Supporting Information

Reactions of Cyclopropyl Aryl Ketones with α-ketoacetic acids Catalyzed by C$_8$F$_{17}$SO$_3$H in Fluorous Phase

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Typical reaction procedure for Reaction of Cyclopropyl Aryl Ketone with α-ketoacetic acid Catalyzed by C$_8$F$_{17}$SO$_3$H in Fluorous Phase.

To a solution of C$_8$F$_{17}$SO$_3$H (45 mg, 0.006 mmol) in perfluorodecalin (C$_{10}$F$_{18}$, cis- and trans-mixture) (solvent, 1.0 mL) was added cyclopropyl aryl ketone (1, 0.3 mmol), α-ketoacetic acid (2, 0.3 mmol) and DCE (solvent, 1.0 mL). Then, the mixture was stirred at 60 °C for the necessary time. The fluorous layer was separated for the next reaction. The reaction mixture (organic layer) was washed by water (5 mL) and extracted with dichloromethane (2 x 15 mL). The combined organic layers were dried over anhydrous Na$_2$SO$_4$. The solvent was removed under reduced pressure and the residue was purified by column chromatography on silica gel (EtOAc : hexane = 1 : 4) to give the corresponding product 3.

4-Benzoyl-3-phenyl-5,6-dihydropyran-2-one (3a):
This compound was obtained as a white solid, yield: 77 mg, 92%. This is a known compound. Its $^1$H NMR spectroscopic data are consistent with those reported in our previous paper.$^1$ $^1$H NMR (300 MHz, CDCl$_3$, TMS): $\delta$ 2.87 (t, $J = 6.3$ Hz, 2H, CH$_2$), 4.63 (t, $J = 6.3$ Hz, 2H, OCH$_2$), 7.10-7.13 (m, 3H, Ar), 7.20-7.23 (m, 2H, Ar), 7.26-7.31 (m, 2H, Ar), 7.40-7.45 (m, 1H, Ar), 7.66-7.69 (m, 2H, Ar).
4-Benzoyl-3-p-tolyl-5,6-dihydropyran-2-one (3b):

This compound was obtained as a red oil, yield: 70 mg, 80%. This is a known compound. Its $^1$H NMR spectroscopic data are consistent with those reported in our previous paper.$^1$ $^1$H NMR (300 MHz, CDCl$_3$, TMS): $\delta$ 2.17 (s, 3H, CH$_3$), 2.87 (t, $J$ = 6.3 Hz, 2H, CH$_2$), 4.64 (t, $J$ = 6.3 Hz, 2H, OCH$_2$), 6.93 (d, $J$ = 8.1 Hz, 2H, Ar), 7.11 (d, $J$ = 8.1 Hz, 2H, Ar), 7.31 (t, $J$ = 7.5 Hz, 2H, Ar), 7.46 (t, $J$ = 7.5 Hz, 1H, Ar), 7.70 (d, $J$ = 7.8 Hz, 2H, Ar).
4-Benzoyl-3-(4-methoxy-phenyl)-5,6-dihydropyran-2-one (3c):
This compound was obtained as a pale-red oil, yield: 66 mg, 71%. This is a known compound. Its $^1$H NMR spectroscopic data are consistent with those reported in our previous paper.  

$^1$H NMR (300 MHz, CDCl$_3$, TMS): $\delta$ 2.88 (t, $J = 6.0$ Hz, 2H, CH$_2$), 3.66 (s, 3H, OCH$_3$), 4.64 (t, $J = 6.0$ Hz, 2H, OCH$_2$), 6.65 (d, $J = 8.1$ Hz, 2H, Ar), 7.17 (d, $J = 8.1$ Hz, 2H, Ar), 7.30 (t, $J = 7.5$ Hz, 2H, Ar), 7.42 (t, $J = 6.9$ Hz, 1H, Ar), 7.69 (d, $J = 7.4$ Hz, 2H, Ar).

4-Benzoyl-3-(4-chloro-phenyl)-5,6-dihydropyran-2-one (3d):
This compound was obtained as a white solid, yield: 86 mg, 92%. This is a known compound. Its $^1$H NMR spectroscopic data are consistent with those reported in our previous paper.  

$^1$H NMR (300 MHz, CDCl$_3$, TMS): $\delta$ 2.88 (t, $J = 6.0$ Hz, 2H, CH$_2$), 4.65 (t, $J = 6.0$ Hz, 2H, OCH$_2$), 7.10 (dd, $J = 9.0$ Hz, $J = 2.1$ Hz, 2H, Ar), 7.17 (dd, $J = 9.0$ Hz, $J = 2.1$ Hz, 2H, Ar),
7.33 (t, J = 7.2 Hz, 2H, Ar), 7.48 (t, J = 7.2 Hz, 1H, Ar), 7.67-7.70 (m, 2H, Ar).

4-Benzoyl-3-methyl-5,6-dihydropyran-2-one (3e):
This compound was obtained as a yellow oil, yield: 61 mg, 94%. This is a known compound. Its $^1$H NMR spectroscopic data are consistent with those reported in our previous paper. $^1$H NMR (300 MHz, CDCl$_3$, TMS): δ 1.81 (s, 3H, CH$_3$), 2.70 (t, J = 6.6 Hz, 2H, CH$_2$), 4.54 (t, J = 6.6 Hz, 2H, OCH$_2$), 7.53-7.58 (m, 2H, Ar), 7.67-7.70 (m, 1H, Ar), 7.89-7.93 (m, 2H, Ar).
4-(4-Fluoro-benzoyl)-3-methyl-5,6-dihydropyran-2-one (3f):

This compound was obtained as a white solid, yield: 50 mg, 71%. This is a known compound. Its \(^1\)H NMR spectroscopic data are consistent with those reported in our previous paper.\(^1\) \(^1\)H NMR (300 MHz, CDCl\(_3\), TMS): \(\delta\) 1.81 (t, \(J = 1.5\) Hz, 3H, CH\(_3\)), 2.70 (dt, \(J = 1.5\) Hz, \(J = 6.0\) Hz, 2H, CH\(_2\)), 4.55 (t, \(J = 6.0\) Hz, 2H, OCH\(_2\)), 7.21-7.26 (m, 2H, Ar), 7.93-7.98 (m, 2H, Ar).
3-Methyl-4-(4-methyl-benzoyl)-5,6-dihydropyran-2-one (3g):

This compound was obtained as a white solid, yield: 64 mg, 93%. This is a known compound. Its $^1$H NMR spectroscopic data are consistent with those reported in our previous paper.$^1$ $^1$H NMR (300 MHz, CDCl$_3$, TMS): $\delta$ 1.80 (s, 3H, CH$_3$), 2.46 (s, 3H, CH$_3$), 2.69 (dt, $J$ = 1.2 Hz, $J$ = 6.0 Hz, 2H, CH$_2$), 4.53 (t, $J$ = 6.0 Hz, 2H, OCH$_2$), 7.34 (d, $J$ = 7.8 Hz, 2H, Ar), 7.80 (t, $J$ = 7.8 Hz, 2H, Ar).

4-(3,5-Dimethyl-benzoyl)-3-methyl-5,6-dihydropyran-2-one (3h):

This compound was obtained as a white solid, yield: 63 mg, 86%. This is a known compound. Its $^1$H NMR spectroscopic data are consistent with those reported in our previous paper.$^1$ $^1$H NMR (300 MHz, CDCl$_3$, TMS): $\delta$ 1.80 (s, 3H, CH$_3$), 2.40 (s, 6H, CH$_3$), 2.69 (dt, $J$ = 1.8 Hz, $J$ = 6.0 Hz, 2H, CH$_2$), 4.54 (t, $J$ = 6.0 Hz, 2H, OCH$_2$), 7.30 (s, 1H, Ar), 7.49 (s, 2H, Ar).
4-(4-Methoxy-benzoyl)-3-methyl-5,6-dihydropyran-2-one (3i):

This compound was obtained as a pale oil, yield: 66 mg, 89%. This is a known compound. Its $^1$H NMR spectroscopic data are consistent with those reported in our previous paper. $^1$H NMR (300 MHz, CDCl$_3$, TMS): $\delta$ 1.80 (t, $J = 1.8$ Hz, 3H, CH$_3$), 2.69 (dt, $J = 1.8$ Hz, $J = 6.3$ Hz, 2H, CH$_2$), 3.92 (s, 3H, OCH$_3$), 4.53 (t, $J = 6.3$ Hz, 2H, OCH$_2$), 7.01 (dd, $J = 7.2$ Hz, $J = 2.1$ Hz, 2H, Ar), 7.88 (dd, $J = 7.2$ Hz, $J = 2.1$ Hz, 2H, Ar).
3-Methyl-4-(thiophene-2-carbonyl)-5,6-dihydropyran-2-one (3j):

This compound was obtained as a white solid, yield: 37 mg, 56%. This is a known compound. Its $^1$H NMR spectroscopic data are consistent with those reported in our previous paper. $^1$H NMR (300 MHz, CDCl$_3$, TMS): $\delta$ 1.89 (d, $J = 1.8$ Hz, 3H, CH$_3$), 2.73 (dt, $J = 1.8$ Hz, $J = 6.0$ Hz, 2H, CH$_2$), 4.53 (t, $J = 6.0$ Hz, 2H, OCH$_2$), 7.22 (dd, $J = 5.1$ Hz, $J = 3.9$ Hz, 1H, Ar), 7.67 (dd, $J = 3.9$ Hz, $J = 1.2$ Hz, 1H, Ar), 7.67 (dd, $J = 5.1$ Hz, $J = 1.2$ Hz, 1H, Ar).
References and Notes