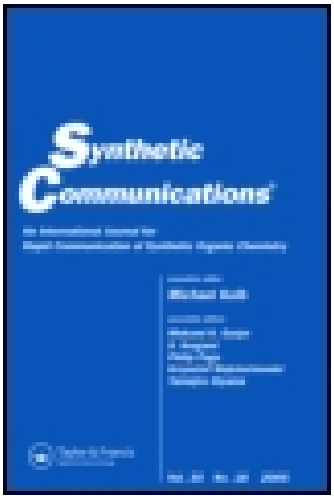

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K. C. Majumdar [a] & N. Kundu [a]
[a] Department of Chemistry , University of Kalyani , Kalyani, West Bengal, India
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Effect of Substitution in Stannic Chloride–Mediated Heterocyclization of 4-Allyl-3-hydroxyquinolin-2(1*H*)-ones

K. C. Majumdar and N. Kundu
Department of Chemistry, University of Kalyani, Kalyani, West Bengal, India

Abstract: Effect of substituents at the allylic position in a stannic chloride–iodine–mediated heterocyclization of 4-allyl-3-hydroxyquinolin-2(1*H*)-ones for the regioselective formation of five- and six-membered heterocyclic rings has been rationalized by the application of restricted Hatree–Fock calculation.

Keywords: Claisen rearrangement, *6-endo-trig*, *5-exo-trig*, Hatree–Fock method, iodine, regioselective cyclization, stannic chloride, substituent effect

INTRODUCTION

Quinolone derivatives are biologically significant because of their antimicrobial activity, DNA-gyrase inhibition, and marked cytotoxicity against animal and plant tumors.[1] Keeping these biological activities in mind, a number of attempts have been made in the past few decades to synthesize various biologically active quinolone derivatives, many of which are abundant in nature.[2] Furo[2,3-*c*]quinolin-4(5*H*)-one and 2*H*-pyrano[3,2-*c*]quinolin-5(6*H*)-one derivatives are profusely distributed in nature, and a number of synthesis of these heterocycles,[3] including those from our own work,[4] have been reported. Continued interest in this area inspired us to undertake a study on the synthesis of these heterocycles.

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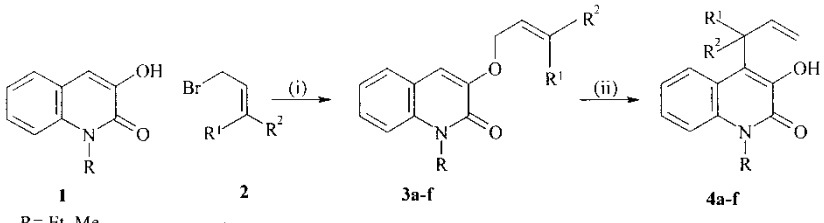
Address correspondence to K. C. Majumdar, Department of Chemistry, University of Kalyani, Kalyani 741235, West Bengal, India. E-mail: kcm_ku@yahoo.co.in

Recently, we reported *N*-iodosuccinimide (NIS)–mediated heterocyclization of *ortho*-cyclohex-2′-enylphenols,[5] 3-cyclohex-2′-enyl-4-hydroxycoumarin,[6] and 3-allyl-4-hydroxycoumarin[7] in acetonitrile at 0–5°C in almost quantitative yield. We have also reported heterocyclization using pyridine hydrotribromide,[8,9] mercuric acetate,[10] and hexamethylenetetramine hydrotribromide.[9,11] However, no study of the substitution effect on these reactions was conducted. NIS has been used for *6-endo* heterocyclization of different substrates via iodonium intermediate. Recently, $SnCl_4$-I_2 has been found to be a convenient and practical reagent to provide positive iodine[12]. This prompted us to undertake a study on the heterocyclization of 4-allyl-3-hydroxyquinolin-2(1*H*)-ones with $SnCl_4$-I_2. Herein we report the results.

RESULTS AND DISCUSSION

The starting materials **4a**–**f**[13] for this study were obtained in 85–95% yield by the thermal rearrangement of the corresponding allyl ethers **3a**–**f** in refluxing chlorobenzene (132°C). The ethers **3a**–**f**[13] were in turn synthesized by the reaction of substrate **1** with allylic halides **2** in refluxing acetone in the presence of anhydrous K_2CO_3 and a catalytic amount of sodium iodide (Finkelstein condition). The ethers were obtained in 85–95% yield (Scheme 1).

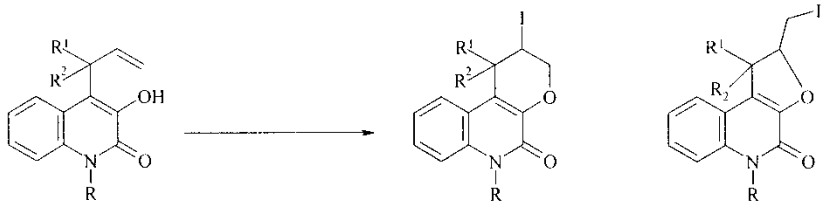
Substrates **4a**–**f** were treated with $SnCl_4$-I_2 in dichloromethane at 25°C for 6 h and surprisingly, depending on the substituents R_1 and R_2, either exclusively *5-exo* or *6-endo* products or a mixture of *5-exo* and *6-endo* cyclization products were formed (Scheme 2). With substrate **4a**, where $R_1 = R_2 = H$ was treated



1 R= Et, Me **2** **3a-f** **4a-f**

4	R	R^1	R^2
a	Et	H	H
b	Et	H	Me
c	Et	Me	Me
d	Me	H	H
e	Me	H	Me
f	Me	Me	Me

Scheme 1. Reagents and conditions: (i) Me_2CO, K_2CO_3, reflux, 6–8 h; (ii) chlorobenzene, reflux, 8–10 h.



Scheme 2. Reagents and conditions: (i) $SnCl_4/I_2$, CH_2Cl_2, r.t., stirring, 6 h.

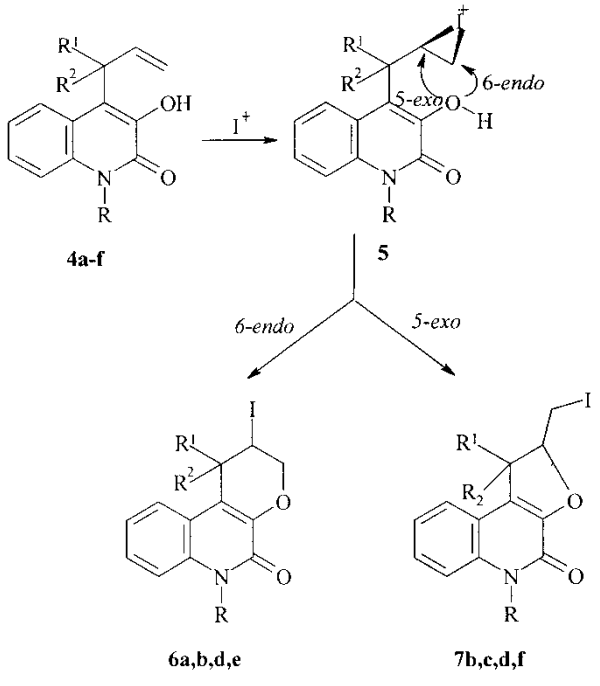
with $SnCl_4$-I_2 in dichloromethane at 25°C for 6 h, exclusively *6-endo* product **6a** was formed. Apart from ^{1}H NMR, ^{13}C NMR, and mass spectrometry, the final confirmation that **4a** cyclizes to a *6-endo* product **6a** and not to a 5-*exo* product was made by an APT experiment. Multiplicity was also assigned by the APT experiment. There are nine carbons carrying hydrogen atoms: one CH_3, three CH_2, and five CH moieties. If **4a** would have cyclized to *5-exo* product, multiplicities would have been exactly the same. However, a carbon resonance at δ 71.82 due to a CH_2 moiety clearly indicated that a CH_2 moiety must be directly attached to the ring oxygen atom. This is only possible if a *6-endo* cyclization takes place. With substrate **4c**, where $R_1 = R_2 =$ Me was treated with $SnCl_4$-I_2 in dichloromethane at 25°C for 6 h, exclusively 5-*exo* product **7c** was formed. In this case also, final confirmation of the *5-exo* product was made by the Attached Proton Test (APT) experiment. APT showed ten protonated carbons: three CH_3, two CH_2, five CH groups. Carbon resonance at δ 91.86 due to a CH group clearly indicated that a CH group must be directly attached to the ring oxygen atom. This is only possible if a *5-exo* cyclization takes place. However, with substrate **4c**, where $R_1 =$ H and $R_2 =$ Me was treated similarly with $SnCl_4$-I_2, a mixture of *6-endo* **6c** and *5-exo* **7c** products was obtained.

The important role substituents R_1 and R_2 play in the formation of five-membered and six-membered products can be explained by the semiemperical calculation of the heat of formation values of each of the *6-endo* and *5-exo* products by restricted Hatree–Fock method (Table 1) as well as by the use of a molecular model (Dreiding model). When $R_1 = R_2 =$ H (**4a**, **4d**), the heat of formation values clearly support the formation of the *6-endo* product (**6a**, **6d**) and certainly not the *5-exo* product. With $R_1 =$ H and $R_2 =$ Me (**4b, 4e**), heat of formation values are comparable in case of *6-endo* (**6b**, **6e**) and *5-exo* (**7b**, **7e**) products, and thus both the compounds were formed in comparable yields. However, when $R_1 = R_2 =$ Me (**4f, 4c**), although a restricted Hatree–Fock calculation showed that *5-exo* product formation is slightly favorable over *6-endo* product energetically, this could not explain the exclusive formation of the *5-exo* product (**7c**, **7f**). Thus, in this case, construction of the Dreiding model of the substrate showed that in the transition state **5** (Scheme 3), *6-endo* attack becomes sterically hindered

Table 1. Yields of *5-exo* and *6-endo* products with varying substituents and semi-emperical calculation of heat of formation by the retricted Hatree–Fock method

	6-endo cyclization			*5-exo* cyclization		
Substrate	Product	Yield (%)	Heat of formation (Kcal/mol)	Product	Yield (%)	Heat of formation (Kcal/mol)
4a	**6a**	90	−14.79	—	—	−7.76
4b	**6b**	45	−12.43	**7b**	43	−10.03
4c	—	—	−11.79	**7c**	91	−12.22
4d	**6d**	90	−9.60	—	—	−2.42
4e	**6e**	46	−7.38	**7e**	44	−4.57
4f	—	—	−6.56	**7f**	92	−6.84

because of the close proximity of the iodonium ion to the two methyls, favoring the formation of the *5-exo* product (**7c**, **7f**) exclusively. In the present instance, the five-membered product **7** is more stable than the six-membered one because of the anomeric effect present in the six-membered ring product. In the six-membered ring product **6**, the anomeric effect is



Scheme 3.

derived from the interaction of the p-orbital of oxygen with the antibonding σ-orbital of the C-I bond, but in the case of the five-membered ring product, this anomeric effect is absent because the iodine atom is not bonded with the ring carbon.

A literature search revealed that $SnCl_4$-I_2 has been used for the cyclization of *ortho*-allyl phenols by Orito et al.[12] Formation of five-membered and six-membered products has been explained in terms of substituent effects at the vinylic position. In the present study, we have successfully demonstrated how substituents at the allylic position play a key role in the regioselective formation of five- and six-membered heterocyclic compounds at room temperature.

The key step of the synthesis that we report here is based on the intramolecular cyclization allowed by activation of an olefinic double bond by means of an iodonium intermediate. The intramolecular ring closure may occur via *5-exo-trig* or by *6-endo-trig* cyclization to give five-membered and six-membered heterocyclic rings respectively (Scheme 3).

Thus, we demonstrate the selectivity in the formation of five- and six-membered oxygen heterocyclic rings by the combined Claisen rearrangement followed by substituent dependent ring-closure methodology. All new compounds gave satisfactory spectroscopic and analytical data. The reagent $SnCl_4$-I_2, used for this protocol, is quite cheap and easily accessible compared to other reagents for similar cyclizations.[14] This offers a facile synthesis for potentially bioactive heterocycles.

EXPERIMENTAL

Melting points are uncorrected. IR spectra were recorded on a Perkin-Elmer L 120-000A spectrometer (ν_{max} in centimeters^{-1}) using samples as neat liquids, and solid samples were recorded on KBr disks. ^{1}H NMR (300 MHz, 400 MHz, 500 MHz) and ^{13}C NMR (125 MHz) spectra were recorded on a Bruker DPX-300, Bruker DPX-400, and Bruker DPX-500 spectrometer in $CDCl_3$ (chemical shift in δ) with TMS as internal standard. UV absorption spectra were recorded in EtOH on a Shimadzu UV-2401PC spectrophotometer (λ_{max} in nanometers). Elemental analyses and mass spectra were recorded on a Leco 932 CHNS anlyser and on a JEOL JMS-600 instrument respectively. Restricted Hatree–Fock calculations (semiemperical) were done using Hyper-Chem software. Silica gel [(60–120 mesh), Spectrochem, India] was used for chromatographic separation. Silica gel G [E-Merck (India)] was used for TLC. Petroleum ether refers to the fraction boiling between 60 and 80°C.

General Procedure for the Preparation of Compounds 3a–f

A mixture of 3-hydroxy-1-methylquinolin-2(1*H*)-one or 3-hydroxy-1-ethylquinolin-2(1*H*)-one (**1,** 1 mmol), appropriate halides (**2,** 1 mmol), sodium

iodide (50 mg), and anhydrous K_2CO_3 (5 g) was refluxed in dry acetone (50 mL) for 6–8 h. The reaction mixture was cooled, filtered, and concentrated. The residual mass was subjected to column chromatography on silica gel. Compounds **3a**–**f** were obtained when the column was eluted with 10% ethyl acetate–petroleum ether.

Compounds **3d** and **f** were previously reported.[13]

Data

3-Allyloxy-1-ethylquinolin-2(1*H*)-one (**3a**)

Yield: 85%; viscous liquid; IR (neat): 3125, 1777, 1560, 1520, 1420 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz): $\delta_H = 1.35$ (t, $J = 7.2$ Hz, 3H, -C**H**$_3$), 4.41 (q, $J = 7.2$ Hz, 2H, -NC**H**$_2$), 4.65 (d, $J = 5$ Hz, 2H, -OC**H**$_2$), 5.25–5.65 (m, 2H, -CH=C**H**$_2$), 5.95–6.37 (m, 1H, C**H**=CH$_2$), 6.93 (s, 1H, -C**H**=), 7.25–7.62 (m, 4H, Ar**H**); MS: $m/z = 229$ (M^+); UV (EtOH): $\lambda_{max} = 225$, 280, 320 nm; anal. calcd. for $C_{14}H_{15}NO_2$: C, 73.36; H, 6.55; N, 6.11. Found: C, 73.61; H, 6.33; N, 6.23.

3-(But-2-en-1-yloxy)-1-ethylquinolin-2(1*H*)-one (**3b**)

Yield: 88%; viscous liquid; IR (neat): 1774, 1721, 1620, 1595, 1547, 1436 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz): $\delta_H = 1.36$ (t, $J = 7.2$ Hz, 3H, -CH$_2$C**H**$_3$), 1.72 (d, $J = 5$ Hz, 3H, =CHC**H**$_3$), 4.41 (q, $J = 7.2$ Hz, 2H, -NC**H**$_2$), 4.60 (d, $J = 5$ Hz, 2H, -OC**H**$_2$), 5.57–6.15 (m, 2H, -C**H**=C**H**-), 6.82 (s, 1H, -C**H**=), 7.25–7.79 (m, 4H, Ar**H**); MS: $m/z = 243$ (M^+); UV (EtOH): $\lambda_{max} = 222$, 275, 320 nm; anal. calcd. for $C_{15}H_{17}NO_2$: C, 74.07; H, 6.99; N, 5.76. Found: C, 74.35; H, 7.18; N, 5.51.

1-Methyl-3-(3-ethylbut-2-en-1-yloxy)quinolin-2(1*H*)-one (**3c**)

Yield: 87%; viscous liquid; IR (neat): 3124, 1622, 1605, 1458 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz): $\delta_H = 1.35$ (t, $J = 7.2$ Hz, 3H, -NCH$_2$C**H**$_3$), 1.76 [s, 6H, C(C**H**$_3$)$_2$], 4.42 (q, $J = 7.2$ Hz, 2H, -NC**H**$_2$), 4.65 (d, $J = 6$ Hz, 2H, -OC**H**$_2$), 5.54–5.69 [m, 1H, -C**H**=C(CH$_3$)$_2$], 6.91 (s, 1H, -C**H**=), 7.28–7.59 (m, 4H, Ar**H**); MS: $m/z = 257$ (M^+); UV (EtOH): $\lambda_{max} = 225$, 278, 320 nm; anal. calcd. for $C_{16}H_{19}NO_2$: C, 74.70; H, 7.39; N, 5.44. Found: C, 74.49; H, 7.58; N, 5.28.

3-(But-2-en-1-yloxy)-1-methylquinolin-2(1*H*)-one (**3e**)

Yield: 88%; viscous liquid; IR (neat): 1770, 1745, 1622, 1598, 1545, 1435 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz): $\delta_H = 1.76$ (d, $J = 5$ Hz, 3H, =CHC**H**$_3$), 3.76 (s, 3H, -NC**H**$_3$), 4.58 (d, $J = 5$ Hz, 2H, -OC**H**$_2$),

5.59–6.12 (m, 2H, -C**H**=C**H**-), 6.80 (s, 1H, -C**H**=), 7.20–7.76 (m, 4H, Ar**H**); MS: $m/z = 229$ (M^+); UV (EtOH): $\lambda_{max} = 223$, 276, 319 nm; anal. calcd. for $C_{14}H_{15}NO_2$: C, 73.36; H, 6.55; N, 6.11. Found: C, 73.61; H, 5.35; N, 5.92.

General Procedure for the Claisen Rearrangement of Compounds 3a–f

The ether (**3a–f**, 2 mmol) was refluxed in chlorobenzene (4 mL) for 8–10 h. Chlorobenzene was removed in vacuo, and the residual mass was chromatographed on silica gel. Elution of the column with petroleum ether (60–80°C) removed the residual chlorobenzene, and then compounds **4a–f** were obtained by eluting the column with 10% ethyl acetate–petroleum ether. Compounds **4d** and **f** were previously reported.[13]

Data

4-Allyl-3-hydroxy-1-ethylquinolin-2(1*H*)-one (**4a**)

Yield: 90%; viscous liquid; IR (neat): 3545, 1738, 1719, 1617, 1562, 1492 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz): $\delta_H = 1.37$ (t, $J = 7.2$ Hz, 3H, -C**H**$_3$), 3.67–3.68 (m, 2H, -C**H**$_2$-CH=), 4.42 (q, $J = 7.2$ Hz, 2H, -NC**H**$_2$), 5.06–5.13 (m, 2H, -CH=C**H**$_2$), 5.93–6.01 (m, 1H, -CH=C**H**$_2$), 7.14–7.72 (m, 5H, Ar**H** and O**H**); MS: $m/z = 229$ (M^+); UV (EtOH): $\lambda_{max} = 222$, 274, 286, 331 nm; anal. calcd. for $C_{14}H_{15}NO_2$: C, 73.36; H, 6.55; N, 6.11. Found: C, 73.65; H, 6.34; N, 5.99.

3-Hydroxy-1-ethyl-4-(1-methylallyl)-quinolin-2(1*H*)-one (**4b**)

Yield: 90%; viscous liquid; IR (neat): 3514, 2925, 1648, 1604, 1455 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz): $\delta_H = 1.36$ (t, $J = 7.2$ Hz, 3H, -NCH$_2$C**H**$_3$), 1.60 (d, $J = 2$ Hz, 3H, CHC**H**$_3$), 4.12–4.35 (m, 1H, C**H**CH$_3$), 4.41 (q, $J = 7.2$ Hz, 2H, -NC**H**$_2$), 5.10–5.38 (m, 2H, =C**H**$_2$), 6.14–6.50 (m, 1H, -C**H**=CH$_2$), 7.17–7.81 (m, 5H, Ar**H** and O**H**); MS: $m/z = 243$ (M^+); UV (EtOH): $\lambda_{max} = 222$, 278, 321 nm; anal. calcd. for $C_{15}H_{17}NO_2$: C, 74.07; H, 6.99; N, 5.76. Found: C, 74.26; H, 7.11; N, 5.06.

4-(1,1-Dimethylallyl)-3-hydroxy-1-ethylquinolin-2(1*H*)-one (**4c**)

Yield: 91%; viscous liquid; IR (neat): 3265, 1622, 1600, 1505, 1468, 1418 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz): $\delta_H = 1.36$ (t, $J = 7.2$ Hz, 3H, -NCH$_2$C**H**$_3$), 1.73 [s, 6H, C(C**H**$_3$)$_2$], 4.41 (q, $J = 7.10$ Hz, 2H, -NC**H**$_2$), 4.92–5.20 (m, 2H, CH=C**H**$_2$), 6.15–6.49 (dd, 1H, $J = 16.8$ Hz,

C**H**=CH_2), 7.15–7.87 (m, 5H, Ar**H** and O**H**); MS: $m/z = 257$ (M^+); UV (EtOH): $\lambda_{max} = 223, 278, 317$ nm; anal. calcd. for $C_{16}H_{19}NO_2$: C, 74.70; H, 7.39; N, 5.44. Found: C, 74.92; H, 7.48; N, 5.23.

3-Hydroxy-1-methyl-4-(1-methylallyl)-quinolin-2(1*H*)-one (4e)

Yield: 90%; viscous liquid; IR (neat): 3510, 2920, 1640, 1600, 1455, 1400 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz): $\delta_H = 1.58$ (d, $J = 2$ Hz, 3H, -CHC**H**$_3$), 3.78 (s, 3H, -NC**H**$_3$), 4.02–4.33 (m, 1H, -C**H**CH_3), 5.00–5.36 (m, 2H, =C**H**$_2$), 6.04–6.49 (m, 1H, -C**H**=CH_2), 7.16–7.79 (m, 5H, Ar**H** and O**H**); MS: $m/z = 229$ (M^+); UV (EtOH): $\lambda_{max} = 224, 276, 320$ nm; anal. calcd. for $C_{14}H_{15}NO_2$: C, 73.36; H, 6.55; N, 6.11. Found: C, 73.11; H, 6.71; N, 6.32.

General Procedure for the Preparation of Compounds 6 and 7

$SnCl_4$ (0.13 mL, 2 mmol) and I_2 (512 mg, 2 mmol) were added to a CH_2Cl_2 (10 mL) solution of the compounds (**4a**–**h**, 2 mmol) at room temperature, and the mixture was stirred for 1 h. The mixture was treated with ice-cold water (40 mL), extracted with CH_2Cl_2 (3 × 10 mL), washed with 5% $Na_2S_2O_3$ (2 × 20 mL), water (2 × 20 mL), and dried (Na_2SO_4). The residual mass after removal of the solvent was subjected to column chromatography on silica gel, and the cyclic products **6**, **7** were collected using 20% ethylacetate–petroleum ether as eluant.

Data

2,3-Dihydro-6-ethyl-2-iodo-2*H*-pyrano[2,3-*c*]quinolin-5-one (**6a**)

Yield: 90%; white solid; mp 166–168°C; IR (KBr): 1647, 1620, 1461, 1210, 751 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz): $\delta_H = 1.34$ (t, $J = 7.2$ Hz, 3H, C**H**$_3$), 3.32 (dd, $J = 17.5$, 8.5 Hz, 1H, =CC**H**$_2$), 3.52 (dd, $J = 17.5$, 5.5 Hz, 1H, =CC**H**$_2$), 4.26 (t, $J = 10.5$ Hz, 1H, OC**H**$_2$), 4.42 (q, $J = 7.2$ Hz, 2H, NC**H**$_2$), 4.51–4.61 (m, 2H, OC**H**$_2$ and C**H**I), 7.24–7.50 (m, 4H, Ar**H**); ^{13}C NMR ($CDCl_3$, 125 MHz): $\delta_C = 12.63$ (NCH$_2$**C**H$_3$), 15.05 (C**H**I), 33.83 (C**H**$_2$CHI), 37.78 (NC**H**$_2$), 71.82 (OC**H**$_2$), 114.13 (ArC**H**), 118.53 (Ar**C**), 119.90 (Ar**C**), 122.28 (ArC**H**), 122.45 (ArC**H**), 127.90 (ArC**H**), 134.21 (Ar**C**), 142.01 (Ar**C**), 156.66 (**C**O); MS: $m/z = 355$ (M^+); UV (EtOH): $\lambda_{max} = 225, 279, 290, 320, 334$ nm; anal. calcd. for $C_{14}H_{14}NO_2I$: C, 47.32; H, 3.94; N, 3.94. Found: C, 47.06; H, 4.13; N, 4.10.

2,3-Dihydro-6-ethyl-1-methyl-2-iodo-2*H*-pyrano[2,3-*c*]quinolin-5-one (**6b**)

Yield: 45%; white solid; mp 160–162°C; IR (KBr): 1643, 1597, 1445, 1210, 751 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): $\delta_H = 1.35$ (t, $J = 7.1$ Hz, 3H, NCH_2CH_3), 1.53 (d, $J = 7.0$ Hz, 3H, CH_3CH), 3.46–3.51 (m, 1H, CH_3CH), 4.42 (q, $J = 7.1$ Hz, 2H, NCH_2), 4.47 (t, $J = 11.8$ Hz, 1H, OCH_2), 4.59 (dd, $J = 11.0$ Hz, 4.1 Hz, 1H, OCH_2), 4.68–4.72 (m, 1H, CHI), 7.27–7.57 (m, 4H, ArH); MS: $m/z = 369$ (M^+); UV (EtOH): $\lambda_{max} = 226$, 268, 280, 290, 321, 334 nm; anal. calcd. for $C_{15}H_{16}NO_2I$: C, 48.78; H, 4.33; N, 3.79. Found: C, 49.01; H, 4.45; N, 3.50.

2,3-Dihydro-2-iodo-6-methyl-2*H*-pyrano[2,3-*c*]quinolin-5-one (**6d**)

Yield: 90%; white solid; mp 163–165°C; IR (KBr): 1649, 1623, 1457, 1119, 753 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz): $\delta_H = 3.30$ (dd, $J = 17.5$, 8.5 Hz, 1H, $=CCH_2$), 3.54 (dd, $J = 17.5$, 5.5 Hz, 1H, $=CCH_2$), 3.77 (s, 3H, NCH_3), 4.27 (t, $J = 10.5$ Hz, 1H, OCH_2), 4.50–4.60 (m, 2H, OCH_2 and CHI), 7.28–7.50 (m, 4H, ArH); MS: $m/z = 341$ (M^+); UV (EtOH): $\lambda_{max} = 225$, 279, 290, 321, 335 nm; anal. calcd. for $C_{13}H_{12}NO_2I$: C, 45.74; H, 3.51; N, 4.10. Found: C, 45.97; H, 3.32; N, 3.98.

2,3-Dihydro-2-iodo-1,6-dimethyl-2*H*-pyrano[2,3-*c*]quinolin-5-one (**6e**)

Yield: 46%; white solid; mp 138–140°C; IR (KBr): 1651, 1615, 1459, 1120, 738 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): $\delta_H = 1.53$ (d, $J = 7.0$ Hz, 3H, CH_3CH), 3.47–3.51 (m, 1H, CH_3CH), 3.76 (s, 3H, NCH_3), 4.46 (t, $J = 11.8$ Hz, 1H, OCH_2), 4.60 (dd, $J = 11.0$, 4.1 Hz, 1H, OCH_2), 4.68–4.72 (m, 1H, CHI), 7.26–7.56 (m, 4H, ArH); MS: $m/z = 355$ (M^+); UV (EtOH): $\lambda_{max} = 215$, 225, 256, 263, 321, 335 nm; anal. calcd. for $C_{14}H_{14}NO_2I$: C, 47.32; H, 3.94; N, 3.94. Found: C, 47.09; H, 4.15; N, 3.83.

2,3-Dihydro-5-ethyl-2-iodomethyl-1-methylfuro[2,3-*c*]quinolin-4-one (**7b**)

Yield: 43%; white solid; mp 120–122°C; IR (KBr): 1663, 1628, 1457, 1206, 751 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): $\delta_H = 1.36$ (t, $J = 7.1$ Hz, 3H, NCH_2CH_3), 1.52 (d, $J = 7.0$ Hz, 3H, $CHCH_3$), 3.22 (t, $J = 9.9$ Hz, 1H, CH_2I), 3.49 (dd, $J = 9.9$, 3.86 Hz, 1H, CH_2I), 3.66–3.71 (m, 1H, CH_3CH), 4.42 (q, $J = 7.1$ Hz, 2H, NCH_2), 4.64–4.68 (m, 1H, $CHCH_2I$), 7.25–7.54 (m, 4H, ArH); MS: $m/z = 369$ (M^+). UV (EtOH): $\lambda_{max} = 228$, 287, 298, 324, 339 nm; anal. calcd. for $C_{15}H_{16}NO_2I$: C, 48.78; H, 4.33; N, 3.79. Found: C, 49.04; H, 4.14; N, 3.68.

2,3-Dihydro-5-ethyl-2-iodomethyl-1,1-dimethylfuro[2,3-*c*]quinolin-4-one (**7c**)

Yield: 91%; white solid; mp 92–94°C; IR (KBr): 2917, 1662, 1622, 1463, 1215, 755 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz): $\delta_H = 1.33$ (t, $J = 7.1$ Hz, 3H, NCH_2CH_3), 1.46 (s, 3H, CH_3), 1.76 (s, 3H, CH_3), 3.39 (dd, $J = 7.1$, 10.6 Hz, 1H, CH_2I), 3.52 (dd, $J = 7.1$, 10.6 Hz, 1H, CH_2I), 4.38 (q, $J = 7.1$ Hz, 2H, NCH_2), 4.71 (t, 6.9 Hz, 1H, $CHCH_2I$), 7.24–7.74 (m, 4H, ArH); ^{13}C NMR ($CDCl_3$, 125 MHz): $\delta_C = -1.42$ (CH_2I), 12.78 (NCH_2CH_3), 20.18 (CH_3), 27.90 (CH_3), 37.45 (NCH_2), 47.28 [$C(CH_3)_2$], 91.86 (OCH), 115.08 (ArCH), 118.37 (ArC), 112.19 (ArCH), 122.72 (ArCH), 127.27 (ArCH), 131.70 (ArC), 136.19 (ArC), 144.48 (ArC), 154.28 (CO); MS: $m/z = 383$ (M^+); UV (EtOH): $\lambda_{max} = 227$, 287, 298, 324, 339 nm; anal. calcd. for $C_{16}H_{18}NO_2I$: C, 50.13; H, 4.69; N, 3.65. Found: C, 50.24; H, 4.54; N, 3.51.

2,3-Dihydro-2-iodomethyl-1,5-dimethylfuro[2,3-*c*]quinolin-4-one (**7e**)

Yield: 44%; white solid; mp 118–120°C; IR (KBr): 1663, 1628, 1457, 1226, 752 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): $\delta_H = 1.52$ (d, $J = 7.0$ Hz, 3H, CH_3), 3.22 (t, $J = 9.9$ Hz, 1H, CH_2I), 3.48 (dd, $J = 9.9$, 3.8 Hz, 1H, CH_2I), 3.66–3.71 (m, 1H, CH_3CH), 3.78 (s, 3H, NCH_3), 4.63–4.67 (m, 1H, $CHCH_2I$), 7.26–7.54 (m, 4H, ArH); MS: $m/z = 355$ (M^+); UV (EtOH): $\lambda_{max} = 227$, 288, 298, 325, 340 nm; anal. calcd. for $C_{14}H_{14}NO_2I$: C, 47.32; H, 3.94; N, 3.94. Found: C, 47.53; H, 3.83; N, 4.06.

2,3-Dihydro-2-iodomethyl-1,1,5-trimethylfuro[2,3-*c*]quinolin-4-one (**7f**)

Yield: 92%; white solid; mp 90–92°C; IR (KBr): 2927, 1662, 1622, 1458, 1238, 752 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz): $\delta_H = 1.49$ (s, 3H, CH_3), 1.77 (s, 3H, CH_3), 3.40 (dd, $J = 7.1$, 10.5 Hz, 1H, CH_2I), 3.53 (dd, $J = 7.1$, 10.50 Hz, 1H, CH_2I), 3.75 (s, 3H, NCH_3), 4.75 (t, $J = 6.9$ Hz, 1H, $CHCH_2I$), 7.24–7.75 (m, 4H, ArH); MS: $m/z = 369$ (M^+); UV (EtOH): $\lambda_{max} = 227$, 287, 298, 352, 340 nm; anal. calcd. for $C_{15}H_{16}NO_2I$: C, 48.78; H, 4.33; N, 3.79. Found: C, 49.01; H, 4.21; N, 4.01.

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