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# Regioselective synthesis of sugar fused dispiropyrrolizidines *via* intermolecular 1,3-dipolar cycloaddition reaction

**Sirisha Nallamala and Raghavachary Raghunathan***

*Department of Organic Chemistry, University of Madras, Guindy Campus, Chennai, INDIA*

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**ABSTRACT**

*An expedient method for the synthesis of glyco dispiropyrrolizidines is reported through 1,3-dipolar cycloaddition reaction (1,3 DC reaction). The novel glycosyl dipolarophile derived from D-glucose underwent neat [3+2] cycloaddition reaction with the azomethine ylides generated from di/tri ketones and proline to give the corresponding glycosidic heterocycles in good yields.*

**Keywords:** 1,3-dipolar cycloaddition, azomethine ylide, spiro pyrrolizidines, glycosides.

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## INTRODUCTION

Carbohydrates and their derivatives which are potential useful substrates in chemical and biological fields[1] are present in natural products.[2] Recent studies on these glycomolecules,[3] such as proteoglycans, glycoproteins,[4] glycolipids,[5] and antibiotics have shed light on the significance of carbohydrate parts (glycons) in molecular recognition for the transmission of biological information.[6] Therefore, it is now recognized that carbohydrates are at the heart of a multitude of biological events. With this stimulating biological background, the efficient synthesis of not only carbohydrates themselves, but also carbohydrate-containing heterocycles is becoming more and more important in the field of organic chemistry and chemical biology.[7] Hence there has been renewed interest in the synthesis of carbohydrate based heterocycles.

The intermolecular [3+2]-cycloaddition reaction of azomethine ylides with olefinic and acetylenic dipolarophiles has resulted in a number of novel heterocyclic scaffolds, which are particularly useful for the creation of diverse chemical libraries of drug-like molecules for biological screening.[8,9] Functionalised pyrrolizidines and oxindoles are the central skeleton for numerous alkaloids and constitute classes of compounds with significant biological activity.[10,11] Spirooxindoles are an important class of naturally occurring substances characterized by highly pronounced biological properties.[12] Recently we have reported bioactivity of some of the spiropyrrolidines.[13]

## MATERIALS AND METHODS

IR spectra were recorded on a SHIMADZU 8300 series FT-IR instrument. $^{1}$H NMR spectra were recorded in $CDCl_3$ using TMS as an internal standard on a Bruker 300 spectrometer at 300 MHz. $^{13}$C NMR was recorded on a Bruker 300 spectrometer at 75 MHz. Mass spectra were recorded Thermo Finnigan (LCQ) Amax 6000 ESI mass spectrometer. Elemental analysis was carried out using Perkin-Elmer CHNS 2400B instrument.

**Representative procedure for the synthesis of dipolarophiles 3**

To a stirred solution of sugar aldehyde **1** (1mmol) and indane1,3-dione **2** (1mmol) in ethanol (10 mL), triethylamine (1 mmol) was added at room temperatue and stirring was continued for 4 h. After completion of the reaction, the reaction mixture was poured in to the ice water (5 mL) sticky solid was formed which was extracted with ethyl acetate (3×20 mL). The organic phase was successively washed with brine (15 mL) and dried over anhydrous

$Na_2SO_4$. The solvent was removed under reduced pressure to give the crude product, which was purified by column chromatography using hexane and ethyl acetate and (8:2) as eluent to afford the corresponding dipolarophile in good yields.

**2.3.3.1:** ***2-(((3a'R,5'R,6'S,6a'R)-6'-(benzyloxy)tetrahydrospiro[cyclohexane-1,2'-furo [2,3-d] [1,3]dioxole]-5'-yl)methylene)-1H-indene-1,3(2H)-dione (3)***

Colourless powder. yield; 70%. m.p; 148 ˚C. $^1$H NMR ($CDCl_3$, 300 MHz); $\delta$ 1.39-1.57 (m, 10H), 3.62 (d, *J* = 3.6 Hz, 1H), 3.92-4.11(m, 2H), 4.17 (d, *J* = 12 Hz, 1H),4.24 (d, *J* = 3.6 Hz, 1H), 5.87 (d, *J* = 3.6 Hz, 1H), 6.74-6.82 (m, 5H), 7.39 (s, 1H), 7.70-7.99 (s, 4H). $^{13}$C NMR (75 MHz); ppm 23.19, 23.72, 25.07, 33.49, 34.02, 67.79, 70.14, 73.42, 84.49, 106.32, 114.49, 126.92, 127.49, 127.81, 133.29, 136.39, 148.34, 190.29, 191.17. MS (ESI); *m/z* 447.21 ($M^+$+1).

**General procedure for synthesis of cycloadducts (6, 8, 10)**

To a mixture of isatin **7**/ ninhydrin **4**/ acenaphthequinone **9** (1 mmol) and proline **5** (2 mmol), glycosylidene 1,3-indanedione **3** (1 mmol) was added and heated under reflux in methanol (20 mL) until the disappearance of the starting materials as evidenced by TLC. The solvent was removed under vacuo. The crude product was subjected to column chromatography using petroleum ether-ethyl acetate as eluent.

***Spectral data of compound 6:*** Colourless powder. yield; 66%. m.p; 62 ˚C. IR (KBr); 1730, 1732, 1736, 1737 $cm^{-1}$: $^1$HNMR ($CDCl_3$, 300 MHz); $\delta$ 1.29-1.41 (m, 8H), 1.47-1.62 (m, 6H), 1.92- 1.96 (m, 1H), 2.14- 2.18 (m, 1H), 2.91-2.98 (m, 1H), 3.39 (d, *J* = 6.9 Hz, 1H), 3.52 (dd, *J* = 6.9, 3.6 Hz, 1H), 4.09- 4.14 (m, 2H), 4.46 (d, *J* = 12.3 Hz, 1H), 4.74 (d, *J* = 3.6 Hz, 1H), 6.02 (d, *J* = 3.6 Hz, 1H), 6.79- 6.81 (m, 5H), 7.89- 8.02 (m, 8H). $^{13}$C NMR (75 MHz); ppm 22.52, 22.94, 23.97, 24.08, 26.67, 28.78, 32.54, 33.18, 49.53, 53.41, 61.28, 63.27, 66.35, 76.79, 78.82, 78.91, 104.02, 113.71, 118.42, 118.59, 120.37, 121.32, 121.48, 121.79, 122.01, 122.39, 122.58, 123.12, 124.49, 126.61, 128.89, 129.42, 132.39, 132.48, 134.58, 196.41, 196.48, 198.19, 198.22. MS (ESI); *m/z* 660.3 ($M^+$+1). Anal.Calcd for $C_{40}H_{37}NO_8$; C, 72.82; H, 5.65; N, 2.12%. Found; C, 72.90; H, 5.71; N, 2.05%.

***Spectral data of compound 8:*** Colourless powder. yield; 60%. m.p; 48 ˚C. IR (KBr); 1703, 1732, 1738 $cm^{-1}$: $^1$HNMR ($CDCl_3$, 300 MHz); $\delta$ 1.25-1.49 (m, 10H), 1.55-1.62 (m, 4H), 1.88- 1.93 (m, 1H), 2.09- 2.15 (m, 1H), 2.88-2.92 (m, 1H), 3.32 (d, *J* = 6.6 Hz, 1H), 3.57 (dd, *J* = 6.6, 3.6 Hz, 1H), 3.98- 4.07 (m, 2H), 4.42 (d, *J* = 12.3 Hz, 1H), 4.67 (d, *J* = 3.6 Hz, 1H), 5.99 (d, *J* = 3.6 Hz, 1H), 6.82- 7.28 (m, 7H), 7.78- 7.94 (m, 6H), 8.34 (s, 1H). $^{13}$C NMR (75 MHz); ppm 21.47, 22.02, 24.37, 24.81, 25.59, 28.92, 33.19, 33.74, 48.71, 54.27, 60.18, 62.54, 65.44, 73.72, 76.14, 77.97, 103.77, 113.24, 119.41, 120.31, 120.48, 121.84, 122.39, 122.77, 124.49, 125.03, 125.25, 125.74, 126.37, 126.82, 127.49, 128.03, 128.49, 132.34, 133.07, 134.49, 174.62, 191.49, 191.64. MS (ESI); *m/z* 647.5 ($M^+$+1). Anal.Calcd for $C_{39}H_{38}N_2O_7$; C, 72.43; H, 5.92; N, 4.33%. Found; C, 72.52; H, 5.98; N, 4.21%.

***Spectral data of compound 10:*** Colourless powder. yield; 62%. m.p; 54 ˚C. IR (KBr); 1721, 1736, 1739 $cm^{-1}$: $^1$HNMR ($CDCl_3$, 300 MHz); $\delta$ 1.22-1.48 (m, 8H), 1.52-1.69 (m, 6H), 1.89- 1.94 (m, 1H), 2.17- 2.22 (m, 1H), 2.91-2.97 (m, 1H), 3.35 (d, *J* = 6.9 Hz, 1H), 3.60 (dd, *J* = 6.9, 3.6 Hz, 1H), 4.01- 4.13 (m, 2H), 4.39 (d, *J* = 12.6 Hz, 1H), 4.72 (d, *J* = 3.6 Hz, 1H), 6.01 (d, *J* = 3.6 Hz, 1H), 6.74- 7.49 (m, 15H). $^{13}$C NMR (75 MHz); ppm 22.17, 23.27, 23.88, 25.12, 25.49, 27.91, 31.23, 32.14, 47.34, 51.49, 59.64, 62.24, 67.32, 74.91, 76.32, 80.12, 104.27, 113.44, 117.41, 119.41, 120.32, 121.49, 122.34, 123.44, 124.72, 125.49, 126.42, 128.17, 128.43, 129.41, 130.14, 132.79, 134.19, 136.44, 137.42. 139.94, 141.42, 192.37, 193.11, 195.42. MS (ESI); *m/z* 682.6 ($M^+$+1). Anal.Calcd for $C_{43}H_{39}NO_7$; C, 75.75; H, 5.77; N, 2.05%. Found; C, 75.83; H, 5.84; N, 1.97%.

**General procedure for synthesis of cycloadducts (12, 13, 14)**

To a mixture of isatin **7**/ ninhydrin **4**/ acenaphthequinone **9** (1 mmol), and pipecolinic acid **16** (2 mmol), glycosylidene 1,3-indanedione **3** (1 mmol) was added and heated under reflux in methanol (20 mL) until the disappearance of the starting materials as evidenced by TLC. The solvent was removed under vacuo. The crude product was subjected to column chromatography using petroleum ether-ethyl acetate as eluent.

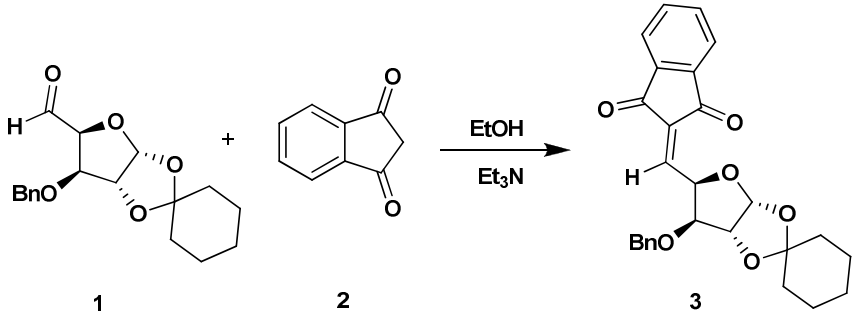
***Spectral data of compound 12:*** Colourless powder. yield; 65%. m.p; 62 ˚C. IR (KBr); 1728, 1730, 1735, 1738 $cm^{-1}$: $^1$HNMR ($CDCl_3$, 300 MHz); $\delta$ 1.18-1.39 (m, 6H), 1.45-1.53 (m, 5H), 1.59-1.67 (m, 5H), 1.88- 1.95 (m, 1H), 2.08-2.15 (m, 1H), 2.84-2.90 (m, 1H), 3.48 (d, *J* = 6.9 Hz, 1H), 3.57 (dd, *J* = 6.9, 3.6 Hz, 1H), 3.97- 4.04 (m, 2H), 4.32 (d, *J* = 12.3 Hz, 1H), 4.71(d, *J* = 3.6 Hz, 1H), 5.89 (d, *J* = 3.6 Hz, 1H), 6.68- 6.89 (m, 5H), 7.72- 7.92 (m, 8H). $^{13}$C NMR (75 MHz); ppm 20.47, 21.19, 22.07, 22.54, 26.45, 27.32, 29.51, 34.72, 35.31, 46.24, 55.14, 62.71, 63.72, 65.41, 76.77, 80.04, 80.62, 104.07, 113.32, 118.16, 118.32, 123.35, 123.49, 127.31, 127.72, 128.14. 131.97, 132.97, 136.24, 136.39, 136.44, 140.93, 141.87, 192.74, 193.24, 197.54, 198.04. MS (ESI); *m/z* 674.2 ($M^+$+1). Anal.Calcd for $C_{41}H_{39}NO_8$; C, 73.09; H, 5.83; N, 2.08%. Found; C, 73.18; H, 5.89; N, 2.01%.

***Spectral data of compound 13:*** Colourless powder. yield; 66%. m.p; 72 ˚C. IR (KBr); 1704, 1731, 1738 $cm^{-1}$: $^1$HNMR ($CDCl_3$, 300 MHz); $\delta$ 1.17-1.35 (m, 5H), 1.41-1.59 (m, 6H), 1.63-1.71 (m, 5H), 1.79- 1.84 (m, 1H), 1.98-2.07 (m, 1H), 2.98-3.01 (m, 1H), 3.29 (d, *J* = 6.6 Hz, 1H), 3.51 (dd, *J* = 6.6, 3.6 Hz, 1H), 4.02- 4.09 (m, 2H), 4.37 (d, *J* = 12.3 Hz, 1H), 4.82 (d, *J* = 3.6 Hz, 1H), 5.98 (d, *J* = 3.6 Hz, 1H), 6.75- 7.19 (m, 8H), 7.62- 7.91 (m, 5H) 8.29 (s, 1H). $^{13}$C NMR (75 MHz); ppm 21.07, 22.18, 23.05, 23.64, 25.51, 26.22, 28.42, 32.14, 32.55, 45.71, 52.32, 60.27, 61.48, 66.34, 72.34, 79.92, 81.07, 103.71, 114.02, 117.19, 119.42, 121.44, 122.41, 125.07, 125.59, 126.69, 127.31, 128.12, 128.47, 129.42, 132.79, 134.19, 137.24, 140.17, 141.42, 175.42, 191.54, 191.97. MS (ESI); *m/z* 661.4 ($M^+$+1). Anal.Calcd for $C_{40}H_{40}N_2O_7$; C, 72.71; H, 6.10; N, 4.24%. Found; C, 72.80; H, 6.17; N, 4.06%.

***Spectral data of compound 14:*** Colourless powder. yield; 64%. m.p; 58 ˚C. IR (KBr); 1725, 1732, 1741$cm^{-1}$: $^1$HNMR ($CDCl_3$, 300 MHz); $\delta$ 1.20-1.49 (m, 9H), 1.54-1.71 (m, 7H), 1.89- 1.95 (m, 1H), 2.04- 2.11 (m, 1H), 2.89-2.94 (m, 1H), 3.33 (d, *J* = 6.9 Hz, 1H), 3.63 (dd, *J* = 6.9, 3.6 Hz, 1H), 3.97- 4.06 (m, 2H), 4.38 (d, *J* = 12.3 Hz, 1H), 4.81 (d, *J* = 3.6 Hz, 1H), 5.98 (d, *J* = 3.6 Hz, 1H), 6.59- 7.42 (m, 15H). $^{13}$C NMR (75 MHz); ppm 20.32, 21.15, 22.49, 23.51, 24.59, 25.48, 26.63, 31.72, 32.21, 48.72, 55.41, 61.41, 63.37, 67.17, 74.48, 78.89, 80.55, 103.77, 113.74, 118.32, 119.19, 120.17, 121.34, 122.54, 123.77, 124.15, 125.11, 126.65, 128.54, 128.89, 129.31, 130.35, 132.65, 134.41, 135.54, 136.12. 139.85, 142.12, 192.51, 193.09, 196.41. MS (ESI); *m/z* 696.4 ($M^+$+1). Anal.Calcd for $C_{44}H_{41}NO_7$; C, 75.95; H, 5.94; N, 2.01%. Found; C, 76.03; H, 6.01; N, 1.91%.

## RESULTS AND DISCUSSION

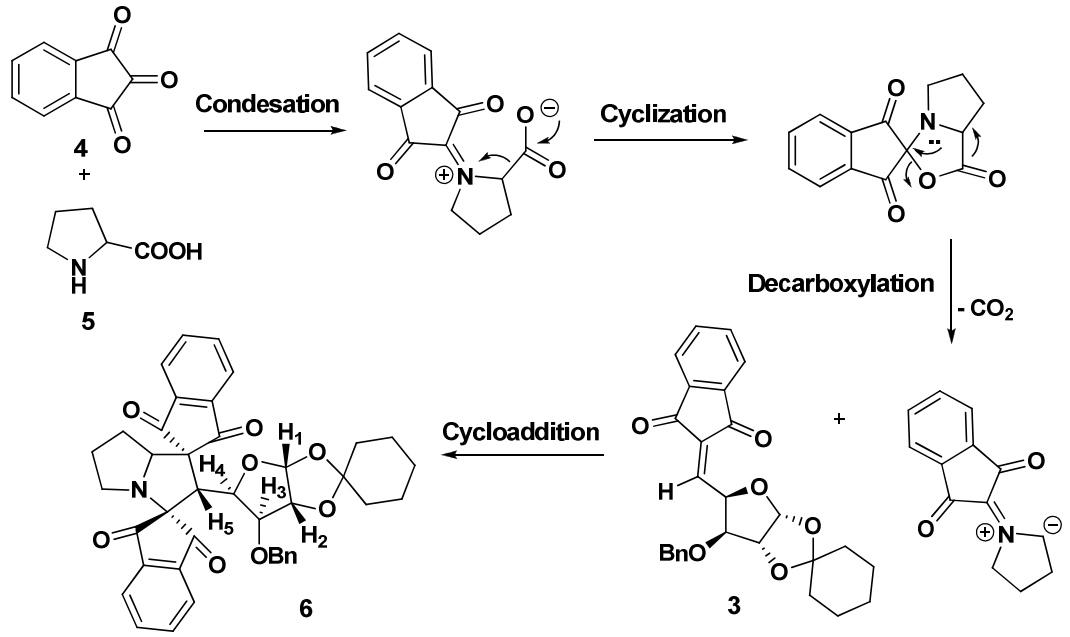
Our strategy commenced with the synthesis of glycosylidene 1,3-indanedione **3** by the base catalysed condensation of 1,3-indanedione **2** with O-benzyl tethered sugar aldehyde**1** (Scheme-1). The structure of the glycoside **3** was deduced on the basis of $^1$H NMR spectral data where the presence of singlet at δ 7.39 for alkene proton confirmed the formation of the product.



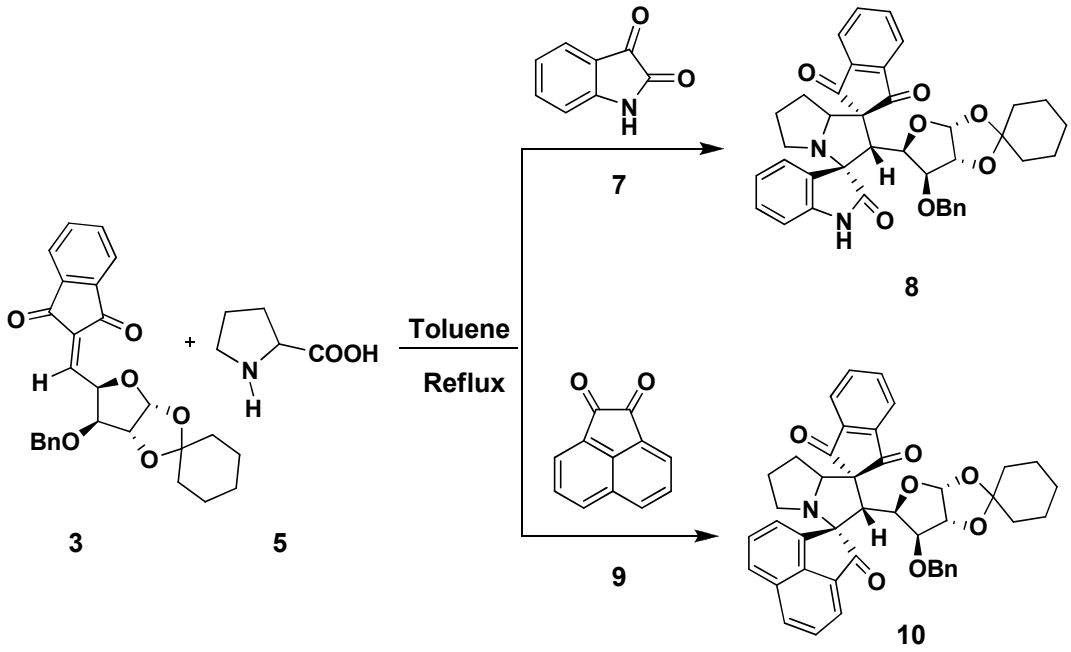

**Scheme-1**

Having synthesized carbohydrate derived dipolarophile **3** we carried out the cycloaddition reaction of azomethine ylide generated in situ by the decarboxylative condensation of ninhydrin **4**/ isatin **7**/ acenaphthequinone **9** and proline **5** with dipolarophile **3** in refluxing toluene, which led to the formation of glyco-dispiropyrrolidines 6/ 8/ 10 as a single product in each case, as evidenced by TLC and spectral analysis. The cycloaddition was found to be highly regioselective in all cases (Schemes 2&3). The reaction of secondary amino acid (proline) with the di/tri ketones generates azomethine ylide, which underwent neat 1,3-dipolar cycloaddition with the dipolarophile **3** to afford a series of novel dispiro pyrrolizidines **6/8/10**.

The structure and the stereochemistry of all the products **6**, **8** and **10** were determined by analysis of their $^1$H, $^{13}$C, DEPT-135, $^1$H-$^1$H-, $^1$H-$^{13}$C-COSY, NOESY experiments in the NMR spectrum. The absolute configurations of these compounds were assigned by establishing the relative stereochemistry of the newly formed stereo centres with those already present in the starting material.[14]




**Scheme-2**




**Scheme-3**

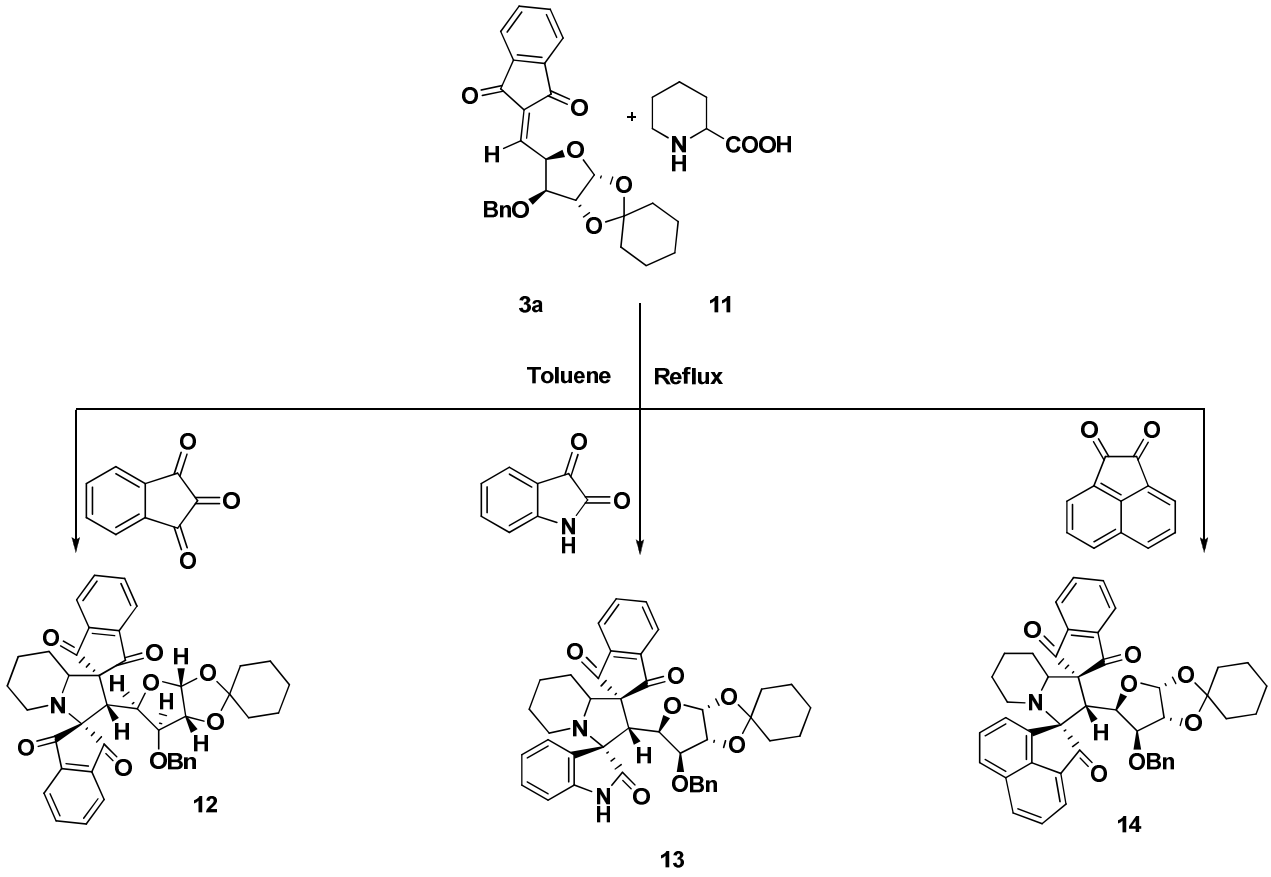
In the $^1$H NMR spectrum of the compound **6** the *N*-CH proton ($H_5$) of the pyrrolizidine ring appeared as a doublet at $\delta$ 3.39 (J = 6.9 Hz) which clearly shows the regioselectivity of the cycloadduct. If other isomer had formed $H_5$ proton would have shown a multiplet instead of a doublet. The $H_4$ proton of the furanose moiety appeared as a doublet of doublet at $\delta$ 3.52 ($J$ = 3.6, 6.9 Hz). The $H_1$ and $H_2$ protons of the furanose ring appeared as two doublets at $\delta$ 6.02 ($J$ = 3.6 Hz), and $\delta$ 4.74 ($J$ = 3.6 Hz) respectively. One of the benzyl proton and the $H_3$ proton appeared as a multiplet in the region $\delta$ 4.09-4.14 and the other benzyl proton appeared as a doublet at $\delta$ 4.46 ($J$ = 12.3 Hz). The $H_6$ proton of the pyrrolizidine moiety appeared as a multiplet in the region $\delta$ 2.91-2.98 and the *N*-$CH_2$ protons showed two separate multiplets in the region $\delta$ 2.14-2.18 and $\delta$ 1.92-1.96. From the $^1$H–$^1$H COSY and $^1$H–$^{13}$C COSY spectra of **6** we have assigned the signals at $\delta$ 6.02 to $H_1$ proton, $\delta$ 4.74 to $H_2$ proton, $\delta$ 3.52 to $H_4$ proton and $\delta$ 3.39 to $H_5$ proton.

The off resonance decoupled $^{13}$C NMR spectrum of the product **6** showed a peak at 53.41 ppm due to *N*-CHcarbon of pyrrolizidine ring. The two spiro carbons appeared at 78.91 and 61.28 ppm. The *N*-$CH_2$ carbon of the pyrrolizidine ring exhibited peak at 49.53 ppm and was confirmed by DEPT-135 & $^1$H-$^{13}$C correlation spectrum.

The DEPT -135 spectrum showed a peak at 66.35 ppm in negative region confirmed the presence of *O*-$CH_2$ carbon. The furanose ring carbons appeared at 63.27, 76.79, 78.82 and 104.02 ppm. The indane-1,3-dione ring carbonyl carbons exhibited at 196.41, 196.48, 198.19 and 198.22 ppm.

The mass spectrum of the compound **6** showed a molecular ion peak at m/z 660.3 ($M^+$+1) which when coupled with the above spectral features confirms the structure of the cycloadduct. Also the product exhibited satisfactory elemental analysis.

In order to extend the scope of the reaction, the carbohydrate derived dipolarophile **3** was subjected to [3+2] cycloaddition reaction with the azomethine ylide generated from pipecolinicacid and ninhydrin **4**/ isatin **7**/ acenaphthequinone **9.** The reaction yielded a series of novel dispiro pyrrolizidines **12/13/14** in good yields (Scheme 4). The structure of the cycloadducts **12-14** were also established by spectroscopic data.




**Scheme-4**

For instance, the IR spectrum of the product **13** exhibited a peak at 1704 $cm^{-1}$characteristic of oxindole carbonyl carbon. The absorption bands at 1731, 1738 $cm^{-1}$ are attributed to the presence of the indanedione ring carbonyls. The $^1$H NMR spectrum of **13** exhibited a doublet at $\delta$ 3.29 ($J$ = 6.3 Hz) for the *N*-CH proton ($H_5$) of the pyrrolizidine ring which clearly shows the regioselectivity of the cycloadduct. The $H_4$ proton of the furanose moiety appeared as a doublet of doublet at $\delta$ 3.51 ($J$ = 3.6, 6.3Hz). The $H_6$ proton of the pyrrolizidine moiety appeared as a multiplet in the region $\delta$ 2.98-3.01 and the *N*-$CH_2$ protons showed two separate multiplets in the region $\delta$1.98-2.07 and $\delta$1.79-1.84.The oxindole –*N*H proton appeared as a singlet at $\delta$8.29. The signals in the $^{13}$C NMR spectrum of **13** at 60.27 and 72.34 ppm correspond to the two spiro carbons. The indanedione ring carbonyls resonated at 191.54 and 191.97 ppm, respectively. The oxindole carbonyl carbon resonated at 175.42 ppm. Moreover, the presence of a molecular ion peak at m/z 661.4 ($M^+$+1) in the mass spectrum of **13** confirming the structure of the cycloadduct.

## CONCLUSION

In conclusion we have synthesized a series of novel sugar fused dispiro pyrrolizidine derivatives through 1,3-dipolar cycloaddition reaction of azomethine ylide generated from proline/ pipecolinic acid and isatin/ ninhydrin/

acenaphthequinone with sugar derived dipolarophile. The addition is highly regioselective and gave single regioisomer in all the cases studied.

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## REFERENCES

[1] (a) N. Blow. *Nature*, **2009**, 457, 617. (b) V. R. Doddi, H. P. Kokatla, A. P. J. Pal, R. K. Basak, Y. D. Vankar. *Eur. J. Org. Chem*., **2008**, 5731. (c) T. J. Boltje, J. H. Kim, J. Park, G. J. Boons, *Nature*, **2010,** 464, 908.
[2] (a) A. Luzhetskyy, A.Vente, A. Bechthold. *Mol. BioSyst*, **2005**, 1, 117. (b) B. L. Jane, N. John. *Chem. Rev*., **2004**, 104, 1663.
[3] (a) R. E. Moore, P. J. Scheuer. *Science*, **1971**, 172, 495. (b) R. E. Moore, G. Bartolini, *J. Am. Chem. Soc*., **1981**, 103, 2491.
[4] S. I. Murahashi, Y. Makabe, K. Kunita, *J. Org. Chem.*, **1988**, 53, 4489.
[5] (a) L. Jun, F. R. Bert, C. Gowda, *Org. Lett.*, **2005,** 7, 3841. (b) J. George, H. J. Jong, M. Mitsutoshi, S. Toshimi. *Langmuir*, **2004**, 20, 2060.
[6] (a) B. Ernst, G. W. Hart, P. Sinay. Carbohydrates in Chemistry and Biology, Eds.; Wiley-VCH: Weinheim, **2000**, Vols. 1–4. (b) B. O. Fraser-Reid, K. Tatsuta, J. Thiem. Glycoscience, Chemistry and Chemical Biology, Eds.; Springer: Berlin, **2001**, Vols. 1–3.
[7] S. Hanessian. Preparative CarbohydrateChemistry, Ed.; Marcel Dekker: New York, **1997**.
[8] A. Padwa. 1,3-Dipolar Cycloaddition Chemistry; Ed.; Wiley: New York, **1984**, Vols. 1 and 2.
[9] R. Grigg, V. Sridharan, D. P. Curran. In Advances in Cycloaddition, Ed.; Jai: London, **1993**; Vol. 3, p 161.
[10] R. J. Monlineux, S. W. Pelletier. In Alkaloids: Chemical and Biological Perspective; Ed.; Wiley: New York, **1987**, Chapter 1.
[11] Fujimori. Jap. Pat. Appl. 88-2912; Chem. Abstr. **1990**, 112, 98409.
[12] W. G. Rajeswaran, R. B. Labroo, E. A. Cohen, *J. Org. Chem.*, **1999**, 64, 1369.
[13] (a) A. Amalraj, R. Raghunathan, M. Sridevikumari, N. Raaman. *Bioorg. Med. Chem.*, **2003**, 11, 407. (b) A. R. Suresh Babu, R. Raghunathan, R. Madhivanan, G. Omprabha, D. Velmurugan, R. Raghu, *Curr. Chem. Biol.*, **2008**, 2, 312.
[14] (a) J. S. Yadav, B. V. Subbareddy, A. V. Hara Gopal, R. Nageshwar Rao, R. Somaiah, P. Purushottam Reddy, A. C. Kunwar. *Tetrahedron Lett*., **2010**, 51, 2305. (b) N. Sirisha, R. Raghunathan. *Tetrahedron Lett*., **2010**, 51, 2515.