Three-component spiropyran synthesis *via* tandem alkylation-condensation

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Abstract
A catalyst-free, three-component alkylation-condensation cascade for spiropyran synthesis has been developed, using readily available building blocks (indoles, alkyl halides, salicylaldehydes) and environmentally benign solvents (water, ethanol). A cascade approach enables this sequence to proceed under mild conditions which, in turn, promote broad substrate tolerance and operational simplicity. Consequently, we have demonstrated the utility of this process in the synthesis of 25 structurally-diverse spiropyrans, incorporating useful functionality across the spiropyran framework, and on multi-gram scale.

Introduction
Dynamic functional materials have transformed the nature of contemporary materials science, and this technology is founded upon robust, versatile and tuneable molecular switches and sensors.[1-3] Light-responsive spiropyrans[4] are central in this field and provide the molecular machinery upon which many exciting and important photoactive materials are based,[5] including photocontrolled proteins,[6-9] polymers[10-12] and surfaces.[13-16]

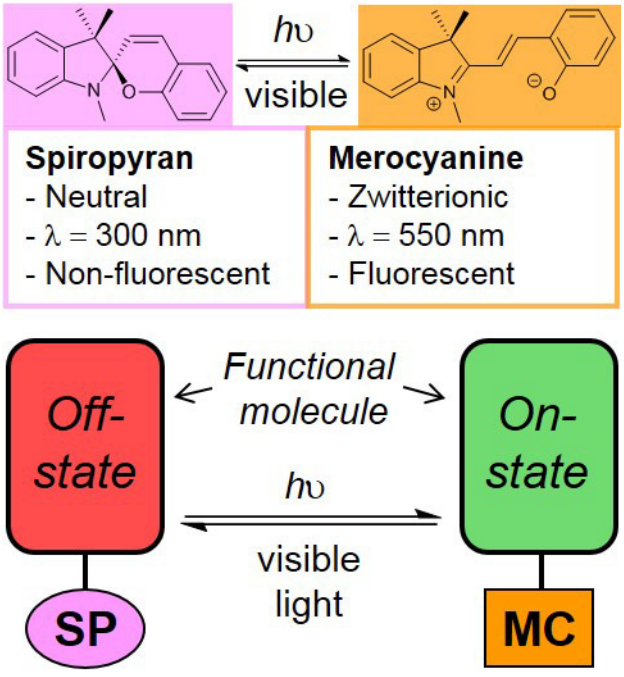


Figure 1 – Generic spiropyran-merocyanine system: *(top)* structure and properties; *(bottom)* as a vehicle for light control of functional molecules

Despite the extensive and imaginative roles in which they have been employed, spiropyrans are surprisingly limited in their structural diversity. For example, in the research presented in Klajn's seminal 2014 review of

spiropyran-based dynamic materials (covering 435 publications),[5] spiropyran ligation is achieved almost exclusively through the indolenine nitrogen, only ten examples are presented in which spiropyrans bear any substituent in an aromatic indolenine position and *every* spiropyran structure includes an indolenine *gem*-dimethyl component. Whilst the function of these molecules is not necessarily compromised by their lack of diversity, it is entirely possible that spiropyran-based materials with improved, alternative, unpredicted and unheralded properties are not being discovered because the field is constrained by limitations and preconceptions in synthetic methodology for spiropyran synthesis. That is to say, if we have neither the tools nor the inclination to discover new spiropyran structures, then they are unlikely to be found by chance.

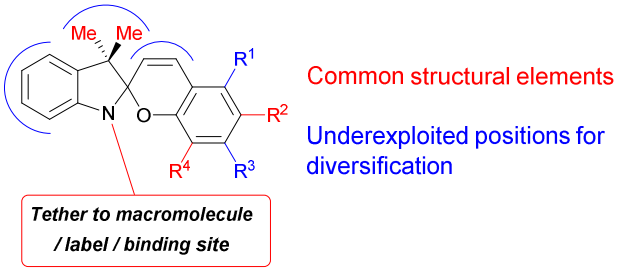
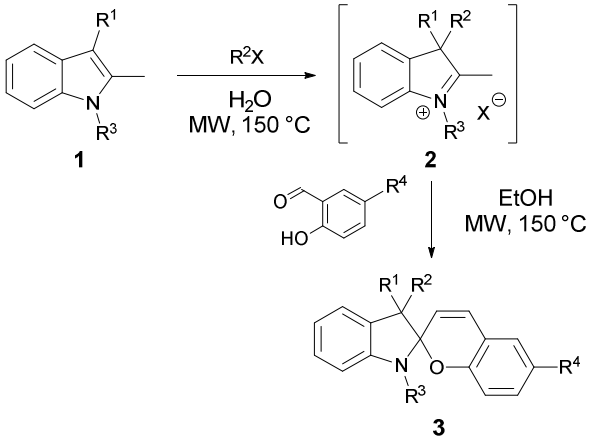


Figure 2 – Standard (red) and non-standard (blue) elements in spiropyran structure

In order to address this concern and make the opportunities that are inherent in new molecular architecture broadly accessible, we have focussed on the development of robust, simple methodologies to generate new spiropyran structures. Recently, we documented a microwave-promoted, one-pot, alkylation-condensation protocol for spiropyran synthesis from readily available precursors, employing environmentally benign solvents (Scheme 1).[17] The unusual substituent pattern possessed by structures such as **3** – in which inequivalent substituents occupy the indole 3-position – influences the stereoselectivity of spiropyran ring-closure and hence has relevance in the development of sensors for chiral substrates and asymmetric catalysts.[18-20] Moreover, the sterically-congested nature of such spiropyrans impacts upon spiropyran-merocyanine isomerisation and enables control of equilibrium position on the basis of steric effects – a complementary approach to more common electronic strategies.[21]



Scheme 1 – Microwave promoted alkylation-condensation in spiropyran synthesis.

Although this alkylation-condensation methodology provided robust and rapid access to novel spiropyran structures, its general use is constrained by several limitations. Principally, methodology based around microwave irradiation is not universally accessible – focussed microwave facilities for synthetic chemistry remain specialist and expensive – and scale-up of microwave processes is non-trivial due to the limited penetration depth of microwave irradiation, often requiring flow or multimode apparatus.[22-24] Further limitations include the narrow scope of the process, its harsh conditions (150 °C, 200 W, sealed tube), non-ideal stoichiometry and dependence on silica gel chromatography for product purification. Furthermore, as a telescoped process employing a different solvent for each step, the necessity to evaporate water (the solvent for alkylation) at the mid-point of the sequence is inconvenient and onerous.

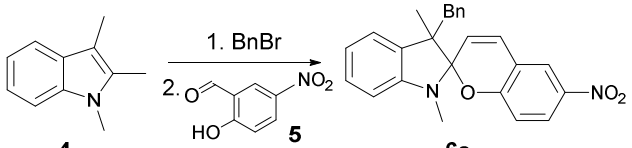
Despite these caveats, alkylation-condensation does provide a versatile and convenient pathway for the discovery of new spiropyran structures and we have explored how the potential of this synthetic strategy might be unlocked. Herein, we document the development of alkylation-condensation as a 3-component cascade sequence, complementary to related spirocycle syntheses employing indole dearomatisation cascades.[25,26] This has resulted in an operationally simple protocol which enables general, high-yielding synthesis of functionalised spiropyrans from accessible substrates, employing mild, catalyst-free conditions, environmentally benign solvents and short reaction times, and, for the majority of substrates, obviating the requirement for either microwave irradiation or silica gel chromatography. To demonstrate that this process is amenable to scale-up, we have applied this methodology on gram scale with no reduction in yield.

Results and discussion

The overall goal of this work was to adapt a telescoped procedure which employed forceful reaction conditions, into a cascade sequence with mild conditions and greater substrate tolerance. To realise this aim, our primary concern was to identify a suitable solvent system which could tolerate both alkylation and condensation steps, as this is a prerequisite for their successful application in a reaction cascade. Previous studies into alkylation-condensation for spiropyran synthesis had identified optimal conditions as involving discrete synthetic steps in different solvents, with both steps requiring microwave irradiation in a sealed tube at 150 °C (alkylation in water: 16 minutes; water evaporated, ethanol and nitrosalicylaldehyde added to reaction vessel; condensation in ethanol: 8 minutes) (see Scheme 1 and Table 1, entry 1).[17] Our initial experimentation replicated this general protocol in the stepwise alkylation-condensation of 1,2,3-trimethylindole (**4**) with benzyl bromide then 5-nitrosalicylaldehyde (**5**) to give spiropyran **6a**, as a test sequence for solvent screening. Polar aprotic solvents such as DMF, acetonitrile and acetone were ineffective, as were alcohols (entries 2-6) and whilst water provided a suitable medium for alkylation, subsequent condensation was low yielding (entry 7). Conversely, when the reaction was

performed in 1:1 ethanol–water, the reaction proceeded in a comparable yield to the optimised, microwave-promoted published process (*cf.* entry 1 and entry 8).[17] This yield was unaffected by an increased aqueous component but was eroded by use of a higher ethanol concentration (entries 9,10), and acetone–water was also effective, albeit lower yielding (entry 11). With this key result in hand, we then repeated the same microwave-promoted protocol in 1:1 ethanol–water but with all reagents present from the outset (*i.e.* as a tandem process), and with a single, 10 minute heating period. Gratifyingly, this again produced **6a** in comparably high yield (entry 12). In order to confirm that the role of microwave irradiation in this process was supplementary to a simple thermal effect, the reaction was repeated using a hotplate/oil bath, with reactions carried out both in a sealed tube at 150 °C and in an open vessel fitted with a condenser at 85 °C (entries 13 and 14). In both cases, the yield remained undiminished and synthesis of **6a** was equally effective *with or without* microwave irradiation. This is in contrast to previous results, which clearly emphasise the requirement for microwave-promotion of indole alkylation under catalyst-free conditions.[17,27]

Intrigued by the opportunity presented by this result, we ascertained optimal conditions for this process with respect to substrate stoichiometry and temperature, using a standard hotplate/oil bath/open vessel set-up (entries 15-17). The previously published telescoped procedure employed an optimised 1:1.5:1.2 molar ratio of indole : alkylating agent : salicylaldehyde. By contrast, the tandem reaction described here is effective with the ideal 1:1:1 reagent stoichiometry. In terms of reaction temperature, we observed a steady decline in reaction rate below 100 °C (at 50 °C, the process required ~1 h to reach completion; at 20 °C, **6a** was produced in 29% yield after 1 h), hence a compromise between duration and temperature is necessary depending on specific requirements. For our purposes, we view 1 h at 50 °C as a reasonable trade-off between duration, mildness and energy efficiency. Finally, we ensured that this protocol was effective (although somewhat slower) for larger scale application, through synthesis of 2.33 g (93%) of **6a** in a single batch (entry 18).



4 **5** **6a**

Conditions: *See Table 1*

Entry	Method[a]	**4**:BnBr:**5**	Solvent	T (°C)	Heat source[b]	Time (mins)[c]	Yield (%)[d]
1[e]	Stepwise	1.0:1.5:1.2	H_2O, EtOH	150	Microwave	16 + 8	77
2	Stepwise	1.0:1.5:1.2	DMF	150	Microwave	16 + 8	0
3	Stepwise	1.0:1.5:1.2	MeCN	150	Microwave	16 + 8	0
4	Stepwise	1.0:1.5:1.2	Acetone	150	Microwave	16 + 8	0
5	Stepwise	1.0:1.5:1.2	MeOH	150	Microwave	16 + 8	0
6	Stepwise	1.0:1.5:1.2	EtOH	150	Microwave	16 + 8	0
7	Stepwise	1.0:1.5:1.2	H_2O	150	Microwave	16 + 8	45
8	Stepwise	1.0:1.5:1.2	1:1 H_2O–EtOH	150	Microwave	16 + 8	80

9	Stepwise	1.0:1.5:1.2	1:3 H_2O–EtOH	150	Microwave	16 + 8	56
10	Stepwise	1.0:1.5:1.2	3:1 H_2O–EtOH	150	Microwave	16 + 8	78
11	Stepwise	1.0:1.5:1.2	1:1 H_2O–acetone	150	Microwave	16 + 8	64
12	Tandem	1.0:1.5:1.2	1:1 H_2O–EtOH	150	Microwave	10	88
13	Tandem	1.0:1.5:1.2	1:1 H_2O–EtOH	150	Oil bath[f]	10	87
14	Tandem	1.0:1.5:1.2	1:1 H_2O–EtOH	85	Oil bath	10	88
15	Tandem	1.0:1.0:1.0	1:1 H_2O–EtOH	85	Oil bath	10	85
16	Tandem	1.0:1.0:1.0	1:1 H_2O–EtOH	50	Oil bath	60	86
17	Tandem	1.0:1.0:1.0	1:1 H_2O–EtOH	20	Oil bath	60	29
18[g]	Tandem	1.0:1.0:1.0	1:1 H_2O–EtOH	50	Oil bath	110	93

Table 1 – Optimisation of alkylation-condensation for spiropyran synthesis *a* – All reactions were performed using **4** (99 mg, 0.622 mmol, 1 eq.) in 1 mL of solvent. "Stepwise" refers to heating a mixture of **4**, BnBr and solvent, then addition of **5** and subsequent heating; "tandem" infers that all reagents and solvent were combined then exposed to a single period of heating. *b* – Microwave heating was conducted in sealed 10 mL pressure tubes using a maximum power of 300 W. *c* – Time at the specified temperature. For stepwise reactions, the two given times refer to the duration of heating for each step. Microwave reactions required ~30 s to reach 150 °C; oil baths were preheated to the specified temperature before the reaction vessel was immersed. *d* – Isolated yield. *e* – Taken from reference 17, with different solvents employed for each step. *f* – Reaction conducted in a sealed tube. *g* – Reaction employed **4** (1 g, 6.28 mmol).

Spiropyrans are unusual and often challenging substrates for chromatographic purification due to isomerisation between neutral spiropyran and charged merocyanine forms, with this equilibrium being strongly affected by the dielectric of the surrounding medium. If there is a general case for seeking to minimise use of labour-intensive and solvent-hungry silica gel chromatography, it is particularly pronounced in spiropyran synthesis, and where possible we have employed an alternative purification method. Following brief experimentation, we discovered that **6a** could be isolated in high purity and high yield, simply by precipitation of (presumably) the charged merocyanine isomer, by addition of acetone to the crude reaction mixture following concentration *in vacuo*. This approach provided successful purification of the majority of spiropyrans presented in this manuscript, though it was somewhat less effective with more lipophilic products. Beyond the operational simplicity and limited environmental impact of this protocol, it is immediately applicable to scale-up (as demonstrated by Table 1, entry 18), in contrast to the challenges presented by large-scale chromatography.[28]

With mild, efficient and operationally simple conditions identified, we determined the scope of our three-component reaction cascade in the synthesis of a range of spiropyran structures. In general, broad substrate tolerance was exhibited by the reaction sequence towards each of the three components (indole, alkylating agent, salicylaldehyde). The greatest impact on scope was observed in substituents that directly influenced indole alkylation, whilst the salicylaldehyde condensation was generally more

accommodating. Accordingly, indole components incorporating varied *N*- or benzenoid substituents were generally successful substrates (Table 2, **6b-f**), with the exception of *N*-acetate **6z** which underwent decarboxylation to give **6a**, presumably *via* azomethine ylid formation,[29,30] whereas substituents in the 3-position presented varied outcomes: alkyl, branched alkyl, aryl, benzyl and carboxyl substituents were effective (**6g-k**); whereas the presence of a 3-formyl substituent (**6aa**) lead to a complex mixture of products and, although a 3-acetyl moiety could be incorporated into spiropyran **6ab**, this underwent decarboxylative degradation (analogous to natural[31,32] and synthetic[33] decarboxyation processes) and could not be isolated in acceptable purity. Appropriate alkylating agents for this process were strictly defined by steric inflences on one hand and electronics on the other. In general, "classical" primary substrates for nucleophilic substitution could be successfully incorporated into spiropyran products (*e.g.* benzyl, allyl, propargyl, phenacyl (**6l-p**)); however, quaternisation imposes steric demands, and secondary and tertiary alkylating agents were unreactive (*e.g.* α-phenylbenzyl, α-methylbenzyl and ^{t}butyl spiropyrans **6ac-ae** could not be synthesised). Nevertheless, spiropyrans **6h** (*i*Pr/Bn), **6i** (4-BrPh/Bn) and **6j** (Bn/Bn) demonstrate the power of this methodology to deliver particularly congested structures. Mechanistically, indole alkylation in polar protic media is predominantly an S_N1 process.[17,27] Consequently, only the most active S_N2 electrophiles were tolerated (e.g. α-bromocarbonyl), and even primary alkyl halides were ineffective substrates (e.g. **6af** was inaccessible *via* this procedure).

The reaction sequence displayed general tolerance for salicylaldehydes, hence a range of functional groups – possessing contrasting electronic character – could be incorporated into the spiropyran chromene ring in any position (**6q-y**). Reactions of electron-rich salicylaldehydes were comparatively slow (e.g. synthesis of methoxyspiropyran **6s** required 6 h), consistent with their reduced aldehyde electrophilicity, and, somewhat surpisingly, salicylaldehyde itself proved to be a singularly reluctant electrophile. In this case, a reasonable yield of spiropyran **6q** was only obtained through use of particularly forcing conditions.

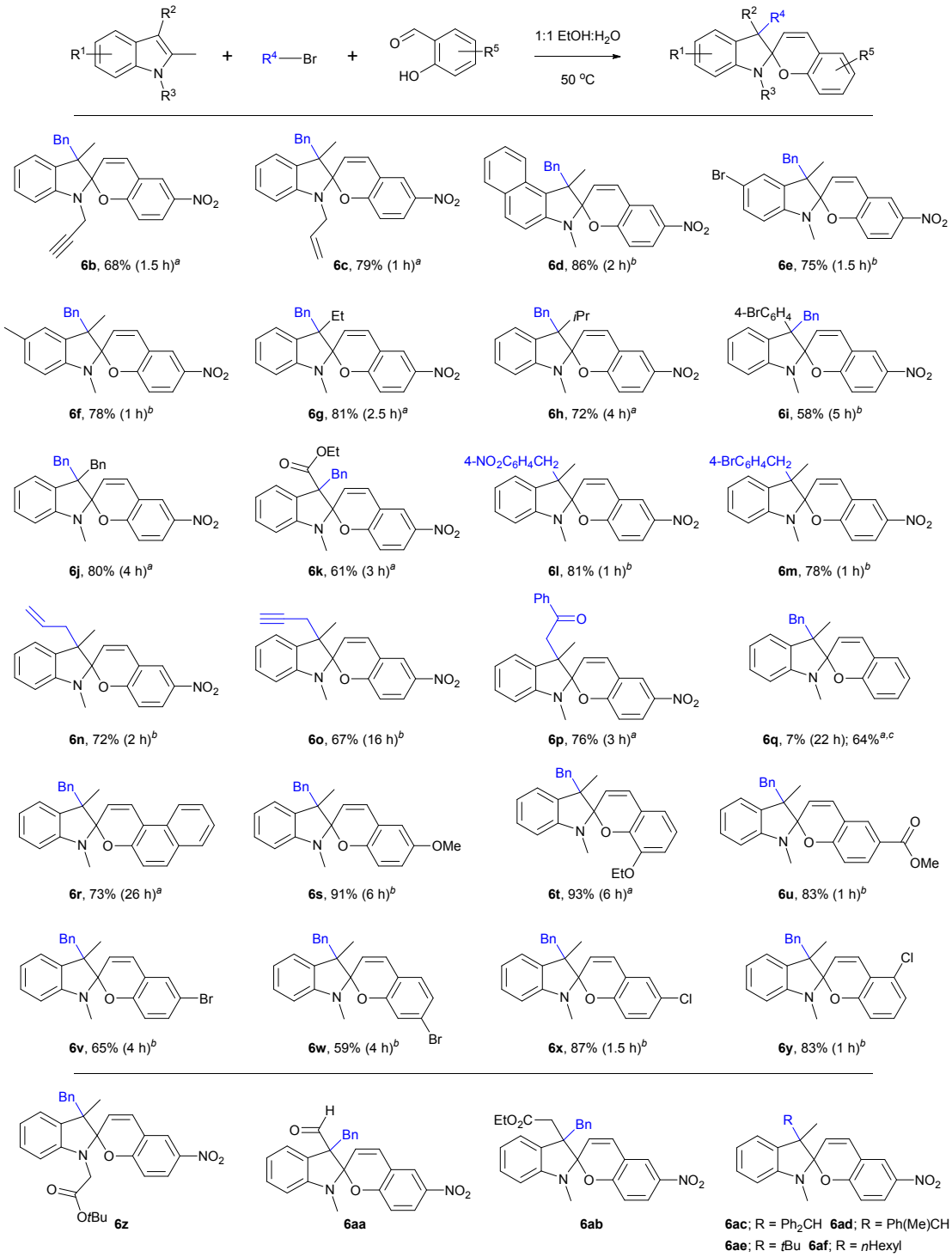


Table 2 – Scope of tandem alkylation-condensation. All reactions conducted at 0.622 M and 1:1:1 reagent stoichiometry. Yields refer to isolated products. Reaction times are given in parentheses. Attempted synthesis of **6z-6af** (bottom) was not successful using this procedure. *a* – purified by silica gel chromatography; *b* – purified by precipitation from acetone; *c* – reaction employed 3 eq. salicylaldehyde and microwave irradiation (150 °C, 15 mins, 300 W max.)

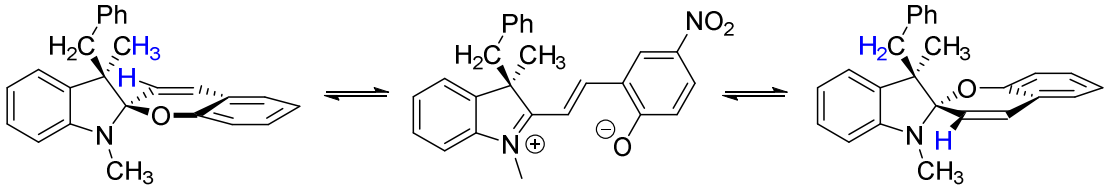
The placement and variety of substituents that we have included to demonstrate the versatility of this alkylation-condensation cascade is very deliberate. Firstly, we have focussed on incorporating substituents in positions that are known to influence *spiro-mero* equilibration, hence giving control and tunability to spiropyran products in this fundamental property. This is achieved either electronically, through stabilisation/destabilisation of the merocyanine phenoxide and iminium moieties[34,35] – hence we have demonstrated control over all benzenoid chromene positions (*i.e.* **6q-6y**) and the indole 5-position (**6e,f**) respectively‡ – or by exerting steric control through incorporation of large substituents in the indole 3-position (*e.g.* **6h-k**). Secondly, we have synthesised derivatives bearing groups with a large difference in size in the indole 3-position (*e.g.* **6m**,**p**), as this has been previously demonstrated to influence facial discrimination in spiropyran ring closure, and this is of relevance to the design of sensors for chiral substrates.[17] Thirdly, we have included examples bearing extended π-conjugation (benzoindole **6d** and benzochromene **6r**) to exhibit that this methodology is appropriate for generating structures possessing red-shifted absorbance maxima.[34,37] This is an important consideration both conceptually, in that control over the *mero-spiro* switching wavelength is desirable, and biomedically, in that the greater tissue penetration offered by near IR is important for *in vivo* application.[38] Fourthly, a majority of important spiropyran applications involve ligation of spiropyran units onto polymers, biopolymers or surfaces, or construction of bespoke binding sites around the spiropyran core for specific ligands.[5] The success of either approach is underpinned by synthetic versatility and this is a principal virtue of tandem alkylation-condensation. We have demonstrated this by synthesis of spiropyrans bearing useful handles for further synthetic transformations, in a variety of positions. This includes substrates for click chemistry (**6b,o**), alkene metathesis (**6c,n**), palladium-catalysed cross-couplings (**6e,i,m,v-y**), standard carbonyl chemistry (**6p**) and ester linkage (**6k,u**). Finally, we have synthesised several spiropyrans which are inaccessible using our previous telescoped methodology, to exhibit that a cascade sequence in an accommodating solvent system with mild conditions has greater substrate tolerance than the more forcing conditions that preceded it. This includes arylspiropyran **6i**, ethylcarboxylate **6k** and dibenzylspiropyran **6j**.

It is striking that simply through identification of an appropriate solvent system and adoption of a cascade approach, we have been able to generate an effective, convenient, mild protocol, far removed from its genesis as a microwave-promoted telescoped procedure. Underpinning this drastic improvement are two key factors: (i) The requirement for water in the alkylation step might suggest that on-water reactivity is relevant, particularly in a process employing profoundly hydrophobic indole and alkyl bromide substrates.[39,40] On the other hand, it is plausible that water is necessary to stabilise charge in S_N1 transition states and indolium bromide salt products. We favour this latter hypothesis, given that the reaction only appears to become viable when efforts are made to solubilise these hydrophobic

‡ It is also of interest that substituents in this position prevent oxidative spiropyran dimerisation, an important consideration in electrochemical applications.[36]

reagents, rather than force them into on-water behaviour. In the telescoped process, a degree of solubilisation is provided by the reduced polarity of water at 150 °C in a sealed system,[41] whereas a similar effect can be achieved by addition of ethanol under a considerably milder regime.
(ii) Synthesis of indolium salts by alkylation of 3-substituted indoles constitutes an electronically and sterically challenging dearomatising quaternisation. In contrast, the condensation of indolium salts with salicylaldehydes is thermodynamically driven by generation of stabilised, conjugated merocyanines. Consequently, conducting indole alkylation in the presence of a salicylaldehyde enables rapid reaction of intermediate indolium salts, thereby driving an otherwise unfavourable alkylation process towards completion. Clearly, this accelerative effect is absent in the comparative telescoped sequence.
Overall, the unfavourable alkylation is made possible under mild conditions by transition state and intermediate stabilisation by water, and by rapid consumption of its indolium product by salicylaldehyde which occurs most effectively in the presence of ethanol. The summative consequence of these effects is that cascade alkylation-condensation can proceed at 50 °C without excess alkylating agent, whereas the analogous telescoped process cannot.

Whilst the focus of this study was to develop efficient methodology for spiropyran synthesis, products **6a-y** present interesting stereochemical features, worthy of comment here. In solution, spiropyran diastereomers exist in dynamic equilibrium, interconverting *via* their merocyanine form (Figure 3). We have previously reported that assignment of spiropyran relative configuration can be achieved using NOESY analysis and diastereoisomeric ratios can be estimated by ^{1}H NMR.[17] Our previous analysis demonstrated a bias for *anti*-configured structures, in which larger substituents on the indole 3-position were placed to minimise interaction with the chromene oxygen atom, with the exception of carbonyl-containing substituents wherein this trend was reversed.[17] In this study, we have observed a similar general trend for *anti*-selectivity with similar magnitude (in the range *syn*:*anti* 25:75 to 33:67), and similar *syn*-configured exceptions wherein interactions between carbonyl and alkene functionalities are minimised (**6k** and **6p**).



syn-**6q** *mero*-**6q** *anti*-**6q**

Figure 3 – Interconversion between *syn* and *anti* spiropyran diastereomers *via* a merocyanine isomer, illustrated by compound **6q**. Transient *cis*-merocyanine forms are omitted for brevity. Diagnostic NOESY correlations are depicted in blue.

Conclusion

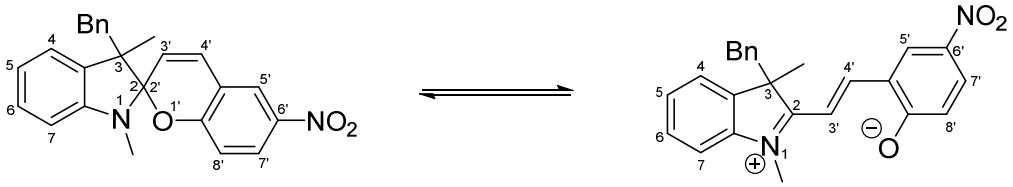
In summary, we have designed, optimised and road-tested a catalyst-free, three-component alkylation-condensation cascade for spiropyran synthesis from cheap, accessible building blocks (indoles, alkylating agents,

salicylaldehydes). The reaction sequence is operationally simple, employs mild conditions, environmentally benign solvents, short reaction times and ideal stoichiometry, and generates useful spiropyran products in generally high yield, often with no requirement for chromatographic purification. The process demonstrates broad substrate tolerance and enables incorporation of substituents that influence fundamental spiropyran properties (*spiro-mero* equilibrium, absorbance wavelength, facial selectivity) in most possible positions, and incorporation of versatile functional groups (alkene, alkyne, aryl halide, ester, ketone) for subsequent synthetic transformations. In terms of synthetic strategy and design, this tandem alkylation-condensation sequence epitomises the value of a well-designed reaction cascade over an analogous telescoped, stepwise process, with impacts upon operational simplicity, mildness of conditions and breadth of substrate scope. Given the simplicity and versatility of this methodology, we anticipate that it will underpin the design and synthesis of novel spiropyran architectures and their application in future dynamic materials.

Experimental

General Experimental Information

Solvents and reagents were used as commercially supplied. The fraction of light petroleum ether boiling in the range 40 to 60 °C is referred to as "petrol". Water refers to deionised water. Analytical thin layer chromatography was carried out using Merck Kieselgel 60 F254, coated on aluminium plates, with visualisation of spots where necessary by quenching of UV(254 nm) fluorescence. Silica gel with particle size 40–63 mm was used for flash chromatography. Microwave reactions were performed in a CEM Discover microwave in 10 mL, thick-walled microwave tubes, sealed with septum caps and were magnetically stirred. Infrared spectra were recorded as thin films using attenuated total reflectance with a Nicolet iS5 FTIR spectrometer. Mass spectra were recorded on a QToF 6520 mass spectrometer (Agilent Technologies, Palo Alto, USA). ^{1}H NMR and ^{13}C NMR spectra were recorded at 400 MHz and 100 MHz respectively, using a Bruker Avance III HD400 spectrometer. Chemical shifts are quoted in ppm relative to tetramethylsilane, the residual solvent peak being used for referencing purposes. Coupling constants are quoted to the nearest 0.1 Hz with peak multiplicities for single resonances being labelled as: s, singlet; d, doublet; t, triplet; q, quartet; m, unresolved multiplet. NMR assignments of spiropyrans and merocyanines are labelled as follows (using **6a** as an example):



For simplicity, spiropyran atom labelling has been retained in merocyanine structures. The compounds documented in this publication exist in solution as equilibrating mixtures of spiropyran diastereoisomers which interconvert *via* their merocyanine form. The merocyanines themselves can exist as zwitterionic, protonated or quinoidal forms. Although interpretation of NMR

spectra from such multicomponent mixtures is challenging due to overlapping resonances and broadened signals from charged species, and full analysis is occasionally impossible, we have sought to assign nuclei as far as we can within reasonable doubt and merocyanine:*syn*:*anti* ratios are quoted for NMR spectra as appropriate. 2D NOESY experiments were used – and proved invaluable – for assignment of ^{1}H NMR spectra and for determination of relative configurations. In general, ^{13}C NMR spectra have been fully assigned and this has been achieved through use of HSQC and HMBC experiments.

Synthetic Methods and Characterisation Data

Example procedure for spiropyran synthesis:

3-Benzyl-1,3-dimethyl-6′-nitrospiro[chromene-2,2'-indoline][17] 6a

A stirred mixture of 1,2,3-trimethylindole (99.0 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) in ethanol–water (1 mL, 1:1 v:v) was heated at 50 °C for 1 h then concentrated under reduced pressure. Acetone (10 mL) was added to the crude reaction mixture and the resulting precipitate was filtered, washing with acetone, to give spiropyran **6a** (213 mg, 86%) as a yellow powder, spectroscopically identical to that previously reported.[17]

Reaction on gram-scale:

Following the same general method, a mixture of 1,2,3-trimethylindole (1.00 g, 6.28 mmol), benzyl bromide (746 µL, 6.28 mmol) and 5-nitrosalicylaldehyde (1.05 g, 6.28 mmol) in ethanol–water (10.1 mL, 1:1 v:v) was heated for 110 minutes to give spiropyran **6a** (2.33 g, 93%) (purified by precipitation from acetone).

3-Benzyl-3-methyl-1-propargyl-6′-nitrospiro[chromene-2,2'-indoline] 6b

Following the same general method, 2,3-dimethyl-1-propargylindole (95.0 mg, 0.518 mmol), benzyl bromide (62.0 µL, 0.518 mmol) and 5-nitrosalicylaldehyde (87.0 mg, 0.518 mmol) were heated for 1.5 h to give spiropyran **6b** (148 mg, 68%) as an amorphous purple film (purified by flash chromatography, eluting with EtOAc, then 10% MeOH in EtOAc, then 20% MeOH in EtOAc). ν_{max} = 3290, 3029, 2933, 1707, 1512, 1495, 1336, 1292, 1148, 949 and 746 cm^{-1}; δ_H (400 MHz; DMSO-d$_6$; 25:75 *syn*:*anti*) 8.26 (1 H, d, *J* 2.8, 5'-H *anti*), 8.19 (1 H, d, *J* 2.8, 5'-H *syn*), 8.09 (1 H, dd, *J* 9.0, 2.8, 7'-H *syn*), 8.00 (1 H, dd, *J* 9.0, 2.8, 7'-H *anti*), 7.33 (1 H, d, *J* 10.4, 4'-H *anti*), 7.22 – 7.10 (7 H, m, 4-, 6-, Bn 4-H *syn*; 6-, Bn 3,4,5-H *anti*), 7.07 (2 H, t, *J* 7.2, Bn 3,5-H *syn*), 7.01 (2 H, d, *J* 7.2, Bn 2,6-H *syn*), 7.00 (1 H, d, *J* 9.0, 8'-H *syn*), 6.97 (1 H, d, *J* 10.3, 4'-H *syn*), 6.87 (1 H, t, *J* 7.5, 5-H *syn*), 6.83 (1 H, d, *J* 7.5, 7-H *anti*), 6.82 (1 H, d, *J* 9.0, 8'-H *anti*), 6.72 (1 H, d, *J* 7.5, 7-H *syn*), 6.66 – 6.61 (3 H, m, 5-, Bn 2,6-H *anti*), 6.20 (1 H, d, *J* 10.4, 3'-H *anti*), 6.06 (1 H, d, *J* 7.5, 4-H *anti*), 5.70 (1 H, d, *J* 10.3, 3'-H *syn*), 4.20 (1 H, dd, *J* 18.3, 2.3, NC*H*H *anti*), 4.00 (1 H, dd, *J* 18.3, 2.3, NC*H*H *syn*), 3.92 (1 H, dd, *J* 18.3, 2.3, NCH*H anti*), 3.69 (1 H, dd, *J* 18.3, 2.3, NCH*H syn*), 3.22 (1 H, d, *J* 13.5, Bn C*H*H *syn*), 3.14 (1 H, d, *J* 13.5, Bn CH*H syn*), 2.99 (1 H, t, *J* 2.3, ≡CH *anti*), 2.87 (1 H, t, *J* 2.3, ≡CH *syn*), 2.78 (1 H, d, *J* 12.4, Bn C*H*H *anti*), 2.58 (1 H, d, *J* 12.4, Bn CH*H anti*), 1.18 (3 H, s, Me *syn*) and 1.12 (3 H, s, Me *anti*); δ_C (100 MHz; DMSO-d$_6$); *anti* diastereoisomer: 159.5 (8a'), 146.4 (7a), 141.0 (6'), 136.9 (Bn

1), 132.1 (3a), 131.7 (Bn 2,6), 129.8 (4'), 128.3 (6), 127.7 (Bn 3,5), 126.8 (Bn 4), 126.3 (7'), 124.9 (4), 123.4 (5'), 121.2 (3'), 119.1 (4a'), 119.0 (5), 116.2 (8'), 108.5 (7), 107.3 (2), 80.7 (*C*≡CH), 74.4 (C≡*C*H), 57.3 (3), 41.6 (Bn CH_2), 32.4 (NCH_2) and 16.6 (3-Me); *syn* diastereoisomer: 158.9 (8a'), 144.9 (7a), 141.0 (6'), 137.6 (Bn 1), 136.2 (3a), 130.0 (Bn 2,6), 128.2 (6), 128.1 (4'), 127.9 (Bn 3,5), 126.8 (Bn 4), 126.0 (7'), 123.2 (5'), 122.6 (4), 120.4 (3'), 120.3 (5), 119.3 (4a'), 117.0 (8'), 108.5 (7), 104.0 (2), 80.5 (*C*≡CH), 74.3 (C≡*C*H), 54.8 (3), 38.8 (Bn CH_2), 31.0 (NCH_2) and 24.3 (3-Me); HRMS-ES+ (*m/z*): Found: 423.1714 (MH^+, $C_{27}H_{23}N_2O_3$ requires: 423.1708).

1-Allyl-3-benzyl-3-methyl-6′-nitrospiro[chromene-2,2'-indoline] 6c

Following the same general method, 1-allyl-2,3-dimethylindole (115 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) were heated for 1 h to give spiropyran **6c** (209 mg, 79%) as an amorphous purple film (purified by flash chromatography, eluting with EtOAc, then 10% MeOH in EtOAc, then 20% MeOH in EtOAc). ν_{max} = 3028, 2967, 2923, 1711, 1608, 1516, 1479, 1332, 1266, 1087, 945, 803, 746 and 702 cm^{-1}; δ_H (400 MHz; DMSO-d_6; 40:20:40 MC:*syn*:*anti*) 9.08 (1 H, d, *J* 2.8, MC 5'-H), 8.71 (1 H, d, *J* 16.2, MC 4'-H), 8.25 (1 H, dd, *J* 9.2, 2.8, MC 7'-H), 8.22 (1 H, d, *J* 2.8, 5'-H *anti*), 8.16 (1 H, d, *J* 2.7, 5'-H *syn*), 8.11 (1 H, d, *J* 7.5, MC 4-H), 8.06 (1 H, dd, *J* 8.8, 2.7, 7'-H *syn*), 8.04 (1 H, d, *J* 16.2, MC 3'-H), 7.97 (1 H, dd, *J* 9.0, 2.8, 7'-H *anti*), 7.67 (1 H, d, *J* 7.5, MC 7-H), 7.66 (1 H, t, *J* 7.5, MC 5-H), 7.57 (1 H, t, *J* 7.5, MC 6-H), 7.28 (1 H, d, *J* 10.4, 4'-H *anti*) 7.18 – 6.90 (17 H, m, MC Bn 3,4,5-, 8'-H; Bn 2,3,4,5,6-, 4-, 4'-, 8'-, 6-H *syn*; Bn 3,4,5-, 6-H *anti*), 6.82 (1 H, d, *J* 9.0, 8'-H *anti*), 6.77 (1 H, t, *J* 7.5, 5-H *syn*), 6.60 (2 H, d, *J* 7.0, Bn 2,6-H *anti*), 6.58 (1 H, t, *J* 7.5, 5-H *anti*), 6.57 (1 H, d, *J* 7.5, 7 *anti*), 6.52 (1 H, t, *J* 7.4, MC Bn 2,6-H), 6.49 (1 H, d, *J* 7.5, 7-H *syn*), 6.17 (1 H, d, *J* 10.4, 3'-H *anti*), 6.09 (1 H, d, *J* 7.5, 4-H *anti*), 5.88 – 5.77 (1 H, m, allyl 2-H *anti*), 5.73 (1 H, d, *J* 10.3, 3'-H *syn*), 5.73 – 5.65 (1 H, m, allyl 2-H *syn*), 5.58 – 5.47 (1 H, m, MC allyl 2-H), 5.16 – 4.94 (7 H, m, MC allyl 1,3-H; allyl 3-H *syn*; allyl 3-H *anti*), 4.43 (1 H, d, *J* 17.3, MC allyl 3-H), 3.93 – 3.88 (1 H, m, allyl 1-H *anti*), 3.88 (1 H, d, *J* 13.5, MC PhC*H*H), 3.82 (1 H, d, *J* 13.5, MC PhCH*H*), 3.66 (2 H, dd, *J* 17.1, 5.3, allyl 1-H *syn*; allyl 1-H *anti*), 3.50 (1 H, dd, *J* 17.1, 5.3, allyl 1-H *syn*), 3.20 (1 H, d, *J* 13.5, PhC*H*H *syn*), 3.09 (1 H, d, *J* 13.5, PhCH*H syn*), 2.78 (1 H, d, *J* 12.5, PhC*H*H *anti*), 2.62 (1 H, d, *J* 12.5, PhCH*H anti*), 1.98 (3 H, s, MC 3-Me), 1.20 (3 H, s, 3-Me *syn*) and 1.11 (3 H, s, 3-Me *anti*); δ_C (100 MHz; DMSO-d_6); merocyanine: 181.6 (C=N), 167.8 (8a'), 150.2 (4'), 142.0 (3a), 141.8 (7a), 139.3 (6'), 134.9 (Bn 1), 129.9 (7'), 129.7 (6), 129.6 (5'), 129.6 (5), 129.4 (allyl 2), 129.3 (Bn 2,6), 128.4 (Bn 3,5), 128.3 (Bn 4), 124.6 (4), 121.9 (4a'), 119.4 (8'), 119.0 (allyl 3), 115.4 (7), 114.8 (3'), 58.6 (3), 49.3 (allyl 1), 45.8 ($PhCH_2$) and 25.8 (3-Me); *anti* diastereoisomer: 159.6 (8a'), 147.5 (7a), 141.0 (6'), 137.0 (Bn 1), 135.3 (allyl 2), 132.0 (3a), 131.6 (Bn 2,6), 129.3 (4'), 127.7 (Bn 4), 127.6 (Bn 3,5), 126.7 (6), 126.3 (7'), 124.6 (4), 123.5 (5'), 121.9 (3'), 119.2 (4a'), 118.4 (5), 116.4 (allyl 3), 116.0 (8'), 107.9 (2), 107.8 (7), 57.5 (3), 46.2 (allyl 1), 41.9 ($PhCH_2$) and 17.0 (3-Me); *syn* diastereoisomer: 158.8 (8a'), 146.0 (7a), 141.0 (6'), 137.7 (Bn 1), 136.0 (3a), 135.0 (allyl 2), 131.1 (Bn 2,6), 128.1 (Bn 4), 127.9 (Bn 3,5), 127.7 (6), 126.1 (7'), 123.2 (5'), 122.6 (4), 121.1 (3'), 119.6 (5), 119.5 (4a'), 116.4 (8'), 116.4 (allyl 3), 107.8 (7), 104.6 (2), 54.8 (3), 44.8 (allyl 1),

38.9 ($PhCH_2$) and 24.6 (3-Me); HRMS-ES+ (*m/z*): Found: 425.1885 (MH^+, $C_{27}H_{25}N_2O_3$ requires: 399.1708).

3-Benzyl-1,3-dimethyl-6′-nitrospiro[chromene-2,2'-benzo[e]indoline] 6d
Following the same general method, 1,2,3-trimethylbenzo[e]indole (130 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) were heated for 2 h to give spiropyran **6d** (240 mg, 86%) as an orange powder (purified by precipitation from acetone). ν_{max} = 2942, 1610, 1540, 1520, 1493, 1440, 1342, 1287, 1262, 1230, 1085, 959, 810, 745, 703 and 637 cm^{-1}; δ_H (400 MHz; DMSO-d_6) 9.15 (1 H, s, 5'-H), 8.71 – 8.67 (2 H, m, 4- and 4'-H), 8.35 (1 H, d, *J* 8.0, 7'-H), 8.22 (2 H, d, *J* 7.5, 7- and 8-H), 8.09 (1 H, d, *J* 16.3, 3'-H), 7.91 – 7.88 (2 H, m, 5- and 9-H), 7.79 (1 H, br t, *J* 7.5, 6-H), 7.26 (1 H, d, *J* 8.0, 8'-H), 7.01 – 6.90 (3 H, m, Bn 3,4,5-H), 6.40 (2 H, d, *J* 7.0, Bn 2,6-H), 4.22 (1 H, d, *J* 13.3, C*H*H), 4.15 (3 H, s, NMe), 4.04 (1 H, d, *J* 13.3, CH*H*) and 2.20 (3 H, s, 3-Me); δ_C (100 MHz; DMSO-d_6) 182.2 (C=N), 164.6 (8a'), 146.8 (4'), 140.7 (9a), 140.5 (6'), 136.7 (3a), 134.6 (Bn 1), 133.6 (7a), 131.9 (8), 130.6 (7), 129.8 (7'), 129.2 (5), 128.3 (Bn 2,6), 128.3 (Bn 3,5), 128.3 (4a), 128.0 (6), 127.7 (Bn 4), 127.6 (5'), 124.1 (4), 122.1 (4a'), 117.9 (8'), 115.7 (3'), 113.3 (9), 60.5 (3), 45.5 (CH_2), 35.5 (NMe) and 24.9 (3-Me); HRMS-ES+ (*m/z*): Found: 449.1882 (MH^+, $C_{29}H_{25}N_2O_3$ requires: 449.1865).

3-Benzyl-5-bromo-1,3-dimethyl-6′-nitrospiro[chromene-2,2'-indoline] 6e
Following the same general method, 5-bromo-1,2,3-trimethylindole (148 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) were heated for 1.5 h to give spiropyran **6e** (222 mg, 75%) as a yellow powder (purified by precipitation from acetone). ν_{max} = 2931, 2777, 2690, 2566, 1738, 1619, 1607, 1584, 1548, 1473, 1348, 1288, 1266, 1226, 1084, 821, 744 and 705 cm^{-1}; δ_H (400 MHz; DMSO-d_6) 9.18 (1 H, d, *J* 2.7, 5'-H), 8.69 (1 H, d, *J* 16.5, 4'-H), 8.41 (1 H, dd, *J* 9.1, 2.7, 7'-H), 8.31 (1 H, d, *J* 1.7, 4-H), 8.06 (1 H, d, *J* 16.6, 3'-H), 7.87 (1 H, dd, *J* 8.6, 1.7, 6-H), 7.76 (1 H, d, *J* 8.6, 7-H), 7.32 (1 H, d, *J* 9.1, 8'-H), 7.16 – 7.10 (3 H, m, Bn 3,4,5-H), 6.74 (2 H, d, *J* 6.5, Bn 2,6-H), 3.93 (3 H, s, NMe), 3.79 (1 H, d, *J* 13.9, C*H*H), 3.75 (1 H, d, *J* 13.9, CH*H*) and 1.96 (3 H, s, 3-Me); δ_C (100 MHz; DMSO-d_6) 181.7 (C=N), 164.8 (8a'), 148.8 (4'), 143.8 (3a), 141.9 (7a), 140.7 (6'), 134.7 (Bn 1), 132.7 (6), 130.1 (7'), 129.3 (Bn 2,6), 128.4 (Bn 3,5), 128.2 (5'), 127.8 (Bn 4), 127.7 (4), 123.2 (5), 121.9 (4a'), 117.9 (8'), 117.3 (7), 116.1 (3'), 58.6 (3), 45.5 (CH_2), 35.0 (NMe) and 24.6 (3-Me); HRMS-ES+ (*m/z*): Found: 477.0822 (MH^+, $C_{25}H_{22}{}^{79}BrN_2O_3$ requires: 477.0814).

3-Benzyl-1,3,5-trimethyl-6′-nitrospiro[chromene-2,2'-indoline] 6f
Following the same general method, 1,2,3,5-tetramethylindole (108 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) were heated for 1 h to give spiropyran **6f** (201 mg, 78%) as a yellow powder (purified by precipitation from acetone). ν_{max} = 3027, 2777, 2692, 2567, 1736, 1622, 1610, 1585, 1556, 1517, 1442, 1348, 1289, 1262,

1229, 1126, 1084, 969, 838, 817, 762, 745 and 703 cm^{-1}; δ_H (400 MHz; DMSO-d_6) 9.11 (1 H, d, *J* 2.8, 5'-H), 8.58 (1 H, d, *J* 16.6, 4'-H), 8.34 (1 H, dd, *J* 9.2, 2.8, 7'-H), 7.98 (1 H, d, *J* 16.6, 3'-H), 7.77 (1 H, s, 4-H), 7.64 (1 H, d, *J* 8.2, 7-H), 7.41 (1 H, d, *J* 8.2, 6-H), 7.28 (1 H, d, *J* 9.2, 8'-H), 7.10 – 7.01 (3 H, m, Bn 3,4,5-H), 6.64 (2 H, d, *J* 6.9, Bn 2,6-H), 3.92 (3 H, s, NMe), 3.74 (2 H, s, CH_2), 2.50 (3 H, s, 5-Me) and 1.92 (3 H, s, 3-Me); δ_C (100 MHz; DMSO-d_6) 180.4 (C=N), 164.6 (8a'), 147.2 (4'), 141.9 (3a), 140.7 (7a), 140.6 (6'), 140.4 (5), 134.9 (Bn 1), 130.3 (6), 129.8 (7'), 129.3 (Bn 2,6), 128.4 (Bn 3,5), 127.9 (5'), 127.7 (Bn 4), 124.9 (4), 122.0 (4a'), 117.9 (8'), 116.3 (3'), 115.2 (7), 58.2 (3), 45.6 (CH_2), 34.9 (NMe), 25.0 (3-Me) and 21.7 (5-Me); HRMS-ES+ (*m/z*): Found: 413.1910 (MH^+, $C_{26}H_{25}N_2O_3$ requires: 413.1865).

3-Benzyl-3-ethyl-1-methyl-6′-nitrospiro[chromene-2,2'-indoline][17] 6g
Following the same general method, 1,2-dimethyl-3-ethylindole (108 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) were heated for 2.5 h to give spiropyran **6g** (208 mg, 81%) as an amorphous purple film (purified by flash chromatography, eluting with EtOAc, then 50% MeOH in EtOAc), spectroscopically identical to that previously reported.[17]

3-Benzyl-3-isopropyl-1-methyl-6′-nitrospiro[chromene-2,2'-indoline] 6h
Following the same general method, 1,2-dimethyl-3-isopropylindole (116 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) were heated for 4 h to give spiropyran **6h** (191 mg, 72%) as an amorphous purple film (purified by flash chromatography, eluting with EtOAc, then 5% MeOH in EtOAc, then 10% MeOH in EtOAc). ν_{max} = 2969, 1738, 1652, 1597, 1455, 1411, 1283, 1216, 1023, 990, 826 and 698 cm^{-1}; δ_H (400 MHz; DMSO-d_6) 8.79 (1 H, d, *J* 3.1, 5'-H), 8.65 (1 H, d, *J* 15.2, 4'-H), 8.43 (1 H, d, *J* 15.2, 3'-H), 7.93 (1 H, d, *J* 7.5, 4-H), 7.86 (1 H, dd, *J* 9.7, 3.1, 7'-H), 7.60 – 7.50 (3 H, m, 5-, 6-, 7-H), 6.99 – 6.85 (3 H, m, Bn 3,4,5-H), 6.54 (2 H, d, *J* 7.0, Bn 2,6-H), 6.34 (1 H, d, *J* 9.7, 8'-H), 3.65 (2 H, s, CH_2), 3.39 (3 H, s, NMe), 2.60 – 2.49 (1 H, m, $HCMe_2$), 1.16 (3 H, d, *J* 6.6, CMe) and 0.08 1.16 (3 H, d, *J* 6.6, CMe); δ_C (100 MHz; DMSO-d_6) 181.1 (C=N), 180.4 (8a'), 154.9 (4'), 144.1 (7a), 136.6 (3a), 136.2 (Bn 1), 134.9 (5'), 132.5 (6'), 129.7 (6), 129.1 (Bn 2,6), 128.8 (7'), 128.2 (Bn 3,5), 127.2 (5), 127.2 (Bn 4), 125.8 (4), 125.2 (8'), 121.7 (4a'), 113.7 (7), 108.3 (3'), 65.6 (3), 42.1 (CH_2), 39.1 (CMe_2), 33.0 (NMe), 18.4 (CMe) and 17.6 (CMe); HRMS-ES+ (*m/z*): Found: 427.2015 (MH^+, $C_{27}H_{27}N_2O_3$ requires: 427.2021).

3-Benzyl-3-(4-bromophenyl)-1-methyl-6′-nitrospiro[chromene-2,2'-indoline] 6i
Following the same general method, 3-(4-bromophenyl)-1,2-dimethylindole (187 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) were heated for 5 h to give spiropyran **6i** (195 mg, 58%) as an orange powder (purified by precipitation from acetone). ν_{max} = 2683, 1734, 1602, 1517, 1490, 1336, 1289, 1262, 1077,

975, 749 and 700 cm^{-1}; δ_H (400 MHz; DMSO-d_6) 9.04 (1 H, d, *J* 2.7, 5'-H), 8.29 (1 H, dd, *J* 9.2, 2.7, 7'-H), 8.04 (1 H, d, *J* 17.0, 4'-H), 8.00 (1 H, d, *J* 17.0, 3'-H), 7.75 – 7.55 (6 H, m, 4-, 5-, 6-, 7-, 3''- and 5''-H), 7.50 (2 H, d, *J* 8.5, 2''-, 6''-H), 7.12 (1 H, d, *J* 9.2, 8'-H), 7.10 (1 H, d, *J* 7.3, Bn 4-H), 7.01 (2 H, t, *J* 7.3, Bn 3,5-H), 6.54 (2 H, d, *J* 7.3, Bn 2,6-H), 4.42 (1 H, d, *J* 12.7, C*H*H), 3.98 (1 H, d, *J* 12.7, CH*H*) and 3.94 (3 H, s, NMe); δ_C (100 MHz; DMSO-d_6) 180.4 (C=N), 164.5 (8a'), 149.1 (4'), 142.6 (7a), 141.8 (3a), 140.7 (6'), 138.1 (4''),133.1 (Bn 1), 132.8 (3'',5''), 130.5 (5), 130.5 (6), 130.2 (7'), 129.7 (2'',6''), 129.5 (Bn 2,6), 128.2 (Bn 3,5), 128.0 (Bn 4), 126.1 (5'), 124.9 (4), 122.6 (1''), 121.7 (4a'), 117.8 (8'), 115.8 (7), 114.7 (3'), 64.9 (3), 44.3 (CH_2) and 35.0 (NMe); HRMS-ES+ (*m/z*): Found: 539.0998 (MH^+, $C_{30}H_{24}{}^{79}BrN_2O_3$ requires: 539.0970).

3,3-Dibenzyl-1-methyl-6′-nitrospiro[chromene-2,2'-indoline] 6j

Following the same general method, 3-benzyl-1,2-dimethylindole (172 mg, 0.731 mmol), benzyl bromide (87.0 µL, 0.731 mmol) and 5-nitrosalicylaldehyde (122 mg, 0.731 mmol) were heated for 4 h to give spiropyran **6j** (235 mg, 80%) as an amorphous purple film (purified by flash chromatography, eluting with EtOAc, then 50% MeOH in EtOAc). ν_{max} = 2975, 1601, 1520, 1494, 1455, 1337, 1286, 1081, 979, 830, 747 and 700 cm^{-1}; δ_H (400 MHz; DMSO-d_6) 9.06 (1 H, d, *J* 2.8, 5'-H), 8.83 (1 H, d, *J* 16.1, 4'-H), 8.21 (1 H, d, *J* 16.1, 3'-H), 8.19 (1 H, dd, *J* 9.1, 2.8, 7'-H), 8.09 (1 H, d, *J* 7.6, 4-H), 7.63 – 7.59 (1 H, m, 5-H), 7.49 – 7.45 (2 H, m, 6-, 7-H), 7.07 – 6.95 (7 H, m, 8'-, Bn 3,4,5-H), 6.66 (4 H, d, *J* 6.9, Bn 2,6-H), 3.98 (4 H, s, 2 × CH_2) and 3.62 (3 H, s, NMe); δ_C (100 MHz; DMSO-d_6) 179.5 (C=N), 171.0 (8a'), 151.5 (4'), 143.1 (7a), 139.2 (3a), 137.9 (6'), 134.5 (Bn 1), 130.8 (5'), 130.0 (6), 129.7 (7'), 129.4 (Bn 2,6), 129.0 (5), 128.4 (Bn 3,5), 127.6 (Bn 4), 125.4 (4), 122.0 (4a'), 120.6 (8'), 114.6 (7), 114.0 (3'), 64.1 (3), 44.9 (CH_2) and 34.1 (NMe); HRMS-ES+ (*m/z*): Found: 475.2044 (MH^+, $C_{31}H_{27}N_2O_3$ requires: 475.2021).

Ethyl 3-benzyl-1-methyl-6′-nitrospiro[chromene-2,2'-indoline]-3-carboxylate 6k

Following the same general method, ethyl 1,2-dimethylindole-3-carboxylate (135 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) were heated for 3 h to give spiropyran **6k** (173 mg, 61%) as an amorphous purple film (purified by flash chromatography, eluting with EtOAc, then 50% MeOH in EtOAc). ν_{max} = 3036, 2794, 1743, 1600, 1548, 1486, 1470, 1442, 1377, 1339, 1258, 1218, 1167, 1132, 1089, 1045, 972, 858, 744 and 696 cm^{-1}; δ_H (400 MHz; DMSO-d_6; 83:17 MC:*syn*) 9.14 (1 H, s, MC 5'-H), 8.36 (1 H, d, *J* 8.0, MC 7'-H), 8.35 (1 H, d, *J* 16.4, MC 4'-H), 8.34 (1 H, s, 5'-H *syn*), 8.12 (1 H, d, *J* 16.4, MC 3'-H), 7.99 (1 H, d, *J* 8.3, 7'-H *syn*), 7.94 (1 H, d, *J* 6.5, MC 4-H), 7.77 (1 H, d, *J* 6.5, MC 7-H), 7.71 (1 H, t, *J* 7.5, MC 5-H), 7.70 (1 H, t, *J* 7.5, MC 6-H), 7.34 (1 H, d, *J* 10.3, 4'-H *syn*), 7.26 – 7.20 (5 H, m, MC 8'-H; Bn 3,4,5-, 6-H *syn*), 7.09 (1 H, t, *J* 6.7, MC Bn 4-H), 7.01 (2 H, t, *J* 6.7, MC Bn 3,5-H), 6.78 (1 H, d, *J* 8.3, 8'-H *syn*), 6.69 (1 H, d, *J* 6.2, 7-H *syn*), 6.68 – 6.65 (4 H, m, MC Bn 2,6-H; Bn 2,6-H *syn*), 6.61 (1 H, t, *J* 6.2, 5-H *syn*), 6.29 (1 H, d, *J* 10.3, 3'-H *syn*), 6.21 (1

H, d, *J* 6.2, 4-H *syn*), 4.35 – 4.32 (1 H, m, MC C*H*HMe), 4.15 – 4.09 (1 H, m, MC CH*H*Me), 4.06 (1 H, d, *J* 13.7, MC PhC*H*H), 4.04 (3 H, s, MC NMe), 3.95 (1 H, d, *J* 13.7, MC PhCH*H*), 3.89 – 3.86 (1 H, m, C*H*HMe *syn*), 3.75 – 3.72 (1 H, m, CH*H*Me *syn*), 2.70 (3 H, s, NMe *syn*), 2.55 (1 H, d, *J* 12.8, PhCH*H syn*), 2.52 (1 H, d, *J* 12.8, PhC*H*H *syn*), 1.10 (3 H, t, *J* 6.5, MC CH_2CH_3) and 0.81 (3 H, t, *J* 6.6, CH_2CH_3 *syn*); δ_C (100 MHz; DMSO-d_6); merocyanine: 176.0 (C=N), 167.4 (C=O), 164.8 (8a'), 149.4 (4'), 143.3 (7a), 140.8 (6'), 134.9 (3a), 132.4 (Bn 1), 131.3 (6), 131.3 (5), 130.8 (7'), 129.7 (Bn 2,6), 128.4 (Bn 3,5), 128.3 (Bn 4), 126.8 (5'), 124.7 (4), 121.7 (4a'), 117.9 (8'), 116.2 (7), 115.0 (3'), 66.3 (3), 64.0 (OCH_2), 43.5 ($PhCH_2$), 35.2 (NMe) and 14.1 (CH_2CH_3); *syn* diastereoisomer: 169.4 (C=O), 158.8 (8a'), 148.4 (7a), 141.3 (6'), 135.7 (Bn 1), 131.3 (Bn 2,6), 129.1 (6), 128.9 (4'), 128.4 (Bn 3,5), 128.1 (4), 127.5 (Bn 4), 126.1 (4a), 126.1 (7'), 123.5 (5'), 121.2 (3'), 119.5 (4a'), 118.5 (5), 115.7 (8'), 107.9 (7), 104.8 (2'), 68.1 (3), 61.1 (OCH_2), 34.8 ($PhCH_2$), 28.6 (NMe) and 14.0 (CH_2CH_3); HRMS-ES+ (*m/z*): Found: 457.1767 (MH^+, $C_{27}H_{25}N_2O_5$ requires: 457.1763).

1,3-Dimethyl-3-(4-nitrobenzyl)-6′-nitrospiro[chromene-2,2'-indoline][17] 6l
Following the same general method, 1,2,3-trimethylindole (99.0 mg, 0.622 mmol), 4-nitrobenzyl bromide (134 mg, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) were heated for 1 h to give spiropyran **6l** (223 mg, 81%) as a yellow powder (purified by precipitation from acetone), spectroscopically identical to that previously reported.[17]

3-(4-Bromobenzyl)-1,3-dimethyl-6′-nitrospiro[chromene-2,2'-indoline][17] 6m
Following the same general method, 1,2,3-trimethylindole (99.0 mg, 0.622 mmol), 4-bromobenzyl bromide (155 mg, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) were heated for 1 h to give spiropyran **6m** (231 mg, 78%) as a yellow powder (purified by precipitation from acetone), spectroscopically identical to that previously reported.[17]

3-Allyl-1,3-dimethyl-6′-nitrospiro[chromene-2,2'-indoline][17] 6n
Following the same general method, 1,2,3-trimethylindole (99.0 mg, 0.622 mmol), allyl bromide (54.0 µL, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) were heated for 2 h to give spiropyran **6n** (155 mg, 72%) as a yellow powder (purified by precipitation from acetone), spectroscopically identical to that previously reported.[17]

1,3-Dimethyl-3-propargyl-6′-nitrospiro[chromene-2,2'-indoline][17] 6o
Following the same general method, 1,2,3-trimethylindole (99.0 mg, 0.622 mmol), propargyl bromide (47.0 µL, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) were heated for 22 h to give spiropyran **6o** (144 mg, 67 %) as a yellow powder (purified by precipitation from acetone), spectroscopically identical to that previously reported.[17]

2-(1,3-Dimethyl-6′-nitrospiro[chromene-2,2'-indolin]-3-yl)-1-phenylethan-1-one[17] 6p

Following the same general method, 1,2,3-trimethylindole (99.0 mg, 0.622 mmol), phenacyl bromide (124 mg, 0.622 mmol) and 5-nitrosalicylaldehyde (104 mg, 0.622 mmol) were heated for 3 h to give spiropyran **6p** (202 mg, 76%) as an amorphous purple film (purified by flash chromatography, eluting with EtOAc, then 50% MeOH in EtOAc), spectroscopically identical to that previously reported.[17]

3-Benzyl-1,3-dimethylspiro[chromene-2,2'-indoline] 6q

A microwave reactor tube equipped with a magnetic follower was charged with a mixture of 1,2,3-trimethylindole (99.0 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and salicylaldehyde (195 µL, 1.87 mmol), water (0.5 mL) and ethanol (0.5 mL) and sealed with a septum cap. The reaction mixture was stirred and heated to 150 °C under microwave irradiation (maximum power = 300 W), held at 150 °C for 15 minutes, then cooled to room temperature and concentrated *in vacuo*. The resulting crude product was purified by flash chromatography, eluting with EtOAc, then 10% MeOH in EtOAc, then 50% MeOH in EtOAc, to give spiropyran **6q** (141 mg, 64%) as an amorphous purple film. ν_{max} = 2967, 2930, 1605, 1484, 1454, 1372, 1235, 1110, 961, 824, 748 and 700 cm^{-1}; δ_H (400 MHz; DMSO-d_6; 60:10:30 MC:*syn*:*anti*) 8.70 (1 H, d, *J* 16.5, MC 4'-H), 8.23 (1 H, dd, *J* 8.0, 1.2, MC 5'-H), 7.94 (1 H, d, *J* 7.5, MC 4-H), 7.79 (1 H, d, *J* 16.5, MC 3'-H), 7.70 (1 H, d, *J* 7.5, MC 7-H), 7.60 (1 H, t, *J* 7.5, MC 5-H), 7.54 (1 H, t, *J* 7.5, MC 6-H), 7.50 (1 H, td, *J* 8.4, 1.2, MC 7'-H), 8.70 (1 H, d, *J* 16.5, MC 4'-H), 7.20 – 6.97 (16 H, m, MC Bn 3,4,5-, 8'-, 6'-H; Bn 3,4,5-H *syn*; Bn 3,4,5-, 4'-, 5'-, 7'-, 6-H *anti*), 6.88 (1 H, t, *J* 7.2, 6'-H *syn*), 6.82 (1 H, t, *J* 7.2, 6'-H *anti*), 6.80 (1 H, d, *J* 8.3, 8'-H *syn*), 6.76 (1 H, d, *J* 7.5, 4-H *syn*), 6.75 (1 H, d, *J* 10.4, 4'-H *syn*), 6.64 – 6.52 (8 H, m, MC Bn 2,6-H; Bn 2,6-H *syn*; Bn 2,6-, 7-, 8'-H *anti*), 6.53 (1 H, t, *J* 7.3, 5-H *anti*), 6.52 (1 H, d, *J* 7.5, 7-H *syn*), 5.98 (1 H, t, *J* 7.0, 4-H *anti*), 5.95 (1 H, d, *J* 10.3, 3'-H *anti*), 5.48 (1 H, d, *J* 10.2, 3'-H *syn*), 3.89 (3 H, s, MC NMe), 3.79 (1 H, d, *J* 13.7, MC C*H*H), 3.65 (1 H, d, *J* 13.7, MC CH*H*), 3.16 – 3.11 (2 H, m, CH_2 *syn*), 2.74 (1 H, d, *J* 12.4, C*H*H *anti*), 2.70 (3 H, s, NMe *anti*), 2.57 (1 H, d, *J* 12.4, CH*H anti*), 2.48 (3 H, s, NMe *syn*), 1.88 (3 H, s, MC 3-Me), 1.18 (3 H, s, 3-Me *syn*) and 1.16 (3 H, s, 3-Me *anti*); δ_C (100 MHz; DMSO-d_6) 181.1 (MC C=N), 159.7 (MC 8a'), 154.5 (8a' *anti*), 153.7(8a' *syn*), 149.8 (MC 4'), 148.9 (7a *anti*), 147.4 (7a *syn*), 142.7 (MC 7a), 141.3 (MC 3a), 138.0 (Bn 1 *syn*), 137.5 (Bn 1 *anti*), 136.4 (3a *syn*), 136.1 (MC 7'), 134.9 (3a *anti*), 132.6, 131.7, 131.2, 131.1, 130.3, 130.3, 129.7, 129.4, 129.2, 128.5, 128.3, 128.2, 128.1, 127.7, 127.6, 127.6, 127.5, 127.4, 126.6, 126.6, 124.4, 122.4, 121.8, 120.9, 120.7, 120.5, 119.9, 119.6, 119.3, 119.2, 118.8, 118.1, 117.3, 115.6, 115.1, 114.9, 114.8, 113.2 (MC 3'), 107.4 (7 *syn*), 107.4 (7 *anti*), 105.7 (2 *anti*), 102.4 (2 *syn*), 58.1 (MC 3), 56.7 (3 *anti*), 53.7 (3 *syn*), 46.1 (MC CH_2), 41.3 (CH_2 *anti*), 39.0 (CH_2 *syn*), 34.7 (MC NMe), 29.3 (NMe *anti*), 28.2 (NMe *syn*), 25.4 (MC 3-Me), 23.7 (3-Me *syn*) and 16.9 (3-Me *anti*); HRMS-ES+ (*m/z*): Found: 354.1872 (MH^+, $C_{25}H_{24}NO$ requires: 354.1858).

3-Benzyl-1,3-dimethylspiro[benzo[f]chromene-2,3'-indoline] 6r
Following the same general method, 1,2,3-trimethylindole (99.0 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 2-hydroxy-1-naphthaldehyde (107 mg, 0.622 mmol) were heated for 26 h to give spiropyran **6r** (183 mg, 73%) as an amorphous purple film (purified by flash chromatography, eluting with EtOAc, then 5% MeOH in EtOAc, then 50% MeOH in EtOAc). ν_{max} = 3072, 3005, 2965, 2880, 1640, 1607, 1482, 1460, 1360, 1275, 1246, 1169, 1081, 1021, 993, 928, 810, 741 and 701 cm^{-1}; δ_H (400 MHz; DMSO-d_6; 30:70 *syn*:*anti*) 8.23 (1 H, d, *J* 8.4, 10'-H *anti*), 8.16 (1 H, d, *J* 8.4, 10'-H *syn*), 7.87 (1 H, d, *J* 10.3, 1'-H *anti*), 7.85 – 7.81 (2 H, m, 6' and 7'-H *syn*), 7.81 (1 H, d, *J* 8.0, 7'-H *anti*), 7.72 (1 H, d, *J* 8.8, 6'-H *anti*), 7.58 – 7.52 (3 H, m, 1'-, 9'-H *syn*; 9'-H *anti*), 7.39 (1 H, t, *J* 8.0, 8'-H *syn*), 7.38 (1 H, t, *J* 8.0, 8'-H *anti*), 7.21 – 7.13 (7 H, m, 4-, 6-, 5'-H *syn*; 6-, Bn 3,4,5-H *anti*), 7.08 – 7.00 (5 H, m, Bn 2,3,4,5,6-H *syn*), 6.96 (1 H, d, *J* 8.8, 5'-H *anti*), 6.81 (1 H, t, *J* 7.4, 5-H *syn*), 6.66 (3 H, d, *J* 7.3, 7-, Bn 2,6-H *anti*), 6.58 (1 H, t, *J* 7.3, 5-H *anti*), 6.55 (1 H, *J* 7.4, 7-H *syn*), 6.09 (1 H, d, *J* 10.3, 2'-H *anti*), 6.04 (1 H, d, *J* 7.3, 4-H *anti*), 5.62 (1 H, d, *J* 10.2, 2'-H *syn*), 3.25 (1 H, d, *J* 13.6, C*H*H *syn*), 3.17 (1 H, d, *J* 13.6, C*H*H *syn*), 2.84 (1 H, d, *J* 12.3, C*H*H *anti*), 2.76 (3 H, s, NMe *anti*), 2.64 (1 H, d, *J* 12.3, CH*H anti*), 2.48 (3 H, s, NMe *syn*), 1.20 (3 H, s, 3-Me *syn*) and 1.15 (3 H, s, 3-Me *anti*); δ_C (100 MHz; DMSO-d_6); *anti* diastereoisomer: 152.6 (5a'), 148.8 (7a), 137.5 (Bn 1), 132.5 (3a), 131.7 (Bn 2,6), 130.7 (6'), 129.9 (10a'), 128.9 (6a'), 128.8 (7'), 128.2 (Bn 4), 127.6 (Bn 3,5), 127.5 (9'), 126.6 (6), 126.1 (1'), 124.7 (4), 124.0 (8'), 121.6 (10'), 118.5 (2'), 118.2 (5), 117.4 (5'), 111.1 (1a'), 107.4 (7), 105.9 (3'), 56.6 (3), 41.2 (CH_2), 29.4 (NMe) and 17.1 (3-Me); *syn* diastereoisomer: 151.7 (5a'), 147.3 (7a), 138.1 (Bn 1), 136.4 (3a), 131.1 (Bn 2,6), 130.7 (6'), 129.9 (10a'), 129.0 (6a'), 129.0 (7'), 127.7 (Bn 3,5), 127.6 (Bn 4), 127.4 (9'), 126.6 (6), 124.3 (1'), 124.1 (8'), 122.4 (4), 121.7 (10'), 119.5 (5), 117.5 (2'), 117.4 (5'), 111.7 (1a'), 107.5 (7), 102.3 (3'), 53.8 (3), 39.0 (CH_2), 28.2 (NMe) and 23.8 (3-Me); HRMS-ES+ (*m/z*): Found: 404.2027 (MH^+, $C_{29}H_{26}NO$ requires: 404.2014).

3-Benzyl-1,3-dimethyl-6'-methoxyspiro[chromene-2,2'-indoline] 6s
Following the same general method, 1,2,3-trimethylindole (127 mg, 0.798 mmol), benzyl bromide (95.0 µL, 0.798 mmol) and 5-methoxysalicylaldehyde (100 µL, 0.798 mmol) were heated for 6 h to give spiropyran **6s** (278 mg, 91%) as a red powder (purified by precipitation from acetone). ν_{max} = 3024, 1738, 1585, 1538, 1496, 1475, 1448, 1433, 1372, 1298, 1256, 1233, 1208, 1161, 1116, 1038, 1021, 968, 817, 752 and 700 cm^{-1}; δ_H (400 MHz; DMSO-d_6) 8.69 (1 H, d, *J* 16.3, 4'-H), 7.94 (1 H, d, *J* 6.6, 4-H), 7.78 (1 H, d, *J* 16.3, 3'-H), 7.75 – 7.66 (2 H, m, 5'-, 7-H), 7.63 (1 H, t, *J* 6.6, 5-H), 7.57 (1 H, t, *J* 6.6, 6-H), 7.24 – 7.12 (1 H, m, 7'-H), 7.10 – 7.04 (2 H, m, 8'-, Bn 4-H), 7.04 – 6.97 (2 H, m, Bn 3,5-H), 6.61 (2 H, d, *J* 6.1, Bn 2,6-H), 3.91 (3 H, s, NMe), 3.84 (3 H, s, OMe), 3.82 (1 H, d, *J* 13.6, C*H*H), 3.66 (1 H, d, *J* 13.6, CH*H*) and 1.93 (3 H, s, 3-Me); δ_C (100 MHz; DMSO-d_6) 181.0 (C=N), 154.5 (8a'), 153.1 (6'), 149.7 (4'), 142.7 (7a), 141.3 (3a), 134.9 (Bn 1), 129.7 (6), 129.4 (5), 129.2 (Bn 2,6), 128.4 (Bn 3,5), 127.7 (Bn 4), 124.3 (4), 124.1 (7'), 121.8 (4a'), 118.4 (8'), 115.1 (5'), 113.2 (3'), 113.0 (7), 58.1 (3), 56.5 (OMe), 46.1 (CH_2), 34.6 (NMe) and 25.5 (3-Me); HRMS-ES+ (*m/z*): Found: 384.1966 (MH^+, $C_{26}H_{26}NO_2$ requires: 384.1963).

3-Benzyl-1,3-dimethyl-8'-ethoxyspiro[chromene-2,2'-indoline] 6t
Following the same general method, 1,2,3-trimethylindole (99.0 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 3-ethoxysalicylaldehyde (104 mg, 0.622 mmol) were heated for 6 h to give spiropyran **6t** (230 mg, 93%) as an amorphous purple film (purified by flash chromatography, eluting with EtOAc, then 50% MeOH in EtOAc). ν_{max} = 3027, 2978, 2930, 1601, 1579, 1538, 1462, 1393, 1249, 1182, 1078, 1020, 941, 737 and 701 cm^{-1}; δ_H (400 MHz; DMSO-d_6; 57:14:29 MC:*syn*:*anti*) 8.73 (1 H, d, *J* 16.4, MC 4'-H), 7.92 (1 H, d, *J* 7.5, MC 4-H), 7.78 (1 H, d, *J* 7.9, MC 5'-H), 7.72 (1 H, d, *J* 16.4, MC 3'-H), 7.67 (1 H, d, *J* 7.4, MC 7-H), 7.59 (1 H, t, *J* 7.4, MC 5-H), 7.53 (1 H, t, *J* 7.5, MC 6-H), 7.20 (1 H, d, *J* 7.9, MC 7'-H), 7.15 – 7.05 (5 H, m, 6-H *syn*; 6-, Bn 3,4,5-H *anti*), 7.05 – 7.00 (5 H, m, 5-, Bn 3,4,5-H *syn*; 4'-H *anti*), 7.00 – 6.92 (5 H, m, 4-H *anti*; MC 6'-, Bn 3,4,5-H), 6.88 (1 H, d, *J* 7.6, 7'-H *syn*), 6.82 – 6.76 (3 H, m, 6'-H *syn*; 6'-, 7'-H *anti*), 6.73 (1 H, d, *J* 7.8, 5'-H *anti*), 6.72 (1 H, d, *J* 7.8, 5'-H *syn*), 6.70 (1 H, d, *J* 10.2, 4'-H *syn*), 6.57 (5 H, d, *J* 7.2, 7-, Bn 2,6-H *anti*; MC Bn 2,6-H), 6.49 (1 H, t, *J* 7.1, 5-H *anti*), 6.46 (1 H, d, *J* 7.2, 7-H *syn*), 5.95 (1 H, d, *J* 7.1, 4-H *anti*), 5.90 (1 H, d, *J* 10.2, 3'-H *anti*), 5.43 (1 H, d, *J* 10.2, 3'-H *syn*), 4.11 (2 H, q, *J* 7.0, MC OCH_2), 3.91 (2 H, q, *J* 7.0, OCH_2 *syn*), 3.88 (3 H, s, MC NMe), 3.79 (1 H, d, *J* 14.0, MC C*H*H), 3.78 (2 H, q, *J* 7.0, OCH_2 *anti*), 3.59 (1 H, d, *J* 14.0, MC CH*H*), 3.14 (1 H, d, *J* 13.3, C*H*H *syn*), 3.09 (1 H, d, *J* 13.3, CH*H syn*), 2.71 (1 H, d, *J* 12.4, C*H*H *anti*), 2.66 (3 H, s, NMe *anti*), 2.52 (1 H, d, *J* 12.4, CH*H anti*), 2.45 (3 H, s, NMe *syn*), 1.89 (3 H, s, MC 3-Me), 1.35 (3 H, t, *J* 7.0, MC CH_2CH_3) 1.08 (3 H, s, 3-Me *syn*), 1.07 (3 H, s, 3-Me *anti*), 1.02 (3 H, t, *J* 7.0, MC CH_2CH_3 *syn*) and 0.91 (3 H, t, *J* 7.0, MC CH_2CH_3 *anti*); δ_C (100 MHz; DMSO-d_6) 181.0 (MC C=N), 149.5 (MC 8a'), 149.4 (MC 4'), 148.7 (7a *anti*), 147.8 (MC 8'), 147.3 (7a *syn*), 145.7 (8' *syn*), 144.4 (8a' *anti*), 143.7 (8a' *syn*), 142.6 (MC 7a), 141.2 (MC 3a), 138.1 (Bn 1 *syn*), 137.5 (Bn 1 *anti*), 136.1 (3a *syn*), 134.8 (MC Bn 1), 132.6 (3a *anti*), 131.6 (Bn 2,6 *anti*), 131.1 (Bn 2,6 *syn*), 130.3 (4' *anti*), 129.8 (MC 6), 129.5 (MC 5), 129.1 (MC Bn 2,6), 128.4 (4' *syn*), 128.3 (MC Bn 4), 128.1 (6 *anti*), 127.7, 127.7, 127.5, 126.6, 126.5, 125.5 (4 *anti*), 124.3 (MC 4), 122.5, 122.1 (MC 4a'), 121.5 (MC 5'), 120.6, 120.5, 120.4, 120.3, 120.3, 120.2 (MC 6'), 120.0 (3' *anti*), 119.2 (5' *syn*), 118.9 (3' *syn*), 118.2 (MC 7'), 117.9 (5 *anti*), 117.3 (7' *syn*), 117.2 (7' *anti*), 115.1 (MC 7), 113.3 (MC 3'), 107.2 (7 *syn*), 107.2 (7 *anti*), 105.5 (2 *anti*), 102.2 (2 *syn*), 65.4 (OCH_2 *syn*), 65.1 (OCH_2 *anti*), 65.0 (MC OCH_2), 58.1 (MC 3), 56.4 (3 *anti*), 53.7 (3 *syn*), 46.1 (MC Bn CH_2), 41.5 (Bn CH_2 *anti*), 39.2 (Bn CH_2 *syn*), 34.7 (MC NMe), 29.3 (NMe *anti*), 28.1 (NMe *syn*), 25.4 (MC 3-Me), 23.6 (3-Me *syn*), 16.8 (3-Me *anti*), 15.2 (CH_2CH_3 *syn*), 15.0 (CH_2CH_3 *anti*) and 14.9 (MC CH_2CH_3); HRMS-ES+ (*m/z*): Found: 398.2217 (MH^+, $C_{27}H_{28}NO_2$ requires: 398.2120).

Methyl 3-benzyl-1,3-dimethylspiro[chromene-2,2'-indoline]-6'-carboxylate[17] 6u
Following the same general method, 1,2,3-trimethylindole (64.0 mg, 0.400 mmol), benzyl bromide (48.0 µL, 0.400 mmol) and methyl 3-formyl-4-hydroxybenzoate (112 mg, 0.400 mmol) were heated for 1 h to give

spiropyran **6u** (136 mg, 83%) as a yellow powder (purified by precipitation from acetone), spectroscopically identical to that previously reported.[17]

3-Benzyl-6'-bromo-1,3-dimethylspiro[chromene-2,2'-indoline][17] 6v
Following the same general method, 1,2,3-trimethylindole (99.0 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 5-bromosalicylaldehyde (125 mg, 0.622 mmol) were heated for 4 h to give spiropyran **6v** (174 mg, 65%) as a yellow powder (purified by precipitation from acetone), spectroscopically identical to that previously reported.[17]

3-Benzyl-7'-bromo-1,3-dimethylspiro[chromene-2,2'-indoline] 6w
Following the same general method, 1,2,3-trimethylindole (99.0 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 4-bromosalicylaldehyde (125 mg, 0.622 mmol) were heated for 4 h to give spiropyran **6w** (158 mg, 59%) as an orange powder (purified by precipitation from acetone). ν_{max} = 2980, 1588, 1537, 1475, 1452, 1419, 1371, 1297, 1243, 1113, 1071, 1022, 967, 939, 906, 853, 787, 753 and 701 cm^{-1}; δ_H (400 MHz; DMSO-d_6) 8.58 (1 H, d, *J* 15.6, 4'-H), 8.15 (1 H, br s, 5'-H), 7.92 (1 H, br s, 4-H), 7.81 (1 H, d, *J* 15.6, 3'-H), 7.70 (1 H, br s, 7-H), 7.62 – 7.50 (2 H, m, 5-, 6-H), 7.32 (1 H, s, 8'-H), 7.26 (1 H, br s, 6'-H), 7.12 – 6.92 (3 H, m, Bn 3,4,5-H), 6.61 (2 H, br s, Bn 2,6-H), 3.92 (3 H, s, NMe), 3.76 (1 H, d, *J* 13.5, C*H*H), 3.63 (1 H, d, *J* 13.5, CH*H*) and 1.96 (3 H, s, 3-Me); δ_C (100 MHz; DMSO-d_6) 181.1 (C=N), 160.0 (8a'), 148.6 (4'), 142.7 (7a), 141.4 (3a), 134.9 (Bn 1), 132.7 (5'), 129.8 (6), 129.6 (5), 129.2 (Bn 2,6), 128.9 (7'), 128.3 (Bn 3,5), 127.7 (Bn 4), 124.4 (4), 123.6 (6'), 121.3 (4a'), 119.9 (8'), 115.3 (7), 113.9 (3'), 58.2 (3), 45.9 (CH_2), 34.7 (NMe) and 25.2 (3-Me); HRMS-ES+ (*m/z*): Found: 432.0968 (MH^+, $C_{25}H_{23}{}^{79}BrNO$ requires: 432.0963).

3-Benzyl-6'-chloro-1,3-dimethylspiro[chromene-2,2'-indoline] 6x
Following the same general method, 1,2,3-trimethylindole (99.0 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 5-chlorosalicylaldehyde (97.0 mg, 0.622 mmol) were heated for 1.5 h to give spiropyran **6x** (209 mg, 87%) as a yellow powder (purified by precipitation from acetone). ν_{max} = 2983, 1652, 1558, 1474, 1456, 1365, 1217, 1028, 1007, 826, 765 and 668 cm^{-1}; δ_H (400 MHz; DMSO-d_6) 8.58 (1 H, d, *J* 16.5, 4'-H), 8.31 (1 H, s, 5'-H), 7.92 (1 H, d, *J* 7.3, 4-H), 7.83 (1 H, d, *J* 16.5, 3'-H), 7.72 (1 H, d, *J* 7.2, 7-H), 7.65 (1 H, t, *J* 7.3, 5-H), 7.58 (1 H, t, *J* 7.3, 6-H), 7.53 (1 H, d, *J* 8.3, 7'-H), 7.11 (1 H, d, *J* 8.3, 8'-H), 7.08 – 6.99 (3 H, m, Bn 3,4,5-H), 6.61 (2 H, d, *J* 7.2, Bn 2,6-H), 3.89 (3 H, s, NMe), 3.78 (1 H, d, *J* 13.7, C*H*H), 3.66 (1 H, d, *J* 13.3, CH*H*) and 1.92 (3 H, s, 3-Me); δ_C (100 MHz; DMSO-d_6) 181.2 (C=N), 158.3 (8a'), 148.0 (4'), 142.7 (7a), 141.5 (3a), 135.1 (7'), 134.8 (Bn 1), 129.8 (5), 129.8 (6), 129.7 (5'), 129.2 (Bn 2,6), 128.4 (Bn 3,5), 127.7 (Bn 4), 124.4 (6'), 124.3 (4a'), 123.2 (4), 119.0 (8'), 115.3 (7), 114.5 (3'), 58.3 (3), 45.9 (CH_2), 34.7 (NMe) and 25.1 (3-Me); HRMS-ES+ (*m/z*): Found: 388.1480 (MH^+, $C_{25}H_{23}{}^{35}ClNO$ requires: 388.1468).

3-Benzyl-5'-chloro-1,3-dimethylspiro[chromene-2,2'-indoline] 6y
Following the same general method, 1,2,3-trimethylindole (99.0 mg, 0.622 mmol), benzyl bromide (74.0 µL, 0.622 mmol) and 6-chlorosalicylaldehyde (97.0 mg, 0.622 mmol) were heated for 1 h to give spiropyran **6y** (200 mg, 83%) as a yellow powder (purified by precipitation from acetone). ν_{max} = 2984, 1586, 1539, 1472, 1448, 1388, 1311, 1282, 1268, 1231, 1162, 1129, 1078, 1021, 971, 939, 911, 853, 782, 752 and 703 cm^{-1}; δ_H (400 MHz; DMSO-d_6) 8.59 (1 H, d, *J* 16.3, 4'-H), 8.07 (1 H, d, *J* 16.3, 3'-H), 7.96 (1 H, d, *J* 7.5, 4-H), 7.78 (1 H, d, *J* 7.5, 7-H), 7.67 (1 H, t, *J* 7.5, 5-H), 7.60 (1 H, t, *J* 7.5, 6-H), 7.48 (1 H, t, *J* 8.0, 7'-H), 7.20 (1 H, d, *J* 8.0, 6'-H), 7.14 (1 H, d, *J* 8.0, 8'-H), 7.09 – 7.01 (3 H, m, Bn 3,4,5-H), 6.66 (2 H, d, *J* 6.9, Bn 2,6-H), 3.86 (3 H, s, NMe), 3.81 (1 H, d, *J* 13.3, C*H*H), 3.61 (1 H, d, *J* 13.3, CH*H*) and 1.95 (3 H, s, 3-Me); δ_C (100 MHz; DMSO-d_6) 181.7 (C=N), 161.3 (8a'), 147.1 (4'), 142.7 (7a), 141.5 (3a), 137.0 (5'), 135.3 (7'), 134.7 (Bn 1), 129.9 (5), 129.8 (6), 129.3 (Bn 2,6), 128.4 (Bn 3,5), 127.8 (Bn 4), 124.5 (4), 121.5 (6'), 119.2 (4a'), 118.0 (3'), 116.6 (8'), 115.5 (7), 58.2 (3), 46.1 (CH_2), 34.7 (NMe) and 25.2 (3-Me); HRMS-ES+ (*m/z*): Found: 388.1528 (MH^+, $C_{25}H_{23}{}^{35}ClNO$ requires: 388.1468).

Supporting Information
^1H and ^{13}C NMR spectra of all products.

Conflicts of Interest

There are no conflicts to declare.

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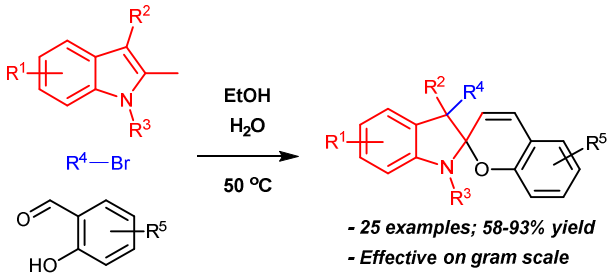
Table of contents entry / Graphical abstract



- 25 examples; 58-93% yield

- Effective on gram scale