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Oxidation of alcohol to carboxylic acid under mild acidic condition and followed by synthesis of ester analogues of Corey's lactone

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ABSTRACT

Reaction of (3aR,4S,5R,6aS)-4-(hydroxymethyl)-2-oxohexahydro-2H-cyclopenta[b] furan-5-yl biphenyl-4-carboxylate(1) with sodium per iodide/sodium bromide and TEMPO as a catalyst gives (3aR,4R,5R,6aS)-5-[(biphenyl-4-ylcarbonyl)oxy]-2-oxohexahydro-2H-cyclopenta[b] furan -4-carboxylic acid (2), which on reaction with different alcohols in presence of EDC.HCl/DMAP gives corresponding esters of compound (2).All the synthesized compounds were characterized by their FT-IR, ^{1}H-NMR and mass spectral data.

Keywords: Oxidation, alcohol, esterification, 2,2,6,6-tetramethylpiperdine-1-oxyl**,** 1-ethyl-3-(3'-dimethylamino) carbodiimide HCl salt, 4-dimethyl amino pyridine.

INTRODUCTION

Corey's lactone was fist synthesized by E.J.Corey from cyclopentadiene[1] and it is key starting material for synthesis of prostaglandins [2] and prostaglandin possess a diverse range of biological activities including the treatment of glaucoma and ocular hypertension[3], chronic constipation and irritable bowel syndrome[4]. In this paper, we report the Oxidation of Corey lactone, which is sensitive to basic condition, to corresponding carboxylic acid with sodiumperiodide/sodiumchloride/water [5] in presence of TEMPO catalyst under biphasic reaction. The acid is further reacted with different alcohols in presence of EDC/DMAP [6-9] gives corresponding ester analogues. The synthetic scheme of these compounds is shown in Scheme-2.

MATERIALS AND METHODS

All the reagents used for reactions are of L.R. Grade.IR spectra were recorded as KBr pellets on Thermo Nicolet Avatar 330 FT-IR spectrometer.^{1}H NMR spectra were recorded on Bruker Avance-300 spectrometer operating at 200 MHz using TMS as internal standard. Mass spectra (EI, 70 eV) were recorded on an HP5989B mass spectrometer.

Synthesis of (3a*R*, 4*R*, 5*R*, 6a*S*)-5-[(biphenyl-4-ylcarbonyl)oxy]-2-oxohexahydro-2*H*-cyclopenta[*b*] furan -4-carboxylic acid (2).

To a mixture of Corey's lactone (2.0g, 0.0056 mol), Dichloromethane (20 ml) and TEMPO at room temperature, a solution of sodiumperiodide (2.39gm 2.0eq), sodium chloride (0.065gm 0.2eq) in water (20 ml) were added at room temperature. The reaction mixture was stirred for 10-12hrs.Separated the bottom organic layer and aqueous layer extracted with DCM.combined both organic layers was washed with 5% sodium thiosulfate solution. Dried the organic layer over sodium sulphate and distilled off the solvent under reduced pressure. The crude compound was recrystallized in di isopropyl ether (10ml) for 15mins at room temperature. The odtained solid was filtered and washed with di isopropyl ether to give pure white solid compound wt.:1.9gm Yield: 95%. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ=2.45-2.53(t, 2H), 2.58-2.74(d, 1H), 2.98-3.09(m, 1H), 3.16(s, 1H), 3.45(s, 1H), 5.20(s, 1H), 5.77(s, 1H), 6.72-6.91(s, 1H), 7.39-7.49(m, 3H), 7.61-7.71(dd, 4H), 8.05-8.09(d, 2H); IR (KBr): 2523 , 1776 ,1706 cm^{-1}; found: m/z 383.10 [M+18].

Synthesis of esters analogues of Corey's lactone (3a-f).

EDC.HCl(1.0 eq) was added to a mixture of acid (2) (0.2gm, 1.0 mole), and dichloromethane(5.0 ml) which was pre cooled to 0-5^{o}C and stirred for 15 mins, followed by addition of alcohol(1.0 eq) and DMAP(1.0 eq) into the reaction mass, then the reaction mass temperature slowly raised to room temperature, stirred for 1.0 hr. added 5% citric acid solution into reaction mass. Separated the bottom organic layer and aqueous layer extracted with DCM. Combined the both organic layers and dried over sodium sulphate. Concentrated the organic layer under reduced pressure and purified the compounds by column chromatography (10% Acetone: Cyclohexane mixture) .

The specific compounds 3a to 3f have been synthesized according to the above general procedure; yield and reaction cycle time have been reported in below examples and table-1.

(3aR, 4R, 5R, 6aS)-isopropyl 5-(([1,1'-biphenyl]-4-carbonyl)oxy)-2-oxohexa hydro-2H-cyclopenta[b]furan-4-carboxylate (3a).

Yield:85%. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ=1.25-1.27(s, 6H), 2.44-2.46(t, 2H), 2.59-2.64 (d, 1H), 2.97-3.07(m, 2H), 3.45(t, 1H), 5.01-5.07(m, 1H), 5.19(t, 1H), 5.71(s, 1H), 7.37-7.47(m, 3H), 7.60-7.68(dd, 4H), 8.03-8.05(d, 2H); IR (KBr): 1771 , 1733 ,1708 cm^{-1}; found: m/z 409.20 [M+1].

(3aR, 4R, 5R, 6aS)- propyl 5-(([1,1'-biphenyl]-4-carbonyl)oxy)-2-oxohexa hydro-2H-cyclopenta[b]furan-4-carboxylate (3b).

Yield:87%. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ= 0.91(t, 3H), 1.69-1.75(m, 2H), 2.48-2.49(d, 2H), 2.62-2.67(d, 1H), 2.90(m, 1H), 3.04(s, 1H), 3.43-3.47(t, 1H), 4.11-4.15(t, 2H), 4.60(m, 1H), 5.22-5.23(t, 1H),5.75-5.67(s, 1H), 7.39-7.50(m, 3H), 7.62-7.70(dd, 4H), 8.06-8.08(d, 2H); IR (KBr): 1773 , 1724 cm^{-1}; found: m/z 409.15 [M+1].

(3aR, 4R, 5R, 6aS)-4-phenylbutyl 5-(([1,1'-biphenyl]-4-carbonyl)oxy)-2-oxo hexa hydro -2H-cyclopenta[b]furan-4-carboxylate (3c).

Yield:89%. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ= 1.71(s, 4H), 2.47(s, 2H), 2.60-2.65(m, 3H), 2.98-3.05(m, 1H), 3.11(s, 1H), 3.40-3.43(t, 1H), 4.10-4.18(t, 2H), 5.19-5.21(t, 1H),5.75-5.67(s, 1H), 7.17-7.22(m, 3H), 7.28-7.32(m, 2H), 7.40-7.50(m, 3H), 7.63-7.70(dd, 4H) 8.06-8.08(d, 2H); IR (KBr): 1773 , 1722cm^{-1}; found: m/z 499.30 [M+1].

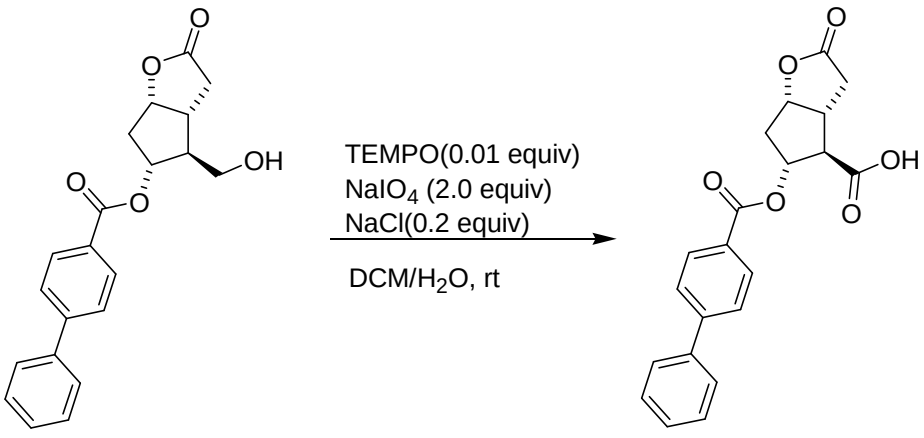
(3aR, 4R, 5R, 6aS)-4-nitrobenzyl 5-(([1,1'-biphenyl]-4-carbonyl)oxy)-2-oxo hexahydro -2H-cyclopenta[b]furan-4-carboxylate (3d).
Yield:86%. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ= 2.49(s, 2H), 2.60-2.64(d, 1H), 2.94-3.06(m, 1H), 3.20(s, 1H), 3.42-3.45(t, 1H), 5.20-5.33(m, 3H), 5.75(s, 1H), 7.40-7.55(m, 5H), 7.63-7.70(dd, 4H), 8.04-8.06(d, 2H), 8.20-8.27(d, 2H); IR (KBr): 1773 ,1722, 1520,1348cm^{-1}; found: m/z 519.35 [M+18].

(3aR, 4R, 5R, 6aS)-(S)-4,4-dimethyl-2-oxotetrahydrofuran-3-yl 5-(([1,1'-bi phenyl] -4-carbonyl)oxy)-2-oxohexahydro-2H-cyclopenta[b]furan-4-carboxylate (3e).
Yield:86%. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ= 1.21-1.26(d, 6H), 2.51-2.52(s, 2H), 2.61-2.66(d, 1H), 3.01-3.08(m, 1H), 3.30(s, 1H), 3.55-3.59(t, 1H), 4.06-4.12(s, 2H), 5.24-5.27(m, 1H), 5.45(s, 1H), 5.85(s, 1H), 7.39-7.50(m, 3H), 7.62-7.70(dd, 4H), 8.04-8.06(d, 2H),); IR (KBr): 1786 ,1745, 1704, 1606cm^{-1}; found: m/z 496.20 [M+18].

(3aR, 4R, 5R, 6aS)-3-(trifluoromethyl)phenyl 5-(([1,1'-biphenyl]-4-carbonyl) oxy)-2-oxohexahydro-2H-cyclopenta[b]furan-4-carboxylate (3f).
Yield:89%. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ= 2.59-2.61(s, 2H), 2.70-2.75(d, 1H), 3.06-3.14(m, 1H), 3.38-3.40(s, 1H), 3.54-3.60(t, 1H), 5.25-5.29(m, 1H), 5.89-5.92(t, 1H), 7.35(m, 1H), 7.36-7.40(d, 2H), 7.42-7.49(d, 2H), 7.51-7.57(d, 2H), 7.63-7.72(dd, 4H), 8.10-8.12(d, 2H),); IR (KBr): 1767 , 1717, 1608cm^{-1}; found: m/z 528.15 [M+18].

RESULTS AND DISCUSSION

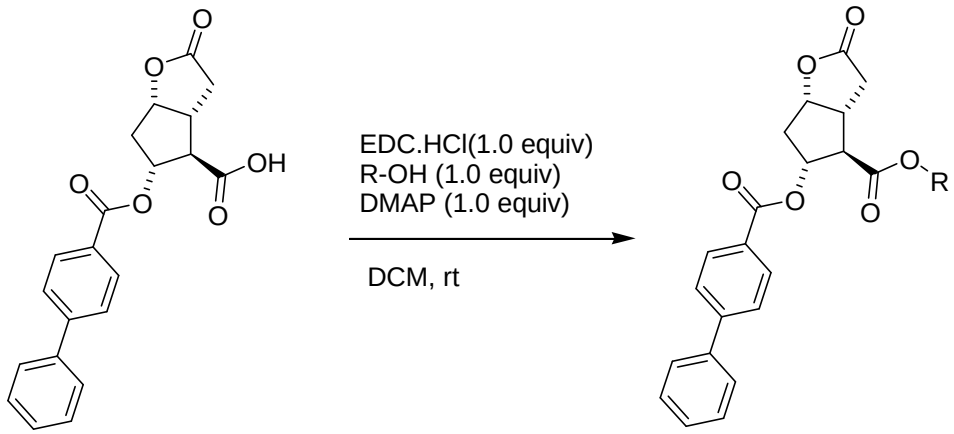
Oxidation of the aliphatic primary alcohol of Corey's lactone to corresponding carboxylic acid is achieved with TEMPO catalyst by using $NaIO_4$/ $NaCl/H_2O$. The reaction is bi phasic reaction in DCM and water at room temperature and reaction condition is mild acidic. After completion of reaction, it is quenched with 10% citric acid, 95% yield is observed and this method is applicable to the oxidation of alcohols that are sensitive to basic condition and gives high yield (Scheme-1).



1 2

Scheme 1

An efficient method for esterification of the carboxylic acid with different alcohols by using EDC.HCl/DMAP. This process gives high yield, and this process is applicable to those carboxylic acids which are sensitive to basic condition (Scheme 2).

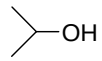
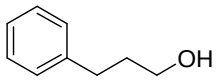
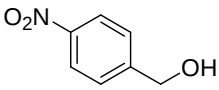
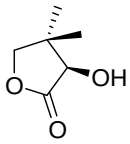
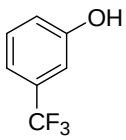


2 3a-f

Scheme 2

In order to illustrate the scope of this method, some esters were prepared as shown in Table 1.

Table 1. Conversion of carboxylic acid to esters (3a-f) by EDC.HCl/DMAP

Entery	R	Time(hr)	Yield(%)
3a		4.5	85
3b		2.5	90
3c		2.5	94
3d		3.5	92
3e		4.0	94
3f		3.0	90

CONCLUSION

In summary, we have developed an efficient method for oxidation of basic sensitive alcohol of Corey's lactone 1 to carboxylic acid with $NaIO_4/NaCl/H_2O$ in presence of TEMPO catalyst. The

Carboxylic acid 2 further reacts with different alcohols gives corresponding esters in presence of EDC.HCl/DMAP. The procedure provides an alternative method for the esterification of carboxylic acid that is sensitive to basic conditions.

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