 mmol, 1.5 equiv) in anhydrous THF (15 mL) was sonicated in a commercial ultrasonic cleaning bath for 30 min. After the sonication, an aqueous HCl solution (2 M, 11 mL) was added and the mixture was extracted with ether (20 mL × 3). The combined organic layers were washed with brine (20 mL), dried (Na_2SO_4), filtered and concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether/EtOAc (4:1) as eluent to give **19** (568.7 mg, 73%) as colorless oil. ^1H NMR (400 MHz, $CDCl_3$): δ = 0.89 (t, *J* = 6.6 Hz, 3H), 1.28–1.37 (m, 6H), 1.51–1.56 (m, 2H), 1.90 (br s, 1H, *OH*), 2.05 (t, *J* = 2.6 Hz, 1H), 2.31 (ddd, *J* = 16.7, 6.8, 2.8 Hz, 1H), 2.43 (ddd, *J* = 16.7, 4.7, 2.8 Hz, 1H), 3.72–3.78 (m, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 14.0, 22.6, 25.2, 27.3, 31.7, 36.2, 69.9, 70.7, 80.9 ppm. IR ($CHCl_3$) ppm: υ_{max} = 3454, 2925, 2854, 2305, 2149, 1659, 1463, 1374, 1261, 1081, 1042, 966, 762 cm^{-1}.

*3,4-bis(Benzyloxy)benzaldehyde (**21**):* To a solution of 3,4-dihydroxybenzaldehyde **20** (1.0 g, 7.24 mmol) in acetone (40 mL) was added benzyl bromide (1.9 mL, 15.93 mmol, 2.2 equiv), followed by anhydrous K_2CO_3 (3.0 g, 21.72 mmol, 3.0 equiv). The mixture was stirred at room temperature for 10 h. This was then concentrated and the residue dissolved in EtOAc and water. The organic layer was separated, and the aqueous layer extracted with EtOAc (3 × 40 mL). The combined organic layers were washed with water (2 × 40 mL) and brine (50 mL). The organic layer was dried (Na_2SO_4) and concentrated. The residue was purified by silica gel column chromatography using petroleum ether/EtOAc (4:1) as eluent to give **21** (1.959 g, 85%) as white semisolid. ^1H NMR (400 MHz, $CDCl_3$): δ = 5.11 (s, 2H), 5.14 (s, 2H), 6.60 (d, *J* = 2.1 Hz, 1H), 6.64 (dd, *J* = 8.6, 1.9 Hz, 1H), 7.34–7.44 (m, 10H), 7.84 (d, *J* = 8.6 Hz, 1H), 10.39 (m, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 70.36, 70.4, 100.1, 107.0, 119.5, 127.3, 127.5, 128.3, 128.4, 128.7, 130.5, 135.88, 135.9, 162.7, 165.2, 188.2 ppm. IR ($CHCl_3$): υ_{max} = 3423, 3040, 2928, 2861, 1686, 1595, 1583, 1508, 1434, 1386, 1269, 1161, 1132, 1018, 737, 696 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{21}H_{18}O_3Na$ 341.1148; Found 341.1148.

*1-[3,4-bis(Benzyloxy)phenyl]dec-2-yne-1,5-diol (**22**):* Alkyne **19** (0.528 g, 3.77 mmol, 1.0 equiv) was dissolved in THF (30 mL). The mixture was cooled to –78 °C and *n*-BuLi (1.6 M solution in hexane, 5.2 mL, 8.3 mmol, 2.2 equiv) was added dropwise. After the addition, the reaction was left to stir for 0.5 h at –78 °C and then aldehyde **21** (1.20 g, 3.77 mmol, 1.0 equiv) in THF (10 mL) was added in one portion. The reaction was allowed to warm to 0 °C for 1 h and then quenched by addition of saturated aq. NH_4Cl solution (20 mL). The two layers were separated and the aqueous phase was extracted with EtOAc (3 × 35 mL). The organic layers were combined and washed with distilled water (50 mL) and brine. The organic phase was dried (Na_2SO_4), filtered and concentrated. The residue was purified by silica gel column chromatography using petroleum ether/EtOAc (7:3 to 1:1) as eluent to afford compound **22** (1.262 g, 73%) as colorless semi-solid. ^1H NMR (500 MHz, $CDCl_3$): δ = 0.89 (t, *J* = 6.6 Hz, 3H), 1.24–1.40 (m, 6H), 1.50–1.53 (m, 2H), 2.35 (ddd, *J* = 16.6, 6.9, 1.6 Hz, 1H), 2.47 (ddd, *J* = 16.7, 4.5, 1.6 Hz, 1H), 3.71–3.77 (m, 1H), 5.15 (s, 2H), 5.17 (s, 2H), 5.34 (s, 1H), 6.90 (d, *J* = 8.3 Hz, 1H), 7.03 (dd, *J* = 8.3, 2.0 Hz, 1H), 7.17 (t, *J* = 1.3 Hz, 1H), 7.28–7.38 (m, 6H), 7.42–7.47 (m, 4H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 14.0, 22.6, 25.3, 27.7, 31.7, 36.3, 64.4, 70.0, 71.16, 71.2, 82.4, 83.6, 113.4, 114.7, 119.7, 127.2, 127.3, 127.8, 128.43, 128.4, 134.4, 137.2, 148.9, 149.0 ppm. IR ($CHCl_3$): υ_{max} = 3388, 2924, 2864, 2250, 1641, 1512, 1454, 1426, 1379, 1159, 1135, 1024, 750, 696 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{30}H_{34}O_4Na$ 481.2349; Found 481.2351.

*1-[3,4-bis(Benzyloxy)phenyl]-5-hydroxydec-2-yn-1-one (**10y**):* Diol **22** (0.510 g, 1.11 mmol, 1.0 equiv) was dissolved in CH_2Cl_2 (30 mL) and MnO_2 (1.451 g, 16.7 mmol, 15.0 equiv) was added to the solution. The mixture was stirred at room temperature for 14 h. MnO_2 was filtered and the solvent evaporated. Purification of the residue by column chromatography with petroleum ether/EtOAc (7:3) as eluent gave **10y** (471.3 mg, 93%) as yellow semi-solid. ^1H NMR (400 MHz, $CDCl_3$): δ = 0.89 (t, *J* = 6.8 Hz, 3H), 1.26–1.50 (m, 6H), 1.58–1.63 (m, 2H), 2.60 (dd, *J* = 17.1, 6.5 Hz, 1H), 2.69 (dd, *J* = 17.1, 4.8 Hz, 1H), 3.87–3.93 (m, 1H), 5.21 (s, 2H), 5.25 (s, 2H), 6.95 (d, *J* = 8.4 Hz, 1H), 7.31–7.40 (m, 6H), 7.43–7.48 (m, 4H), 7.71 (d, *J* = 2.0 Hz, 1H), 7.77 (dd, *J* = 8.4, 2.0 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 14.0, 22.6, 25.3, 28.1, 31.6, 36.6, 69.8, 70.8, 71.0, 81.2, 92.2, 112.8, 113.7, 125.7, 127.0, 127.3, 128.0, 128.1, 128.5, 128.6, 130.4, 139.2, 136.6, 148.5, 154.1, 176.7 ppm. IR ($CHCl_3$): υ_{max} = 3431, 2931, 2857, 2221, 1735, 1635, 1593, 1578, 1511, 1454, 1430, 1381, 1216, 1106, 1021, 858, 697 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + K]^+$ Calcd for $C_{30}H_{32}O_4K$ 495.1932; Found 495.1936.

*6-[3,4-bis(Benzyloxy)phenyl]-2-pentyl-2H-pyran-4(3H)-one (**9y**):* Compound **9y** was prepared from **10y** (0.456 g, 1.0 mmol) by the same procedure as used in the preparation of compound **10** to give **9** (reaction time = 10 h, 415.5 mg, 91%) as yellow semi-solid. ^1H NMR (500 MHz, $CDCl_3$): δ = 0.93 (t, *J* = 6.4 Hz, 3H), 1.6–1.37 (m, 4H), 1.48 (m, 1H), 1.57–1.58 (m, 1H), 1.70–1.76 (m, 1H), 1.87–1.95 (m, 1H), 2.44–2.54 (m, 2H), 4.46–4.50 (m, 1H), 5.18 (s, 2H), 5.22 (s, 2H), 5.85 (s, 1H), 6.94 (d, *J* = 8.3 Hz, 1H), 7.30–7.45 (m, 12H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 14.0, 22.5, 24.8, 31.5, 41.4, 70.9, 71.3, 79.4, 100.9, 113.0, 113.8, 120.8, 125.7, 127.1, 127.3, 128.00, 128.03, 128.6, 128.61, 136.5, 136.7, 148.5, 151.9, 170.0, 193.4 ppm. IR ($CHCl_3$): υ_{max} = 2930, 2861, 1636, 1602, 1570, 1515, 1442, 1379, 1328, 1275,

1141, 1041, 1027, 901, 733, 695 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{30}H_{33}O_4$ 457.2373; Found 457.2374.

*(±)-4-(4-Hydroxy-6-pentyltetrahydro-2H-pyran-2-yl)benzene-1,2-diol (**23**):*[8] To a solution of compound **9y** (100 mg, 0.219 mmol) in EtOH and EtOAc (1:1, 3.0 mL) was added 10% Pd/C (6 mg) and the mixture hydrogenated for 10 h in autoclave (pressure 30 psi). Then the reaction mixture was filtered and the filtrate was concentrated in vacuo. The residue was purified by silica gel column chromatography using petroleum ether/EtOAc (1:2) as eluent to give **23** (49.7 mg, 81%) as a colorless solid. M.p. 122–124 °C (lit.,[8] M.p. 129–131 °C). ^1H NMR (500 MHz, CD_3OD): δ = 0.92 (t, *J* = 7.9 Hz, 3H), 1.19 (q, *J* = 11.4 Hz, 1H), 1.31–1.38 (m, 6H), 1.40–1.43 (m, 1H), 1.48–1.54 (m, 1H), 1.57–1.64 (m, 1H), 1.98 (dt, *J* = 12.3, 2.1 Hz, 1H), 2.08 (dt, *J* = 12.3, 2.1 Hz, 1H), 3.46–3.50 (m, 1H), 3.83–3.90 (m, 1H), 4.23 (d, *J* = 10.7 Hz, 1H), 6.68 (dd, *J* = 8.1, 1.4 Hz, 1H), 6.73 (d, *J* = 8.1 Hz, 1H), 6.84 (d, *J* = 1.4 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, CD_3OD): δ = 12.9, 22.2, 24.8, 31.6, 35.7, 40.3, 42.2, 67.6, 75.9, 77.3, 113.1, 114.5, 117.3, 133.9, 144.2, 144.6 ppm. IR ($CHCl_3$): υ_{max} = 3414, 2930, 2856, 1609, 1534, 1453, 1360, 1279, 1054, 1023, 814, 770 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{16}H_{24}O_4Na$ 303.1567; Found 303.1568.

*1-(tert-Butydimethylsilyloxy)hex-5-yn-3-ol (**25**):* To a solution of DMSO (0.336 mL, 4.73 mmol, 1.5 equiv) in CH_2Cl_2 (90 mL) was added oxalyl chloride (0.35 mL, 4.1 mmol, 1.3 equiv) dropwise at –78 °C. The reaction mixture was stirred for 20 minutes at –78 °C. Then the solution of 3-(*tert*-butyldimethylsilyloxy)propan-1-ol (600 mg, 3.15 mmol, 1.0 equiv) in CH_2Cl_2 (45 mL) was added drop wise to the above reaction mixture at –78 °C. The reaction mixture was stirred for 1 h. Then triethylamine (2.2 mL, 17.75 mmol, 5.0 equiv) was added and the reaction mixture was allowed to warm to room temperature and quenched with water (30 mL). The organic layer was separated and aqueous layer was extracted with CH_2Cl_2 (3 × 15 mL). The combined organic layers were dried (Na_2SO_4) and concentrated under reduced pressure. The crude oily residue (546 mg) was directly used for next reaction.

To a stirred solution of propargyl bromide (80% solution in toluene, 0.702 mL, 4.728 mmol, 1.5 equiv) and THF (45 mL) was added the solution of above prepared crude aldehyde (546 mg) in THF (45 mL) at room temperature in a sonicater. Then 1,2-diiodoethane (888 mg, 3.15 mmol, 1.0 equiv) was added pinch wise followed by portion wise addition of zinc (825 mg, 12.6 mmol, 4.0 equiv). The reaction mixture was stirred for 30 min and then quenched with saturated aq. NH_4Cl solution. The organic layer was separated and aqueous layer was extracted with EtOAc (2 × 45 mL). The combined organic layers were washed with brine, dried (Na_2SO_4), and concentrated under reduced pressure. The residue was purified by silica gel column chromatography with petroleum ether/EtOAc (9:1) as eluent to give **25** (482.1 mg, 67%) as a colorless oil. ^1H NMR (500 MHz, $CDCl_3$): δ = 0.05 (s, 6H), 0.87 (s, 9H), 1.67–1.83 (m, 2H), 1.99 (t, *J* = 2.5 Hz, 1H), 2.30–2.43 (m, 2H), 3.77–3.82 (m, 1H), 3.85–3.91 (m, 1H), 3.93–3.99 (m, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = –5.7, –5.6, 18.0, 25.8, 27.0, 37.1, 62.1, 70.1, 70.2, 81.0 ppm. IR ($CHCl_3$): υ_{max} = 3400, 3310, 2930, 2858, 2118, 1642, 1472, 1424, 1256, 1092, 1006, 954, 837, 777, 637 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{12}H_{24}O_2SiNa$ 251.1438; Found 251.1433.

*(E)-9-(tert-Butyldimethylsilyloxy)-1-phenylnon-1-en-4-yne-3,7-diol (**26**):* To a solution of **25** (150 mg, 0.657 mmol, 1.0 equiv) in THF (15 mL) was added *n*-BuLi (1.6 M solution in *n*-hexane, 0.862 mL, 1.38 mmol, 2.1 equiv) drop wise at –78 °C and stirred for 30 min. To the above reaction mixture, a solution of cinnamaldehyde (91.2 mg, 0.690 mmol, 1.05 equiv) in THF (10 mL) was added dropwise. The reaction mixture was allowed to warm to room temperature (1 h) and quenched with saturated aq. NH_4Cl solution (2 mL). The organic layer was separated and aqueous layer was extracted with EtOAc (2 × 10 mL). The combined organic layers were washed with brine, dried (Na_2SO_4), and concentrated under reduced pressure. The residue was purified by silica gel column chromatography with petroleum ether/EtOAc (7:3) as eluent to give **26** (170.6 mg, 72%) as yellow oil. ^1H NMR (400 MHz, $CDCl_3$): δ = 0.08 (s, 6H), 0.89 (s, 9H), 1.71–1.86 (m, 2H), 2.48 (td, *J* = 5.7, 1.8 Hz, 2H), 3.78–3.85 (m, 1H), 3.87–3.93 (m, 1H), 3.95–4.05 (m, 1H), 5.04 (dt, *J* = 6.0, 1.8 Hz, 1H), 6.28 (dd, *J* = 15.8, 6.0 Hz, 1H), 6.74 (d, *J* = 15.8 Hz, 1H), 7.24–7.27 (m, 1H), 7.28–7.33 (m, 2H), 7.37–7.41 (m, 2H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = –5.6, –5.56, 18.1, 25.8, 27.4, 37.3, 62.1, 62.9, 70.2, 81.3, 83.5, 126.7, 127.9, 128.5, 128.6, 131.4, 136.2 ppm. IR ($CHCl_3$): υ_{max} = 3389, 2947, 2927, 2862, 2216, 1626, 1493, 1449, 1425, 1297, 1260, 1203, 1182, 1080, 973, 867, 836, 764, 699, 680 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{21}H_{32}SiO_3Na$ 383.2013; Found 383.2008.

*(E)-9-(tert-Butyldimethylsilyloxy)-7-hydroxy-1-phenylnon-1-en-4-yn-3-one (**10z**):* To a solution of alcohol **26** (75 mg, 0.208 mmol, 1.0 equiv) in CH_2Cl_2 (10 mL) was added MnO_2 (271.3 mg, 3.120 mmol, 15.0 equiv) and the reaction mixture was stirred at room temperature for 5 h. After completion of reaction, the mixture was filtered through celite and the filtrate was dried (Na_2SO_4) and concentrated under reduced pressure. The residue was purified by silica gel column chromatography with petroleum ether/EtOAc (4:1) as eluent to give **10z** (64.1 mg, 86%) as a yellow oil. ^1H NMR (500 MHz, $CDCl_3$): δ = 0.09 (s, 6H), 0.90 (s, 9H), 1.78–1.92 (m, 2H), 2.62–2.73 (m, 2H), 3.83–3.90 (m, 1H), 3.92–3.99 (m, 1H), 4.10–4.18 (m, 1H), 6.76 (d, *J* = 16.1 Hz, 1H), 7.38–7.43 (m, 3H), 7.55 (dd, *J* = 7.7, 2.5 Hz, 2H), 7.85 (d, *J* = 16.2 Hz, 1H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = –5.63, –5.6, 18.1, 25.8, 27.7, 37.2, 62.3, 70.2, 80.6, 91.4, 128.4, 128.6, 129.0, 131.0, 134.1, 148.6, 178.4 ppm. IR ($CHCl_3$): υ_{max} = 3460, 2955, 2929, 2857, 2215, 1629, 1471, 1449, 1329, 1296, 1258, 1203, 1093, 976, 836, 777, 764, 701, 678, 575 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + K]^+$ Calcd for $C_{21}H_{30}O_3SiK$ 397.1596; Found 397.1591.

*(E)-2-(2-Hydroxyethyl)-6-styryl-2H-pyran-4(3H)-one (**9z**):* Compound **9z** was prepared from **10z** (336 mg, 0.937 mmol, 1.0 equiv) by the same procedure as used for preparation of compound **9** to give **9z** (reaction time = 1 h, 174 mg, 76%) as a orange oil. ^1H NMR (400 MHz, $CDCl_3$): δ = 1.93–2.05 (m, 1H), 2.12–2.23 (m, 1H), 2.41 (br s, 1H, *OH*),

2.47–2.62 (m, 2H), 3.84–4.00 (m, 2H), 4.64–4.76 (m, 1H), 5.52 (s, 1H), 6.53 (d, *J* = 15.9 Hz, 1H), 7.28–7.39 (m, 4H), 7.46–7.51 (m, 2H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 37.2, 41.5, 58.5, 76.4, 106.1, 121.5, 127.7, 128.9, 129.7, 135.0, 137.2, 168.3, 193.4 ppm. IR ($CHCl_3$): υ_{max} = 3432, 2924, 1733, 1620, 1578, 1410, 1347, 1227, 1124, 1034, 1010, 816, 694, 568 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{15}H_{17}O_3$ 245.1172; Found 245.1168.

*(E)-2-(2-Hydroxypent-4-enyl)-6-styryl-2H-pyran-4(3H)-one (**27**):* To a solution of **9z** (151 mg, 0.618 mmol, 1.0 equiv) in dry CH_2Cl_2 (20 mL) was added Dess–Martin periodinane (393.3 mg, 0.927 mmol, 1.5 equiv) at 0 °C, and the reaction mixture was stirred for 3 h. After completion of reaction, the mixture was quenched with 1:1 mixture of saturated aq. solution of $Na_2S_2O_3$ and $NaHCO_3$. The organic layer was separated and aqueous layer was extracted with CH_2Cl_2 (3 × 10 mL). The combined organic layers were washed with brine, dried (Na_2SO_4) and concentrated under reduced pressure to give crude aldehyde (142 mg) as a orange oil. This aldehyde was used for next step without purification.

To a solution of allyl bromide (0.079 mL, 0.927 mmol, 1.5 equiv) in THF (15 mL) was added a solution of above prepared crude aldehyde (142 mg) in THF (10 mL) at room temperature in a sonicater. To the above reaction mixture 1,2-diiodoethane (174.2 mg, 0.618 mmol, 1.0 equiv) was added pinch wise followed by portion wise addition of zinc (121.2 mg, 1.854 mmol, 3.0 equiv) and the reaction mixture was then stirred for 1 h. It was then quenched with saturated aq. NH_4Cl solution. The organic layer was separated and aqueous layer extracted with EtOAc (2 × 10 mL). The combined organic layers were washed with brine, dried (Na_2SO_4) and concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether/EtOAc (3:2) as eluent to give a mixture of diastereomers **27** (119.5 mg, 68%) in 1:1.3 ratio of *cis* and *trans*[6] isomers as a yellow oil. ^1H NMR (400 MHz, $CDCl_3$) : δ = 1.71–1.78 (m, 1H), 1.88–1.95 (m, 1H), 2.04–2.16 (m, 2H), 2.24–2.33 (m, 2H), 2.35–2.60 (m, 6H), 3.90–4.00 (m, 1H), 4.06–4.14 (m, 1H), 4.68–4.84 (m, 2H), 5.16–5.23 (m, 4H), 5.52 (s, 2H), 5.80–5.94 (m, 2H), 6.54 (d, *J* = 15.9 Hz, 2H), 7.27–7.38 (m, 8H), 7.47–7.51 (m, 4H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 41.0, 41.4, 41.5, 42.0, 42.1, 42.5, 66.5, 67.7, 76.1, 77.5, 106.3, 118.9, 121.5, 121.7, 127.6, 127.7, 128.9, 129.6, 129.7, 133.9, 135.0, 135.1, 136.9, 137.1, 167.9, 168.1, 193.1, 193.3 ppm. IR ($CHCl_3$): υ_{max} = 3405, 2924, 1649, 1624, 1579, 1564, 1447, 1405, 1345, 1246, 1169, 1105, 912, 757, 694 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{18}H_{21}O_3$ 285.1485; Found 285.1488.

*(E)-1-(4-Oxy-6-styryl-3,4-dihydro-2H-pyran-2-yl)pent-4-en-2-yl acrylate (**30**).* To a solution of alcohol **27** (180 mg, 0.633 mmol, 1.0 equiv) in dry CH_2Cl_2 (20 mL) was added triethylamine (0.132 mL, 0.95 mmol, 1.5 equiv) followed by addition of DMAP (15.5 mg, 0.127 mmol, 0.2 equiv) at 0 °C under nitrogen atmosphere, and the reaction mixture was stirred for 30 min at 0 °C. Then acryloyl chloride (0.077 mL, 0.95 mmol, 1.5 equiv) solution in dry CH_2Cl_2 (10 mL) was added drop wise. The reaction mixture was further stirred at 0 °C for 1 h and then quenched with saturated aq. $NaHCO_3$ solution. The organic layer was separated and aqueous layer was extracted with CH_2Cl_2 (3 × 10 mL). The combined organic layers were washed with brine, dried (Na_2SO_4) and concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether/EtOAc (4:1) as eluent to give the mixture of diastereomers **30** (143.5 mg, 67%) as a pale yellow semi-solid. ^1H NMR (400 MHz, $CDCl_3$): δ = 1.93–2.00 (m, 1H,), 2.00–2.07 (m, 1H), 2.15–2.22 (m, 1H), 2.28–2.35 (m, 1H), 2.44–2.55 (m, 8H), 4.50–4.64 (m, 2H), 5.1–5.2 (m, 4H), 5.24–5.34 (m, 1H), 5.50 (s, 1H), 5.52 (s, 1H), 5.75–5.88 (m, 5H), 6.09 (dd, *J* = 10.4. 5.2, 1H), 6.13 (dd, *J* = 10.4. 5.3, 1H), 6.36–6.44 (m, 2H), 6.52 (dd, *J* = 15.9. 4.6, 2H), 7.30–7.42 (m, 8H), 7.47–7.55 (m, 4H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 38.2, 38.5, 38.6, 39.2, 41.4, 41.8, 69.0, 70.0, 75.2, 76.4, 106.1, 106.2, 118.6, 118.7, 121.1, 121.4, 127.4, 127.7, 127.8, 128.3, 128.34, 128.8, 128.84, 129.6, 131.1, 131.2, 132.7, 131.72, 135.1, 135.2, 137.2, 137.8, 165.45, 165.5, 168.0, 168.1, 192.6, 192.8 ppm. IR ($CHCl_3$): υ_{max} = 2925, 2854, 1722, 1659, 1627, 1580, 1567, 1406, 1343, 1296, 1271, 1248, 1194, 1047, 984, 915, 809, 757, 695 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{21}H_{23}O_4$ 339.1591; Found 339.1590.

*(E)-6-[(4-Oxy-6-styryl-3,4-dihydro-2H-pyran-2-yl)methyl]-5,6-dihydro-2H-pyran-2-one (**28**):*[9b] To a solution of compound **30** (50 mg, 0.148 mmol, 1.0 equiv) in toluene (20 mL) was added Grubbs 2nd generation catalyst (6.3 mg, 7.4 µmol, 0.05 equiv) under nitrogen atmosphere at room temperature. The reaction mixture was stirred at 100 °C for 1 h. It was then cooled to room temperature and concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether/EtOAc (9:1 to 7:3) as eluent to give (±)–*trans*-obolactone **28b** (18.8 mg, 41%) followed by (±)–*cis*-obolactone **28a** (14.2 mg, 31%) as pale yellow solids.

(±)–*cis*-Obolactone (**28a)**: M.p. 118–120 °C (lit.,[9b] M.p. 115–117 °C), ^1H NMR (400 MHz, $CDCl_3$): δ = 2.05–2.18 (m, 1H), 2.44–2.68 (m, 5H), 4.68–4.85 (m, 2H), 5.54 (s, 1H), 6.09 (d, *J* = 9.7 Hz, 1H), 6.55 (d, *J* = 15.1 Hz, 1H), 6.89–6.98 (m, 1H), 7.34–7.42 (m, 4H), 7.50–7.56 (m, 2H) ppm. $^{13}C\{^1H\}$ NMR (125 MHz, $CDCl_3$): δ = 29.4, 39.3, 41.2, 74.5, 75.6, 106.2, 121.2, 121.5, 127.8, 128.9, 129.8, 135.0, 137.6, 144.6, 163.6, 168.1, 192.3 ppm. IR ($CHCl_3$): υ_{max} = 2924, 2854, 1722, 1655, 1627, 1581, 1568, 1449, 1406, 1343, 1237, 1194, 1114, 1080, 1031, 984, 971, 917, 864, 808, 695, 668 cm^{-1}. HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{19}H_{18}O_4Na$ 333.1097; Found 333.1092.

(±)–*trans*-Obolactone (**28b)**: M.p. 114–116 °C (lit.,[9b] M.p. 113–116 °C). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.05–2.17 (m, 1H), 2.18–2.29 (m, 1H), 2.41–2.50 (m, 2H), 2.51–2.60 (m, 2H), 4.81–4.97 (m, 2H), 5.55 (s, 1H), 6.09 (d, *J* = 9.4 Hz, 1H), 6.55 (d, *J* = 15.9 Hz, 1H), 6.90–6.99 (m, 1H), 7.27–7.31 (m, 1H), 7.33–7.41 (m, 3H), 7.48–7.53 (m, 2H) ppm. $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ = 29.7, 40.0, 41.7, 73.5, 74.2, 106.4, 121.5, 127.6, 128.9, 129.7, 135.0, 137.0, 144.7, 163.6, 167.5, 192.3 ppm. IR ($CHCl_3$): υ_{max} = 2959, 2924, 2847, 1718, 1654, 1625, 1576, 1566, 1447, 1400, 1344, 1256, 1171, 1153, 1097, 1049, 966, 912, 861, 807, 693, 666 cm^{-1}. HRMS (ESI-

TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{19}H_{18}O_4Na$ 333.1097; Found 333.1092.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI:

NMR spectra and X-ray data (PDF)

Accession Codes

CCDC 1875202, 1878906, 1878913, 1878925, 1878941 and 1875203 contain the supplementary crystallographic data for this paper. These data can be obtained free of charge via www.ccdc.cam.ac.uk/data_request/cif.

AUTHOR INFORMATION

Corresponding Author

E-mail: rfernand@chem.iitb.ac.in

ORCID

Rodney A. Fernandes: 0000-0001-8888-0927

Notes

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REFERENCES

(1) (a) Cavalieri, L. F. The Chemistry of the Monocyclic α- and γ-Pyrones. *Chem. Rev.* **1947**, *41*, 525. (b) Dumontet, V.; Hung, N. V.; Adeline, M.-T.; Riche, C.; Chiaroni, A.; Sévenet, T.; Gueéritte, F. Cytotoxic Flavonoids and α-Pyrones from *Cryptocarya obovate*. *J. Nat. Prod.* **2004**, *67*, 858. (c) Danishefsky, S.; Larson, E. R.; Askin, D. Stereochemical Variations in the Cyclocondensation of Aldehydes with Siloxydienes. An Application to the Erythronolide Series. *J. Am. Chem. Soc.* **1982**, *104*, 6457. (d) Danishefsky, S. J.; Biolodeau, M. T. Glycals in Organic Synthesis: The Evolution of Comprehensive Strategies for the Assembly of Oligosaccharides and Glycoconjugates of Biological Consequence. *Angew. Chem., Int. Ed.* **1996**, *35*, 1380. (e) Yamashita, Y.; Saito, S.; Ishitani, H.; Kobayashi, S. Chiral Hetero Diels-Alder Products by Enantioselective and Diastereoselective Zirconium Catalysis. Scope, Limitation, Mechanism, and Application to the Concise Synthesis of (+)-Prelactone C and (+)-9-Deoxygoniopypyrone. *J. Am. Chem. Soc.* **2003**, *125*, 3793. (f) Lee, J. S. Recent Advances in the Synthesis of 2-Pyrones. *Mar. Drugs* **2015**, *13*, 1581.

(2) (a) Davis, R. A.; Demirkiran, O.; Sykes, M. L.; Avery, V. M.; Suraweera, L.; Fechner, G. A.; Quinn, R. J. 7′,8′-Dihydroobolactone, a Typanocidal *α*-Pyrone from the Rainforest Tree *Cryptocarya obovata*. *Bioorg. Med. Chem. Lett.* **2010**, *20*, 4057. (b) Kubo, I.; Matsumoto, T.; Wagner, D. L. Isolation and Structure of Hepialone; Principal Component from Male Sex Scales of Hepialus Californicus (Lepidoptera). *Tetrahedron Lett.* **1985**, *26*, 563. (c) Yin, J.; Kouda, K.; Yasuhiro, T.; Tran, Q. L.; Miyahara, T.; Chen, Y.; Kadota, S. New Diarylheptanoids from the Rhizomes of *Dioscorea spongiosa* and their Antiosteoporotic Activity. *Planta Med*. **2004**, *70*, 54. (d) Zhao, W.; He, J.; Xi, J. A Second Discussion on the Position of a New Species Mianbixie. *China J. Chin. Mater Med.* **1994**, *19*, 199. (e) Wright, A. E.; Botelho, J. C.; Guzmán, E.; Harmody, D.; Linley, P.; McCarthy, P. J.; Pitts, T. P.; Pomponi, S. A.; Reed, J. K. Neopeltolide, a Macrolide from a Lithistid Sponge of the Family Neopeltidae. *J. Nat. Prod.* **2007**, *70*, 412. (f) Luesch, H.; Yoshida, W. Y.; Harrigan, G. G.; Doom, J. P.; Moore, R. E.; Paul, V. J. Lyngbyaloside B, a New Glycoside Macrolide from a Palauan Marine Cyanobacterium, *Lyngbya* sp. *J. Nat. Prod.* **2002,** *65*, 1945. (g) Matteson, D. S.; Man, H.-W. High-Precision Asymmetric Synthesis of Stegobiol and Stegobinone via Boronic Esters. *J. Org. Chem.* **1993**, *58*, 6545. (h) Agtarap, A.; Chamberlin, J. W.; Pinkerton, M.; Steinrauf, L. The Structure of Monensic Acid, a New Biologically Active Compound. *J. Am. Chem. Soc.* **1967**, *89*, 5737. (i) Ohta, S.; Uy, M. M.; Yanai, M.; Ohta, E.; Hirata, T.; Ikegami, S. Exiguolide, a New Macrolide from the Marine Spong Ce *Geodia exigua*. *Tetrahedron Lett.* **2006**, *47*, 1957.

(3) For selected examples see: (a) Marson, C. M.; Harper, S.; Oare, C. A. Stereospecific Synthesis of 2,3-Dihydro-4*H*-pyran-4-ones by Hg(II)-Catalyzed Rearrangement of 1-Alkynyl-2,3-epoxy Alcohols. *J. Org. Chem.* **1998**, *63*, 3798. (b) Reiter, M.; Ropp, S.; Gouverneur, V. Oxidative Cyclization of *β*-Hydroxyenones with Palladium(II): A Novel Entry to 2,3-Dihydro-4*H*-pyran-4-ones. *Org. Lett.* **2004**, *6*, 91. (c) Yang, W.; Shang, D.; Liu, Y.; Du, Y.; Feng, X. Highly Enantioselective Synthesis of 2,6-Disubstituted and 2,2,6-Trisubstituted Dihydropyrones: A One-Step Synthesis of (*R*)-(+)-Hepialone and Its Analogues. *J. Org. Chem.* **2005**, *70*, 8533. (d) Schuler, M.; Silva, F.; Bobbio, C.; Tessier, A.; Gouverneur, V. Gold(I)-Catalyzed Alkoxyhalogenation of β-Hydroxy-α,α-Difluoroynones. *Angew. Chem., Int. Ed.* **2008**, *47*, 7927. (e) Khera, R. A.; Ahmad, R.; Ullah, I.; Abid, O.; Fatunsin, O.; Sher, M.; Villinger, A.; Langer, P. Cyclization *vs.* Elimination Reactions of 5-Aryl-5-hydroxy 1,3-Diones: One-Pot Synthesis of 2-Aryl-2,3-dihydro-4*H*-pyran-4-ones. *Helv. Chim. Acta,* **2010**, *93*, 1705. (f) Egi, M.; Azechi, K.; Saneto, M.; Shimizu, K.; Akai, S. Cationic Gold(I)-Catalyzed Intramolecular Cyclization of γ-Hydroxyalkynones into 3(2*H*)-Furanones. *J. Org. Chem.* **2010**, *75*, 2123. (g) Gu, H.; Sun, X.; Wang, Y.; Wu, H.; Wu, P. Highly Efficient Mesoporous Polymer Supported Phosphine-gold(I) Complex Catalysts for Amination of Allylic Alcohols and Intramolecular Cylization Reactions. *RSC Adv*. **2018**, *8*, 1737.

(4) McQuaid, K. M.; Sames, D. C-H Bond Functionalization via Hydride Transfer: Lewis Acid Catalyzed Alkylation Reactions by Direct Intramolecular Coupling of sp^3 C-H Bonds and Reactive Alkenyl Oxocarbenium Intermediates. *J. Am. Chem. Soc.* **2009**, *131*, 402.

(5) CCDC 1875202 (**9e**), 1878906 (**13l**), 1878913 (**13m**), 1878925 (**13m′**), 1878941 (**13u′**), and 1875203 (**14**) contains the supplementary crystallographic data. These data can be obtained free of charge from the Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

(6) (a) Nicolaou, K. C.; Bulger, P. C.; Sarlah, D. Palladium-Catalyzed Cross-Coupling Reactions in Total Synthesis. *Angew. Chem., Int. Ed.* **2005**, *44*, 4442. (b) Chinchilla, R.; Nájera, C. The Sonogashira Reaction: A Booming Methodology in Synthetic Organic Chemistry. *Chem. Rev.* **2007**, *107*, 874. (c) Mao, J.; Hua, Q.; Guo, J.; Shi, D.; Ji, S. CuI-Catalyzed Cross-Coupling Reaction of (*E*)-Vinyl Bromides with Nitrogen-Containing Heterocycles. *Synlett* **2008**, 2011.

(7) Juch, M.; Rüedi, P. Isolation, Structure, and Biological Activities of Long-Chain Catechols of *Plectranthus sylvestris (Labiatae)*. *Helv. Chem. Acta* **1997**, *80*, 436.

(8) Crosby, S. R.; Harding, J. R.; King, C. D.; Parker, G. D.; Willis, C. L. Prins Cyclizations: Labeling Studies and Application to Natural Product Synthesis. *Org. Lett.*, **2002**, *4*, 3407.

(9) (a) Zhang, J.; Li, Y.; Wang, W.; She, X.; Pan, X. Concise Asymmetric Total Synthesis of Obolactone. *J. Org. Chem*. **2006**, *71*, 2918. (b) Walleser, P.; Brückner, R. Enantioselective Synthesis of (+)-Obolactone Based on a Symmetry-Breaking Wacker Monooxidation of a Diene. *Org. Lett.* **2013**, *15*, 1294.

(10) Eiden, C. G.; Aldrich, C. C. Synthesis of a 3-Amino-2,3-dihydropyrid-4-one and Related Heterocyclic Analogues as Mechanism-Based Inhibitors of BioA, a Pyridoxal Phosphate-Dependent Enzyme. *J. Org. Chem.* **2017**, *82*, 7806.

(11) Li, W.; Wu, X.-F. Palladium-catalyzed carbonylative Sonogashira coupling between aryl triazenes and alkynes. *Org. Biomol. Chem.* **2015**, *13*, 5090.
(12) Fernandes, R. A.; Gholap, S. P.; Mulay, S. V. A Facile Chemoselective Deprotection of Aryl Silyl Ethers using Sodium Hydride/DMF and *in situ* Protection of Phenol with Various Groups. *RSC Adv.* **2014**, *4*, 16438.
(13) Umana, C. A.; Cabezas, J. A. Palladium-Catalyzed One-Pot Conversion of Aldehydes and Ketones into 4-Substituted Homopropargyl Alcohols and 5-En-3-yn-1-ols. *J. Org. Chem.* **2017**, *82*, 9505.