Supporting Information

© Copyright Wiley-VCH Verlag GmbH & Co. KGaA, 69451 Weinheim, 2014

Rapid Assembly of Functionalised Spirocyclic Indolines by Palladium-Catalysed Dearomatising Diallylation of Indoles with Allyl Acetate

Persis Dhankher, Laure Benhamou, and Tom D. Sheppard

chem_201403940_sm_miscellaneous_information.pdf
# Table of contents

1. GENERAL METHODS .................................................................................................................. 2

2. SYNTHESIS OF SUBSTITUTED 3,3-DIALYL-3H-INDOLES ....................................................... 3

3. UGI REACTIONS .......................................................................................................................... 12

4. SYNTHESIS OF SUBSTITUTED 3,3-DIALYL-2-HYDROXYINDOLINE ................................... 20

5. SYNTHESIS OF 2,3-DIALYLINDOLES ..................................................................................... 23

6. (L)-PROLINE CATALYSED ASYMMETRIC MANNICH REACTION ...................................... 26

7. RING CLOSING METATHESIS REACTIONS OF UGI COMPOUNDS ................................... 28

8. RING CLOSING METATHESIS REACTIONS OF SUBSTITUTED 3,3-DIALYL-2- HYDROXYINDOLINES .................................................................................................................. 32

9. PREPARATION OF DIHYDRO-1H-CARBAZOLE BY RING CLOSING METATHESIS ............ 33

10. REFERENCES ............................................................................................................................ 34

11. SPECTRA .................................................................................................................................... 35

   Synthesis of substituted 3,3-diallyl-3H-indole ........................................................................... 35
   UGI reactions ............................................................................................................................ 51
   Synthesis of substituted 3,3-diallyl-2-hydroxyindoline .............................................................. 66
   Synthesis of 2,3-diallylindoles .................................................................................................. 71
   (L)-Proline catalysed asymmetric Mannich reaction ............................................................... 76
   Ring closing metathesis reaction on UGI compounds ............................................................... 79
   Ring closing metathesis reaction on substituted 3,3-diallyl-2-hydroxyindoline ....................... 85
   (L)-Proline catalysed asymmetric Mannich reaction: HPLC data ........................................... 87
   Solvent screening ..................................................................................................................... 88
   Substrate scope ....................................................................................................................... 88
   Chiral HPLC chromatograms of Mannich products .................................................................. 89
1. General methods

All chemicals were purchased from Sigma-Aldrich, Acros, Alfa Aesar, Santa Cruz Biotechnology and used without further purification. 1-allyl-1H-indole 5a, 3-allyl-1H-indole 4a, 1,3-diallyl-1H-indole 6a were synthesized according to literature procedures.\(^1\) Anhydrous Tetrahydrofuran, Dichloromethane and Acetonitrile were purchased from Fisher Scientific. All other solvents used as received. PE refers to Petroleum Ether. Flash column chromatography was carried out using normal phase silica gel (33-70 μm) supplied by VWR. Thin layer chromatography was carried out using Merck TLC Silica gel 60 F\(_{254}\) plates and products were visualized using combinations of UV light (254 nm) and potassium permanganate (KMnO\(_4\)) when required. \(^1\)H NMR spectra were recorded at 400 or 600 MHz on a Bruker AMX400 and AMX600 spectrometer using the residual protic solvent CDCl\(_3\) (\(\delta = 7.26\) ppm, s) as the internal standard. Chemical shifts are quoted in ppm to the nearest 0.01 ppm using the following abbreviations: s (singlet), d, (doublet), t (triplet), q, (quartet), qn (quintet), sext (sextet), dd (doublet of doublets), dt (doublet of triplets), m (multiplet) defined as all multi-peak signals where overlap or complex coupling of signals makes definitive descriptions of peaks difficult. The coupling constants \(J\) are measured in Hz. \(^{13}\)C\(\{^1\)H\}\) NMR spectra were recorded at 100 or 150 MHz on a Bruker AMX400 and AMX600 at 25°C in CDCl\(_3\) as described below. All chemical shifts were referenced with CDCl\(_3\) solvent (\(\delta = 77.0\) ppm, t) as the internal standard. Chemical shifts are reported to the nearest 0.1 ppm. Coupling constants are defined as \(J\) and quoted in Hz. Mass spectra were performed in the Department of Chemistry, University College London. Infrared spectra were obtained on a Perkin Elmer Spectrum 100 FT-IR Spectrometer operating in ATR mode. Melting points were measured with a Gallenkamp apparatus and are uncorrected. The enantiomeric excess were determined using a Varian ProStar and PrepStar HPLC, with a UV detector system at 254 nm with a CHIRALPAK-AD column (Daicel; Chemical Industries, LTD) 25 × 0.46 cm. Optical rotation \([\alpha]_D^o\) values are given in 10\(^{-1}\)deg cm\(^2\) g\(^{-1}\), concentration (c) in g/100 mL and were measured on a Perkin-Elmer 343 polarimeter.
2. Synthesis of substituted 3,3-diallyl-3H-indoles

**General procedure A:** The indole (1 eq.), [Pd(allyl)Cl]$_2$ (2.5 mol%), DPEPhos (5 mol%), K$_2$CO$_3$ (3 eq.) were placed in an oven dried carousel tube. After three vacuum/Ar cycles, acetonitrile (C = 0.025 mol/L) and allyl acetate (5 eq.) were successively added. The heterogeneous mixture was stirred at room temperature for 18-14 h before addition of water. The solution was extracted with Et$_2$O and washed with water. The combined organic layers were dried with Na$_2$SO$_4$, filtered and volatiles were removed under vacuum. Purification by flash chromatography on SiO$_2$ gave the corresponding 3,3-diallyl-3H-indole compound.

**3,3-Diallyl-3H-indole (3a)**

The product was obtained by following the General procedure A. The crude residue was purified by column chromatography on SiO$_2$ using a mixture of PE/EtOAc (100/0 to 90/10) as eluent. The product was obtained as pale orange oil (70 mg, 82%). R$_f$ = 0.64 (PE/EtOAc 1/1); $^1$H NMR (600 MHz, CDCl$_3$) $\delta$ 8.05 (br s, 1H, H$_2$), 7.62 (d, 1H, $J$ = 7.1 Hz, H$_7$), 7.35 (td, 1H, $J$ = 7.1, 1.1 Hz, H$_6$), 7.31 (brd, 1H, $J$ = 7.1 Hz, H$_4$), 7.26 (br t, 1H, $J$ = 7.1 Hz, H$_5$), 5.44 (ddt, 2H, $J$ = 17.1, 10.1, 7.3 Hz, =CH), 5.01 (dd, 2H, $J$ = 17.1, 1.1 Hz, =CH$_2$), 4.95 (dd, 2H, $J$ = 10.1, 1.1 Hz, =CH$_2$), 2.57 (dd, 2H, $J$ = 13.9, 7.3 Hz, CH$_2$ allyl), 2.52 (dd, 2H, $J$ = 13.9, 7.3 Hz, CH$_2$ allyl); $^{13}$C($^1$H) NMR (150 MHz, CDCl$_3$) $\delta$ 177.9 (CH), 155.6 (C$_q$), 141.4 (C$_q$), 132.5 (CH), 128.0 (CH), 126.1 (CH), 122.4 (CH), 121.3 (CH), 118.8 (CH$_2$), 60.9 (C$_q$), 38.6 (CH$_2$); HRMS (EI) calcd. for C$_{14}$H$_{15}$N $[M]^+$ 197.1199, found 197.1194; FT-IR (ATR) $\nu$ = 3074 (CH), 2978 (CH), 1600 (N=CH), 1559, 1475 cm$^{-1}$. Data in accordance with the literature.$^2$

**3,3-Diallyl-5,6-dimethoxy-3H-indole (3b)**

The product was obtained by following the General procedure A. The crude residue was purified by column chromatography on SiO$_2$ using a mixture of PE/EtOAc (100/0 to 90/10) as eluent. The product was obtained as a yellow oil (169 mg, 88%); R$_f$ = 0.44 (PE/EtOAc 4/1); $^1$H NMR (600 MHz, CDCl$_3$) $\delta$ 7.94 (s, 1H, H$_2$), 7.20 (s, 1H, H$_7$), 6.81 (s, 1H, H$_4$), 5.42 (ddt, 2H, $J$ = 17.0, 10.2, 7.3 Hz, =CH), 5.00 (dq, 2H, $J$ =
17.0, 1.1 Hz, =CH₂), 4.95 (dq, 2H, J = 10.2, 1.1 Hz, =CH₂), 3.92 (s, 3H, OCH₃), 3.90 (s, 3H, OCH₃), 2.53 (ddt, 2H, J = 13.9, 7.3, 1.1 Hz, CH₂ allyl), 2.48 (ddt, 2H, J = 13.9, 7.3, 1.1 Hz, CH₂ allyl); ¹³C{¹H} NMR (150 MHz, CDCl₃) δ 176.8 (CH), 149.1 (C₆), 148.8 (C₆), 148.0 (C₆), 133.3 (C₆), 132.6 (CH), 118.7 (=CH₂), 105.6 (CH), 104.9 (CH), 61.3 (C₆), 56.5 (CH₃), 56.2 (CH₃), 38.8 (CH₂); HRMS (Cl) calcd. for C₁₆H₂₆NO₂ [M+H]⁺ 258.1488, found 258.1484; FT-IR (ATR) ν = 3075 (CH), 2938 (CH), 1600 (N=C), 1465, 1442, 1305, 1214 cm⁻¹.

3, 3-Diallyl-5-methyl-3H-indole (3c)

The product was obtained by following the General procedure A. The crude residue was purified by column chromatography on SiO₂ using a mixture of PE/EtOAc (100/0 to 90/10) as eluent. The product was obtained as a brown oil (212 mg, 66%); Rₕ = 0.49 (PE/EtOAc 4/1); ¹H NMR (600 MHz, CDCl₃) δ 7.97 (s, 1H, H₆), 7.49 (d, 1H, J = 7.9 Hz, H₇), 7.14 (dd, 1H, J = 7.9, 1.3 Hz, H₈), 7.11 (d, 1H, J = 1.3 Hz, H₉), 5.44 (ddt, 2H, J = 17.1, 10.2, 7.3 Hz, =CH₂), 5.01 (dq, 2H, J = 17.1, 1.4 Hz, =CH₂), 4.96 (dd, 2H, J = 10.2, 1.4 Hz, =CH₂), 2.54 (ddt, 2H, J = 14.0, 7.3, 1.4 Hz, CH₂ allyl), 2.49 (ddt, 2H, J = 14.0, 7.3, 1.4 Hz, CH₂ allyl), 2.41 (s, 3H, CH₃); ¹³C{¹H} NMR (150 MHz, CDCl₃) δ 176.9 (CH), 153.5 (C₆), 141.7 (C₆), 136.0 (C₆), 132.6 (CH), 128.7 (CH), 123.1 (CH), 120.8 (CH), 118.7 (=CH₂), 60.9 (C₆), 38.8 (CH₂), 21.2 (CH₃); HRMS (EI) calcd for C₁₅H₁₇N [M⁺]⁺ 211.1355, found 211.1349; FT-IR (ATR) ν = 3077 (CH), 2921 (CH), 1640 (N=C), 1556, 1465 cm⁻¹.

3,3-Diallyl-5-methoxy-3H-indole (3d)

The product was obtained by following the General procedure A. The crude residue was purified by column chromatography on SiO₂ using a mixture of PE/EtOAc (100/0 to 80/20) as eluent. The product was obtained as orange oil (233 mg, 76%). Rₕ = 0.22 (PE/EtOAc 4/1); ¹H NMR (600 MHz, CDCl₃) δ 7.91 (s, 1H, H₆), 6.86 (dd, 1H, J = 8.3, 2.2 Hz, H₇), 6.84 (d, 1H, J = 2.2 Hz, H₈), 5.45 (ddt, 2H, J = 17.0, 10.1, 7.2 Hz, =CH₂), 5.02 (dq, 2H, J = 17.0, 1.1 Hz, =CH₂), 4.96 (dd, 2H, J = 10.1, 1.1 Hz, =CH₂), 3.84 (s, 3H, OCH₃), 2.54 (ddt, 2H, J = 13.9, 7.2, 1.1 Hz, CH₂ allyl), 2.49 (ddt, 2H, J = 13.9, 7.2, 1.1 Hz, CH₂ allyl); ¹³C{¹H} NMR (150 MHz, CDCl₃) δ 175.8 (CH), 158.6 (C₆), 149.4 (C₆), 143.2 (C₆), 132.5 (CH), 121.6 (CH), 118.8 (=CH₂), 112.4 (CH), 109.2 (CH), 61.0 (C₆), 55.9 (CH₃), 38.8 (CH₂); HRMS (EI) calcd. for C₁₅H₁₇NO [M⁺]⁺ 227.1310, found 227.1303; FT-IR (ATR) ν = 3074 (CH), 2921 (CH), 1591 (N=C), 1500, 1437, 1264 cm⁻¹.
3,3-Diallyl-4-methyl-3H-indole (3e)

The product was obtained by following the General procedure A. The crude residue was purified by column chromatography on SiO₂ using a mixture of PE/EtOAc (100/0 to 70/30) as eluent. The product was obtained as a brown oil (185 mg, 57%); Rf = 0.47 (PE/EtOAc 4/1); ¹H NMR (600 MHz, CDCl₃) δ 8.04 (s, 1H, H₂), 7.16 (m, 2H, H₅,₇), 7.12 (m, 1H, H₆), 5.45 (ddt, 2H, J = 17.2, 10.0, 7.3 Hz, =CH₂), 5.01 (dq, 2H, J = 17.2, 1.4 Hz, =CH₂), 4.96 (ddt, 2H, J = 14.0, 7.3, 1.4 Hz, CH₂allyl), 2.49 (ddt, 2H, J = 14.0, 7.3, 1.4 Hz, CH₂allyl); ¹³C{¹H} NMR (150 MHz, CDCl₃) δ 176.7 (CH), 154.1 (C₆), 141.4 (C₄), 132.7 (CH), 130.9 (C₄), 129.4 (CH), 126.1 (CH), 119.8 (CH), 118.7 (=CH₂), 61.1 (C₇), 38.7 (CH₃), 17.0 (CH₃); HRMS (EI) calcd. for C₁₃H₁₈N [M⁺] 211.1355, found 211.1359; FT-IR (ATR) ν = 3076 (CH), 2921 (CH), 1640 (N=C), 1558, 1439 cm⁻¹.

3,3-Diallyl-5-benzyloxy-3H-indole (3f)

The product was obtained by following the General procedure A. The crude residue was purified by column chromatography on SiO₂ using a mixture of PE/EtOAc (100/0 to 70/30) as eluent. The product was obtained as orange oil (196 mg, 76%). Rf = 0.29 (PE/EtOAc 4/1); ¹H NMR (600 MHz, CDCl₃) δ = 7.92 (s, 1H, H₂), 7.52 (d, 1H, J = 8.4 Hz, H₇), 7.45 (br d, 2H, J = 7.3 Hz, CH₃-Bn), 7.40 (t, 2H, J = 7.3 Hz, CH₃-Bn), 7.34 (td, 1H, J = 7.3, 1.4 Hz, CH₃-P-Bn), 6.95 (dd, 1H, J = 8.4, 2.5 Hz, H₆), 6.92 (d, 1H, J = 2.5 Hz, H₄), 5.43 (ddt, 2H, J = 17.1, 10.5, 7.4 Hz, =CH₂), 5.08 (s, 2H, OCH₂), 5.00 (dq, 2H, J = 17.1, 1.4 Hz, =CH₂), 4.96 (br d, 2H, J = 10.5 Hz, =CH₂), 2.53 (dd, 2H, J = 14.1, 7.4 Hz, CH₂allyl), 2.48 (dd, 2H, 14.1, 7.4 Hz, CH₂allyl); ¹³C{¹H} NMR (150 MHz, CDCl₃) δ 175.9 (CH), 157.7 (C₆), 154.1 (C₅), 143.2 (C₄), 137.0 (C₇), 132.4 (CH), 128.7 (CH), 128.2 (CH), 127.7 (CH), 121.6 (CH), 118.9 (=CH₂), 113.6 (CH), 110.2 (CH), 70.7 (CH₂), 61.1 (C₇), 38.8 (CH₂); HRMS (EI) calcd. for C₂₃H₂₁NO [M⁺] 303.1617 found, 303.1612; FT-IR (ATR) ν = 3076 (CH), 2910 (CH), 1590 (N=C), 1580, 1575, 1181, 1022 cm⁻¹.

3,3-Diallyl-3,6,7,8-tetrahydrocyclopenta-3H-indole (3g)

The product was obtained by following the General procedure A. The crude residue was purified by column chromatography on SiO₂ using a mixture of PE/EtOAc (100/0 to 80/20) as eluent. The title compound was obtained as a yellow oil (152 mg, 50%); Rf = 0.31 (PE/EtOAc 4/1); ¹H NMR (600 MHz, CDCl₃) δ 8.03 (br s, 1H, H₂), 7.12 (d, 1H, J = 7.5 Hz, H₆), 7.08 (d, 1H, J = 7.5 Hz, H₅), 5.47 (ddt, 2H, J = 17.1, 10.0, 7.2 Hz, =CH₂), 5.02 (dd, 2H, J = 17.1, 10.0, 7.2 Hz, =CH₂), 4.96 (ddt, 2H, J = 14.0, 7.3, 1.4 Hz, CH₂allyl); HRMS (EI) calcd. for C₂₃H₂₁NO [M⁺] 303.1617 found, 303.1612; FT-IR (ATR) ν = 3076 (CH), 2910 (CH), 1590 (N=C), 1580, 1575, 1181, 1022 cm⁻¹.
= 17.1, 1.2 Hz, H=CH₂), 4.96 (d, 2H, J = 10.0 Hz, =CH₂), 3.19 (t, 2H, J = 7.5 Hz, C₆H₂), 2.96 (t, 2H, J = 7.5 Hz, C₆H₂), 2.70 (dd, 2H, J = 13.4, 7.2 Hz, CH₂(allyl)), 2.49 (dd, 2H, J = 13.8, 7.2 Hz, CH₂(allyl)), 2.16 (quintet, 2H, J = 7.2 Hz, CH₂), 13C{¹H} NMR (150 MHz, CDCl₃) δ 177.8 (CH), 151.4 (C₆), 145.4 (C₆), 139.4 (C₆), 136.6 (C₆), 132.8 (CH), 122.7 (CH), 120.1 (CH), 118.6 (=CH₂), 60.6 (C₆), 38.9 (CH₂), 33.0 (CH₂), 30.0 (CH₂), 25.7 (CH₂); HRMS (ES) C₁₇H₂₃N [M+H]^+ 238.1590, found 238.1590; FT-IR (ATR) ν = 3078 (CH), 2951 (CH), 1639 (N=C), 1553, 1438 cm⁻¹.

3,3-Diallyl-4-bromo-3H-indole (3h)

![3,3-Diallyl-4-bromo-3H-indole (3h)](image)

The product was obtained by following the **General procedure A** with slight modifications. The reaction was conducted at 50 °C for 24 hours. The crude residue was purified by column chromatography on SiO₂ using a mixture of PE/EtOAc (100/0 to 90/10) as eluent. The product was obtained as a purple oil (159 mg, 56%); Rf = 0.41 (PE/EtOAc 4/1); ³¹H NMR (600 MHz, CDCl₃) δ 8.02 (s, 1H, H₂), 7.53 (d, 1H, J = 7.7 Hz, H₅), 7.36 (d, 1H, J = 7.7 Hz, H₅), 7.21 (t, 1H, J = 7.7 Hz, H₆), 5.24 (ddt, 2H, J = 16.9, 10.2, 7.7 Hz, =CH₂), 5.02 (d, 2H, J = 16.9 Hz, =CH₂), 4.85 (d, 2H, J = 10.2 Hz, =CH₂), 2.99 (dd, 2H, J = 13.9, 7.7 Hz, CH₂(allyl)), 2.78 (dd, 2H, J = 13.9, 7.7 Hz, CH₂(allyl)); ¹³C{¹H} NMR (150 MHz, CDCl₃) δ 178.7 (CH), 157.8 (C₆), 138.9 (C₆), 131.8 (CH), 130.2 (CH), 129.8 (CH), 120.4 (CH), 118.6 (=CH₂), 118.0 (C₆), 64.7 (C₆), 36.2 (CH₂); HRMS (ES) calcd. for C₁₄H₁₄NBr [M⁺] 275.0304, found 275.0302; FT-IR (ATR) ν = 3077 (CH), 2979 (CH), 1641 (N=C), 1574, 719 cm⁻¹.

3,3-Diallyl-5-bromo-3H-indole (3i)

![3,3-Diallyl-5-bromo-3H-indole (3i)](image)

The product was obtained by following the **General procedure A** with slight modifications. The reaction was conducted at 50 °C for 8 hours. The crude residue was purified by column chromatography on SiO₂ using a mixture of PE/EtOAc (100/0 to 80/20) as eluent. The product was obtained as a brown oil (123 mg, 58%); Rf = 0.36 (PE/EtOAc 7/3); ³¹H NMR (600 MHz, CDCl₃) δ 8.02 (s, 1H, H₂), 7.48 (br s, 2H, H₆, H₇), 7.44 (s, 1H, H₄), 5.43 (ddt, 2H, J = 17.2, 10.1, 7.3 Hz, =CH₂), 5.03 (dq, 2H, J = 17.2, 1.5 Hz, =CH₂), 4.99 (dq, 2H, J = 10.1, 1.5 Hz, =CH₂), 2.55 (dd, 2H, J = 14.1, 7.3 Hz, CH₂(allyl)), 2.50 (dd, 2H, J = 14.1, 7.3 Hz, CH₂(allyl)); ¹³C{¹H} NMR (150 MHz, CDCl₃) δ 178.4 (CH), 154.7 (C₆), 143.7 (C₆), 131.9 (CH), 131.2 (CH), 125.8 (CH), 122.7 (CH), 120.2 (C₆), 119.4 (=CH₂), 61.5 (C₆), 38.4 (CH₂); HRMS (ES) calcd. for C₁₄H₁₃NBr [M-H]⁻ 274.0231, found 274.0232; FT-IR (ATR) ν = 3076 (CH), 2911 (CH), 1719 (N=C), 1596, 1435 cm⁻¹.
3,3-Diallyl-5-chloro-3H-indole (3j)

The product was obtained by following the **General procedure A** with slight modifications. The reaction was conducted at 50 °C for 3 hours, then stirred at room temperature for a further 18 hours. The crude residue was purified by column chromatography on SiO₂ using a mixture of PE/EtOAc (100/0 to 90/10) as eluent. The product was obtained as pale yellow oil (126 mg, 41%). \( R_f = 0.21 \) (PE/EtOAc 4/1); \(^1\text{H} \) NMR (600 MHz, CDCl₃) \( \delta \) 8.03 (s, 1H, \( H_2 \)), 7.53 (d, 1H, \( J = 8.3 \) Hz, \( H_7 \)), 7.32 (dd, 1H, \( J = 8.3, 2.1 \) Hz, \( H_6 \)), 7.28 (d, 1H, \( J = 2.1 \) Hz, \( H_4 \)), 5.43 (ddt, 2H, \( J = 17.0, 10.1, 7.2 \) Hz, =CH₂), 5.03 (dq, 2H, \( J = 17.0, 1.0 \) Hz, =CH₂), 5.00 (br dd, 2H, \( J = 10.1, 1.0 \) Hz, =CH₂), 2.56 (dd, 2H, \( J = 13.7, 7.2 \) Hz, CH₂₋allyl), 2.51 (dd, 2H, \( J = 13.7, 7.2 \) Hz, CH₂₋allyl); \(^{13}\text{C}\{^1\text{H}\} \) NMR (150 MHz, CDCl₃) \( \delta \) 178.2 (C₇), 154.2 (C₉), 143.3 (C₉), 132.1 (C₉), 131.9 (CH), 128.3 (CH), 122.9 (CH), 122.2 (CH), 119.3 (=CH₂), 61.5 (Cₗ), 38.2 (Cₗ₂₋allyl); HRMS (CI) calcd. for \( \text{C}_{14}\text{H}_{15}\text{ClN} [\text{M+H}]^+ \) 232.0887, found 232.0886; FT-IR (ATR) \( \nu = 3055 \) (CH), 2954 (CH), 1640 (N=C), 1555, 1447 cm⁻¹.

3,3-Diallyl-5-flouro-3H-indole (3k)

The product was obtained by following the **General procedure A**. The crude residue was purified by column chromatography on SiO₂ using a mixture of PE/EtOAc (100/0 to 80/20) as eluent. The product was obtained as red-brown oil (101 mg, 32%). \( R_f = 0.4 \) (PE/EtOAc 7/3); \(^1\text{H} \) NMR (600 MHz, CDCl₃) \( \delta \) 7.99 (s, 1H, \( H_2 \)), 7.53 (dd, 1H, \( J = 8.4, 4.6 \) Hz, \( H_7 \)), 7.02 (dd, 1H, \( J = 8.4, 2.8 \) Hz, \( H_6 \)), 6.99 (dd, 1H, \( J = 8.0, 2.8 \) Hz, \( H_4 \)), 5.41 (ddt, 2H, \( J = 17.1, 10.0, 7.5 \) Hz, =CH₂), 5.00 (dd, 2H, \( J = 17.1, 1.3 \) Hz, =CH₂), 4.96 (br d, 2H, \( J = 10.0 \) Hz, =CH₂), 2.53 (dd, 2H, \( J = 14.0, 7.5 \) Hz, CH₂₋allyl), 2.48 (dd, 2H, \( J = 14.0, 7.5 \) Hz, CH₂₋allyl); \(^{13}\text{C}\{^1\text{H}\} \) NMR (150 MHz, CDCl₃) \( \delta \) 177.7 (CH), 161.7 (d, \( J_{C-F} = 245.8 \) Hz, Cₗ), 151.5 (d, \( J_{C-F} = 2.1 \) Hz, Cₗ), 143.6 (d, \( J_{C-F} = 8.7 \) Hz, Cₗ), 132.0 (CH), 122.0 (d, \( J_{C-F} = 9.1 \) Hz, CH), 119.2 (=CH₂), 114.7 (d, \( J_{C-F} = 23.7 \) Hz, CH), 110.2 (d, \( J_{C-F} = 24.6 \) Hz, CH), 61.6 (Cₗ), 38.5 (CH₂); HRMS (CI) calcd. for \( \text{C}_{14}\text{H}_{15}\text{ClF} [\text{M+H}]^+ \) 216.1183, found 216.1187; FT-IR (ATR) \( \nu = 3055 \) (CH), 2928 (CH), 1597 (N=C), 1460, 1165 cm⁻¹.

3,3-Diallyl-2-methyl-3H-indole (3l)

The product was obtained by following the **General procedure A**. The crude residue was purified by column chromatography on SiO₂ using a mixture of PE/EtOAc (100/0 to 80/20) as eluent. The product was obtained as a yellow oil (290 mg, 98%); \( R_f = 0.60 \) (PE/EtOAc 7/3); \(^1\text{H} \) NMR (600 MHz, CDCl₃) \( \delta \) 7.51 (d, 1H, \( J = 7.4 \) Hz, \( H_7 \)), 7.31 (t,
1H, J = 7.4 Hz, H2), 7.26 (d, 1H, J = 7.4 Hz, H4), 7.19 (t, 1H, J = 7.4 Hz, H3), 5.10 (ddt, 2H, J = 16.7, 9.9, 7.1 Hz, =CH), 4.95 (br d, 2H, J = 16.7 Hz, =CH2), 4.84 (br d, 2H, J = 9.9 Hz, =CH2), 2.68 (dd, 2H, J = 14.0, 7.1 Hz, CH2_allyl), 2.45 (dd, 2H, J = 14.0, 7.1 Hz, CH2_allyl), 2.25 (s, 3H, CH3). 13C{1H} NMR (150 MHz, CDCl3) δ 185.2 (Cq), 155.2 (Cq), 141.2 (Cq), 132.2 (CH), 128.0 (CH), 125.1 (CH), 122.3 (CH), 120.0 (CH), 118.2 (=CH2), 61.9 (Cq), 40.5 (CH2), 167.1 (CH2); HRMS (ES) calcd. for C15H16N [M-H]− 210.1282, found 210.1273; FT-IR (ATR) v = 3077 (CH), 2916 (CH), 1640 (N=C), 1457 cm−1. Characterizations were in accordance with literature reports.2

3,3-Diallyl-5-methoxy-2-methyl-3H-indole (3m)

The product was obtained by following the General procedure A. The crude residue was purified by column chromatography on SiO2 using a mixture of PE/EtOAc (100/0 to 90/10) as eluent. The product was obtained as a yellow oil (173 mg, 80%); Rf = 0.33 (PE/EtOAc 7/3); 1H NMR (600 MHz, CDCl3) δ 7.40 (dd, 1H, J = 7.2, 1.8 Hz, H7), 6.83 (dd, 1H, J = 7.2, 2.5 Hz, H6), 6.82 (s, 1H, H4), 5.12 (ddt, 2H, J = 16.9, 10.1, 7.0 Hz, =CH), 4.96 (dq, 2H, J = 16.9, 1.4 Hz, =CH2), 4.85 (dq, 2H, J = 10.1, 1.2 Hz, =CH2), 3.83 (s, 3H, OCH3), 2.64 (ddt, 2H, J = 13.9, 7.0 Hz, CH2_allyl), 2.44 (ddt, 2H, J = 13.9, 7.0 Hz, CH2_allyl), 2.21 (s, 3H, CH3); 13C{1H} NMR (150 MHz, CDCl3) δ 183.0 (Cq), 157.9 (Cq), 148.8 (Cq), 143.0 (Cq), 132.3 (CH), 120.1 (CH), 118.2 (=CH2), 112.2 (CH), 109.2 (CH), 61.9 (Cq), 55.8 (CH3), 40.5 (CH2), 16.6 (CH3); HRMS (ES) calcd. for C15H16NO [M-H]− 240.1388, found 240.1376; FT-IR (ATR) v = 2919 (CH), 1581 (N=C), 1471, 1266 cm−1.

3,3-Diallyl-2-phenyl-3H-indole (3n)

The product was obtained by following the General procedure A. The crude residue was purified by column chromatography on SiO2 using a mixture of PE/EtOAc (100/0 to 80/20) as eluent. The product was obtained as a colourless oil (232 mg, 74%); Rf = 0.63 (PE/EtOAc 4/1); 1H NMR (600 MHz, CDCl3) δ 8.11 (m, 2H, CHp_p), 7.66 (d, 1H, J = 7.5 Hz, H7), 7.48 (m, 3H, CHm_p_p), 7.37 (td, 1H, J = 7.5, 1.0 Hz, H6), 7.34 (d, 1H, J = 7.5 Hz, H4), 7.28 (d, 1H, J = 7.5 Hz, H3), 5.11 (ddt, 2H, J = 17.2, 9.8, 7.2 Hz, =CH), 4.76 (br d, 2H, J = 17.2 Hz, =CH2), 4.72 (br d, 2H, J = 9.8 Hz, =CH2), 2.92 (dd, 2H, J = 14.1, 7.2 Hz, CH2_allyl), 2.88 (dd, 2H, J = 14.1, 7.2 Hz, CH2_allyl); 13C{1H} NMR (150 MHz, CDCl3) δ 180.4 (Cq), 154.6 (Cq), 143.1 (Cq), 134.1 (Cq), 132.0 (=CH2), 130.7 (CH), 128.7 (CH), 128.2 (CH), 128.1 (CH), 125.8 (CH), 121.8 (CH), 120.9 (CH), 118.3 (CH), 62.5 (Cq), 42.0 (CH2); HRMS (CI) calcd. for C28H28N [M+H]+ 274.1590, found 274.1571; FT-IR (ATR) v = 3075 (CH), 2924 (CH), 1640 (N=C), 1522, 1443 cm−1.
2-(((tert-Butyldimethylsilyl)oxy)methyl)-1H-indole 3

To an oven dry flask purged with vacuum/Argon cycles, were added indole-2-methanol (250 mg, 1.7 mmol), NEt₃ (0.71 ml, 5.1 mmol, 3 eq) and TBDMSCl (384 mg, 2.5 mmol, 1.5 eq) in CH₂Cl₂ (2 ml). The reaction mixture was stirred for 4 hrs at R.T. before addition of a NaHCO₃sat (2 × 20 ml). The product was extracted with CH₂Cl₂ and the combined organic layers were washed with water (15 ml), brine (15 ml) and concentrated under vacuum. The residue was purified by flash chromatography on SiO₂ using (PE/EtOAc 100/0 to 90/10) as eluent to yield the title compound as an orange brown oil (254 mg, 57%). Rf = 0.63 (PE/EtOAc 4/1); ¹H NMR (600 MHz, CDCl₃) δ 8.29 (s, 1H, N), 7.56 (d, 1H, J = 7.8 Hz, H₂), 7.37 (d, 1H, J = 7.8 Hz, H₃), 7.16 (td, 1H, J = 7.8, 1.1 Hz, H₄), 7.08 (td, 1H, J = 7.8, 1.1 Hz, H₅), 6.31 (s, 1H, H₆), 4.87 (s, 2H, CH₂), 0.93 (s, 9H, CH₃), 0.12 (s, 6H, CH₂); ¹³C{¹H} NMR (150 MHz, CDCl₃) δ 138.3 (C₉), 136.0 (C₉), 128.5 (C₉), 121.7 (CH), 120.5 (CH), 119.8 (CH), 110.9 (CH), 98.9 (CH), 59.4 (CH₂), 26.0 (CH₃), 18.5 (C₉), 5.17 (CH₃); FT-IR (ATR) ν = 3015 (CH), 2928 (CH), 2857 (CH), 1457, 1255, 1074 cm⁻¹.

3,3-Diallyl-2-(((tert-butyldimethylsilyl)oxy)methyl)-3H-indole (3o)

The product was obtained by following the General procedure A. The crude residue was purified by column chromatography on SiO₂ using a mixture of PE/EtOAc (100/0 to 90/10) as eluent. The title compound was obtained as orange oil (172 mg, 66%). Rf = 0.80 (PE/EtOAc 4/1); ¹H (600 MHz, CDCl₃) δ 7.52 (d, 1H, J = 7.5 Hz, H₄), 7.25 (td, 1H, J = 7.5, 1.3 Hz, H₅), 7.25 (d, 1H, J = 7.5 Hz, H₆), 7.21 (td, 1H, J = 7.5, 1.3 Hz, H₇), 5.18 (dddt, 2H, J = 17.0, 9.9, 7.2 Hz, =CH₁), 4.91 (dq, 2H, J = 17.0, 1.9 Hz, =CH₂), 4.80 (dq, 2H, J = 9.9, 1.9 Hz, =CH₂), 4.77 (s, 2H, OCH₂), 2.84 (dddt, 2H, J = 13.5, 7.2, 1.1 Hz, CH₂), 2.71 (dddt, 2H, J = 13.6, 7.2, 1.1 Hz, CH₂), 0.97 (s, 9H, CH₃), 0.17 (s, 6H, CH₂); ¹³C{¹H} (150 MHz, CDCl₃) δ 185.5 (C₉), 154.5 (C₉), 142.3 (C₉), 132.9 (CH), 127.9 (CH), 125.6 (CH), 122.1 (CH), 120.5 (CH), 117.9 (CH), 64.3 (CH₂), 62.7 (C₉), 40.4 (CH₂), 26.4 (CH₃), 18.6 (C₉), 5.6 (SiCH₃); HRMS (CI) calcd. for C₁₅H₁₆NO [M-SiC₂H₆]⁺ 226.1237, found 226.1226; FT-IR (ATR) ν = 3015 (CH), 2929 (CH), 1693 (N=C), 1501, 1490, 1254, 1090 cm⁻¹.

1-Allyl-5-nitro-1H-indole (7a)

The product was obtained by following the General procedure A with slight modifications. The reaction mixture was heated at 50 °C overnight. The crude residue was purified by column chromatography on SiO₂ using a mixture of PE/EtOAc (100/0 to 80/20) as eluent. The title compound was obtained as a
yellow oil (177 mg, 79%); \( R_f = 0.88 \) (PE/EtOAc 7/3); \(^1\)H NMR (600 MHz, CDCl\(_3\) \( \delta \)
8.60 (d, 1H, \( J = 2.4 \) Hz, \( H_4 \)), 8.11 (dd, 1H, \( J = 9.2, 2.4 \) Hz, \( H_6 \)), 7.34 (d, 1H, \( J = 9.2 \) Hz, \( H_7 \)), 7.25 (d, 1H, \( J = 3.3 \) Hz, \( H_2 \)), 6.70 (dd, 1H, \( J = 3.3, 0.7 \) Hz, \( H_3 \)), 6.00 (ddt, 1H, \( J = 17.1, 10.1, 7.8 \) Hz, =CH), 5.26 (dq, 1H, \( J = 10.1, 1.3 \) Hz, =CHH), 5.08 (dq, 1H, \( J = 17.1, 1.3 \) Hz, =CHH); \(^{13}\)C\{\(^1\)H\} NMR (150 MHz, CDCl\(_3\) \( \delta \)
141.8 (C\(_q\)), 139.0 (C\(_q\)), 132.4 (CH), 131.2 (CH), 127.9 (C\(_q\)), 118.4 (CH), 118.2 (=CH\(_2\)), 117.4 (CH), 109.6 (CH), 104.3 (CH), 49.4 (CH\(_2\)); HRMS (ES\(^-\)) calcd. for \( C_{11}H_{11}N_2O_2 \) [M-H] \( m/z \) 201.0664, found 201.0666; FT-IR (ATR) \( \nu = 2923 \) (CH), 2924 (CH), 1509, 1478, 1340 (O=N=O), 1069 cm\(^{-1}\).

Data were in accordance with the literature.\(^4\)

**1-Allyl-2-methyl-5-nitro-1\(H\)-indole (7b)**

The product was obtained by following the General procedure A with slight modifications. The reaction mixture was heated at 50 °C overnight. The crude residue was purified by column chromatography on SiO\(_2\) using a mixture of PE/EtOAc (100/0 to 80/20) as eluent. The title compound was obtained as an orange oil (234 mg, 86%); \( R_f = 0.56 \) (PE/EtOAc 4/1); \(^1\)H NMR (600 MHz, CDCl\(_3\) \( \delta \)
8.48 (d, 1H, \( J = 1.9 \) Hz, \( H_4 \)), 8.04 (dd, 1H, \( J = 8.9, 1.9 \) Hz, \( H_6 \)), 7.22 (d, 1H, \( J = 8.9 \) Hz, \( H_7 \)), 6.45 (s, 1H, \( H_3 \)), 5.94 (ddd, 1H, \( J = 17.2, 9.7, 5.5 \) Hz, =CH), 5.16 (d, 1H, \( J = 9.7 \) Hz, =CHH), 4.77 (d, 2H, \( J = 17.2 \) Hz, =CHH\(_2\)), 4.23 (dd, 2H, \( J = 5.5, 2.8 \) Hz, NCH\(_2\)), 2.42 (s, 3H, CH\(_3\)); \(^{13}\)C\{\(^1\)H\} NMR (150 MHz, CDCl\(_3\) \( \delta \)
141.7 (C\(_q\)), 140.4 (C\(_q\)), 139.9 (C\(_q\)), 132.4 (CH), 127.4 (C\(_q\)), 116.9 (=CH\(_2\)), 108.9 (CH), 102.7 (CH), 45.7 (CH\(_2\)), 12.8 (CH\(_3\)); HRMS (ES\(^+\)) calcd. for \( C_{12}H_{12}N_2O_2 \) [M] \( ^+ \) 216.2400, found 216.2430; FT-IR (ATR) \( \nu = 2923 \) (CH), 1513 (N=C), 1476, 1350 (O=N=O), 1071 cm\(^{-1}\).
3. UGI reactions

**General procedure B:** The carboxylic acid (1eq.) and the isocyanide (1eq.) were added to a solution of 3,3-diallyl-3H-indole (1eq.) in MeOH (C ≈ 0.25 mol/L). The reaction mixture was left to stir between 2 - 24 hours at room temperature before evaporation of the volatiles under vacuum. Pure compounds were obtained by washing the crude residue with PE, or by purification by column chromatography on SiO₂.

### 3,3-Diallyl-1-benzoyl-N-(tert-butyl)indoline-2-carboxamide (8a)

The product was obtained by following the General procedure B. After evaporation of the volatiles The desired product was obtained as a pale yellow oil (81 mg, 79%); m.p. 137-138 °C; Rₜ = 0.37 (PE/EtOAc 4/1); ¹H NMR (600 MHz, CDCl₃, R.T.) δ 7.53 (d, 2H, J = 7.4 Hz, CHo-Bz), 7.50 (t, 1H, J = 7.4 Hz, CHp-Bz), 7.43 (t, 2H, J = 7.4 Hz, CHm-Bz), 7.17 (d, 1H, J = 7.5 Hz, H₄), 7.06 (br s, 1H, H₆), 7.02 (t, 1H, J = 7.5 Hz, H₅), 6.00 (ddt, 1H, J = 16.5, 9.2, 7.2 Hz, =CH), 5.58 (ddt), 1H, J = 16.5, 9.2, 7.2 Hz, =CH), 5.49 (br s, 1H, NH), 5.15-5.05 (m, 4H, =CH₂), 4.48 (s, 1H, H₂), 2.62 (dd, 1H, J = 14.7, 7.2 Hz, CHH allyl), 2.55 (dd, 1H, J = 14.7, 7.2 Hz, CHH allyl), 2.42 (m, 2H, CH₂ allyl), 1.30 (s, 9H, C₃H₃tBu); H₇ peak present at baseline 7.06 ppm; ¹³C{¹H} NMR (150 MHz, CDCl₃, R.T.) δ 169.5 (Cq), 167.6 (Cq), 142.0 (Cq), 137.1 (Cq), 136.1 (Cq), 134.0 (CH), 133.6 (CH), 131.1 (CH), 128.9 (CH), 128.1 (CH), 127.6 (CH), 124.2 (CH), 124.0 (CH), 119.4 (=CH₂), 119.2 (=CH₂), 73.1 (CH), 51.9 (Cq), 49.8 (Cq), 44.7 (CH), 38.9 (CH₂), 28.6 (CH₃ allyl); C₇H not observed by ¹³C{¹H} NMR; HRMS (CI) calcd. for C₂₆H₃₁N₂O₂ [M+H]^+ 403.2380, found 403.2353; FT-IR ν = 3347 (N-H), 2970 (CH), 2925 (CH), 1685 (C=O), 1624 (C=O), 1501, 1393 cm⁻¹.

### 3,3-Diallyl-1-benzoyl-N-cyclohexylindoline-2-carboxamide (8b)

The product was obtained by following the General procedure B. After evaporation of the volatiles under vacuum, the residue was purified by column chromatography on SiO₂ using (PE/EtOAc 100/0 to 70/30) as eluent. The desired product was obtained as a pale yellow oil (174 mg, 87%); Rₜ = 0.30 (PE/EtOAc 4/1); ¹H NMR (400 MHz, CDCl₃, 55°C) δ 7.54-7.47 (m, 3H, CHo-Bz, CHp-Bz),
7.42 (t, 2H, J = 7.9 Hz, CH$_{m}$-Br), 7.20 (d, 1H, J = 7.5 Hz, H$_4$), 7.15 (br s, 1H, H$_3$), 7.11 (t, 1H, J = 7.8 Hz, H$_6$), 7.05 (td, 1H, J = 7.1, 1.4 Hz, H$_5$), 6.00 (ddt, 1H, J = 17.0, 9.9, 7.5 Hz, =CH), 5.62 (ddt, 2H, J = 17.0, 9.9, 7.5 Hz, =CH), 5.14-5.03 (m, 4H, =CH$_2$), 4.60 (s, 1H, H$_2$), 3.75 (m, 1H, (NH)CH$_2$-Cy), 2.63 (dd, 2H, J = 14.3, 7.5 Hz, CH$_2$-allyl), 2.47 (dt, 2H, J = 14.3, 7.5 Hz, CH$_2$-allyl), 1.95 (dd, 1H, J = 11.7, 2.8 Hz, CHH$_{Cy}$), 1.81-1.73 (m, 1H, CHH$_{Cy}$), 1.69-1.64 (m, 1H, CHH$_{Cy}$), 1.62-1.54 (m, 2H, CH$_2$-Cy), 1.44-1.28 (m, 2H, CH$_2$-Cy), 1.23-1.12 (qd, 2H, J = 12.0, 4.0 Hz, CH$_2$-Cy), 1.07 (qd, 1H, J = 11.3, 3.4 Hz, CHH$_{Cy}$); $^{13}$C[$^1$H] NMR (150 MHz, CDCl$_3$, R.T.) δ 169.5 (C$_q$), 167.6 (C$_q$), 141.8 (C$_q$), 137.2 (C$_q$), 136.0 (C$_q$), 133.9 (CH), 133.5 (CH), 131.0 (CH), 128.8 (CH), 128.0 (CH), 127.4 (CH), 124.3 (CH), 119.5 (=CH$_2$), 119.0 (=CH$_2$), 73.0 (CH), 50.0 (C$_q$), 48.2 (CH), 45.1 (CH$_2$), 38.8 (CH$_2$), 32.9 (CH$_2$), 32.8 (CH$_2$), 25.5 (CH$_2$), 24.8 (CH$_2$), 24.7 (CH$_2$); C$_7$H was not observed by $^{13}$C[$^1$H] NMR; HRMS (Cl) calcd. for C$_{25}$H$_{32}$N$_2$O$_4$ [M]$^+$ 428.2463, found 428.2460; FT-IR (ATR) ν = 3314 (N-H), 2930 (CH), 2855 (CH), 1638 (C=O), 1594, 1559, 1470 cm$^{-1}$.

3,3-Diallyl-1-benzoyl-N-(tert-buty1)-5,6-dimethoxyindoline-2-carboxamide (8c)

The product was obtained by following the General procedure B. Evaporation of the volatiles gave the title compound as yellow brown oil (249 mg, 99%). R$_f$ = 0.15 (PE/EtOAc 4/1); $^1$H NMR (400 MHz, CDCl$_3$, 55°C) δ 7.53 (d, 2H, J = 8.2 Hz, CH$_m$-Br), 7.46 (t, 3H, J = 8.2 Hz, CH$_{m,p}$-Br), 6.88 (br s, 1H, H$_7$), 6.76 (s, 1H, H$_5$), 6.04 (ddt, 1H, J = 17.4, 10.6, 7.1 Hz, =CH), 5.18-5.05 (m, 4H, =CH$_2$), 5.52 (br s, 1H, NH), 4.52 (s, 1H, H$_2$), 3.84 (s, 3H, OCH$_3$), 3.67 (s, 3H, OCH$_3$), 2.64 (dd, 1H, J = 14.6, 7.1 Hz, CHH$_{allyl}$), 2.59 (dd, 1H, J = 14.6, 7.1 Hz, CHH$_{allyl}$), 2.46 (dd, 1H, J = 13.9, 7.1 Hz, CHH$_{allyl}$), 2.40 (dd, 1H, J = 13.7, 7.1 Hz, CHH$_{allyl}$), 1.30 (s, 9H, CH$_3$-nBu); $^{13}$C[$^1$H] NMR (150 MHz, CDCl$_3$, R.T.) δ 168.9 (C$_q$), 167.8 (C$_q$), 148.4 (C$_q$), 145.9 (C$_q$), 136.2 (C$_q$), 135.3 (C$_q$), 134.3 (CH), 133.6 (CH), 130.8 (CH), 128.8 (CH), 128.4 (CH), 127.4 (CH), 119.4 (=CH$_2$), 119.1 (=CH$_2$), 107.4 (CH), 101.0 (C$_q$), 73.9 (CH), 56.6 (CH$_2$), 55.8 (CH$_2$), 51.8 (C$_q$), 45.2 (CH$_2$), 39.1 (CH$_2$), 28.7 (CH$_3$-nBu), C$_7$H and one signal of OCH$_3$ were not observed by $^{13}$C[$^1$H] NMR; HRMS (El) calcd. for C$_{25}$H$_{32}$N$_2$O$_4$ [M]$^+$ 462.2519, found 462.2524; FT-IR (ATR) ν = 3342 (N-H), 2966 (CH), 2936 (CH), 1682 (C=O), 1623 (C=O), 1501, 1448, 1214 cm$^{-1}$.

3,3-Diallyl-N-(tert-buty1)-1-(2-(2-fluorophenyl)acetyl)indoline-2-carboxamide (8d)

The product was obtained according to the General procedure B. After 4 hours at room temperature the crude residue was purified by washing with cold Petroleum ether and dried under vacuum to yield the product as a yellow solid (89 mg, 81%); mp = 128 - 129 °C; R$_f$ = 0.59 (PE/EtOAc 70/30); $^1$H NMR (400 MHz, CDCl$_3$, R.T.) δ 8.18 (br s, 1H, H$_7$), 7.40 – 7.19 (m, 3H, CH$_{Ph}$, H$_4$, H$_6$), 7.19 – 6.92 (m, 4H, CH$_{Ph}$, H$_1$...
3,3-Diallyl-5-(benzoxyl)-N-(tert-butyl)-1-picolinoylindolinede-carboxamide (8e)

The product was obtained by following the General procedure B. Evaporation of the volatiles gave the title compound as a yellow brown oil (286 mg, 99%); Rf = 0.15 (PE/ EtOAc 4/1); 1H NMR (400 MHz, CDCl3, 55°C) δ 8.56 (d, 1H, J = 4.7 Hz, CH₃-py), 8.12-8.00 (br s, 1H, H₃), 7.88 (d, 1H, J = 7.6 Hz, CCH₃-py), 7.81 (td, 1H, J = 7.6, 1.4 Hz, CH₃-py), 7.44 (d, 2H, J = 7.4 Hz, CH₃-py), 7.40 (t, 2H, J = 7.4 Hz, CH₃-Bn), 7.36 (ddd, 1H, J = 7.6, 4.7, 1.4 Hz, (CH)CH₃-py), 7.33 (tt, 1H, J = 7.4, 1.3 Hz, CH₃-Bn), 6.89 (br s, 1H, H₆), 6.86 (br s, 1H, H₅), 6.03 (ddt, 1H, J = 16.8, 10.7, 7.4 Hz, =CH), 5.51 (ddt, 2H, J = 16.8, 10.7, 7.4 Hz, =CH, NH), 5.10 (dd, 2H, J = 16.8, 10.7 Hz, =CH₂), 5.06 (s, 2H, OCH₂), 5.00 (d, 2H, J = 10.7 Hz, =CH₂), 4.92 (s, 1H, H₂), 2.58 (m, 2H, CH₂-allyl), 2.34 (br d, 2H, J = 7.4 Hz, CH₂-allyl), 1.21 (s, 9H, CH₃-allyl), 13C{¹H} NMR (150 MHz, CDCl₃, R.T.) δ 168.6 (C₆), 166.3 (C₅), 156.3 (C₄), 153.5 (C₃), 147.9 (CH), 138.9 (C₆), 137.4 (CH), 137.0 (C₇), 136.1 (C₈), 134.4 (CH), 133.5 (CH), 128.7 (CH), 128.2 (CH), 127.2 (CH), 125.2 (CH), 124.4 (CH), 119.1 (=CH₂), 118.8 (=CH₂), 118.5 (C₇), 113.7 (CH), 111.6 (CH), 74.1 (CH), 70.7 (CH₂), 51.4 (C₆), 50.9 (C₅), 45.5 (CH₂), 39.0 (CH₂), 28.6 (CH₃-allyl); C₁H was not observed by ¹³C{¹H} NMR; HRMS (Cl) calcd. for C₃₂H₃₆N₃O₃ [M+H]⁺ 510.2757, found 510.2729; FT-IR (ATR) ν = 3342 (N-H), 2965 (CH), 2933 (CH), 1683 (C=O), 1630 (C=O), 1501, 1446, 1214 cm⁻¹.

3,3-Diallyl-npentyl-1-(1H-indole-3-carbonyl)indolinede-carboxamide (8f)

The product was obtained according to the General procedure B. After 24 hours at room temperature, purification of the crude residue by column chromatography on SiO₂ (PE/EtOAc 90/10 to 0/100) afford the product as a pale yellow solid (103 mg, 90%); mp = 138 - 139°C; Rf = 0.47 (EtOAc); 1H NMR (400
2.4.1 (dd, J = 7.9, 1.1 Hz, 1H, H4), 8.44 (br s, 1H, H6), 7.89 (m, 2H, H2, H5), 7.31 – 7.21 (m, 3H, H6, H4, H8), 7.12 (dd, J = 11.2, 3.7 Hz, 1H, H3), 6.01 (m, 2H, =CH, NH), 5.58 (ddt, J = 17.4, 10.1, 7.3 Hz, 1H, =CH), 5.17 (t, J = 13.0 Hz, 2H, =CH2), 5.03 – 4.89 (m, 2H, =CH2, H2), 3.25 (td, J = 13.3, 7.0 Hz, 1H, NCHH), 3.14 (td, J = 12.9, 7.0 Hz, 1H, NCHH), 2.69 (qd, J = 14.8, 7.1 Hz, 2H, CH2 allyl), 2.46 (d, J = 7.2 Hz, 2H, CH2 allyl), 1.43 – 1.33 (m, 2H, CH2), 1.27 – 1.06 (m, 4H, CH2), 0.79 (t, J = 7.1 Hz, 3H, CH3); 13C{1H} NMR (101 MHz, CDCl3, R.T.) 169.9 (NHC=O), 164.5 (NC=O), 148.0 (NCN), 144.0 (C6H), 142.8 (Cq), 136.9 (Cq), 134.0 (=CH), 133.2 (=CH), 131.6 (CqH), 128.4 (CqH), 128.1 (CqH), 124.5 (CqH), 124.4 (CqH), 119.3 (=CH2), 118.7 (=CH2), 118.0 (CqH), 117.6 (CqH), 110.6 (CqH), 73.5 (CqH), 51.2 (Cq), 45.9 (CH2 allyl), 39.6 (NCH2), 38.8 (CH2 allyl), 29.02 (CH2), 29.0 (CH2), 22.3 (CH2), 13.8 (CH3); HRMS (EI) calcd for C28H33N2O2 [M]+ 457.2203 found 457.2213; FT-IR (ATR) ν = 3215 (NH), 3075 (CH), 3043 (CH), 1653 (C=O), 1586, 1520, 1477, 1413, 1377, 1290, 1202, 1129, 996, 915, 831, 775, 736, 665 cm−1.

3,3-Diallyl-N-( tert-butyl)-1-(1H-pyrazole-3-carbonyl)indoline-2-carboxamide (8g)

The product was obtained according to the General procedure B. After 4 hours at room temperature, volatiles were removed under vacuum and the crude residue was purified by several washing with PE and dried. The desired product was obtained as a pale yellow solid (145 mg, 97%); mp = 123 - 124 °C; Rf = 0.17 (PE/EtOAc 1/1); 1H NMR (600 MHz, CDCl3, R.T.) δ 8.24 (s, 1H, H2), 7.72 (d, J = 2.3 Hz, 1H, CHp), 7.30 (t, J = 7.7 Hz, 1H, H6), 7.25 (d, J = 6 Hz, 1H, H4), 7.13 (t, J = 7.4 Hz, 1H, H3), 6.97 (d, J = 2.1 Hz, 1H, CHp), 6.08 (ddt, J = 17.0, 10.1, 7.1 Hz, 1H, =CH), 5.63 (s, 1H, NHBu), 5.56 – 5.40 (m, 2H, =CH, H2), 5.16 (m, 2H, =CH2), 4.88 (dd, J = 29.4, 13.5 Hz, 2H, =CH2), 2.68 (d, J = 7.1 Hz, 2H, CH2 allyl), 2.37 (d, J = 7.3 Hz, 2H, CH2 allyl), 1.12 (s, 9H, CH3 Bu); 13C{1H} NMR (151 MHz, CDCl3, R.T.) δ 170.0 (NHC=O), 162.1 (NC=O), 146.1 (Cqpy), 142.3 (Cq), 136.7 (Cq), 134.4 (=CH), 132.8 (=CH), 130.6 (CHp), 128.4 (CqH), 124.8 (CqH), 124.3 (CqH), 119.5 (=CH2), 118.9 (=CH2), 117.9 (CqH), 108.6 (CHp), 73.0 (CqH), 51.7 (Cq Bu), 51.0 (Cq), 46.1 (CH2 allyl), 38.7 (CH2 allyl), 28.4 (CH3 Bu); HRMS (EI) calcd for C23H28N4O2 [M]+ 392.2212 found 392.2213; FT-IR (ATR) ν = 3215 (NH), 3075 (CH), 3043 (CH), 2968 (CH), 2928 (CH), 1662 (C=O), 1636 (C=O), 1592, 1523, 1479, 1456, 1364, 1318, 1224, 1116.8, 917, 755 cm−1.
3,3-Diallyl-1-(1-carbamoylcyclopropanecarbonyl)-N-(4-methoxyphenyl)indoline-2-carboxamide (8h)

The product was obtained according to the General procedure B. After 4 hours at room temperature, purification of the crude residue by column chromatography on SiO₂ (PE/EtOAc 90/10 to 50/50) afford the product as an off-white solid (101 mg, 87%); mp = 121°C; R₆ = 0.71 (EtOAc); ¹H NMR (400 MHz, CDCl₃, R.T.) δ 8.80 (s, 1H, NHH), 8.28 (s, 1H, NHH), 7.46 (d, J = 8.1 Hz, 1H, H₂), 7.35 – 7.24 (m, 3H, CH₂OCCH₂, H₆), 7.19 (d, J = 7.6 Hz, 1H, H₃), 7.08 (t, J = 7.5 Hz, 1H, H₄), 6.69 (d, J = 9.0 Hz, 2H, NHCCCH), 5.85 (dq, J = 10.0, 7.1 Hz, 1H, =CH), 5.67 – 5.49 (m, 2H, =CH, NH), 5.16 – 4.95 (m, 5H, =CH₂, H₂), 3.73 (s, 3H, OCH₃), 2.61 (d, J = 7.1 Hz, 2H, CH₂allyl), 2.48 (dd, J = 13.9, 7.4 Hz, 2H, CH₂allyl), 2.04 (br, 1H, CHH), 1.79 (br, 1H, CHH), 1.59 (br, 1H, CHH), 1.25 (br, 1H, CHH); ¹³C{¹H} NMR (101 MHz, CDCl₃, R.T.) δ = 171.4 (NH₂C=O), 168.1 (NH=O), 167.8 (NC=O), 156.6 (C₆), 140.3 (C₅), 136.6 (C₄), 133.5 (CH), 132.7 (CH), 130.4 (C₆), 128.8 (C₆), 125.0 (C₅), 124.0 (C₆), 121.7 (NHCCCH), 119.9 (=CH₂), 119.6 (=CH₂), 114.0 (CH₃OCCCH), 71.7 (C₂H), 55.5 (OCH₃), 48.7 (C₃), 45.6 (CH₂allyl), 40.2 (CH₂allyl), 31.6 (C₅), 17.5 (CH₂), 16.8 (CH₂); HRMS (Cl) c ald for C₂₇H₃₉N₂O₄ [M+H]+ 460.2236 found 460.2229; FT-IR (ATR) ν = 3310 (NH), 3197 (NH), 3076 (CH), 2930 (CH), 1666 (C=O), 1613 (C=O), 1548, 1510, 1482, 1394, 1298, 1237, 1174, 1032, 919, 829, 750, 472 cm⁻¹.

3,3-Diallyl-1-(2-chloroacetyl)-5-methoxy-N-pentylindoline-2-carboxamide (8i)

The product was obtained by following the General procedure B. After evaporation of the volatiles the crude mixture was purified by column chromatography on SiO₂ using (PE/EtOAc 100/0 to 80/20) as eluent to obtained the desired product as a yellow oil (67 mg, 61%); R₆ = 0.27 (PE/EtOAc 4/1); ¹H NMR (400 MHz, CDCl₃, 55°C) δ 8.00 (br s, 1H, H₇), 6.83 (dd, 1H, J = 8.0, 2.5 Hz, H₆), 6.80 (d, 1H, J = 2.5 Hz, H₅), 5.94 (dtt, 1H, J = 16.4, 9.5, 7.4 Hz, =CH), 5.62 (brs, 1H, NH), 5.53 (dtt, 1H, J = 16.4, 9.5, 7.4 Hz, =CH), 5.20-5.05 (m, 4H, =CH₂), 4.66 (s, 1H, H₃), 4.45 (d, 1H, J = 13.0 Hz, CH₂H), 4.08 (d, 1H, J = 13.0 Hz, CH₂H), 3.81 (s, 3H, OCH₃), 3.21 (sext., 1H, J = 13.3, 7.1, 6.1 Hz, NCHH), 3.10 (sext, 1H, J = 13.3, 7.1, 6.1 Hz, NCHH), 2.64 (d, 2H, J = 7.4 Hz, CH₂allyl), 2.44 (dtt, 1H, J = 13.9, 7.4, 1.0 Hz, CHHallyl), 2.39 (dtt, 1H, J = 13.9, 7.4, 1.0 Hz, CHHallyl), 1.64 (q, 2H, J = 14.7, 7.1 Hz, NCH₂CH₂), 1.27 (m, 2H, CH₂CH₂), 1.18 (m, 2H, CH₂CH₂CH₂), 0.86 (t, 3H, J = 6.7 Hz, CH₃); ¹³C{¹H} NMR (150 MHz, CDCl₃, R.T.) δ 168.5 (C₆), 164.1 (C₅), 157.5
(C₅), 137.9 (C₅), 134.8 (C₅), 133.3 (CH), 132.5 (CH), 120.1 (=CH₂), 119.1 (=CH₂), 118.2 (CH), 112.9 (CH), 110.7 (CH), 71.7 (CH), 55.8 (CH₃), 51.2 (C₆), 46.6 (CH₂), 42.7 (CH₂), 39.6 (CH₂), 38.3 (CH₂), 29.0 (CH₂), 28.9 (CH₂), 22.3 (CH₂), 14.0 (CH₃); HRMS (Cl) calcd. for C₂₃H₃₂ClN₂O₃ [M+H]⁺ 419.2096, found 419.2075; FT-IR (ATR) ν = 3010 (CH), 2930 (N-H), 1648 (C=O), 1488, 1398, 1246, 1204, 1156, 1033, 811 cm⁻¹.

**tert-Butyl(2-(3,3-diallyl-2-(tert-butylcarbamoyl)-5-chloroindolin-1-yl)-2-(oxoethyl)carbamate (8j)**

The product was obtained by following the General procedure B. After evaporation of the volatiles under vacuum, the residue was purified by column chromatography on SiO₂ using (PE/EtOAc 100/0 to 80/20) as eluent. The desired product was obtained as colourless oil (106 mg, 91%). Rf = 0.64 (PE/EtOAc 4/1);

1H NMR (400 MHz, CDCl₃, 55°C) δ 7.89 (br s, 1H, H₂), 7.24 (dd, 1H, J = 8.5, 1.8 Hz, H₆), 7.19 (d, 1H, J = 1.8 Hz, H₄), 6.00 (ddt, 1H, J = 16.8, 8.3, 7.3 Hz, =CH), 5.51 (br s, 1H, NH), 5.50 (ddt, 1H, J = 16.8, 8.3, 7.3 Hz, =CH), 5.31 (br s, 1H, NH), 5.23-5.07 (m, 4H, =CH₂), 4.45 (br s, 1H, H₃), 4.09 (dd, 1H, J = 16.8, 15.4 Hz, NCHH), 3.93 (br d, 1H, J = 15.4 Hz, NCHH), 2.67 (dd, 1H, J = 15.4, 7.3 Hz, CH₃ (allyl)), 4.49 (dd, 1H, J = 15.4, 7.3 Hz, CHH (allyl)), 2.41 (dd, 1H, J = 15.4, 7.3 Hz, CH₃ (allyl)), 2.34 (dd, 1H, J = 15.4, 7.3 Hz, CHH (allyl)), 1.48 (s, 9H, CH₃ (tBu)), 1.33 (s, 9H, CH₃ (tBu)), C₂H was not observed by 13C{¹H} NMR; HRMS (Cl) calcd. for C₂₅H₃₇N₅O₄Cl [M+H]⁺ 490.2467, found 490.2458; FT-IR (ATR) ν = 3455 (N-H), 3348 (N-H), 2977 (CH), 2940 (CH), 1667 (C=O), 1476, 1394, 1366, 1251 cm⁻¹.

**tert-Butyl (2-(3,3-diallyl-2-(tert-butylcarbamoyl)indolin-1-yl)-2-oxoethyl)carbamate (8k)**

The product was obtained according to the General procedure B. After 4 hours at room temperature, purification of the crude residue was purified by washing with cold Petroleum ether and dried under vacuum to yield the product as a white solid (107 mg, 93%); mp = 155 - 156 °C; Rf = 0.43 (PE/EtOAc 70/30); ¹H NMR (400 MHz, CDCl₃, 55°C) δ 7.89 (br s, 1H, H₂), 7.34 – 7.15 (m, 3H, H₄, H₆, H₂), 7.09 (t, J = 7.5 Hz, 1H, H₃), 6.02 (td, J = 16.0, 7.9 Hz, 1H, =CH), 5.55 – 5.38 (m, 2H, =CH, NH), 5.33 (br s, 1H, NH), 5.17 (d, J = 12.3 Hz, 2H, =CH₂), 5.11 – 4.98 (m, 2H, =CH₂), 4.45 (s, 1H, H₂), 4.11 (d, J = 16.5 Hz, 1H, CHH(NH)), 4.03 – 3.88 (m, 1H, CH/NH), 2.64 (m, 2H, CH₃ (allyl)), 2.39 (m, 2H, CH₂ (allyl)), 1.47 (s, 9H, CH₃ (tBu)), 1.29 (s, 9H, CH₃ (tBu)); ¹³C{¹H} NMR (150 MHz, CDCl₃, R.T.) δ 167.5 (C₅), 167.1 (C₅), 155.8 (C₅), 140.3 (C₅), 138.2 (C₅), 133.3 (CH), 132.5 (CH), 129.7 (C₅), 128.5 (CH), 124.4 (CH), 120.1 (=CH₂), 119.9 (=CH₂), 80.2 (C₅), 71.1 (CH), 52.3 (C₅), 50.8 (C₅), 45.8 (CH₂), 44.1 (CH₂), 38.2 (CH₂), 28.6 (CH₃ (tBu)), 28.4 (CH₃ (tBu));
(C₄H), 119.7 (=CH₂), 119.4 (=CH₂), 80.0 (C₆), 71.5 (C₂H), 52.1 (C₆), 50.9 (C₆), 45.9 (CH₂), 44.3 (C₆), 42.4 (CH₂), 38.5 (COCH₂), 28.5 (CH₃), 28.4 (CH₃), C₇H was not observed in ¹³C{¹H} NMR; HRMS (EI) calcd for C₉H₁₁N₂O₃ [M]+ 455.2784 found 455.2781; FT-IR (ATR) ν = 3330 (NH), 3300 (NH), 3074 (CH), 2975 (CH), 2930 (CH), 1669 (C=O), 1647 (C=O), 1527, 1481, 1454, 1406, 1364, 1238, 1163, 916, 752 cm⁻¹.

3,3-Diallyl-N-(tert-butyl)-1-(2-(methylamino)acetyl)indoline-2-carboxamide (8l)

The product was obtained according to the General procedure for B with slight modifications. After a week at 50°C, purification of the crude residue was purified by column chromatography on silica (PE/EtOAc/NEt₃ 90/10/1 to PE/EtOAc/NEt₃ 10/90/1) to give the desired compound as a white solid (78 mg, 87%); mp = 127 - 128 °C; ¹H NMR (400 MHz, CDCl₃, R.T.) δ 7.98 (s, 1H, H₇), 7.34 – 7.15 (m, 2H, H₄, H₆), 7.08 (t, J = 7.5 Hz, 1H, H₃), 6.04 (dd, J = 9.5, 6.4 Hz, 1H, =CH), 5.46 (m, 2H, =CH, NH), 5.16 (br d, J = 12.7 Hz, 2H, =CH₂), 5.03 (br d, J = 12.6 Hz, 2H, =CH₂), 4.48 (s, 1H, H₂), 3.59 (d, J = 16.3 Hz, 1H, NHCHH), 3.40 (d, J = 16.3 Hz, 1H, NHCHH), 2.75 – 2.46 (m, 6H, NHCH₃, NHCH₃, CH₂), 2.38 (m, 2H, CH₂), 1.27 (s, 9H, CH₃), 1.36 (C₆), 134.1 (=CH), 133.2 (=CH), 128.6 (C₆), 124.6 (C₆), 124.3 (C₆), 119.3 (=CH₂), 119.0 (=CH₂), 116.6 (C₆), 71.7 (C₆), 54.2 (NHCH₃), 52.0 (C₅), 50.7 (C₆), 46.2 (CH₂), 38.7 (CH₂), 36.4 (NCH₃), 28.7 (CH₃), 13.C{¹H} NMR (101 MHz, CDCl₃, R.T.) δ 169.8 (NH), 168.1 (NC), 141.7 (C₆), 136.5 (C₆), 134.1 (=CH), 133.2 (=CH), 128.6 (C₆), 124.6 (C₆), 124.3 (C₆), 119.3 (=CH₂), 119.0 (=CH₂), 116.6 (C₆), 71.7 (C₆), 54.2 (NHCH₃), 52.0 (C₅), 50.7 (C₆), 46.2 (CH₂), 38.7 (CH₂), 36.4 (NCH₃), 28.7 (CH₃). HRMS (CI) calcd for C₂₃H₂₃N₂O₂ [M+H]+ 370.2495 found 370.2490; FT-IR (ATR) ν = 3310 (NH), 3072 (CH), 2970 (CH), 1654 (C=O), 1595, 1548, 1480, 1395, 1220, 996, 914, 750 cm⁻¹.

3,3-Diallyl-1-((S)-2-amino-3-phenylpropanoyl)-N-(tert-butyl)indoline-2-carboxamide (8m)

The product was obtained according to the General procedure B with slight modifications. After one week at 50°C volatiles were removed under vacuum and the crude residue was purified by column chromatography on SiO₂ (PE/EtOAc/NEt₃ 90/10/1 to 30/70/1) to afford the UGI product as a pale yellow oil (80 mg, 68%) and a mixture of two inseparable diastereoisomers (A/B : ratio 1/0.8); ¹H NMR (CDCl₃, 400 MHz, 55°C) δ 8.20 (br s, 1H, H₇A), 8.02 (br s, 0.7H, H₇B), 7.41 – 6.96 (m, 14.4H, CH₃A, H₅A, H₆A, H₆B, H₅B, H₆B), 6.11 (dt, J = 17.5, 7.5 Hz, 0.8H, =CH), 6.05 – 5.89 (m, 1H, =CH), 5.67 – 5.33 (m, 3.5H, =CH₂, NH₂, =CH₂, NH₂), 5.28 – 5.08 (m, 3.6H, =CH₂, =CH₂), 5.08 – 4.89 (m, 3.6H, =CH₂ =CH₂), 4.81 (br s, 0.8H, H₂B), 4.29 (br s, 1H, H₂A), 3.94 (br s, 0.7H, NH₂CH₂), 3.81 (br s, 1H, NH₂CH₂), 3.16 (dd, J = 12, 4 Hz, 0.8H, PhCH₂), 3.13 (dd, J = 18.1, 4.5 Hz,
1H, PhCHHₐ), 2.89 – 2.75 (m, 2.8H, PhCHHₐ, PhCHHₐ), 2.70 – 2.63 (m, 1.6H, CH₂_allyl), 2.59 (d, J = 7.1 Hz, 2H, CH₂_allyl), 2.35 (d, J = 6.7 Hz, 1.6H, CH₂_allyl), 2.23 – 2.09 (m, 2H, CH₂_allyl), 1.85 (br s, 4H, NH₂A, NH₂B), 1.29 (s, 9H, CH₃_allyl), 1.23 (s, 5.4H, CH₃_allyl), 13C{¹H} NMR (101 MHz, CDCl₃, 55°C) δ 174.6 (C=O), 172.8 (C=O), 168.1 (C=O), 141.4 (C₉), 137.6 (=CH), 137.5 (=CH), 134.0, 133.7, 133.1, 132.9, 129.6, 129.3, 128.6, 128.5, 128.3, 126.8, 126.4, 124.4, 124.2, 124.1, 119.2 (=CH₂), 119.1 (=CH₂), 118.8 (=CH₂), 118.7 (=CH₂), 72.4 (C₂H), 72.3 (C₂H), 55.7 (NH₂CH), 55.3 (NH₂CH), 51.8 (C₉), 51.6 (C₉), 45.2 (CH₂_allyl), 45.1 (CH₂_allyl), 42.2 (PhCH₂), 41.4 (PhCH₂), 38.2 (CH₂_allyl), 37.7 (CH₂_allyl), 28.5 (CH₃_allyl); HRMS (Cl) calcd for C₂₈H₃₃N₅O₂ [M+H]⁺ 446.2806 found 446.2802; FT-IR (ATR) ν = 3310 (NH), 3068 (CH), 2970 (CH), 2924 (CH), 2874 (CH), 1657 (C=O), 1634 (C=O), 1479, 1455, 1362, 1219, 915, 749, 698, 503 cm⁻¹.

3,3-Diallyl-N-(tert-butyl)-1-((R)-2-hydroxy-2-phenylacetyl)-5-methoxyindole-2-carboxamide (8n)

The product was obtained according to the General procedure B. NMR analysis revealed a mixture of two diastereoisomers (1/1). Purification of the crude residue by column chromatography on SiO₂ (PE/EtOAc: 100/0 to 30/70) allowed separation of the two diastereoisomers (diast 1 = 48 mg, diast 2 = 41 mg, 87%).

### Diastereoisomer 1

Pale yellow oil; Rₜ = 0.35 (PE/EtOAc 70/30); ¹H NMR (CDCl₃, 600 MHz, R.T.) δ 8.26 (d, J = 8.8 Hz, 1H, Hₗ), 7.31 – 7.42 (m, 5H, CH₃Ph), 6.82 (dt, J = 8.8; 2.4 Hz, 1H, Hₐ), 6.75 (d, J = 2.4 Hz, 1H, Hₐ), 5.95 (ddd, J = 16.3; 9.3; 5.7 Hz, 1H, =CH), 5.30 (s, 1H, NH), 5.12 (m, 2H, =CH₂), 5.00 (dt, J = 20.9; 7.0 Hz, 1H, =CH), 4.96 (d, J = 7.0 Hz, 1H, CHOH), 4.59 (d, J = 10.2 Hz, 1H, =CHH), 4.49 (d, J = 7.0 Hz, 1H, OH), 4.25 (d, J = 17.0 Hz, 1H, =CHH), 4.19 (s, 1H, NCH), 3.78 (s, 3H, OCH₃), 2.53 (dd, J = 14.7; 5.4 Hz, 1H, CHH_allyl), 2.44 (dd, J = 14.7; 8.6 Hz, 1H, CHH_allyl), 1.96 (dd, J = 13.8; 7.4 Hz, 1H, CHH_allyl), 1.81 (dd, J = 13.8, 7.4 Hz, 1H, CHH_allyl), 1.29 (s, 9H, CH₃_allyl), 1.23 (s, 9H, CH₃_allyl), 13C{¹H} NMR (CDCl₃, 150 MHz, R.T.) δ 171.0 (NC=O), 167.8 (NHC=O), 157.4 (C₉), 138.1 (C₉), 138.0 (C₉), 134.0 (C₉), 133.5 (=CH), 131.4 (=CH), 129.4 (CH₃Ph), 129.3 (CH₃Ph), 128.0 (CH₃Ph), 119.8 (=CH₂), 119.4 (=CH₂), 117.8 (C₉H), 112.8 (C₉H), 110.9 (C₉H), 73.1 (CHOH), 70.6 (NCH), 55.7 (OCH₂), 52.1 (C₉), 50.8 (C₉), 45.2 (CH₂), 38.0 (CH₂), 28.5 (CH₃_allyl); HRMS (Cl) calcd for C₂₈H₃₃N₅O₂ [M+H]⁺ 463.2597, found 463.2579; FT-IR (ATR) ν = 3419 (OH), 2966 (CH), 2927 (CH), 1679 (C=O), 1650 (C=O), 1486, 1454, 1365, 1270, 1198, 1182, 1062, 1030, 918, 699, 513, 490, 451 cm⁻¹.

### Diastereoisomer 2

White solid; mp = 113 - 114°C; Rₜ = 0.20 (PE/EtOAc 70/30); ¹H NMR (CDCl₃, 400 MHz, 55°C) δ 7.80 (br s, 1H, Hₗ), 7.23 – 7.46 (m, 5H, CH₃Ph), 6.79 – 6.81 (m, 2H, Hₐ, Hₐ), 5.97 – 6.21 (m, 1H, =CH), 5.32 – 5.54 (m, 2H, =CH, CHOH), 4.88 – 5.27 (m, 5H, =CH₂, NH), 4.55 (s, 1H, NCH), 4.20 (d, J = 6.2 Hz, 1H, OH), 3.81 (s, 3H, OCH₃), 2.58 (ddd, J = 23.0, 14.0, 7.0 Hz, 2H, CH₂_allyl), 2.26 (d, J = 5.2
Hz, 2H, CH$_2$-allyl), 0.96 (br s, 9H, CH$_3$-Bu); $^{13}$C{$^1$H} NMR (CDCl$_3$, 100 MHz, 55°C) δ 171.0 (NC=O), 166.7 (NHC=O), 138.3 (C$_q$), 133.9 (=CH), 132.7 (=CH), 128.9 (CH$_{Ph}$), 128.7 (CH$_{Ph}$), 127.6 (CH$_{Ph}$), 119.9 (=CH$_2$), 118.8 (=CH$_2$), 112.5 (C$_6$H), 110.8 (C$_4$H), 72.9 (NCH), 55.6 (OCH$_3$), 51.3 (C$_q$), 44.6 (CH$_2$), 37.6 (CH$_2$), 28.3 (CH$_3$-Bu). C$_7$H not observed by $^{13}$C{$^1$H} NMR; HRMS (CI) calcd for C$_{28}$H$_{34}$N$_2$O$_4$ [M+H]$^+$ 463.2597, found 463.2543; FT-IR (ATR) ν = 3328 (OH), 3072 (CH), 2963 (CH), 1686 (C=O), 1630 (C=O), 1597, 1453, 1270, 1252, 1198, 1030, 804, 624, 568 cm$^{-1}$.

4. Synthesis of substituted 3,3-diallyl-2-hydroxyindoline

**General procedure C:** The chloroformate or acid chloride (1 eq.) was added to a solution of the 3,3-diallyl-3H-indole in CH$_2$Cl$_2$ (C ≈ 0.07 mol/L) and left to stir for 30 minutes at room temperature before addition of NaHCO$_3$ sat. After extraction of the reaction mixture with CH$_2$Cl$_2$, the combined organic layers were washed with water, dried over Na$_2$SO$_4$ and filtered through cotton wool. Pure compounds were obtained by evaporation of the volatiles under reduced pressure or by purification by column chromatography on silica.

**Methyl 3,3-diallyl-2-hydroxyindoline-1-carboxylate (10a)**

The product was obtained by following the **General procedure C**. After evaporation of the volatiles the crude mixture was purified by column chromatography on SiO$_2$ using (PE/EtOAc 100/0 to 70/30) as eluent to obtained the desired product as a yellow oil (78 mg, 94%); R$_f$ = 0.47 (PE/EtOAc 4/1); $^1$H NMR (400 MHz, CDCl$_3$, 60°C) δ 7.65 (br s, 1H, H$_7$), 7.23 (td, 1H, J = 7.4, 1.2 Hz, H$_6$), 7.12 (d, 1H, J = 7.4 Hz, H$_4$), 7.03 (td, 1H, J = 7.4, 1.2 Hz, H$_5$), 5.99 (ddt, 1H, J = 17.8, 10.7, 7.3 Hz, =CH), 5.61 (s, 1H, H$_2$), 5.56 (ddt, 1H, J = 17.8, 10.7, 1.6 Hz, =CH$_2$), 5.14 (td, 2H, J = 17.8, 10.7, 1.6 Hz, =CH$_2$), 3.93 (s, 3H, OCH$_3$), 2.65 (d, 2H, J = 7.2 Hz, CH$_2$-allyl), 2.39 (dd, 1H, J = 13.9, 7.2 Hz, CHH$_{allyl}$), 2.32 (dd, 1H, J = 14.1, 7.7 Hz, CHH$_{allyl}$); $^{13}$C{$^1$H} NMR (100 MHz, CDCl$_3$, 60°C) δ 139.8 (C$_q$), 135.1 (=CH), 132.9 (=CH), 129.6 (C$_q$), 128.0 (CH), 123.8 (CH), 122.8 (CH), 118.5 (=CH$_2$), 117.9 (=CH$_2$), 114.5 (CH), 89.8 (C$_2$H), 52.7 (CH$_3$), 50.0 (C$_q$), 42.8 (CH$_2$-allyl), 36.9 (CH$_2$-allyl); C=O was not observed by $^{13}$C{$^1$H} NMR; HRMS (CI) calcd for C$_{16}$H$_{18}$NO$_2$ [M-OH]$^+$ 256.1332, found 256.1333; FT-IR (ATR) ν = 3437 (OH), 3074 (CH), 2977 (CH), 2955 (CH), 2916 (CH), 1686 (C=O), 1482, 1443, 1382, 1059, 952 cm$^{-1}$.
Methyl 3,3-diallyl-2-hydroxy-5-methoxyindoline-1-carboxylate (10b)

The product was obtained by following the General procedure C. After evaporation of the volatiles the crude mixture was purified by column chromatography on SiO₂ using (PE/EtOAc 100/0 to 70/30) as eluent to obtained the desired product as an orange oil (91 mg, 96%); Rₜ = 0.44 (PE/EtOAc 4/1); ¹H NMR (600 MHz, CDCl₃, 55°C) δ 7.54 (br s, 1H, H₇), 6.78 (dd, 1H, J = 9.0, 2.7 Hz, H₆), 6.71 (d, 1H, J = 2.7 Hz, H₄), 6.00 (ddt, 1H, J = 17.0, 10.2, 7.5 Hz, =CH₂), 5.57 (ddt, 2H, J = 17.0, 10.2, 7.5 Hz, =CH₂, H₂), 5.17-5.02 (m, 4H, =CH₂), 3.91 (s, 3H, C(O)OCH₃), 3.79 (s, 3H, OCH₃), 2.65 (dd, 1H, J = 14.3, 7.5 Hz, CHH₃(allyl), 2.60 (dd, 1H, J = 14.3, 7.5 Hz, CHH₃(allyl)); ¹³C{¹H} NMR (150 MHz, CDCl₃, R.T.) δ 156.0 (C=O), 137.1 (C₉), 136.5 (C₈), 135.5 (=CH), 133.9 (C₉), 132.9 (=CH), 119.0 (=CH₂), 118.5 (=CH₂), 115.8 (CH), 112.5 (CH), 110.8 (CH), 90.4 (C₂H), 55.7 (CH₃), 54.6 (C₃), 52.5 (CH₃), 47.6 (CH₂), 37.3 (CH₂); HRMS (CI) calcd C₁₇H₂₀NO₃ [M+H]+ 286.1438 , found 286.1439; FT-IR (ATR) υ = 3435 (OH), 3074 (CH), 2954 (CH), 2917 (CH), 2849 (CH), 1689 (C=O), 1489, 1459, 1434, 1269, 1031, 998 cm⁻¹.

Isobutyl 3,3-diallyl-2-hydroxy-5-methoxyindoline-1-carboxylate (10c)

The product was obtained by following the General procedure C. After work up and evaporation of the volatiles the crude mixture was purified by column chromatography on SiO₂ using (PE/EtOAc 100/0 to 70/30) as eluent to obtained the desired product as a yellow oil (67 mg, 82%); Rₜ = 0.45 (PETH/EtOAc 4/1); NMR at R.T. showed a mixture of two rotamers (1/1); ¹H NMR (400 MHz, CDCl₃, 55°C) δ 7.53 (br s, 1H, H₂), 6.76 (d, J = 8.8 Hz, 1H, H₆), 6.70 (s, 1H, H₄), 6.09 – 5.89 (m, 1H, =CH), 5.68 – 5.44 (m, 2H, =CH, H₂), 5.13 (t, J = 14.2 Hz, 2H, =CH₂), 5.01 (t, J = 12.1 Hz, 2H, =CH₂), 4.20 – 3.97 (m, 2H, OCH₃), 3.79 (s, 3H, OCH₃), 2.71 – 2.51 (m, 2H, CH₂(allyl)), 2.42 – 2.24 (m, 2H, CH₂(allyl)), 2.15 – 2.02 (m, 1H, CH₂(ør)), 1.03 (d, J = 6.5 Hz, 6H, CH₃(ør)); ¹³C{¹H} NMR (151 MHz, CDCl₃, R.T.) δ 155.9 (br, C=O), 154.8 (br, C=O), 137.1 (br, C₉), 136.6 (br, C₉), 135.2 (=CH), 133.1 (=CH), 118.9 (=CH₂), 118.5 (br, =CH₂), 115.1 (br, C₃H), 112.5 (C₄H), 110.8 (br, C₅H), 90.2 (C₆H), 98.1 (C₇H), 72.6 (OCH₂), 71.8 (OCH₃), 55.9 (OCH₃), 50.5 (C₃), 49.8 (C₃), 42.9 (br, CH₂(allyl)), 37.0 (br, CH₂(allyl)), 28.1 (CH₃(ør)), 19.4 (CH₂(ør)); HRMS (CI) calcd for C₂₀H₂₆NO₄ [M+H]+ 345.1940 found 345.19384; FT-IR (ATR) υ = 3425 (OH), 2960 (CH), 2928 (CH), 2874 (CH), 2834 (CH), 1677 (C=O), 1638 (C=O), 1490, 1466, 1435, 1406, 1384, 1321, 1263, 1206, 1183, 1126, 1053, 1033, 999, 911, 864, 807, 761, 731, 687 cm⁻¹.
1-(3,3-Diallyl-2-methoxyindolin-1-yl)-2-phenylethanone (11d)

Phenyl acetyl chloride (21 μL, 0.16 mmol, 1 eq.) was added to a solution of 3,3-diallyl-5-methoxy-3H-indole (31 mg, 0.16 mmol) in dichloromethane. After 30 minutes at room temperature methanol (0.1 mL) was added and the mixture was stirred for 30 minutes before evaporation of the volatiles under reduced pressure. The crude residue obtained was purified by column chromatography on silica (PE/EtOAc 100/0 to 95/5) to afford the pure compound as a colourless oil (28.5 mg, 51%); NMR at R.T. showed a mixture of two rotamers (1/1); Rf = 0.53 (PE/EtOAc 9/1); 1H NMR (400 MHz, CDCl3, 55°C) δ 7.72 (br s, 1H, H7), 7.35 - 6.99 (m, 8H, CHPh, H3, H5, H6), 5.91 (td, J = 16.7, 8.3 Hz, 1H, =CH), 5.37 (m, 2H, =CH, H2), 5.14 (m, 2H, =CH2), 4.83 (m, 2H, =CH2), 3.93 (s, 2H, COCH2), 3.38 (s, 3H, OCH3), 2.76 – 2.42 (m, 2H, CH2allyl), 2.25 – 1.94 (m, 2H, CH2allyl), 13C1H NMR (151 MHz, CDCl3, R.T.) δ 171.0 (C=O), 170.2 (C=O), 141.5 (Cq), 140.1 (Cq), 139.2 (Cq), 136.4 (Cq), 134.7 (Cq), 134.6 (br =CH), 134.5 (Cq), 132.7 (=CH), 129.3 (CH), 128.8 (CH), 128.2 (CH), 127.7 (CH), 127.2 (CH), 127.1 (CH), 124.6 (CH), 124.3 (CH), 123.0 (CH), 119.0 (=CH2), 118.8 (CH2), 117.6 (C=H), 116.7 (CH), 97.3 (C2H), 95.9 (C2H), 57.6 (OCH3), 54.5 (OCH3), 51.0 (C3), 50.4 (C3), 42.4 (COCH2), 42.1 (COCH2), 41.5 (CH2 allyl), 41.0 (CH2 allyl), 35.5 (CH2 allyl); HRMS (CI) calcd for C23H26NO2 [M+H]+ 348.1963 found 348.1961; FT-IR (ATR) ν = 3072 (CH), 3030 (CH), 2978 (CH), 2936 (CH), 2834 (CH), 1662 (C=O), 1599, 1495, 1476, 1379, 1100, 1075, 996, 914, 751, 718, 694 cm⁻¹.

Methyl 3,3-diallyl-2-methyleneindoline-1-carboxylate (12)

The product was obtained following the General procedure C. After evaporation of the volatiles the product was obtained as a dark purple oil (280 mg, 86%); Rf = 0.58 (PE/EtOAc 4/1); 1H NMR (600 MHz, CDCl3, R.T.) δ 7.76 (d, 1H, J = 7.6 Hz, H7), 7.20 (td, 1H, J = 7.6, 1.5 Hz, H6), 7.13 (dd, 1H, J = 7.6, 0.9 Hz, H4), 7.07 (td, 1H, J = 7.6, 0.9 Hz, H5), 5.82 (s, 1H, C2CHH), 5.43 (ddt, 2H, J = 17.2, 10.2, 7.2 Hz, =CH), 4.93-4.87 (m, 4H, =CH2), 4.62 (d, 1H, J = 1.5 Hz, C2CHH), 3.95 (s, 3H, C2OCH3), 2.56 (dd, 2H, J = 13.8, 7.2 Hz, CH2 allyl), 2.43 (dd, 2H, J = 13.8, 7.2 Hz, CH2 allyl); 13C1H NMR (100 MHz, CDCl3, 55°C) δ 153.5 (C=O), 150.2 (Cq), 141.7 (Cq), 133.8 (Cq), 133.2 (CH), 127.9 (CH), 123.5 (CH), 123.2 (CH), 118.4 (=CH2), 94.3 (=CH2), 53.0 (CH3), 52.2 (C3), 46.6 (CH2); HRMS (CI) calcd for C17H20NO2 [M+H]+ 270.1494 found, 270.1481; FT-IR (ATR) ν = 3020 (CH), 2938 (CH), 1714 (C=O), 1481, 1354, 1237, 1094 cm⁻¹.
5. Synthesis of 2,3-diallylindoles

General procedure D: Preparation of 2,3-diallylindole from 2-hydroxy-3,3-diallylindoline (13)

Aluminium chloride (1.1 eq.) was added to a solution 3,3-diallyl-2-hydroxyindoline (1.0 eq.) in CH₂Cl₂ (C ≈ 1 mol/L) at room temperature. The mixture was stirred for 30 minutes before addition of NEt₃ (≈ 2eq.). After 5 minutes at room temperature water was added and the product was extracted with CH₂Cl₂ (3 times). The combined organic layers were dried over Na₂SO₄. After evaporation, the crude material was purified by filtration through a small pad of SiO₂ to yield the rearranged product.

Methyl 2,3-diallyl-1H-indole-1-carboxylate (13a)

The product was obtained by following the General procedure D. After evaporation, the crude material was purified by filtration through a small pad of silica to yield the rearranged product as a colourless oil (120 mg, 97%); Rf = 0.3 (PE/Et₂O 90/10); ¹H NMR (600 MHz, CDCl₃, R.T.) δ 8.09 (d, J = 8.2 Hz, 1H, H₇), 7.48 (d, J = 7.3 Hz, 1H, H₄), 7.37 – 7.16 (m, 2H, H₅, H₆), 6.08 – 5.83 (m, 2H, =CH₂), 5.19 – 4.84 (m, 4H, =CH₂), 4.02 (s, 3H, OCH₃), 3.79 (dt, J = 5.6, 1.4 Hz, 2H, CH₂ allyl), 3.44 (dt, J = 5.8, 1.4 Hz, 2H, CH₂ allyl); ¹³C{¹H} NMR (151 MHz, CDCl₃) δ 152.5 (C=O), 136.0 (=CH), 135.8 (=CH), 134.8 (C₉), 130.1 (C₉), 124.1 (C₅₋₆H), 122.9 (C₅₋₆H), 118.7 (C₄H), 117.8 (C₉), 115.7 (=CH₂), 115.6 (=CH₂), 115.5 (C₇H), 53.5 (OCH₃), 30.7 (CH₂ allyl), 28.4 (CH₂ allyl); HRMS (EI) calcd for C₁₅H₁₇NO₂ [M]+ 255.12593 found 255.12581; FT-IR (ATR) ν = 3076 (CH), 3005 (CH), 2954 (CH), 2925 (CH), 2852 (CH), 1732 (C=O), 1638 (C=C), 1475, 1457, 1385, 1355, 1284, 1264, 1227, 1187, 1187, 1134, 1066, 1024, 909, 817, 412 cm⁻¹.

Isobutyl 2,3-diallyl-1H-indole-1-carboxylate (13c)

The product was obtained by following the General procedure D. After evaporation, the crude material was purified by filtration through a small pad of silica to yield the rearranged product as a colourless oil (20 mg, 97%); Rf = 0.35 (PE/Et₂O 90/10); ¹H NMR (600 MHz, CDCl₃) δ 8.00 (d, J = 9.0 Hz, 1H, H₇), 6.93 (d, J = 2.5 Hz, 1H, H₄), 6.87 (dd, J = 9.0, 2.6 Hz, 1H, H₆), 6.00 (dtd, J = 16.9, 10.3, 5.6 Hz, 1H, =CH), 5.96 – 5.09 (m, 1H, =CH), 5.11 – 4.91 (m, 4H, =CH₂), 4.20 (d, J = 6.6 Hz, 2H, H₅).
OCH₂), 3.85 (s, 3H, OCH₃), 3.79 (dt, J = 5.6, 1.4 Hz, 2H, CH₂ alkyl), 3.40 (dt, J = 6.0, 1.5 Hz, 2H, CH₂ alkyl), 2.16 (m, 1H, CH₃), 1.05 (d, J = 6.7 Hz, 6H, CH₃); ¹³C{¹H} NMR (151 MHz, CDCl₃) δ 156.0 (Cₘₚ), 152.0 (Cₘₚ), 135.9 (=CH), 153.5 (=CH), 135.7 (Cₘₚ), 131.0 (Cₘₚ), 130.6 (Cₘₚ), 117.5 (Cₘₚ), 116.9 (CH), 115.7 (=CH₂), 115.5 (=CH₂), 112.0 (CH), 101.8 (CH), 73.3 (OCH₂), 55.8 (OCH₃), 30.7 (CH₂ alkyl), 28.4 (CH₂ alkyl), 28.0 (CH₃), 19.5 (CH₃); HRMS (CI) calcd for C₂₀H₂⁶NO₃ [M+H]+ 328.19127 found 328.19681; FT-IR (ATR) ν = 3079 (CH), 2959 (CH), 2928 (CH), 2874 (CH), 1726 (C=O), 1637 (C=C), 1607, 1476, 1454, 1437, 1400, 1382, 1355, 1323, 1283, 1264, 1237, 1210, 1176, 1118, 1103, 1041, 1017 cm⁻¹.

**Preparation of 2,3-diallylindole starting from 3,3-diallylindolinine**

![Chemical structure](image)

**General procedure E: Using an acyl chloride**
The acyl chloride (1 eq.) was added to a solution of 3,3-diallyl-3H-indole (1 eq.) in CH₂Cl₂ (C ≈ 0.3 mol/L) at room temperature. After 30 minutes, the reaction was quenched by addition of water and the mixture was extracted with CH₂Cl₂ (3 times). The combined organic layers were dried over Na₂SO₄ and filtered. Evaporation of the volatiles give the 3,3-diallyl-2-hydroxyindoline which was directly dissolved in CH₂Cl₂ (C ≈ 0.3 mol/L) and AlCl₃ (1.1 eq.) was added. After 30 minutes at room temperature the reaction was quenched with NaHCO₃ sat before extraction with CH₂Cl₂ (3 times). The combined organic phases were washed with water, dried over Na₂SO₄ and filtered. After evaporation of the volatiles under vacuum, the crude residue was purified by a filtration on a small pad of SiO₂ using PE/Et₂O (90/10) as eluent.

**General procedure F: Using a chloroformate**
The chloroformate (1 eq.) was added to a solution of 3,3-diallyl-3H-indole (1 eq.) in CH₂Cl₂ (C ≈ 0.2 mol/L) at room temperature. After 30 minutes, the reaction was quenched by addition of NaHCO₃ sat and the mixture was extracted with CH₂Cl₂ (3 times). The combined organic layers were washed with water and dried over Na₂SO₄ before filtration. Evaporation of the volatiles gave 3,3-diallyl-2-hydroxy-indoline derivative which was directly dissolved in CH₂Cl₂ (C ≈ 0.2 mol/L) and AlCl₃ (1.1 eq.) was added. After 30 minutes at room temperature NEt₃ (≈ 2 eq.) was added. The solution was left to stir for 5 minutes before addition of a saturated solution of K₂CO₃ and extraction with CH₂Cl₂ (3 times). The combined
organic phases were washed with water, dried over Na$_2$SO$_4$ and filtered. After evaporation of the volatiles under vacuum, the crude residue was purified by filtration through a small pad of SiO$_2$ using PE/Et$_2$O (100/0 to 90/10) as eluent.

**1-(2,3-Diallyl-5-methoxy-1H-indol-1-yl)-2-phenylethanone (13d)**

The product was obtained by following the General procedure E. After evaporation of the volatiles under vacuum, the crude residue was purified by a filtration on a small pad of SiO$_2$ using Et$_2$O as eluent. The pure product was obtained as pale yellow oil (82 mg, 78%); Rf = 0.16 (PE/Et$_2$O 90/10); $^1$H NMR (600 MHz, CDCl$_3$) $\delta$ 7.80 (d, $J = 9.1$ Hz, 1H, $H_7$), 7.35 (m, 2H, $CH_{Ph}$), 7.31 – 6.96 (m, 3H, $CH_{Ph}$), 6.95 (d, $J = 2.6$ Hz, 1H, $H_5$), 6.85 (dd, $J = 9.0$, 2.6 Hz, 1H, $H_6$), 5.99 (ddt, $J = 17.1$, 10.5, 5.4 Hz, 1H, =CH), 5.91 (ddt, $J = 16.1$, 10.1, 6.0 Hz, 1H, =CH), 5.11 – 5.01 (m, 3H, =CH$_2$, =CHH), 4.95 (dd, $J = 17.2$, 1.6 Hz, 1H, =CHH), 4.32 (s, 2H, COCH$_3$), 3.84 (s, 3H, OCH$_3$), 3.78 – 3.72 (m, 2H, CH$_2$ allyl), 3.39 (m, 2H, CH$_2$ allyl); $^{13}$C[$^1$H] NMR (151 MHz, CDCl$_3$) $\delta$ 171.0 (C=O), 156.1 (C$_{OMe}$), 135.9 (C$_q$), 135.60 (=CH), 135.59 (=CH), 134.1 (C$_q$), 131.6 (C$_q$), 130.4 (C$_q$), 129.5 (CH), 128.8 (CH), 127.3 (CH), 118.6 (C$_q$), 116.2 (=CH$_2$), 116.0 (CH), 115.9 (=CH$_2$), 112.0 (CH), 102.2 (CH), 55.8 (OCH$_3$), 45.0 (CH$_2$), 31.0 (CH$_2$), 28.4 (CH$_2$); HRMS (Cl) calcd for C$_{23}$H$_{24}$NO$_2$ [M+H]$^+$ 346.1807 found 346.1799; FT-IR (ATR) $\nu$ = 3077 (CH), 3030 (CH), 3003 (CH), 2926 (CH), 2833 (CH), 1697 (C=O), 1637 (C=C), 1606, 1496, 1476, 1454, 1434, 1360, 1319, 1281, 1233, 1169, 1110, 1076, 1052, 1033 cm$^{-1}$.

**1-(2,3-Diallyl-1H-indol-1-yl)(4-methoxyphenyl)methanone (13e)**

The product was obtained by following the General procedure E. After evaporation of the volatiles under vacuum, the crude residue was purified by a filtration through a small pad of SiO$_2$ using PE/Et$_2$O (95/5) as eluent. The pure product was obtained as colourless oil (56 mg, 73%); Rf = 0.16 (PE/Et$_2$O 90/10); $^1$H NMR (600 MHz, CDCl$_3$) $\delta$ 7.72 (d, $J = 8.8$ Hz, 2H, $CH_{Ph}$), 7.51 (d, $J = 7.8$ Hz, 1H, $H_7$), 7.14 (t, $J = 7.5$ Hz, 1H, $H_6$), 7.00 (t, $J = 8.2$ Hz, 1H, $H_5$), 6.96 (d, $J = 8.8$ Hz, 2H, $CH_{Ph}$), 6.81 (d, $J = 8.4$ Hz, 1H, $H_5$), 5.99 (ddt, $J = 16.2$, 10.0, 6.1 Hz, 1H, =CH), 5.88 (ddt, $J = 16.2$, 10.3, 5.9 Hz, 1H, =CH), 5.18 – 5.04 (m, 1H, =CH$_2$), 5.00 – 4.89 (m, 1H, =CH$_2$), 3.90 (s, 3H, OCH$_3$), 3.72 (d, $J = 5.9$ Hz, 2H, CH$_2$ allyl), 3.51 (d, $J = 6.1$ Hz, 2H, CH$_2$ allyl); $^{13}$C[$^1$H] NMR (151 MHz, CDCl$_3$) $\delta$ 169.2 (C$_q$), 163.8 (C$_q$), 137.0 (C$_q$), 136.2 (=CH), 135.8 (C$_q$), 135.4 (=CH), 132.7 (CH), 129.7 (C$_q$), 127.5 (C$_q$), 122.8 (CH), 121.9 (CH), 118.9 (CH), 117.1 (C$_q$), 116.1 (=CH$_2$), 115.6 (=CH$_2$), 114.1 (CH), 113.9 (CH), 55.7 (OCH$_3$), 29.6 (CH$_2$ allyl), 28.5 (CH$_2$ allyl); HRMS (Cl) calcd for C$_{22}$H$_{21}$NO$_2$ [M+H]$^+$ 332.16505 found
332.16502; FT-IR (ATR) v = 3077 (CH), 3005 (CH), 2975 (CH), 2928 (CH), 2839 (CH), 1677 (C=O), 1637 (C=C), 1601, 1575, 1509, 1454, 1419, 1383, 1350, 1313, 1253, 1239, 1171, 1111, 1023 cm\(^{-1}\).

4-Nitrophenyl 2,3-diallyl-5-methyl-1H-indole-1-carboxylate (13f)

The product was obtained by following the General procedure E. After evaporation of the volatiles under vacuum, the crude residue was purified by filtration through a small pad of SiO\(_2\) using PE/Et\(_2\)O (100/0 to 90/10) as eluent. The pure product was obtained as a white solid (56 mg, 74%); mp = 62 - 63°C; Rf = 0.21 (PE/Et\(_2\)O 90/10); \(^1\)H NMR (600 MHz, CDCl\(_3\)) \(\delta\) 8.43 – 8.28 (m, 2H, C\(\text{H}_\text{Ph}\)), 7.99 (d, \(J = 8.5\) Hz, 1H, \(H_7\)), 7.59 – 7.39 (m, 2H, C\(\text{H}_\text{Ph}\)), 7.31 (s, 1H, \(H_4\)), 7.14 (dd, \(J = 8.4, 1.1\) Hz, 1H, \(H_6\)), 6.12 – 5.83 (m, 2H, =C\(\text{H}\)), 5.21 – 4.96 (m, 4H, =C\(\text{H}_2\)), 3.81 (d, \(J = 5.5\) Hz, 2H, C\(\text{H}_2\) allyl), 3.45 (dd, \(J = 4.5, 1.5\) Hz, 2H, C\(\text{H}_2\) allyl), 2.46 (d, 3H, CH\(_3\)) \(^{13}\)C\{\(^1\)H\} NMR (151 MHz, CDCl\(_3\)) \(\delta\) 154.9 (C\(_q\)), 149.0 (C\(_q\)), 145.8 (C\(_q\)), 135.6 (=CH), 135.5 (=CH), 134.6 (C\(_q\)), 134.1 (C\(_q\)), 133.5 (C\(_q\)), 132.0 (C\(_q\)), 126.0 (CH), 125.6 (CH), 122. (CH), 119.5 (C\(_q\)), 119.1 (CH), 116.01 (=CH\(_3\)), 116.59 (=CH\(_3\)), 115.6 (CH), 30.6 (CH\(_2\) allyl), 28.4 (CH\(_2\) allyl), 21.5 (CH\(_3\)); HRMS (ESI) calcd for C\(_{22}\)H\(_{21}\)N\(_2\)O\(_4\) [M+H\(^+\)] \(377,1501\) found 337.1498 ;FT-IR (ATR) v = 3080 (CH), 2919 (CH), 2858 (CH), 1741 (C=O), 1637 (C=C), 1615, 1592, 1522, 1490, 1473, 1375, 1358, 1342, 1320, 1257, 1215, 1194, 1159, 1110, 1091, 1011 cm\(^{-1}\).

6. (L)-Proline catalysed asymmetric Mannich reaction

**General procedure G:** L-proline (30 mol%) was added at 0 °C to a solution of 3,3-diallyl-3H-indole (1 eq.) in a mixture of acetone:CHCl\(_3\) (4.5:1, C \(\approx\) 0.022 mol/L). The reaction mixture was allowed to warm up slowly to room temperature and stirred for 2 days. Evaporation of the solvent followed by purification by column chromatography on SiO\(_2\) afforded the Mannich product.

**General procedure H:** L-proline (30 mol%) was added at 0 °C to a solution of 3,3-diallyl-3H-indole (1 eq.) in a mixture of acetone/DMSO (4:1, C \(\approx\) 0.016 mol/L). The solution was allowed to warm up slowly to room temperature and stirred for 2 days. The reaction mixture was diluted with diethyl ether and washed with NaHCO\(_3\)\(_{\text{sat}}\). The product was extracted with Et\(_2\)O (3 times) and combined organic layers...
were washed with water, brine and dried with MgSO₄. After filtration and removal of the solvents under reduce pressure the crude product was purified by column chromatography on SiO₂.

1-(3,3-Diallylindolin-2-yl)propan-2-one (14a)

The product was obtained by following the General procedure G. After evaporation of the volatiles, the crude mixture was purified by column chromatography on SiO₂ using (CH₂Cl₂/Et₂O 100/0 to 95/5) as eluent. The title compound was obtained as a yellow oil (61 mg, 81%) with 99.3/0.7 er determined by chiral HPLC (Chiralpak Daicel AD // hexane/ iPrOH (95/5) // 0.5 mL/min), tr₁ = 16.71 min (minor), tr₂ = 21.45 min (Major); [α]D²⁰ = + 0.111 (c = 1.01 mg/mL, CHCl₃); Rf = 0.50 (CH₂Cl₂/Et₂O 9.5/0.5); ¹H (600 MHz, CDCl₃) δ 7.04 (td, 1H, J = 7.4, 1.0 Hz, H₃), 6.97 (d, 1H, J = 7.4 Hz, H₄), 6.73 (td, 1H, J = 7.4, 1.0 Hz, H₅), 6.63 (d, 1H, J = 7.4 Hz, H₆), 5.75 (dtd, 1H, J = 17.1, 9.7, 7.3 Hz, =CH), 5.68 (dtd, 1H, J = 17.1, 9.7, 7.3 Hz, =CH), 5.07-5.00 (m, 4H, =CH₂), 4.53 (br s, 1H, NH), 4.00 (dd, 1H, J = 8.5, 4.6 Hz, H₂), 2.80 (m, 2H, C(O)CH₂), 2.52 (dd, 1H, J = 14.1, 7.3 Hz, CHHₐlyl); 2.38 (dd, 1H, J = 14.1, 7.3 Hz, CHHₐlyl), 2.43 (dd, 1H, J = 14.1, 7.3 Hz, CHHₐlyl), 2.10 (dd, 1H, J = 14.1, 7.3 Hz, CHHₐlyl), 2.20 (s, 3H, CH₃); ¹³C [¹H] (150 MHz, CDCl₃) δ 208.6 (C=O), 150.0 (C₉), 143.8 (CH), 134.4 (CH), 133.8 (C₉), 127.8 (CH), 124.1 (CH), 118.6 (CH), 118.2 (=CH₂), 118.0 (=CH₂), 109.9 (CH), 62.1 (CH), 49.0 (C₉), 44.0 (CH₂), 41.0 (CH₂), 38.5 (CH₂), 30.7 (CH₃); HRMS (Cl) calcd. for C₁₇H₂₂NO [M+H]⁺ 256.1696, found 256.1698; FT-IR (ATR) ν = 3010 (CH), 2929 (CH), 1693 (C=O), 1505, 1253 cm⁻¹.

1-(3,3-Diallyl-5-methoxyindolin-2-yl)propan-2-one (14b)

The product was obtained by following the General procedure G. After evaporation of the volatiles, the crude mixture was purified by column chromatography on SiO₂ using CH₂Cl₂/Et₂O (100/0 to 95/5) as eluent. The title compound was obtained as a yellow oil (60 mg, 96%) with 98.8/1.2 er determined by chiral HPLC (Chiralpak Daicel AD // hexane/ iPrOH (75/25) // 0.5 mL/min), tr₁ = 15.12 min (Major), tr₂ = 16.70 min (minor); [α]D²⁰ = + 0.100 (c = 1.01 mg/mL, CHCl₃); Rf = 0.50 (CH₂Cl₂/Et₂O 9.5/0.5); ¹H NMR (600 MHz, CDCl₃) δ 6.61 (dd, 1H, J = 8.3, 2.4 Hz, H₆), 6.59 (d, 1H, J = 2.4 Hz, H₅), 6.56 (d, 1H, J = 8.3 Hz, H₄), 5.74 (dtd, 1H, J = 16.3, 9.2, 7.3 Hz, =CH), 5.67 (dt, 1H, J = 16.3, 9.2, 7.3 Hz, =CH), 5.06-5.00 (m, 4H, =CH₂), 3.99 (dd, 1H, J = 10.5, 2.4 Hz, H₂), 3.74 (s, 3H, OCH₃), 2.81 (m, 2H, C(O)CH₂), 2.51 (dd, 1H, J = 14.3, 7.3 Hz, CHHₐlyl), 2.39 (dd, 1H, J = 14.3, 7.3 Hz, CHHₐlyl), 2.36 (dd, 1H, J = 14.3, 7.3 Hz, CHHₐlyl), 2.12 (dd, 1H, J = 14.3, 7.3 Hz, CHHₐlyl), 2.20 (s, 3H, CH₃); ¹³C [¹H]
NMR (150 MHz, CDCl₃) δ 208.9 (C=O), 154.3 (C₆), 143.8 (C₆), 135.5 (C₆), 134.7 (CH), 134.3 (CH), 118.3 (=CH₂), 118.1 (=CH₂), 112.4 (CH), 111.4 (CH), 110.1 (CH), 62.6 (CH), 56.1 (CH₂), 49.3 (C₆), 44.3 (CH₂), 40.9 (CH₂), 38.4 (CH₂), 30.8 (CH₃); HRMS (CI) calcd. for C₁₈H₂₃NO₂ [M+H]+ 286.1801, found 286.1795; FT-IR (ATR) ν = 3367 (N-H), 2977 (CH), 1713 (C=O), 1500, 1434, 1220, 1168 cm⁻¹.

1-(3,3-Diallyl-5-chloroindolin-2-yl)propan-2-one (14c)

The product was obtained by following the General procedure I. The crude mixture was purified by column chromatography on SiO₂ using PE/EtOAc (100/0 to 80/20) as eluent. The title compound was obtained as a yellow oil (28 mg, 64%) with 99.0/1.0 er determined by chiral HPLC (Chiralpak Daicel AD // hexane/iPrOH (75/25) // 0.5 mL/min), trτ₁ = 11.56 min (minor), trτ₂ = 13.14 min (Major); [α]D²⁰ = +0.360 (c = 1.36 mg/mL, CHCl₃); Rf = 0.50 (CH₂Cl₂/Et₂O 9.5/0.5); ¹H (600 MHz, CDCl₃) δ 6.98 (dd, 1H, J = 8.3, 2.3 Hz, H₆), 6.90 (d, 1H, J = 2.3 Hz, H₄), 6.53 (d, 1H, J = 8.3 Hz, H₇), 5.71 (dd, 1H, J = 17.0, 9.8, 7.0 Hz, =CH), 5.65 (ddt, 1H, J = 17.0, 9.8, 7.0 Hz, =CH), 5.09-5.00 (m, 4H, =CH₂), 4.55 (br s, 1H, NH), 4.01 (dd, 1H, J = 8.4, 4.8 Hz, H₂), 2.79 (m, 2H, C(O)CH₂), 2.48 (dd, 1H, J = 13.8, 7.0 Hz, CHH₄ allyl), 2.39 (dd, 1H, J = 13.8, 7.0 Hz, CHH₄ allyl), 2.35 (dd, 1H, J = 13.8, 7.0 Hz, CHH₄ allyl), 2.12 (dd, 1H, J = 13.8, 7.0 Hz, CHH₄ allyl), 2.20 (s, 3H, CH₃); ¹³C [¹H] (150 MHz, CDCl₃) δ 208.3 (C=O), 148.4 (C₆), 135.9 (C₆), 134.1 (CH), 134.0 (CH), 127.7 (CH), 124.3 (CH), 123.2 (C₆), 118.6 (=CH₂), 118.5 (=CH₂), 110.8 (CH), 63.1 (CH), 49.2 (C₆), 43.8 (CH₂), 40.7 (CH₂), 38.2 (CH₂), 30.7 (CH₃); HRMS (CI) calcd. for C₁₇H₂₁NO [M+H]+ Prediction 290.1306, found 290.1304; FT-IR (ATR) ν = 3010 (CH), 2918 (CH), 1713 (C=O), 1479, 1427, 1169 cm⁻¹.

7. Ring closing metathesis reactions of UGI compounds

General procedure I: First generation Grubbs catalyst (15 mol %) to a degassed solution of the corresponding Ugi product (1eq.) in CH₂Cl₂ (C ≈ 0.06 mol/L) at 45°C. The reaction mixture was heated at reflux overnight under argon before evaporation of the solvent under reduced pressure. The crude residue was purified by column chromatography on SiO₂ to yield the desired product.

1'-Benzoyl-N-(tert-butyl)spiro[cyclopentane-1,3'-indolin]-3-ene-2'-carboxamide (15a)

The product was obtained by following the General procedure I. The crude mixture was purified by column chromatography on SiO₂ using (PE/EtOAc 60/40) as eluent. The title compound was obtained as
a grey oil (56 mg, 96%); $R_f = 0.44$ (PE/EtOAc 4/1); $^1H$ NMR (400 MHz, CDCl$_3$, 55°C) $\delta$ 7.54 (d, 2H, $J = 7.4$ Hz, CH$_2$-Bz), 7.49 (t, 1H, $J = 7.4$ Hz, CH$_{p-Bz}$), 7.44 (t, 2H, $J = 7.4$ Hz, CH$_{m-Bz}$), 7.22 (d, 1H, $J = 7.6$ Hz, $H_d$), 7.13 (br s, 1H, $H_t$), 7.08 (t, 1H, $J = 7.6$ Hz, $H_b$), 7.01 (t, 1H, $J = 7.6$ Hz, $H_{3s}$), 5.91 (dt, 1H, $J = 5.4$, 2.1 Hz, =CHCH$_2$), 5.71 (dt, 1H, $J = 5.4$, 2.1 Hz, =CHCH$_2$), 5.39 (br s, 1H, NH), 4.50 (s, 1H, $H_2$), 2.90 (ddt, 1H, $J = 17.0$, 5.4, 2.1 Hz, C$_3$CHH), 2.79 (ddt, 1H, $J = 16.2$, 5.4, 2.1 Hz, C$_3$CHH), 2.72 (ddt, 1H, $J = 17.0$, 5.4, 2.1 Hz, C$_3$CHH), 2.62 (ddt, 1H, $J = 16.2$, 5.4, 2.1 Hz, C$_3$CHH), 1.27 (s, 9H, CH$_3$-Bu); $^{13}$C($^1$H) NMR (150 MHz, CDCl$_3$, R.T.) $\delta$ 169.3 (C$_q$), 168.3 (C$_q$), 141.4 (C$_q$), 140.1 (C$_q$), 136.2 (C$_q$), 130.81 (CH), 130.76 (CH), 128.9 (CH), 128.1 (CH), 127.8 (CH), 127.5 (CH), 124.5 (CH), 122.3 (CH), 116.1 (CH), 76.0 (CH), 53.8 (C$_q$), 51.7 (C$_q$), 50.4 (CH$_2$), 39.9 (CH$_2$), 28.6 (CH$_3$-Bu); HRMS (Cl) calcd. for C$_{24}$H$_{29}$N$_2$O$_2$ [M+H]$^+$ 375.2067, found 375.2057; FT-IR (ATR) $\nu =$ 3339 (N-H), 2967 (CH), 2925 (CH), 1679 (C=O), 1630 (C=O), 1479, 1390 cm$^{-1}$.

1'-Benzoyl-N-cyclohexylspiro[cyclopentane-1,3'-indolin]-3-ene-2'-carboxamide (15b)

The product was obtained by following the General procedure I. The crude mixture was purified by column chromatography on SiO$_2$ using (PE/EtOAc 60/40) as eluent. The title compound was obtained as a grey oil (60 mg, 98%); $R_f = 0.25$ (PE/EtOAc 4/1); $^1H$ NMR (400 MHz, CDCl$_3$, 55°C) $\delta$ 7.53 (d, 2H, $J = 7.6$ Hz, CH$_2$-Bz), 7.48 (t, 1H, $J = 6.9$ Hz, CH$_{p-Bz}$), 7.44 (t, 2H, $J = 7.2$ Hz, CH$_{m-Bz}$), 7.21 (d, 1H, $J = 7.3$ Hz, $H_d$), 7.15 (br s, 1H, $H_t$), 7.08 (t, 1H, $J = 7.1$ Hz, $H_b$), 7.01 (t, 1H, $J = 7.4$ Hz, $H_s$), 5.89 (m, 1H, =CHCH$_2$), 5.69 (m, 1H, =CHCH$_2$), 5.52 (d, 1H, $J = 6.5$ Hz, NH), 4.64 (s, 1H, $H_2$), 3.76 (m, 1H, NCH$_2$C$_q$), 2.87 (dd, 1H, $J = 17.1$, 1.5 Hz, C$_3$CH), 2.81 (d, 1H, $J = 16.4$ Hz, C$_3$CH), 2.68 (d, 1H, $J = 16.9$ Hz, C$_3$CH), 2.62 (d, 1H, $J = 15.9$ Hz, C$_3$CH), 1.88 (d, 1H, $J = 10.4$ Hz, CH$_2$C$_q$), 1.77 (m, 1H, CH$_2$C$_q$), 1.64 (m, 1H, CH$_2$C$_q$), 1.56 (br d, 1H, $J = 12.6$ Hz, CH$_2$C$_q$), 1.39 (m, 3H, CH$_2$C$_q$) 1.16 (q, 2H, CH$_2$C$_q$), 1.04 (q, 1H, $J = 10.9$ Hz, CH$_2$C$_q$); $^{13}$C($^1$H) NMR (150 MHz, CDCl$_3$, 55°C) $\delta$ 169.5 (C$_q$), 168.1 (C$_q$), 141.2 (C$_q$), 140.3 (C$_q$), 136.0 (C$_q$), 130.7 (CH), 130.7 (CH), 128.8 (CH), 127.9 (CH), 127.4 (CH), 124.7 (CH), 122.3 (CH), 75.7 (CH), 53.8 (C$_q$), 50.2 (CH$_2$), 48.2 (CH), 40.2 (CH$_2$), 32.9 (CH$_2$), 32.8 (CH$_2$), 25.5 (CH$_2$), 24.7 (CH$_2$), 24.6 (CH$_2$); C$_2$H$_2$ was not observed by $^{13}$C($^1$H) NMR; HRMS (Cl) calcd. for C$_{26}$H$_{28}$N$_2$O$_2$ [M]$^+$ 400.2145, found 400.2146; FT-IR (ATR) $\nu =$ 3314 (N-H), 2930 (CH), 2854 (CH), 1634 (C=O), 1479, 1374 cm$^{-1}$.

1'-Benzoyl-N-(tert-butyl)-5',6'-dimethoxyspiro[cyclopentane-1,3'-indolin]-3-ene-2'-carboxamide (15c)
The product was obtained by following the **General procedure I**. The crude mixture was purified by column chromatography on SiO$_2$ using (PE/EtOAc 70/30 to 60/40) as eluent. The title compound was obtained as a grey oil (50 mg, 89%); R$_f$ = 0.15 (PE/EtOAc 4/1); $^1$H NMR (400 MHz, CDCl$_3$, 55°C) $\delta$ 7.77-7.45 (m, 5H, CH$_3$), 6.76 (s, 1H, H$_a$), 5.91 (td, 1H, $J$ = 5.7, 2.1 Hz, =CHCH$_2$), 5.72 (td, 1H, $J$ = 5.7, 2.1 Hz, =CHCH$_2$), 5.36 (br s, 1H, NH), 4.51 (s, 1H, H$_2$), 3.84 (s, 3H, OCH$_3$), 3.69 (s, 3H, OCH$_3$), 2.87 (ddt, 1H, $J$ = 17.1, 5.7, 2.1 Hz, C$_2$CHH), 2.76 (ddt, 1H, $J$ = 16.3, 5.7, 2.1 Hz, C$_3$CHH), 2.67 (ddt, 1H, $J$ = 17.1, 5.7, 2.1 Hz, C$_5$CHH), 2.60 (ddt, 1H, $J$ = 16.3, 5.7, 2.1 Hz, C$_6$CHH), 1.31 (s, 9H, CH$_3$)$_{12}$, H$_7$ was not observed in $^1$H NMR; $^{13}$C{$^1$H} NMR (150 MHz, CDCl$_3$, R.T.) $\delta$ 169.3 (C$_q$), 168.3 (C$_q$), 148.8 (C$_q$), 146.3 (C$_q$), 136.4 (C$_q$), 134.6 (C$_q$), 130.7 (CH), 131.1 (C$_q$), 130.5 (CH), 128.5 (2 × CH), 128.4 (CH), 127.4 (2 × CH), 105.6 (CH), 66.0 (CH), 56.4 (CH$_3$), 55.9 (CH$_3$), 54.1 (C$_q$), 51.8 (C$_q$), 50.1 (CH$_2$), 39.8 (CH$_2$), 28.7 (CH$_3$)$_{12}$; C$_7$H was not observed in $^{13}$C{$^1$H} NMR; HRMS (Cl) calcd. for C$_{20}$H$_{23}$N$_2$O$_4$ [M]$^+$ 434.2205, found 434.2202; FT-IR (ATR) $\nu$ = 3442 (N-H), 3061 (CH), 2965 (CH), 1686 (C=O), 1634 (C=O), 1500, 1447, 1398, 1215 cm$^{-1}$.

**tert-Butyl (2-2'-(tert-butylcarbamoyl)-5'-chlorospirocyclopentane-1,3'-indolin)-3-en-1'-yl)-2-oxoethyl)carbamate (15j)**

The product was obtained by following the **General procedure I**. The crude mixture was purified by column chromatography on SiO$_2$ using (PE/EtOAc 100/0 to 60/40) as eluent. The title compound was obtained as a pale yellow oil (78 mg, 77%); R$_f$ = 0.35 (PE/EtOAc 3/2); $^1$H NMR (400 MHz, CDCl$_3$, 55°C) $\delta$ 7.94 (brs, 1H, H$_7$), 7.21 (dd, 1H, $J$ = 8.8, 2.0 Hz, H$_6$), 7.19 (s, 1H, H$_4$), 5.93 (m, 1H, =CHCH$_2$), 5.73 (m, 1H, =CHCH$_2$), 5.54 (br s, 1H, NH), 5.41 (br s, 1H, NH), 4.53 (s, 1H, H$_2$), 4.20 (dd, 1H, $J$ = 16.7, 4.9 Hz, C(O)CHH), 3.91 (br s, 1H, C(O)CHH), 2.89 (d, 1H, $J$ = 16.6 Hz, C$_2$CHH), 2.74 (d, 1H, $J$ = 17.6 Hz, C$_3$CHH), 2.69 (d, 1H, $J$ = 17.6 Hz, C$_4$CHH), 2.56 (d, 1H, $J$ = 16.6 Hz, C$_5$CHH), 1.48 (s, 9H, CH$_3$)$_{12}$, 1.33 (s, 9H, CH$_3$)$_{12}$; $^{13}$C{$^1$H} NMR (150 MHz, CDCl$_3$, R.T.) $\delta$ 167.4 (C$_q$), 155.9 (C$_q$), 140.5 (C$_q$), 140.0 (C$_q$), 138.6 (C$_q$), 130.7 (CH), 129.9 (C$_q$), 128.4 (CH), 128.2 (CH), 122.5 (CH), 117.6 (CH), 80.2 (C$_q$), 73.8 (CH), 55.0 (C$_q$), 52.2 (C$_q$), 51.0 (CH$_2$), 43.8 (CH$_2$), 40.1 (CH$_2$), 28.6 (CH$_3$)$_{12}$, 28.4 (CH$_3$)$_{12}$; HRMS (Cl) C$_{21}$H$_{33}$ClN$_3$O$_4$ [M+H]$^+$ 462.2154, found 462.2150; FT-IR (ATR) $\nu$ = 3450 (N-H), 3423 (N-H), 2957, 1662 (C=O), 1476, 1366, 1253, 821 cm$^{-1}$.

**tert-Butyl(2-(2'-(tert-butylcarbamoyl)spiro[cyclopentane[3]ene-1,3'-indolin]-1'-yl)-2-oxoethyl)carbamate (15k)**

30
The product was obtained according to the General procedure I. After 24 hours at 50°C, purification of the crude residue by column chromatography on silica using PE/EtOAc (100/0 to 70/30) as eluent give cyclised compound as a white solid (50 mg, 88%). NMR at R.T. showed a mixture of rotamers; Rf = 0.27 (PE/EtOAc 90/10); ¹H NMR (400 MHz, CDCl₃, 55°C) δ 7.91 (s, H₂), 7.26 (dd, J = 13.2, 5.3 Hz, 2H, H₆, H₇), 7.07 (m, 1H, H₄), 5.93 (dt, J = 5.9, 2.1 Hz, 1H, =CHCH₂), 5.72 (dt, J = 6.0, 2.1 Hz, 1H, =CHCH₂), 5.43 (s, 2H, NH₂), 4.53 (s, 1H, H₂), 4.23 (dd, J = 17.1, 4.9 Hz, 1H, NHCHH), 3.99 (br s, 1H, NHCHH), 2.99 – 2.80 (m, 1H, C₃CHH), 2.81 – 2.61 (m, 2H, C₃CHH), 2.67 – 2.30 (m, 1H, C₃CHH), 1.49 (s, 9H, CH₃), 1.31 (s, 9H, CH₃); ¹³C{¹H} NMR (151 MHz, CDCl₃, R.T.) δ 167.8 (br, C=O), 167.4 (C=O), 155.9 (C=O), 141.2 (C₉), 138.4 (C₉), 130.7 (CH), 128.5 (CH), 128.2 (CH), 125.1 (CH), 122.1 (CH), 116.9 (CH), 113.9 (C₉), 80.0 (C₉), 74.4 (CH), 73.9 (CH), 60.5 (CH₂), 55.1 (C₉), 52.9 (C₉), 52.0 (C₉), 51.1 (CH₂), 46.5 (CH₂), 44.8 (CH₂), 40.5 (CH₂), 40.1 (CH₂), 28.6 (CH₃), 28.5 (CH₃); HRMS (Cl) calcd for C₃₇H₇N₃O₅ [M+H]⁺ 428.2549 found 428.2551; FT-IR (ATR) v = 3326 (NH), 2965 (C–H), 2857 (C–H), 1665 (C=O), 1596, 1529, 1479, 1454, 1413, 1392, 1365, 1340, 1250, 1227, 1163, 1110, 1083, 1051; 1027, 973; 948, 931, 864, 750, 673 cm⁻¹.

N-(tert-butyl)-1'-(R)-2-hydroxy-2-phenylacetylspiro[cyclopent[3]ene-1,3'-indoline]-2'-carboxamide (15n)  

The product was obtained according to the General procedure I. Diastereoisomer 1 of compound 8m was used as the starting material. After 24 hours at 50 °C, the crude residue was purified by column chromatography on silica (PE/Et₂O 100/0 to 50/50) give cyclised compound as a pale yellow solid (18 mg, 38%); mp = 63°C; Rf = 0.25 (PE/EtOAc 9/1); ¹H NMR (400 MHz, CDCl₃, R.T.) δ 8.21 (d, J = 8.8 Hz, 1H, H₇), 7.44 – 7.30 (m, 5H, CH₃), 6.81 (dd, J = 8.8, 2.6 Hz, 1H, H₆), 6.71 (d, J = 2.6 Hz, 1H, H₄), 5.77 (dt, J = 5.9, 2.1 Hz, 1H, =CHCH₂), 5.39 (dt, J = 5.9, 2.2 Hz, 1H, =CHCH₂), 5.18 (s, 1H, NH), 5.00 (d, J = 6.1 Hz, 1H, CHOH), 4.52 (d, J = 6.5 Hz, 1H, OH), 4.17 (s, 1H, H₂), 3.78 (s, 3H, OCH₃), 2.72 (dd, J = 10.6, 8.5 Hz, 1H, C₃CHH), 2.53 (d, J = 16.9 Hz, 1H, C₃CHH), 2.08 (dd, J = 10.1, 8.2 Hz, 1H, C₃CHH), 1.79 – 1.63 (m, 1H, C₃CHH), 1.25 (m, 9H, CH₃), 1.25 (m, 9H, CH₃); ¹³C{¹H} NMR (151 MHz, CDCl₃, R.T.) δ 170.6 (C₆), 167.9 (C₉), 157.9 (C₉), 140.7 (C₉), 138.5 (C₉), 134.0 (C₉), 130.0 (CH), 129.4 (CH), 129.2 (CH), 127.9 (CH), 127.8 (CH), 118.0 (CH), 112.8 (CH), 108.8 (CH), 73.3 (CH), 73.0 (CH), 55.8 (CH), 54.5 (C₉), 51.9 (C₉), 50.2 (CH₂), 39.1 (CH₂), 28.6 (CH₃); HRMS (El) calcd for C₃₇H₇N₃O₅ [M+H]⁺ 434.2199 found 434.2194; FT-IR (ATR) v = 3412 (OH), 3335 (NH), 3059 (CH), 2958 (CH), 2919 (CH), 285 (CH), 1650 (C=O), 1485, 1454, 1365, 1330, 1267, 1228, 1181, 1080, 1063, 976, 866, 811, 761, 726, 670, 666, 469, 448 cm⁻¹.
8. Ring closing metathesis reactions on substituted 3,3-diallyl-2-hydroxyindolines

**General procedure J:** The corresponding 3,3-diallyl-2-hydroxyindoline compound was added to a refluxing solution of first generation Grubbs catalyst (15 mol %) in CH$_2$Cl$_2$ (C $\approx$ 0.04 mol/L) under argon. The reaction was heated at reflux for 24 hrs under argon before evaporation of the volatiles under vacuum. The crude material was purified by column chromatography on SiO$_2$ to yield the desired product.

**Methyl 2'-hydroxyspiro[cyclopentane-1,3'-indolin]-3-ene-1'-carboxylate (16a)**

The product was obtained by following the General procedure J. The crude mixture was purified by column chromatography on SiO$_2$ using (PE/EtOAc 100/0 to 80/20) as eluent. The title compound was obtained as a dark green oil (59 mg, 83%); $R_f$ = 0.20 (PE/EtOAc 4/1); $^1$H NMR (400 MHz, CDCl$_3$, 55°C) $\delta$ 7.64 (br s, 1H, $H_7$), 7.28-7.20 (m, 2H, $H_4$, $H_5$), 7.02 (t, 1H, $J$ = 7.1 Hz, $H_6$), 5.90 (s, 1H, =CHCH$_2$), 5.71 (s, 1H, =CHCH$_2$), 5.59 (s, 1H, $H_6$), 3.94 (s, 3H, OCH$_3$), 3.26 (dd, 1H, $J$ = 16.9 Hz, C$_3$CHH), 2.66 (t, 2H, $J$ = 16.9 Hz, C$_2$CH$_2$), 2.41 (d, 1H, $J$ = 16.9 Hz, C$_3$CHH); $^{13}$C($^1$H) NMR (100 MHz, CDCl$_3$, 60°C) $\delta$ 139.9 ($C_q$), 138.1 ($C_q$), 130.5 (CH), 127.8 (CH), 127.5 (CH), 123.4 (CH), 122.2 (CH), 114.5 (CH), 91.3 (CH), 55.0 ($C_q$), 52.7 (CH$_3$), 47.7 (CH$_2$), 37.3 (CH$_2$); C=O was not observed by $^{13}$C($^1$H) NMR at 60°C; HRMS (CI) calcd. for C$_{16}$H$_{14}$NO$_2$ [M-OH]$^+$ 228.1119, found 228.1118; FT-IR (ATR) $\nu$ = 3020 (CH), 2938 (CH), 1687 (C=O), 1481, 1381, 1135, 690 cm$^{-1}$.

**Methyl 2'-hydroxy-5'-methoxyspiro[cyclopentane-1,3'-indolin]-3-ene-1'-carboxylate (16b)**

The product was obtained by following the General procedure J. The crude mixture was purified by column chromatography on SiO$_2$ using (PE/EtOAc 100/0 to 70/30) as eluent. The title compound was obtained as a dark green oil (59 mg, 74%); $R_f$ = 0.29 (PE/EtOAc 7/3); $^1$H NMR (400 MHz, CDCl$_3$, 60°C) $\delta$ 7.53 (br s, 1H, $H_7$), 6.81 (d, 1H, $J$ = 2.6 Hz, $H_4$), 6.75 (dd, 1H, $J$ = 8.5, 2.6 Hz, $H_6$), 5.90 (dtd, 1H, $J$ = 6.4, 4.5, 2.3 Hz, =CHCH$_2$), 5.70 (dtd, 1H, $J$ = 6.4, 4.5, 2.3 Hz, =CHCH$_2$), 5.57 (br s, 1H, $H_2$), 3.91 (s, 3H, C(O)OCH$_3$), 3.79 (s, 3H, OCH$_3$), 3.24 (d, 1H, $J$ = 17.3 Hz, C$_3$CHH), 2.67 (d, 1H, $J$ = 16.5 Hz, C$_3$CHH), 2.61 (d, 1H, $J$ = 17.3 Hz, C$_3$CHH), 2.40 (d, 1H, $J$ = 16.5 Hz, C$_3$CHH); $^{13}$C($^1$H) NMR (150 MHz, CDCl$_3$, 60°C) $\delta$ 156.6 ($C_q$), 140.0 ($C_q$), 132.7 ($C_q$), 130.4 (CH), 127.5 (CH), 125.8 ($C_q$), 115.1 (CH), 112.7 (CH), 108.9 (CH), 91.5 (CH), 55.7 (CH$_3$), 54.6 ($C_q$), 52.6 (CH$_3$), 47.5 (CH$_2$), 37.3 (CH$_2$); HRMS (CI) calcd. for
C_{15}H_{16}NO_3 [M-OH]^- 258.1125, found 258.1127; FT - IR (ATR) \nu = 3075 (CH), 2890 (CH), 1692 (C=O), 1490, 1272, 1135, 1032, 694 cm^{-1}.

9. Preparation of dihydro-1H-carbazole by ring closing metathesis

![Reaction Scheme]

**General procedure H:** To a dried and degassed solution of 2,3-diallyl-1H-indole in CH_2Cl_2 (C \approx 0.015 mol/L) was added the Grubbs catalyst (5 mol%). The mixture was heated overnight at 55°C before evaporation of the volatiles under reduced pressure. The residue obtained was purified by column chromatography on SiO_2.

1-(6-Methoxy-1H-carbazol-9(4H)-yl)-2-phenylethanone (18d)

The product was obtained following the **General procedure H.** The crude residue was purified by column chromatography on SiO_2 using PEth/Et_2O (100/0 to 90/10) as eluent to afford the dihydrocarbazole compound as a colourless sticky foam (13 mg, 72%). Rf = 0.29 (PEth/Et_2O 2/1); \textsuperscript{1}H NMR (600 MHz, CDCl_3) \delta 7.96 (t, J = 8.7 Hz, 1H, H_7), 7.44 – 7.34 (m, 2H, CHPh), 7.35 – 7.22 (m, 3H, CHPh), 6.95 – 6.80 (m, 2H, H_4, H_6), 5.90 (dt, J = 47.5, 23.8 Hz, 2H, =CH), 4.32 (s, 2H, COCH_2), 3.88 (s, 3H; OCH_3), 3.76 (dd, J = 18.6, 11.0 Hz, 2H, =CHCH_2), 3.45 – 3.23 (m, 2H, =CHCH_2); \textsuperscript{13}C{\textsuperscript{1}H} NMR (151 MHz, CDCl_3) \delta = 170.6 (C=O), 156.3 (C_\text{OMe}), 133.9 (C_7), 133.6 (C_9), 131.2 (C_8), 130.4 (C_6), 129.7 (CH), 128.9 (CH), 127.4 (CH), 124.0 (CH), 123.3 (CH), 116.5 (CH), 115.4 (C_5), 111.9 (CH), 101.5 (CH), 55.8 (CH_2), 44.9 (CH_2), 28.5 (CH_2), 23.3 (CH_2); HRMS (Cl) calcd for C_{23}H_{20}NO_2 [M+H]^+ 318.1494 found 318.1490; FT-IR (ATR) \nu = 3030 (CH), 2928 (CH), 2829 (CH), 1690 (C=O), 1667 (C=O), 1609, 1464, 1433, 1400, 1362, 1316, 1283, 1271, 1206, 1167, 1126, 1091, 1031 cm^{-1}. 
10. References

1. Y. Zhang, D. Stephens, G. Hernandez, R. Mendoza, and O. V Larionov, *Chem. Eur. J.*, 2012, **18**, 16612.

2. T. D. Montgomery, Y. Zhu, N. Kagawa, and V. H. Rawal, *Org. Lett.*, 2013, **15**, 1140.

3. P. Agarwal, J. van der Weijden, E. M. Sletten, D. Rabuka, and C. R. Bertozzi, *Proc. Natl. Acad. Sci. USA*, 2013, **110**, 46.

4. S. L. Bender, D. Bhumralkar, M. R. Collins, S. J. Cripps, J. G. Deal, L. Jia, M. D. Nambu, C. L. Palmer, Z. Peng, M. D. Varney, US2002/103203 A1, 2002.
11. Spectra

*Synthesis of substituted 3,3-diallyl-3H-indole*

3,3-Diallyl-3H-indole (3a)
3,3-Diallyl-5,6-dimethoxy-3H-indole (3b)
3, 3-Diallyl-5-methyl-3H-indole (3c)
3,3-Diallyl-5-methoxy-3H-indole (3d)
3,3-Diallyl-4-methyl-3H-indole (3e)
3,3-Diallyl-5-benzyloxy-3H-indole (3f)
3,3-Diallyl-3,6,7,8-tetrahydrocyclopenta-3H-indole (3g)
3,3-Diallyl-4-bromo-3H-indole (3h)
3,3-Diallyl-5-bromo-3H-indole (3i)
3,3-Diallyl-5-chloro-3\textit{H}-indole (3j)
3,3-Diallyl-5-flouro-3H-indole (3k)
3,3-Diallyl-2-methyl-3H-indole (3I)
3,3-Diallyl-5-methoxy-2-methyl-3H-indole (3m)
3,3-Diallyl-2-phenyl-3H-indole (3n)
2-(((tert-Butyldimethylsilyl)oxy)methyl)-1H-indole
3,3-Diallyl-2-(((tert-butyldimethylsilyl)oxy)methyl)-3H-indole (3o)
UGI reactions

3,3-Diallyl-1-benzoyl-N-(tert-butyl)indoline-2-carboxamide (8a)
3,3-Diallyl-1-benzoyl-N-cyclohexyldoline-2-carboxamide (8b)
3,3-Diallyl-1-benzoyl-N-(tert-butyl)-5,6-dimethoxyindoline-2-carboxamide (8c)
3,3-Diallyl-N-(tert-butyl)-1-(2-(2-fluoro)phenyl)acetyl)indoline-2-carboxamide (8d)
3,3-Diallyl-5-(benzylxy)-N-(tert-butyl)-1-picolinoylindoline-2-carboxamide (8e)
3,3-Diallyl-npentyl-1-(1H-indole-3-carbonyl)indoline-2-carboxamide (8f)
3,3-Diallyl-N-(tert-butyl)-1-(1H-pyrazole-3-carbonyl)indoline-2-carboxamide (8g)
3,3-Diallyl-1-(1-carbamoylcyclopropanecarbonyl)-N-(4-methoxyphenyl)indoline-2-carboxamide (8h)
3,3-Diallyl-1-(2-chloroacetyl)-5-methoxy-N-n-pentylindoline-2-carboxamide (8i)
*tert*-Butyl(2-(3,3-diallyl-2-(*tert*-butylcarbamoyl)-5-chloroindolin-1-yl)-2-(oxoethyl)carbamate (8j)
**tert-Butyl (2-(3,3-diallyl-2-(tert-butylcarbamoyl)indolin-1-yl)-2-oxoethyl)carbamate (8k)**

![Chemical Structure Diagram]

The chemical structure shows a detailed representation of the compound, including atomic labels and bond connections. The diagram is accompanied by spectra with chemical shifts and coupling constants, indicating the positions and characteristics of the chemical groups involved in the compound's structure.
3,3-Diallyl-N-(tert-butyl)-1-(2-(methylamino)acetyl)indoline-2-carboxamide (8l)
3,3-Diallyl-1-((S)-2-amino-3-phenylpropanoyl)-N-(tert-butyl)indoline-2-carboxamide (8m)

1/0.8 mixture of 2 diastereoisomers
3,3-Diallyl-N-(tert-butyl)-1-((R)-2-hydroxy-2-phenylacetyl)-5-methoxyindoline-2-carboxamide (8n)
Synthesis of substituted 3,3-diallyl-2-hydroxyindoline

Methyl 3,3-diallyl-2-hydroxyindoline-1-carboxylate (10a)
Methyl 3,3-diallyl-2-hydroxy-5-methoxyindoline-1-carboxylate (10b)
Isobutyl 3,3-diallyl-2-hydroxy-5-methoxyindoline-1-carboxylate (10c)
1-(3,3-Diallyl-2-methoxyindolin-1-yl)-2-phenylethanone (11d)
Methyl 3,3-diallyl-2-methyleneindoline-1-carboxylate (12)
Synthesis of 2,3-diallylindoles

Methyl 2,3-diallyl-1H-indole-1-carboxylate (13a)
Isobutyl 2,3-diallyl-1H-indole-1-carboxylate (13c)
1-(2,3-Diallyl-5-methoxy-1H-indol-1-yl)-2-phenylethanone (13d)
(2,3-Diallyl-1H-indol-1-yl)(4-methoxyphenyl)methanone (13e)
(L)-Proline catalysed asymmetric Mannich reaction

1-(3,3-Diallylindolin-2-yl)propan-2-one (14a)
1-(3,3-Diallyl-5-methoxyindolin-2-yl)propan-2-one (14b)
1-(3,3-Diallyl-5-chloroindolin-2-yl)propan-2-one (14c)
Ring closing metathesis reaction on UGI compounds

1'-Benzoyl-N-((tert-butyl)spiro[cyclopentane-1,3'-indolin]-3-ene-2'-carboxamide(15a)
1'-Benzoyl-N-cyclohexylspiro[cyclopentane-1,3'-indolin]-3-ene-2'-carboxamide (15b)
1'-Benzoyl-N-(tert-butyl)-5',6'-dimethoxyspiro[cyclopentane-1,3'-indolin]-3-ene-2'-carboxamide (15c)
$\text{tert-Butyl (2-((tert-butylcarbamoyl)-5'-chloro}\text{spiro[cyclopentane-1,3'-indolin]-3-en-1'-yl)-2-oxoethyl)carbamate (15j)}$
**tert-Butyl(2'-(tert-butyldimethylsilyl)indoline-1-yl)-2-oxoethylcarbamate (15k)**

![Chemical Structure](image)

**NMR Spectra**

LR235-1

LR235-60
$N$-({\textit{tert}}-butyl)-1'-(\textit{R})-2-hydroxy-2-phenylacetyl)spiro[ cyclopent\{3\}ene-1,3'-indoline]-2'-carboxamide (15n)
Ring closing metathesis reaction on substituted 3,3-diallyl-2-hydroxyindoline

Methyl 2'-hydroxyspiro[cyclopentane-1,3'-indolin]-3-ene-1'-carboxylate (16a)
Methyl-2'-hydroxy-5'-methoxyspiro[cyclopentane-1,3'-indolin]-3-ene-1'-carboxylate (16b)
Synthesis of dihydro-1H-carbazole by ring closing metathesis

1-(6-Methoxy-1H-carbazol-9(4H)-yl)-2-phenylethanone (18d)
**Solvent screening**

![Chemical structure](image)

| Solvents | Retention time (tr, minutes) minor/major * | E.R. |
|----------|------------------------------------------|------|
| DMSO     | 15.86: 17.51                             | 98.7 : 1.3 |
| CHCl₃    | 16.07: 17.87                             | 99.1 : 0.9 |
| MeCN     | 15.94: 17.78                             | 99.7 : 0.4 |
| MeOH     | 16.12: 18.01                             | 54.6: 45.4 |
| DMF      | 16.10: 17.92                             | 98.9 : 1.1 |

*Chiralpak Daicel AD // hexane/iPrOH (75/25) // 0.5 mL/min

**Substrate scope**

![Chemical structure](image)

| R  | Retention time (tr, minutes) minor/major * | E.R. | Yield |
|----|------------------------------------------|------|-------|
| OMe | 15.12: 16.70                             | 98.8 : 1.2 | 96 |
| Cl  | 11.56: 13.14                             | 99.0: 1.0 | 64(a) |
| H   | 16.71: 21.45                             | 99.3: 0.7 | 81 |

*Chiralpak Daicel AD // hexane/iPrOH (75/25) // 0.5 mL/min
Chiral HPLC chromatograms of Mannich products
(Rac)-1-(3,3-Diallyl-5-methoxyindolin-2-yl)propan-2-one

![Chiral HPLC chromatograms](image)

| Peak No. | Peak Name | Result (min) | Ret. Time (min) | Offset (min) | Area (counts) | Sep. 1/2 (sec) | Status |
|----------|-----------|--------------|----------------|--------------|---------------|---------------|--------|
| 1        |           | 50.4550      | 15.518         | 0.000        | 7356187       | BE 37.0       |        |
| 2        |           | 48.8480      | 17.015         | 0.000        | 7782258       | BE 36.8       |        |
| Totals:  |           | 100.0000     | 0.000          | 15178443     |               |               |        |

Enantioenriched 1-(3,3-Diallyl-5-methoxyindolin-2-yl)propan-2-one from asymmetric Mannich reaction

![Enantioenriched HPLC chromatograms](image)

| Peak No. | Peak Name | Result (min) | Ret. Time (min) | Offset (min) | Area (counts) | Sep. 1/2 (sec) | Status |
|----------|-----------|--------------|----------------|--------------|---------------|---------------|--------|
| 1        |           | 1.2189       | 15.115         | 0.000        | 1941044       | BE 32.8       |        |
| 2        |           | 58.7817      | 18.695         | 0.000        | 14922880      | BE 42.3       |        |
| Totals:  |           | 100.0000     | 0.000          | 151106924    |               |               |        |
(Rac)-1-(3,3-Diallyl-5-chloroindolin-2-yl)propan-2-one

Enantioenriched 1-(3,3-Diallyl-5-chloroindolin-2-yl)propan-2-one from asymmetric Mannich reaction
(Rac)-1-(3,3-diallylindolin-2-yl)propan-2-one

Enantioenriched 1-(3,3-diallylindolin-2-yl)propan-2-one from asymmetric Mannich reaction