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# Cobalt-Catalyzed Peroxidation of 2-Oxindoles with Hydroperoxides

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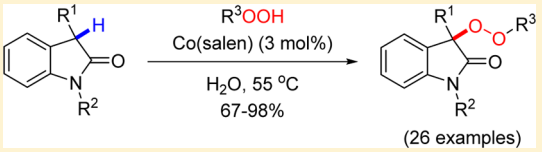
Supporting Information

**ABSTRACT:** A highly efficient and facile cobalt-catalyzed C−H activation and peroxidation of 2-oxindoles was reported, which provides a new pathway for the synthesis of biologically active 3-peroxy-2-oxindoles from readily available starting materials in excellent chemical yields. The resulting products could be further transformed into various substituted 3-peroxyoxindoles in good to excellent yields. The developed method has been successfully applied to the synthesis of the natural product (±)-*N*-[2-(3-hydroxy-2-oxo-2,3-dihydro-1*H*-indol-3-yl)ethyl]acetamide.

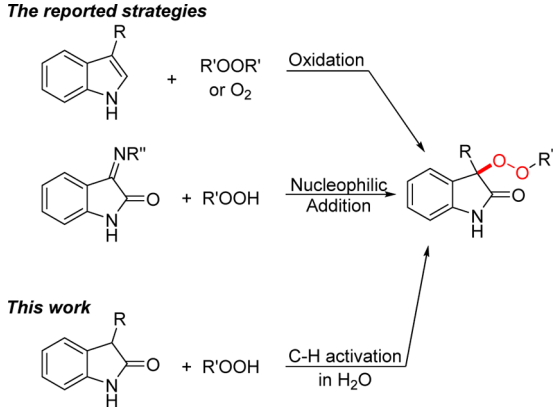



## INTRODUCTION

3,3′-Disubstituted oxindoles are ubiquitous heterocycles found in a large family of bioactive compounds and synthetic derivatives that mimic natural products.[1] Among them, 3-oxyl-substituted oxindole constitutes a key structural feature of a vast majority of natural products and pharmaceuticals with a broad spectrum of biological activities.[2] Therefore, their synthetic importance has prompted considerable interest in developing operative construction methodologies for this motif. On the other hand, the peroxy entity is also a privileged structural motif found in many important natural products and pharmaceutical applications, bearing great potential for the discovery of new antimalarial, antibacterial, and antitumor drugs.[3] However, the development of the synthesis of the 3,3-disubstituted 2-oxindole containing a peroxy group still remains a considerable challenge.[4,5] A survey of the literature shows the reported approaches mainly focused on the oxidation of 3-substituted indoles[4a,b] or nucleophilic addition reaction by using isatin-derived ketimines as electrophiles with appropriate peroxide nucleophiles[4c,d] (Scheme 1). Despite these significant advances, the development of new synthetic methodologies for the construction of the 3-peroxy-2-oxindole derivatives with structural diversity is still one of the most important and promising areas in synthetic and medicinal chemistry. Especially, methods for the direct preparation of 3-peroxy-2-oxindoles from 3-monosubstituted oxindoles, which would promptly provide a vast majority of complex oxindole derivatives, are far less developed.[5]

As part of our research program aimed at establishing novel and environmentally benign methodologies for the synthesis of 3,3-disubstituted 2-oxindoles with a tetrasubstituted carbon center at the C3-position,[6] we are particularly interested in developing novel strategies by using simple and easily accessible 2-oxindoles. Recently, we reported the direct C3 arylation[6b] and olefination[6c] of 2-oxindoles with Fe- and $I_2$-catalyzed cross-dehydrogenative coupling (CDC) methods, respectively. However, most of those direct $sp^3$ C−H functionalizations of 2-oxindoles were carried out in organic solvents.[1] From both an economical and an environmental point of view, water is an ideal solvent since it is the cheapest, most readily available, nontoxic, and nonflammable solvent. Nonetheless, very few examples using a water-rich solvent under phase-transfer conditions have beein reported.[7] To the best of our knowledge, the direct CDC of 2-oxindoles in water has not been explored. Herein, we present an unprecedented synthetic strategy catalyzed by Co(salen) in water affording 3-peroxy-2-oxindole derivatives in good to excellent yields. Considering the mild conditions applied in this method and the potential as a general method for late-stage C−H functionalization, it surely will open a new avenue to structurally diverse tetrasubstituted 3-oxyl-2-oxindole derivatives

**Scheme 1. Strategies for the Synthesis of 3-Peroxy-Substituted Oxindole Analogues**

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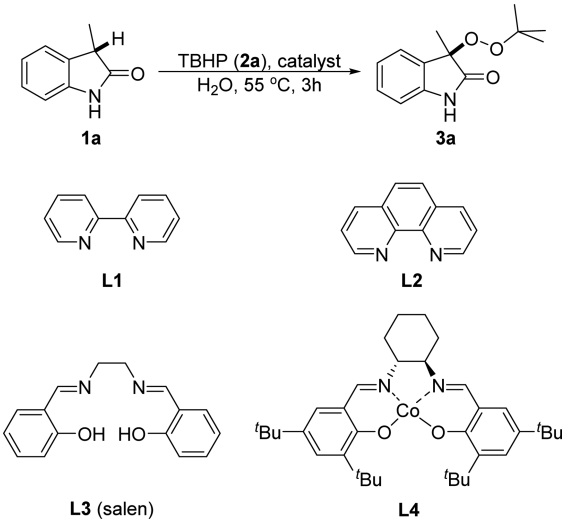
## RESULTS AND DISCUSSION

Initially, 3-methyl-2-oxindole (**1a**) was chosen as a model substrate for the optimization studies (Table 1). Reactions were

**Table 1. Optimization of the Reaction Conditions**[a]




| entry | catalyst | yield of **3a**[b] (%) |
|---|---|---|
| 1 | $Bu_4NI$[c] | trace |
| 2 | CuBr | trace |
| 3 | $NiCl_2$ | trace |
| 4 | $CoBr_2$ | trace |
| 5 | $CoBr_2$/**L1**[d] | <10 |
| 6 | $CoBr_2$/**L2**[d] | 27 |
| 7 | $CoBr_2$/**L3**[d] | 85 |
| 8 | Co(salen) | 98 |
| 9[e] | Co(salen) | 90 |
| 10[f] | Co(salen) | 52 |
| 11 | | NR[h] |
| 12[g] | Co(salen) | NR[h] |
| 13 | $CoBr_2$/**L4**[d] | 91 |

[a]Reaction conditions: **1a** (0.1 mmol), **2a** (0.5 mmol), catalyst (3 mol %), $H_2O$ (0.6 mL), 3 h at 55 °C under open air. [b]Isolated yields. [c]A 20 mol % concentration of $Bu_4NI$ was used. [d]$CoBr_2$/ligand ratio = 1/1. [e]A 0.4 mmol portion of **2a** was used. [f]A 0.3 mmol portion of **2a** was used. [g]Reaction conducted at rt. [h]No reaction.

conducted with *tert*-butyl hydroperoxide (TBHP, **2a**) in water at 55 °C for 3 h. Commonly used catalysts were screened first (Table 1, entries 1−3). However, those catalysts that were previously used for peroxidation or oxidative cross-coupling, such as $Bu_4NI$,[8] CuBr,[9] and $NiCl_2$,[10] were not applicable for this transformation, and only trace product was detected. Cobalt complexes have been proven to be an effective catalyst for the homolytic activation of alkyl hydroperoxides, especially in several large-scale radical oxidation processes.[11] However, no catalytic ability was observed with $CoBr_2$ (entry 4). We envisioned that the inferior catalytic ability might be due to the hydration of cobalt ion in water,[12] which prevented the electron transfer from the outer layer of the metal to the oxidizing form of the substrate molecule; thus, several ligands were tested next. Interestingly, the addition of ligand 2,2′-dipyridyl (**L1**) or 1,10-phenanthroline (**L2**) with 3 mol % $CoBr_2$ in a 1:1 ratio slightly improved the catalytic ability, giving the product **3a** in <10% and 27% yields, respectively (entries 5 and 6). To our surprise, the yield could be exceedingly improved to 87% when a bis-Schiff base ligand, salen (**L3**), was used (entry 7), thus indicating a tetradentate binding model was essential for the cobalt to catalyze the transformation.[13] In an effort to further improve the yield, the commercially available complex Co(salen) was found to be best for this transformation, affording the desired product **3a** in 98% yield (entry 8). A lower loading of **2a** would lead to a decrease of the yield (entries 9 and 10). Furthermore, the reaction did not proceed either in the absence of any catalyst or at room temperature (entries 11 and 12). Finally, in an effort to perform this reaction in an asymmetric manner, a chiral Schiff base ligand (**L4**) was used. However, no enantioselectivity was observed (entry 13). As mentioned above, very little effort was placed on the functionalization of 2-oxindoles in aqueous solution. Notably, water was proven to be the best solvent for this transformation. Identical reactions conducted in organic solvents, such as $CH_2Cl_2$, THF, $CH_3CN$, 1,4-dioxane, or MeOH, only afforded the product **3a** in moderate yields (43−64%; see the Supporting Information for details), which may be attributed to a suggested "on water" effect.[14]

To document the substrate scope, various 2-oxindoles were reacted with TBHP (*tert*-butyl hydroperoxide, **2a**) or CHP (cumene hydroperoxide, **2b**) under optimized conditions (Scheme 2). We first examined the effect of the *N*-substitution and tested *N*-H, *N*-Me, *N*-benzyl, and *N*-Ts 2-oxindoles **1b−e**; all congeners provided the corresponding products **3b−e** in excellent yields (86−95%). We then investigated the effect of the substituent in the phenyl ring of 3-benzyl (**1f−h**) and phenyl (**1i−k**) substituted 2-oxindoles. All electron-donating/withdrawing or *ortho*/*meta*/*para*-substituents were tolerated, and the corresponding products were isolated in good to excellent yields. Heterocyclic substituted 2-oxindoles were also compatible for this transformation, giving the products **3l,m** in good yields. We further examined other more challenging substrates, such as ester (**1n** and **1q**), cyano (**1o**), amide (**1p**), and BocNH (**1r**) substituted 2-oxindoles, and the method was shown to work well with TBHP, affording the products **3m−r** in good to excellent yields. Other oxindoles with substitutions on the aromatic core have been tested, and all afforded the desired products **3s−x** in good to excellent yields (68−97%), regardless of the electronic properties of the substituted group as electron-deficient (Cl, **3s,w,x**; Br, **3t**) or electron-rich (Me, **3u**; OMe, **3v**). Notably, the reaction can also be carried out successfully in place of CHP (**2b**), and oxindoles **3y,z** were prepared in moderate to good yields. Thus, the substrate scope for the synthesis of 3-peroxy-2-oxindoles with hydroperoxides is fairly broad. The structure of 3-peroxy-substituted oxindole **3h** was confirmed by X-ray crystal analysis (CCDC 1426319; see the Supporting Information for details).

Furthermore, these obtained 3-peroxy products can be easily transformed to versatile 3-oxyl-2-oxindoles derivatives (Scheme 3). The *tert*-Butyl group in the 3-peroxidation products was removed with Amberlyst 15 via a C−O cleavage[15] to give the 3-(hydroperoxy)oxindole (**4**) in 90% isolated yield, which could then serve as an important building block in subsequent derivatization (Scheme 3a). Acetyl, sulfonyl, phosphono, and trimethylsilyl could be introduced while the reactive peroxy bond remains untouched, which indicates the feasibility for providing more diversities to the molecular library. Besides, the O−O bond was cleaved via a hydrogenation reaction to give the 3-hydroxy-2-oxindole, providing the first facile synthesis of racemic natural product (±)-*N*-[2-(3-hydroxy-2-oxo-2,3-dihydro-1*H*-indol-3-yl)ethyl]acetamide (**6**) in excellent yield, which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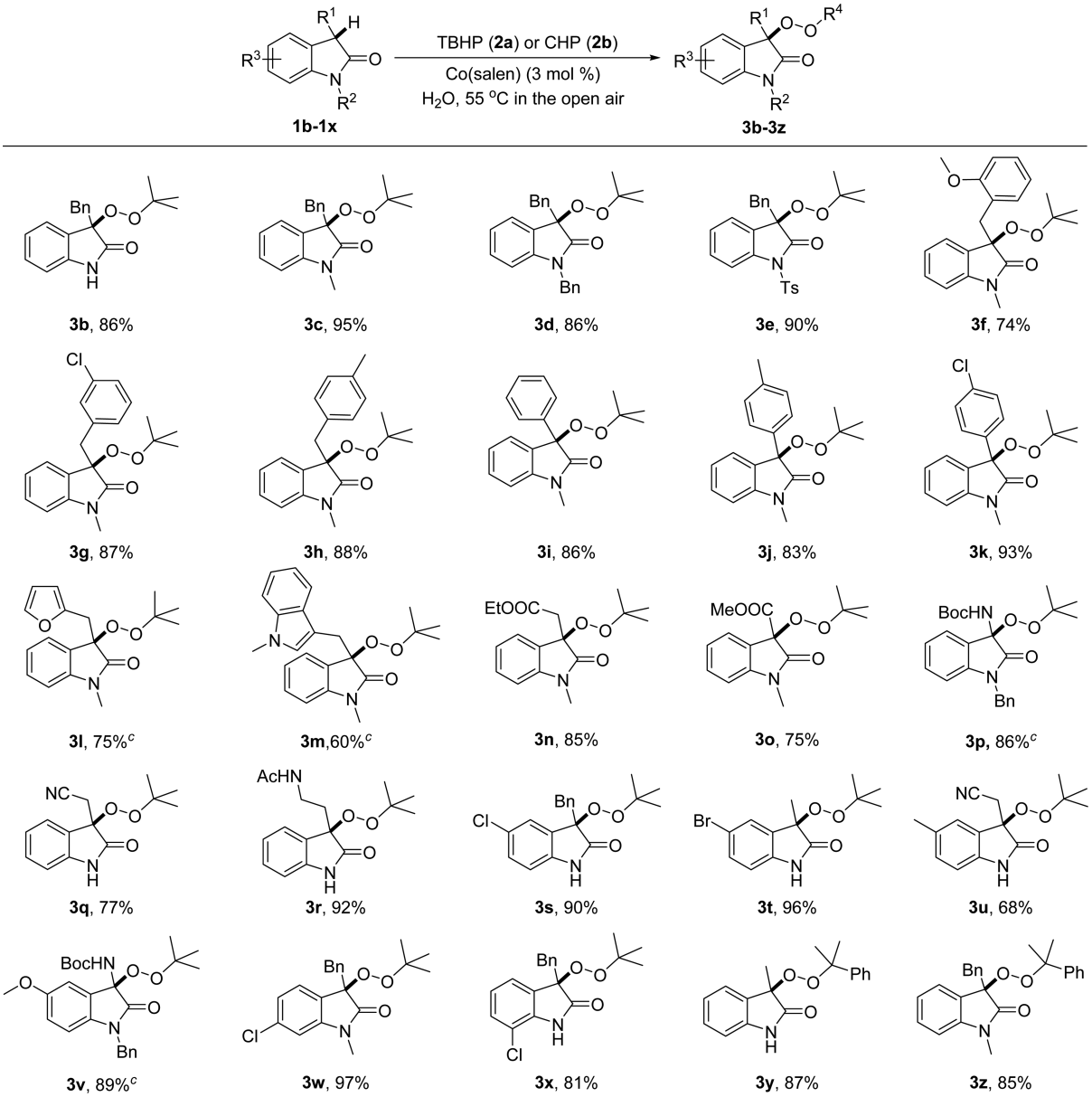
**Scheme 2. Reaction of 2-Oxindoles with Hydroperoxides**[a,b]




[a]Reaction conditions: oxindole **1** (0.2 mmol), TBHP (**2a**) or CHP (**2b**) (1 mmol), Co(salen) (0.006 mmol), $H_2O$ (1.5 mL), at 55 °C for 3−12 h. [b]Isolated yields. [c]Under neat condition.

was isolated from the leaves of *Selaginella pulvinata* and has been proven to exhibit an inhibition effect toward the growth of SK-mel-110 cells and induce cell apoptosis in vitro.[16]

To elucidate the mechanism for this effective peroxidation, a deuterium labeling study was performed and the kinetic isotopic effect (KIE) was determined (Scheme 4). Two parallel reactions were carried out with **1c** and deuterium-labeled *d*-**1c** as the substrate, respectively. A KIE $k_H/k_D$ = 2.4 was obtained, indicating that the $sp^3$ C−H bond dissociation was involved in the rate-limiting step of this transformation.

Although the detailed reaction mechanism still remains to be clarified, on the basis of the previous studies,[11] a radical reaction pathway as shown in Scheme 5 is proposed. Initially, a $Co^{II}$ complex catalyzed the homolytic decomposition of R′OOH, generating the highly reactive $Co^{III}OH$ species, which reacted very rapidly with a second R′OOH molecule to give $Co^{III}OOR'$. The latter, in an almost degenerated singlet/triplet ground state, dissociated to the ROO• radical while generating the starting $Co^{II}$ species. On the other hand, the resulting RO• radical abstracts the $\alpha$-carbonyl hydrogen of 2-oxindole **A** to form the radical intermediate **B**, which further undergoes a selective cross-coupling with the longer lived ROO• radical[17] to give the product **C**.

Finally, to document the potential of the method for process preparation of 3-peroxy-2-oxindoles, we performed a gram-scale reaction in water (Scheme 6). Significantly, with a much lower catalyst loading (0.5 mol %), the product **3a** was obtained in 90% yield.

## ■ CONCLUSION

In summary, a novel class of 3-peroxy-2-oxindoles have been synthesized via a Co(salen)-catalyzed reaction starting from readily accessible 2-oxindoles. The reactions proceeded via a



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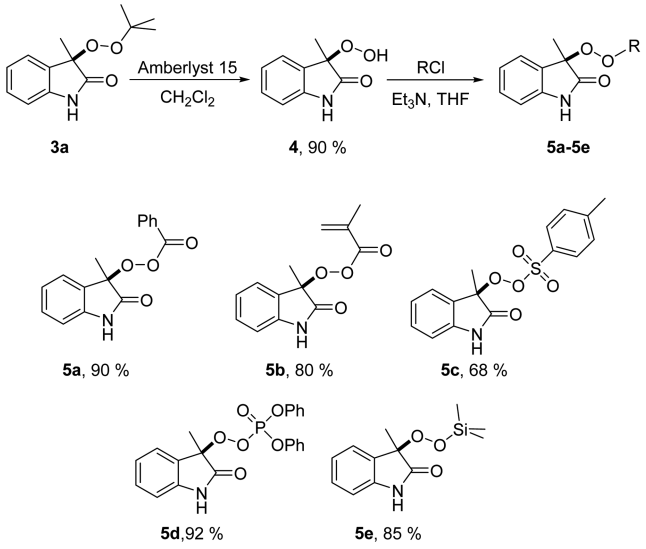
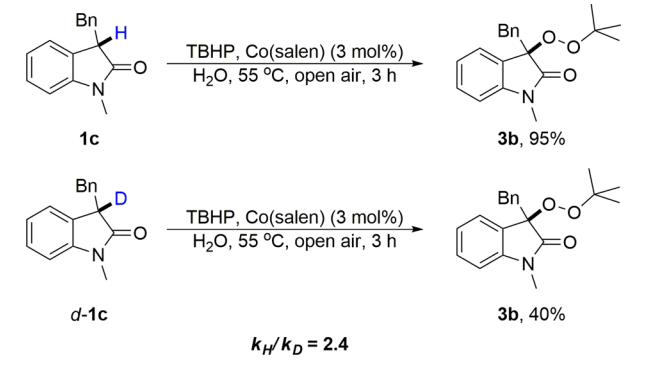
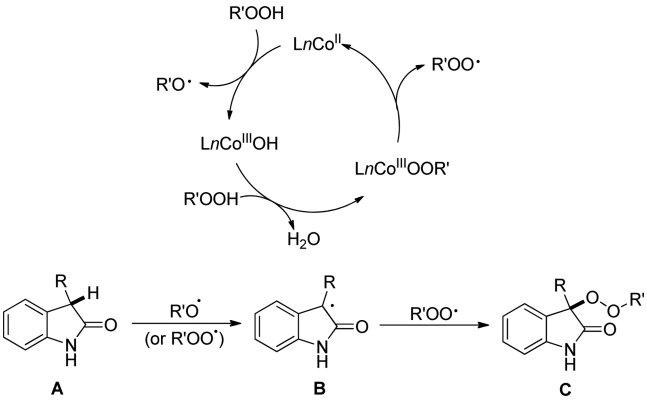
**Scheme 3. Subsequent Transformations of the Coupling Products**




**Scheme 4. Mechanistic Studies**

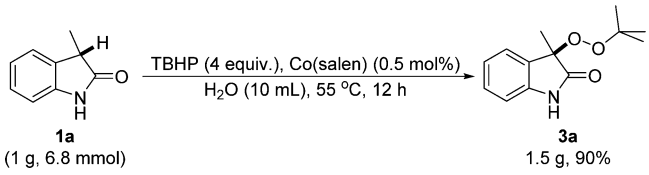



**Scheme 5. Proposed Mechanism**




cobalt-catalyzed hemolytic decomposition of peroxides to generate the oxindole radical, followed by a cross-coupling with the longer lived peroxy radical. The peroxy functionality in the 3-substituted oxindoles can be derived to give the corresponding hydroperoxides via C−O cleavage and the hydroxyl product via O−O cleavage. This method provides easy access to the synthesis of natural product **6** with antiproliferative activity.

**Scheme 6. Gram-Scale Reaction in Water**




## EXPERIMENTAL SECTION

**General Procedure for the Preparation of Compounds 3.** Oxindole **1** (0.2 mmol), hydroperoxides **2** (1 mmol), and Co(salen) (1.9 mg, 0.006 mmol) were added to a tube. Then 1.5 mL of $H_2O$ was added, and the reaction mixture was stirred at 55 °C under air. After the reaction was completed, the reaction solution was extracted with ethyl acetate three times. The organic layer was combined and evaporated. Then the residue was subjected to column chromatography on silica gel with petroleum ether and ethyl acetate as the eluent to give the desired product.

*3-(tert-Butylperoxy)-3-methylindolin-2-one (**3a**).* Silica gel column chromatography (petroleum ether/ethyl acetate =15/1 to 10/1) gave **3a** (46 mg, 98%) as a white solid. Mp: 126−128 °C. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 8.69 (s, 1H), 7.30−7.32 (d, $J$ = 7.4 Hz, 1H), 7.20−7.28 (m, 1H), 7.02−7.06 (t, $J$ = 7.5 Hz, 1H), 6.87−6.89 (d, $J$ = 7.7 Hz, 1H), 1.54 (s, 3H), 1.11 (s, 9H). $^{13}$C NMR (101 MHz, $CDCl_3$): $\delta$ 177.6, 140.7, 130.0, 129.4, 124.2, 122.4, 110.1, 82.2, 80.4, 26.4, 20.3. HRMS (ESI): calcd for $C_{13}H_{17}O_3NNa$ ([M + Na]$^+$) 258.1100, found 258.1102. IR (KBr, cm$^{-1}$): 3222, 2970, 1687, 1533, 1379, 1283, 1117, 1110, 997, 862, 844, 751.

*3-Benzyl-3-(tert-butylperoxy)indolin-2-one (**3b**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3b** (53 mg, 86%) as a pale yellow solid. Mp: 161−163 °C. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 8.22 (s, 1H), 7.21−7.10 (m, 4H), 7.01−7.03 (d, $J$ = 7.0 Hz, 2H), 6.94−6.95 (m, 2H), 6.71−6.73 (d, $J$ = 7.7 Hz, 1H), 3.33−3.36 (d, $J$ = 13.3 Hz, 1H), 3.04−3.07 (d, $J$ = 13.3 Hz, 1H), 1.13 (s, 9H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 176.7, 141.0, 133.5, 130.8, 129.4, 127.8, 127.6, 126.9, 125.7, 122.0, 109.8, 85.6, 80.6, 40.4, 26.5. HRMS (ESI): calcd for $C_{19}H_{21}O_3NNa$ ([M + Na]$^+$) 334.1413, found 334.1412. IR (KBr, cm$^{-1}$): 3250, 2980, 2927, 1729, 1622, 1471, 1364, 1194, 751, 698.

*3-Benzyl-3-(tert-butylperoxy)-1-methylindolin-2-one (**3c**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3c** (60 mg, 95%) as a yellow solid. Mp: 58−60 °C. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.20−7.24 (m, 1H), 7.10−7.13 (m, 3H), 6.94−6.98 (m, 4H), 6.61−6.63 (d, $J$ = 7.8 Hz, 1H), 3.32−3.35 (d, $J$ = 13.1 Hz, 1H), 3.02−3.05 (m, 4H), 1.13 (s, 9H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 174.4, 143.8, 133.6, 130.6, 129.3, 127.6, 127.2, 126.8, 125.2, 121.9, 107.7, 85.4, 80.5, 40.5, 26.5, 25.9. HRMS (ESI): calcd for $C_{20}H_{23}O_3NNa$ ([M + Na]$^+$) 348.1570, found 348.1567. IR (KBr, cm$^{-1}$): 2979, 2927, 1731, 1614, 1494, 1470, 1373, 1193, 1019, 750.

*1,3-Dibenzyl-3-(tert-butylperoxy)indolin-2-one (**3d**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3d** (69 mg, 86%) as a yellow oil. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.07−7.26 (m, 8H), 7.00−7.02 (d, $J$ = 7.5 Hz, 2H), 6.93−6.97 (m, 3H), 6.39−6.40 (d, $J$ = 8.0 Hz, 1H), 4.89−4.92 (d, $J$ = 16.5 Hz, 1H), 4.66−4.69 (d, $J$ = 16.5 Hz, 1H), 3.38−3.40 (d, $J$ = 13.0 Hz, 1H), 3.16−3.19 (d, $J$ = 13.0 Hz, 1H), 1.16 (s, 9H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 174.3, 143.1, 135.3, 133.5, 130.9, 129.5, 128.5, 127.9, 127.3, 127.2, 126.9, 126.7, 125.2, 122.0, 109.0, 85.5, 80.6, 43.3, 40.1, 26.6. HRMS (ESI): calcd for $C_{26}H_{27}O_3NNa$ ([M + Na]$^+$) 424.1883,



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found 424.1880. IR (KBr, $cm^{-1}$): 2980, 2925, 1731, 1615, 1489, 1467, 1363, 1193, 752, 698.

*3-Benzyl-3-(tert-butylperoxy)-1-tosylindolin-2-one (**3e**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3e** (83 mg, 90%) as a colorless oil. $^1H$ NMR (500 MHz, $CDCl_3$): $\delta$ 7.86−7.88 (d, $J$ = 8.3 Hz, 2H), 7.76−7.78 (d, $J$ = 8.2 Hz, 1H), 7.24−7.34 (m, 4H), 7.09−7.13 (q, $J$ = 7.3 Hz, 2H), 7.00−7.07 (m, 3H), 6.83−6.85 (d, $J$ = 7.5 Hz, 2H), 3.19−3.22 (d, $J$ = 13.3 Hz, 1H), 3.03−3.06 (d, $J$ = 13.3 Hz, 1H), 2.40 (s, 3H), 0.92 (s, 9H). $^{13}C$ NMR (126 MHz, $CDCl_3$): $\delta$ 173.1, 145.2, 139.5, 135.5, 132.3, 130.6, 130.1, 129.6, 127.97, 127.91, 127.1, 126.6, 125.4, 124.2, 113.2, 84.8, 80.8, 40.6, 26.2, 21.6. HRMS (ESI): calcd for $C_{26}H_{27}O_5NSNa$ ([M + Na]$^+$) 488.1502, found 488.1498. IR (KBr, $cm^{-1}$): 2980, 2927, 1771, 1607, 1463, 1371, 1233, 1190, 1177, 1088, 702, 672.

*3-(tert-Butylperoxy)-3-(2-methoxybenzyl)-1-methylindolin-2-one (**3f**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3f** (52 mg, 74%) as a yellow oil. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.10−7.21 (m, 3H), 6.85−6.91 (m, 2H), 6.78−6.90 (td, $J$ = 7.4, 0.7 Hz, 1H), 6.61−6.64 (dd, $J$ = 7.9, 3.4 Hz, 2H), 3.42−3.48 (m, 4H), 3.11−3.16 (m, 4H), 1.11 (s, 9H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 175.0, 157.6, 143.7, 132.0, 128.9, 128.2, 127.4, 125.5, 122.5, 121.3, 119.8, 110.0, 107.2, 85.3, 80.3, 54.8, 33.0, 26.5, 26.0. HRMS (ESI): calcd for $C_{21}H_{25}O_4NNa$ ([M + Na]$^+$) 378.1675, found 378.1673. IR (KBr, $cm^{-1}$): 2978, 2931, 1730, 1614, 1495, 1470, 1363, 1278, 1194, 1118, 751.

*3-(tert-Butylperoxy)-3-(3-chlorobenzyl)-1-methylindolin-2-one (**3g**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3g** (62 mg, 87%) as a white solid. Mp: 66−68 °C. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.23−7.27 (m, 1H), 7.11−7.17 (m, 1H), 7.05−7.09 (t, $J$ = 7.8 Hz, 1H), 6.93−7.00 (m, 3H), 6.83−6.91 (m, 1H), 6.65−6.67 (d, $J$ = 7.8 Hz, 1H), 3.30−3.33 (m, 1H), 2.98−3.07 (m, 4H), 1.12 (s, 9H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 174.1, 143.8, 135.8, 133.4, 130.7, 130.5, 129.6, 128.9, 128.4, 127.1, 126.8, 125.2, 122.1, 107.9, 85.0, 80.6, 40.2, 26.5, 26.0. HRMS (ESI): calcd for $C_{20}H_{22}O_3NClNa$ ([M + Na]$^+$) 382.1180, found 382.1179. IR (KBr, $cm^{-1}$): 2979, 2929, 1730, 1614, 1471, 1374, 1363, 1193, 1017, 753.

*3-(tert-Butylperoxy)-1-methyl-3-(4-methylbenzyl)indolin-2-one (**3h**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3h** (59 mg, 88%) as a yellow solid. Mp: 95−97 °C. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.21−7.25 (m, 1H), 6.92−6.98 (m, 4H), 6.85−6.87 (d, $J$ = 8.0 Hz, 2H), 6.62−6.64 (d, $J$ = 7.8 Hz, 1H), 3.28−3.32 (d, $J$ = 13.2 Hz, 1H), 3.05 (s, 3H), 2.97−3.00 (t, $J$ = 10.1 Hz, 1H), 2.25 (s, 3H), 1.12 (s, 9H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 174.5, 143.9, 136.3, 130.53, 130.46, 129.4, 128.4, 127.3, 125.3, 121.8, 107.7, 85.5, 80.4, 40.1, 26.5, 26.0, 21.1. HRMS (ESI): calcd for $C_{21}H_{25}O_3NNa$ ([M + Na]$^+$) 362.1726, found 362.1722. IR (KBr, $cm^{-1}$): 2979, 2928, 1731, 1614, 1515, 1471, 1373, 1194, 1018, 750.

*3-(tert-Butylperoxy)-1-methyl-3-phenylindolin-2-one (**3i**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3i** (53 mg, 86%) as a yellow solid. Mp: 86−88 °C. $^1H$ NMR (500 MHz, $CDCl_3$): $\delta$ 7.42−7.44 (m, 2H), 7.34−7.41 (m, 2H), 7.29−7.33 (m, 3H), 7.11−7.14 (t, $J$ = 7.5 Hz, 1H), 6.86−6.88 (d, $J$ = 7.8 Hz, 1H), 3.20 (s, 3H), 1.18 (s, 9H). $^{13}C$ NMR (126 MHz, $CDCl_3$): $\delta$ 174.1, 144.6, 136.1, 129.8, 128.9, 128.39, 128.44, 127.2, 126.2, 122.6, 108.1, 86.1, 80.7, 26.6, 26.4. HRMS (ESI): calcd for $C_{19}H_{22}O_3N$ ([M + H]$^+$) 312.1594, found 312.1593. IR (KBr, $cm^{-1}$): 2979, 2931, 1732, 1614, 1470, 1019, 756, 696.

*3-(tert-Butylperoxy)-3-(4-chlorophenyl)-1-methylindolin-2-one (**3j**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3j** (57 mg, 83%) as a pale yellow solid. Mp: 97−99 °C. $^1H$ NMR (500 MHz, $CDCl_3$): $\delta$ 7.37−7.41 (m, 3H), 7.33−7.35 (d, $J$ = 7.4 Hz, 1H), 7.28−7.30 (d, $J$ = 8.5 Hz, 2H), 7.12−7.15 (t, $J$ = 7.5 Hz, 1H), 6.87−6.89 (d, $J$ = 7.8 Hz, 1H), 3.19 (s, 3H), 1.16 (s, 9H). $^{13}C$ NMR (126 MHz, $CDCl_3$): $\delta$ 173.5, 144.6, 135.0, 134.6, 130.1, 128.8, 128.6, 127.9, 126.2, 122.7, 108.3, 85.6, 80.9, 26.5. HRMS (ESI): calcd for $C_{19}H_{20}O_3NClNa$ ([M + Na]$^+$) 368.1024, found 368.1023. IR (KBr, $cm^{-1}$): 2980, 2930, 1733, 1613, 1489, 1364, 1344, 1244, 1193, 1092, 1015, 823, 751.

*3-(tert-Butylperoxy)-1-methyl-3-(p-tolyl)indolin-2-one (**3k**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3k** (60 mg, 93%) as a white solid. Mp: 60−62 °C. $^1H$ NMR (500 MHz, $CDCl_3$): $\delta$ 7.31−7.44 (m, 4H), 7.10−7.13 (t, $J$ = 7.0 Hz, 3H), 6.85−6.86 (d, $J$ = 7.7 Hz, 1H), 3.18 (s, 3H), 2.31 (s, 3H), 1.17 (s, 9H). $^{13}C$ NMR (126 MHz, $CDCl_3$): $\delta$ 174.2, 144.6, 138.9, 133.1, 129.7, 129.1, 128.5, 127.2, 126.1, 122.5, 108.1, 86.0, 80.7, 26.6, 26.3, 21.2. HRMS (ESI): calcd for $C_{20}H_{23}O_3NNa$ ([M + Na]$^+$) 348.1570, found 348.1567. IR (KBr, $cm^{-1}$): 2979, 2930, 1733, 1613, 1493, 1470, 1364, 1344, 1194, 1097, 815, 753.

*3-(tert-Butylperoxy)-3-(furan-2-ylmethyl)-1-methylindolin-2-one (**3l**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3l** (47 mg, 75%) as a yellow oil. $^1H$ NMR (500 MHz, $CDCl_3$): $\delta$ 7.23−7.33 (m, 2H), 7.05−7.06 (d, $J$ = 6.6 Hz, 1H), 6.98−7.01 (t, $J$ = 7.4 Hz, 1H), 6.71−6.72 (d, $J$ = 7.8 Hz, 1H), 6.18−6.19 (dd, $J$ = 3.0, 1.9 Hz, 1H), 5.948−5.954 (d, $J$ = 3.1 Hz, 1H), 3.38−3.41 (d, $J$ = 14.7 Hz, 1H), 3.17−3.20 (d, $J$ = 14.7 Hz, 1H), 3.14 (s, 3H), 1.12 (s, 10H). $^{13}C$ NMR (126 MHz, $CDCl_3$): $\delta$ 174.0, 148.6, 144.0, 141.5, 129.6, 127.2, 125.1, 122.2, 110.3, 108.6, 107.8, 83.9, 80.6, 33.0, 26.5, 26.1. HRMS (ESI): calcd for $C_{18}H_{21}O_4NNa$ ([M + Na]$^+$) 338.1362, found 338.1366. IR (KBr, $cm^{-1}$): 2979, 2931, 1731, 1614, 1495, 1471, 1364, 1194, 1017, 751.

*3-(tert-Butylperoxy)-1-methyl-3-((1-methyl-1H-indol-3-yl)-methyl)indolin-2-one (**3m**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3m** (45 mg, 60%) as a yellow oil. $^1H$ NMR (500 MHz, $CDCl_3$): $\delta$ 7.48−7.49 (d, $J$ = 8.0 Hz, 1H), 7.18−7.21 (m, 2H), 7.12−7.15 (m, 1H), 6.99−7.02 (m, 2H), 6.89−6.92 (t, $J$ = 7.0 Hz, 1H), 6.625−6.634 (t, $J$ = 4.5 Hz, 2H), 3.66 (s, 3H), 3.48−3.51 (t, $J$ = 14.0 Hz, 1H), 3.19−3.22 (t, $J$ = 14.0 Hz, 1H), 3.05 (s, 3H), 1.11 (s, 9H). $^{13}C$ NMR (126 MHz, $CDCl_3$): $\delta$ 175.1, 144.0, 136.5, 129.1, 129.0, 128.5, 128.1, 125.2, 121.8, 121.2, 119.8, 118.7, 108.7, 107.6, 106.5, 85.4, 80.3, 32.6, 30.3, 26.6, 26.0. HRMS (ESI): calcd for $C_{23}H_{26}O_3N_2Na$ ([M + Na]$^+$) 401.1835, found 401.1841. IR (KBr, $cm^{-1}$): 2977 2928, 1729, 1614, 1494, 1374, 1350, 1116, 741.

*Ethyl 2-(3-(tert-Butylperoxy)-1-methyl-2-oxoindolin-3-yl)acetate (**3n**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3n** (54 mg, 85%) as a pale yellow solid. Mp: 34−36 °C. $^1H$ NMR (500 MHz, $CDCl_3$): $\delta$ 7.31−7.39 (m, 2H), 7.02−7.05 (t, $J$ = 7.5 Hz, 1H), 6.80−6.82 (d, $J$ = 7.8 Hz, 1H), 3.83−3.95 (m, 2H), 3.21−3.25 (m, 4H), 3.10−3.13 (m, 1H), 1.09 (s, 9H), 0.98−1.01 (m, 3H). $^{13}C$ NMR (126 MHz, $CDCl_3$): $\delta$ 173.3, 168.2, 145.0, 130.1, 126.8, 124.7, 122.2, 107.9, 81.7, 80.7, 60.6, 38.4, 26.33, 26.29, 13.8. HRMS (ESI): calcd for $C_{17}H_{23}O_5NNa$ ([M+Na$^+$]): 344.1468, found 344.1465. IR (KBr, $cm^{-1}$): 2980, 2933, 1736, 1615, 1495, 1471, 1366, 1350, 1193, 1118, 1092, 1023, 755.

*Methyl 3-(tert-Butylperoxy)-1-methyl-2-oxoindoline-3-carboxylate (**3o**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3o** (44 mg, 75%) as a yellow solid. Mp: 90−92 °C. $^1H$ NMR (500 MHz, $CDCl_3$): $\delta$ 7.30−7.35 (m, 2H), 6.99−7.02 (t, $J$ = 7.5 Hz, 1H), 6.76−6.77 (d, $J$ = 7.8 Hz, 1H), 3.68 (s, 3H), 3.17 (s, 3H), 1.11 (s, 9H). $^{13}C$ NMR (126 MHz, $CDCl_3$): $\delta$ 168.7, 164.9, 143.8, 129.9, 124.3, 123.6, 121.8, 107.5, 84.1, 80.5, 52.1, 25.5, 25.3. HRMS (ESI): calcd for $C_{15}H_{19}O_5NNa$ ([M + Na]$^+$) 316.1156, found 316.1161. IR (KBr, $cm^{-1}$): 2980, 1758, 1734, 1611, 1493, 1365, 1347, 1253, 1192, 1115, 1076, 1011, 756.

*tert-Butyl (1-Benzyl-3-(tert-butylperoxy)-2-oxoindolin-3-yl)-carbamate (**3p**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3p** (73 mg, 86%) as a yellow oil. $^1H$ NMR (500 MHz, $CDCl_3$): $\delta$ 7.78−7.79 (d, $J$ = 6.5 Hz, 1H), 7.20−7.33 (m, 6H), 7.02−7.05 (t, $J$ = 7.5 Hz, 1H), 6.64−6.66 (d, $J$ = 7.5 Hz, 1H), 5.90 (s, 1H), 5.08−5.11 (d, $J$ = 16.0 Hz, 1H), 4.73−4.76 (d, $J$ = 16.0 Hz, 1H), 1.36 (s, 9H), 1.16 (s, 9H). $^{13}C$ NMR (126 MHz, $CDCl_3$): $\delta$ 170.7, 153.2, 143.1, 135.2, 130.5, 128.7, 127.6, 127.1, 122.6, 109.3, 87.3, 81.5, 80.7, 43.9, 28.1, 26.3. HRMS (ESI): calcd for $C_{24}H_{30}O_5N_2Na$ ([M + Na]$^+$) 449.2047, found 449.2048. IR (KBr, $cm^{-1}$): 2979, 2921, 1732, 1615, 1487, 1467, 1366, 1243, 1166, 1019, 1005, 753.

*2-(3-(tert-Butylperoxy)-2-oxoindolin-3-yl)acetonitrile (**3q**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to



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10/1) gave **3q** (40 mg, 77%) as a colorless oil. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 8.15 (s, 1H), 7.61−7.63 (d, $J$ = 7.5 Hz, 1H), 7.34−7.37 (m, 1H), 7.12−7.15 (m, 1H), 6.91−6.93 (d, $J$ = 7.8 Hz, 1H), 3.16−3.19 (d, $J$ = 16.7 Hz, 1H), 2.81−2.84 (d, $J$ = 16.7 Hz, 1H), 1.17 (s, 9H). $^{13}$C NMR (126 MHz, CDCl3): $\delta$ 173.2, 140.8, 131.0, 125.6, 125.5, 123.2, 114.8, 110.5, 81.8, 80.1, 26.3, 23.2. HRMS (ESI): calcd for $C_{14}H_{16}N_2O_3Na$ ([M + Na]$^+$) 283.1054; found: 283.1053. IR (KBr, cm$^{-1}$): 2984, 2931, 1728, 1616, 1470, 1243, 1194, 1119, 991, 866, 754.

*N-(2-(3-(tert-Butylperoxy)-2-oxoindolin-3-yl)ethyl)acetamide (**3r**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 10/1 to 2/1) gave **3r** (55 mg, 92%) as a colorless oil. $^1$H NMR (300 MHz, $CDCl_3$): $\delta$ 8.93 (s, 1H), 7.15−7.25 (m, 2H), 6.95−7.00 (t, $J$ = 7.4 Hz, 1H), 6.79−6.81 (d, $J$ = 7.7 Hz, 1H), 6.31 (s, 1H), 3.35−3.36 (m, 2H), 2.10−2.21 (m, 1H), 1.98−2.05 (m, 1H), 1.84 (s, 3H), 1.04 (s, 9H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 176.9, 170.0, 141.2, 129.9, 128.6, 124.8, 122.7, 110.4, 84.4, 80.8, 34.3, 26.5, 23.3. HRMS (ESI): calcd for $C_{16}H_{22}O_4N_2Na$ ([M + Na]$^+$) 329.1472, found 329.1477. IR (KBr, cm$^{-1}$): 3353, 2921, 2849, 1728, 1655, 1614, 1551, 1470, 1364, 1303, 1194, 1119, 754.

*3-Benzyl-3-(tert-butylperoxy)-5-chloroindolin-2-one (**3s**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 10/1 to 5/1) gave **3s** (62 mg, 90%) as a white solid. Mp: 173−175 °C. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.52 (br, 1H), 7.15−7.20 (m, 4H), 7.00−7.01 (m, 2H), 6.94 (s, 1H), 6.61−6.62 (d, $J$ = 8.2 Hz, 1H), 3.29−3.31 (d, $J$ = 13.2 Hz, 1H), 3.05−3.08 (d, $J$ = 13.2 Hz, 1H), 1.15 (s, 9H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 175.9, 139.4, 132.9, 130.7, 129.3, 128.0, 127.4, 127.2, 125.9, 110.6, 85.5, 80.9, 40.3, 26.5. HRMS (ESI): calcd for $C_{19}H_{20}O_3NCl$ ([M − H]$^-$) 344.1059, found 344.1053. IR (KBr, cm$^{-1}$): 3247, 2981, 2928, 1733, 1618, 1473, 1455, 1364, 1193, 817, 736, 699.

*5-Bromo-3-(tert-butylperoxy)-3-methylindolin-2-one (**3t**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 10/1 to 5/1) gave **3t** (60 mg, 96%) as a white solid. Mp: 98−101 °C. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 8.52 (s, 1H), 7.43 (d, $J$ = 1.5 Hz, 1H), 7.37−7.39 (dd, $J$ = 8.2, 1.8 Hz, 1H), 6.76−6.78 (d, $J$ = 8.2 Hz, 1H), 1.53 (s, 3H), 1.13 (s, 9H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 176.0, 138.6, 131.2, 126.4, 114.1, 110.5, 81.1, 79.7, 25.4, 19.2. HRMS (ESI): calcd for $C_{13}H_{15}O_3NBr$ ([M − H]$^-$) 312.0241, found 312.0236. IR (KBr, cm$^{-1}$): 3238, 2966, 1690, 1533, 1379, 1283, 1117, 991, 863, 841, 755.

*2-(3-(tert-Butylperoxy)-5-methyl-2-oxoindolin-3-yl)acetonitrile (**3u**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 10/1 to 5/1) gave **3u** (37 mg, 68%) as a pale yellow oil. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 8.34 (s, 1H), 7.41 (s, 1H), 7.14−7.15 (dd, $J$ = 0.5, 8.0 Hz, 1H), 6.80−6.82 (d, $J$ = 8.0 Hz, 1H), 3.15−3.18 (d, $J$ = 16.5 Hz, 1H), 2.80−2.83 (d, $J$ = 16.5 Hz, 1H), 2.36 (s, 3H), 1.18 (s, 9H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 173.8, 138.5, 132.8, 131.4, 126.1, 125.5, 114.9, 110.4, 81.7, 80.4, 26.3, 23.2, 21.1. HRMS (ESI): calcd for $C_{15}H_{17}O_3N_2$ ([M − H]$^-$) 273.1245, found 273.1241. IR (KBr, cm$^{-1}$): 3277, 2980, 2923, 2852, 1735, 1628, 1493, 1389, 1300, 1193, 1091, 817, 735.

*tert-Butyl (1-Benzyl-3-(tert-butylperoxy)-5-methoxy-2-oxoindolin-3-yl)carbamate (**3v**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 10/1 to 5/1) gave **3v** (82 mg, 89%) as a white solid. Mp: 141−143 °C. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.37 (s, 1H), 7.16−7.25 (m, 6H), 6.66−6.68 (dd, $J$ = 8.5, 2.7 Hz, 1H), 6.45−6.47 (d, $J$ = 8.5 Hz, 1H), 5.79 (s, 1H), 4.98−5.01 (d, $J$ = 15.9 Hz, 1H), 4.65−4.68 (d, $J$ = 15.9 Hz, 1H), 3.69 (s, 3H), 1.30 (s, 9H), 1.10 (s, 9H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 169.4, 154.7, 152.2, 135.4, 134.3, 127.7, 126.5, 126.1, 114.2, 108.7, 86.5, 80.5, 79.6, 54.8, 42.9, 27.1, 25.3. HRMS (ESI): calcd for $C_{25}H_{32}O_6N_2Na$ ([M + Na]$^+$) 479.2153, found 479.2152. IR (KBr, cm$^{-1}$): 3356, 2964, 2922, 1734, 1604, 1492, 1365, 1260, 1075, 1023, 866, 799, 733, 696.

*3-Benzyl-3-(tert-butylperoxy)-6-chloro-1-methylindolin-2-one (**3w**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3w** (69 mg, 97%) as a yellow oil. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.15−7.17 (m, 3H), 6.92−7.00 (m, 3H), 6.82−6.84 (d, $J$ = 7.9 Hz, 1H), 6.63−6.64 (d, $J$ = 1.4 Hz, 1H), 3.31−3.34 (d, $J$ = 13.2 Hz, 1H), 3.00−3.03 (m, 4H), 1.12 (s, 9H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 174.4, 145.1, 135.1, 133.3, 130.6, 127.8, 127.0, 126.1, 125.6, 121.8, 108.6, 85.0, 80.7, 40.4, 26.5, 26.1. HRMS (ESI): calcd for $C_{20}H_{22}O_3NClNa$ ([M + Na]$^+$) 382.1180, found 382.1179. IR (KBr, cm$^{-1}$): 2980, 2926, 1737, 1610, 1495, 1468, 1370, 1193, 1070, 1051, 737, 699.

*3-Benzyl-3-(tert-butylperoxy)-7-chloroindolin-2-one (**3x**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 10/1 to 5/1) gave **3x** (55 mg, 81%) as a pale yellow oil. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.36 (s, 1H), 7.14−7.23 (m, 4H), 6.99−7.07 (m, 2H), 6.87−6.90 (t, $J$ = 7.8 Hz, 1H), 6.79−6.80 (d, $J$ = 7.4 Hz, 1H), 3.33−3.35 (d, $J$ = 13.4 Hz, 1H), 3.02−3.05 (d, $J$ = 13.4 Hz, 1H), 1.14 (s, 9H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 175.0, 138.4, 133.1, 130.8, 129.2, 129.1, 127.9, 127.2, 123.9, 122.8, 114.7, 86.1, 80.9, 40.4, 26.5. HRMS (ESI): calcd for $C_{19}H_{20}O_3NCl$ ([M − H]$^-$) 344.1059, found 344.1053. IR (KBr, cm$^{-1}$): 3245, 2988, 2928, 1733, 1618, 1473, 1455, 1364, 1193, 817, 738, 699.

*3-Methyl-3-((2-phenylpropan-2-yl)peroxy)indolin-2-one (**3y**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3y** (52 mg, 87%) as a pale yellow solid. Mp: 140−142 °C. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 8.36 (s, 1H), 7.23−7.29 (m, 6H), 7.19−7.21 (m, 1H), 7.05−7.08 (t, $J$ = 7.5 Hz, 1H), 6.89−6.90 (d, $J$ = 7.7 Hz, 1H), 1.53 (s, 3H), 1.48 (s, 3H), 1.40 (s, 3H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 177.4, 145.3, 140.6, 130.1, 129.5, 127.9, 126.9, 125.4, 124.2, 122.6, 110.0, 83.2, 82.5, 27.3, 26.5, 20.3. HRMS (ESI): calcd for $C_{18}H_{19}O_3NNa$ ([M + Na]$^+$) 320.1257, found 320.1254. IR (KBr, cm$^{-1}$): 3254, 2983, 2930, 1729, 1622, 1485, 1472, 1200, 1144, 1104, 752, 713.

*3-Benzyl-1-methyl-3-((2-phenylpropan-2-yl)peroxy)indolin-2-one (**3z**).* Silica gel column chromatography (petroleum ether/ethyl acetate = 15/1 to 10/1) gave **3z** (65 mg, 85%) as a yellow oil. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.20−7.33 (m, 6H), 7.09−7.13 (m, 1H), 7.04−7.07 (t, $J$ = 7.3 Hz, 2H), 6.96−6.99 (t, $J$ = 7.5 Hz, 1H), 6.89−6.90 (d, $J$ = 7.3 Hz, 1H), 6.85−6.87 (d, $J$ = 7.2 Hz, 2H), 6.63−6.64 (d, $J$ = 7.8 Hz, 1H), 3.20−3.24 (m, 1H), 3.04 (s, 3H), 2.98−3.00 (d, $J$ = 13.1 Hz, 1H), 1.54 (s, 3H), 1.42 (s, 3H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 174.4, 145.3, 143.9, 133.4, 130.6, 129.4, 127.9, 127.6, 127.1, 126.9, 126.8, 125.6, 125.0, 122.0, 107.7, 85.9, 83.3, 40.5, 27.2, 26.6, 26.0. HRMS (ESI): calcd for $C_{25}H_{25}O_3NNa$ ([M + Na]$^+$) 410.1726, found 410.1723. IR (KBr, cm$^{-1}$): 3059, 3030, 2982, 2932, 1730, 1614, 1494, 1470, 751, 698.

**Procedure for the Preparation of Compound 4.** To a solution of peroxide **3a** (71 mg, 0.3 mmol) in $CH_2Cl_2$ (10 mL) was added Amberlyst 15 (60 mg) at room temperature. The resulting reaction mixture was monitored with a TLC plate until all the starting material was consumed. As the product **4** was slightly soluble in $CH_2Cl_2$, the reaction mixture was turbid. The mixture was filtered, and the filter cake was washed with $CH_3CN$ to remove the Amberlyst. The combined filtrate was concentrated in vacuo and then purified by chromatography on silica gel (petroleum ether/ethyl acetate = 5/1 to 1/1) as the eluent to give the desired product.

*3-Hydroperoxy-3-methylindolin-2-one (**4**).* White solid (48 mg, 90%). Mp: 150−154 °C. $^1$H NMR (500 MHz, MeOD): $\delta$ 6.96−6.97 (d, $J$ = 3.5 Hz, 3H), 6.91−6.92 (m, 1H), 1.71 (s, 3H). $^{13}$C NMR (126 MHz, MeOD): $\delta$ 165.5, 141.8, 127.0, 123.2, 122.1, 117.2, 115.1, 95.5, 22.1. HRMS (ESI): calcd for $C_9H_8O_3N$ ([M − H]$^-$) 178.0504, found 178.0497. IR (KBr, cm$^{-1}$): 3315, 3068, 1691, 1502, 1132, 937, 756, 622.

**General Procedure for the Preparation of Compounds 5.** To a solution of hydroperoxide **4** (54 mg, 0.3 mmol) and RCl (0.45 mmol) in anhydrous THF (10 mL) was added $Et_3N$ dropwise with stirring under $N_2$ while the temperature was maintained below 15 °C. The reaction mixture was then allowed to stand at 50 °C and monitored with a TLC plate to ensure complete reaction. After completion of the reaction, the mixture was concentrated in a rotary evaporator, and the residue was purified by silica gel column chromatography with petroleum ether and ethyl acetate as the eluent to provide the desired products.

*3-Methyl-2-oxoindolin-3-yl benzoperoxoate (**5a**).* White solid (76 mg, 90%). Mp: 115−117 °C. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 9.13 (s, 1H), 8.41−8.43 (d, $J$ = 8.1 Hz, 1H), 8.26−8.28 (d, $J$ = 7.8 Hz, 2H), 7.70−7.73 (t, $J$ = 7.4 Hz, 1H), 7.58−7.61 (t, $J$ = 7.7 Hz, 2H), 7.24−


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7.41 (m, 3H), 2.55 (s, 3H). $^{13}$C NMR (126 MHz, $CDCl_3$): δ 196.8, 164.2, 157.4, 140.8, 134.3, 130.3, 128.9, 128.6, 128.5, 126.6, 125.4, 122.5, 121.2, 23.9. HRMS (ESI): calcd for $C_{16}H_{13}O_4NNa$ ([M + Na]$^+$) 306.0736, found 306.0733. IR (KBr, cm$^{-1}$): 3381, 2923, 1746, 1702, 1608, 1532, 1451, 1358, 1261, 1233, 1177, 1103, 1055, 1022, 753, 706.

*3-Methyl-2-oxoindolin-3-yl 2-Methylprop-2-eneperoxoate (**5b**).* Yellow oil (59 mg, 80%). $^1$H NMR (500 MHz, $CDCl_3$): δ 9.03 (s, 1H), 8.37−8.39 (d, *J* = 8.5 Hz, 1H), 7.26−7.30 (m, 2H), 7.18−7.21 (m, 1H), 6.45 (s, 1H), 5.87 (s, 1H), 2.56 (s, 3H), 2.13 (s, 3H). $^{13}$C NMR (126 MHz, $CDCl_3$): δ 196.9, 164.7, 157.3, 140.6, 135.2, 128.50, 128.48, 126.5, 125.3, 122.3, 120.9, 24.0, 18.5. HRMS (ESI): calcd for $C_{13}H_{14}O_4N$ ([M + H]$^+$) 248.0917, found 248.0920. IR (KBr, cm$^{-1}$): 3382, 2927, 1744, 1704, 1636, 1532, 1456, 1358, 1256, 1180, 1115, 753.

*3-Methyl-2-oxoindolin-3-yl 4-Methylbenzenesulfonoperoxoate (**5c**).* Yellow oil (68 mg, 68%). $^1$H NMR (500 MHz, $CDCl_3$): δ 8.98 (s, 1H), 8.25−8.26 (d, *J* = 8.2 Hz, 1H), 7.76−7.78 (d, *J* = 8.1 Hz, 2H), 7.24−7.32 (m, 4H), 7.13−7.16 (t, *J* = 7.8 Hz, 1H), 2.49 (s, 3H), 2.44 (s, 3H). $^{13}$C NMR (126 MHz, $CDCl_3$): δ 196.0, 157.3, 146.1, 139.3, 131.8, 130.1, 129.5, 128.6, 127.9, 125.5, 123.4, 121.6, 23.9, 21.7. HRMS (ESI): calcd for $C_{16}H_{16}O_5NS$ ([M + H]$^+$) 334.0743, found 334.0744. IR (KBr, cm$^{-1}$): 3379, 2921, 1704, 1529, 1453, 1379, 1358, 1194, 1181, 1087, 870, 805, 768, 713, 661, 564, 548.

*3-Methyl-2-oxoindolin-3-yl Diphenyl Phosphoroperoxoate (**5d**).* Yellow oil (113 mg, 92%). $^1$H NMR (500 MHz, $CDCl_3$): δ 9.25 (s, 1H), 8.34−8.36 (d, *J* = 8.2 Hz, 1H), 7.42−7.53 (m, 1H), 7.34−7.37 (t, *J* = 7.9 Hz, 4H), 7.19−7.31 (m, 7H), 7.14−7.17 (m, 1H), 2.52 (s, 3H). $^{13}$C NMR (126 MHz, $CDCl_3$): δ 196.2, 157.7, 150.2, 150.1, 140.4, 140.3, 130.0, 128.0, 127.9, 126.3, 125.9, 125.6, 121.7, 120.3, 120.2, 120.1, 120.0, 24.0. HRMS (ESI): calcd for $C_{21}H_{19}O_6NP$ ([M + H]$^+$) 412.0944, found 412.0943. IR (KBr, cm$^{-1}$): 3379, 2920, 1702, 1590, 1488, 1355, 1302, 1183, 960, 753, 688.

*3-Methyl-3-((trimethylsilyl)peroxy)indolin-2-one (**5e**).* White solid (63 mg, 85%). Mp: 79−80 °C. $^1$H NMR (400 MHz, $CDCl_3$): δ 9.09 (s, 1H), 6.88−7.00 (m, 4H), 1.82 (s, 3H), 0.09 (s, 10H). $^{13}$C NMR (101 MHz, $CDCl_3$): δ 163.9, 140.1, 125.1, 122.4, 121.3, 116.3, 114.1, 95.7, 22.6, 0.02. HRMS (ESI): calcd for $C_{12}H_{18}NO_3Si$ ([M + H]$^+$) 252.1050, found 252.1056. IR (KBr, cm$^{-1}$): 3212, 2960, 1698, 1503, 1377, 1253, 1176, 1117, 1102, 997, 862, 844, 751.

**General Procedure for the Preparation of Compound 6.** A solution of **3r** (60 mg, 0.2 mmol) and Pd/C (10%, 20 mg in MeOH (6 mL)) was stirred under a hydrogen atmosphere (1 bar) at room temperature for 12 h. The mixture was filtered over Celite, the solvent was removed in vacuo, and the resulting residue was purified by chromatography on silica gel (ethyl acetate/MeOH = 5/1) to afford the desired product **6** (46 mg, 97%) as a colorless solid.

*N-[2-(3-Hydroxy-2-oxo-2,3-dihydro-1H-indol-3-yl)ethyl]-acetamide (**6**).*[16] Colorless solid (46 mg, 97%). $^1$H NMR (500 MHz, DMSO): δ 10.31 (s, 1H), 7.76 (s, 1H), 7.31 (d, *J* = 7.2 Hz, 1H), 7.26 (t, *J* = 7.5 Hz, 1H), 7.03 (t, *J* = 7.4 Hz, 1H), 6.86 (d, *J* = 7.6 Hz, 1H), 5.99 (s, 1H), 2.88−3.07 (m, 2H), 1.90−1.96 (m, 2H), 1.75 (s, 3H). $^{13}$C NMR (126 MHz, DMSO): δ 178.3, 168.1, 140.8, 131.1, 128.3, 123.2, 120.9, 108.9, 73.7, 36.6, 32.9, 21.8. HRMS (ESI): calcd for $C_{12}H_{14}N_2O_3Na$ ([M + Na]$^+$) 257.0897, found 257.0915. IR (KBr, cm$^{-1}$): 3288, 2972, 2874, 1720, 1622, 1555, 1472, 1369, 1299, 1221, 1187, 1100, 1053, 754, 645, 599.

## ■ ASSOCIATED CONTENT

### Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.joc.6b00622.

General methods, investigation of the solvent effect, X-ray crystallography details for oxindole **3h**, comparison of NMR data for synthetic (±)-**6** with those of the natural product, and $^1$H NMR and $^{13}$C NMR spectra of all products (PDF)

X-ray crystallographic data for **3h** (CIF)

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### Notes

The authors declare no competing financial interest.

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