Original Article

A New Divergent Organocatalyst for the Synthesis of Bis Indolyl Methanes with Higher and Hetero Aldehydes with Ketones

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Abstract

The high yield electrophilic substitution procedure for the synthesis of bis indolyl methanes at room temperature has been carried out effectively by using a novel metal supported organo catalyst. The advantages of this method include a simple conditions, great yields, less work-up, an environmentally friendly process and reusable solid catalyst. Several bis indolyl methanes were synthesised and confirmed by IR, H1 and 13C NMR techniques. The Catalyst shortens the Indole Electrophilic Substitution reaction time.

Keywords: Indole, Mo-Al_2O_3 Composites, Bis indolyl methanes, IR, NMR.

Introduction

From ancient years, Indoles is an important biologically and pharmacologically molecules [1]. The compounds of Indoles are also very important pharma cores and having wide range of applications in organic industry. First, marine sources were used to isolate Bis (indolyl) methanes [2]. These compounds are having activities like anti-microbial, anti-cancer, anti-biotic, anti-oxidative and insecticidal properties.

A recent area of focus is to develop a high quantity method for the synthesis of Bis (indolyl) methanes. A wide range of synthetic procedure were reported earlier for the synthesis of Bis (indolyl) methanes. Several reports like acids [3], Lewis acids [4], heterogenous catalysts [5], Iodine [6], oxalic acid dehydrate [7], CAN [8] and hexamethylenetetramine bromine adduct [9]. Also catalysts like $PdCl_2(PPh_3)_2$ [10], PTSA [11], Cobalt managese oxide [12], Sulfamic Acid [13], K10 [14], $InCl_3$ [15], $ZrCl_4$ [16], $Sc(OTf)_3$ [17] are used for this reaction.

The presented reports have numerous drawbacks, such as high reaction temperatures, prolonged reaction durations, expensive chemicals, moisture-sensitive catalysts, long procedures and required for special equipments. Additionally, the reported reaction is not applicable for Indoles with higher carbonyl compounds.

Therefore, it is in our interest to report on Indole electrophilic reaction involving higher aromatic and heterocyclic aldehydes, and certain ketones which leads to Bis (indolyl) methanes with very less reaction time (**Scheme I**).

2.Experimental

2.1. Materials and methods

At room temperature, each reaction was conducted. Magnetic force was applied to mix the reactants. Sigma-Alderich, Alfa Aesar and E.Merck chemical firms are where all of the chemicals purchased. E.Merck silica gel $60F_{254}$ TLC plates are used for Analytical thin-layer chromatography. UV light is used to perform resolution of

established chromatogram (254 nm). The silica gel is used for column chromatography has a mesh size of 200-300. Each bis indolyl methanes uncorrected melting points has been established in open glass capillaries using the Mettler FP51 instrument. Infrared spectra (KBr, 4000-400 cm^{-1}) were recorded on OMNIC Fourier transform spectrophotometer. Using TMS as internal standard, ^{1}H, ^{13}C NMR spectra in $CDCl_3$ solvent are recorded using Bruker AV 400 & 500 NMR spectrometer operating at 500 MHz & 100 MHz.

2.2. Preparation of Mo-Al_2O_3 composites:

A conical flask was filled with around 20 ml of ethanol, to which 5mmol (0.98g) NH_4MoO_3 was added, and the mixture was then sonicated to create the colloidal sespection. 20ml of ethanol containing basic alumina (Al_2O_3) (5mmol, 0.51g) was added to another conical flask and sonicated to get colloidal suspension. The two solutions were then mixed dropwise using a separating funnel and agitated with a magnetic stirrer for 24 h to create a homogeneous mixture. After producing Mo-Al_2O_3 composites, the mixture was sonicated to create a fine powder. At room temperature, the mixture was stirred for 4h. The solution is filtered with Buckner funnel using Whatman filter paper at room temperature. The obtained solid is dried at 110^0C for 5h in oven and grind with a pestle and mortar affords the Mo-Al_2O_3 composites as a fine powder. This catalyst was calcined at 400°C for 2h using muffle furnace.

2.3. *General Synthesis Procedure for the Bis indolyl methanes (scheme I):*

Indole (1.17g, 10mmol), and aromatic aldehyde (5mmol) are added to the round bottom flask, which has 5ml of methanol as a solvent. The mixture is agitated for 2 minutes. Then to the flask, (0.11g, 0.25mmol) of Mo-Al_2O_3 composites (5 mol% with respective aromatic aldehyde) and *p*-Toulene sulphonic acid (0.86g, 5mmol) were added to the reaction mixture. For 0.5h, the reaction kept going at room temperature(30^0C). After reaction completed, 20 ml of ethyl acetate were added to the reaction mixture and filtered the catalyst is recovered from the mixture. To obtain the pure form the product, the ethyl acetate layer was recovered and kept for recrystallization with hexane/ethyl acetate. The obtained product analysed with IR, ^{1}H and ^{13}C analysis.

3,3'-((4-chlorophenyl) methylene) bis(1H-indole) (10a):

Yield, 99%; orange colour solid; m.p. 101-104^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 7.62 (d, 2H), 7.31-7.29 (d, 2H), 7.20-7.18 (m, 3H), 7.12-7.09 (m, 3H), 6.97-6.94 (m, 3H), 6.48-6.39 (d, 2H), 5.76 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.02, 136.81, 132.11, 130.12, 128.56, 127.01, 123.91, 122.15, 119.90, 119.44, 119.01, 111.47, 39.74. IR ($CHCl_3$) υ 3414, 3366, 3076, 2929, 2221, 2139, 1607, 1497, 1435, 1376, 1334, 1224, 1064, 982, 849, 794, 740, 689.

3,3'-(furan-2-ylmethylene) bis(1H-indole) (10b):

Yield, 92%; brown colour solid; m.p. 322-324^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 7.78-7.60 (d, 2H), 7.43-7.31 (d, 2H), 7.23-7.20 (d, 2H), 7.13-6.99 (m, 3H), 6.71-6.51 (d, 2H), 6.26 (s, 1H), 6.01 (s, 1H), 5.89 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.41, 141.21, 136.54, 126.63, 123.17, 121.97, 119.94, 119.21, 117.21, 111.23, 110.50, 106.54, 34.17. IR ($CHCl_3$) υ 3433, 3096, 2932, 2842, 2366, 1967, 1654, 1533, 1455, 1407, 1342, 1280, 1212, 1100, 1005, 947, 849, 794, 736, 681.

3,3'-(thiophen-2-ylmethylene) bis(1H-indole) (10c):

Yield, 91%; red colour solid; m.p. 171-174^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 8.14-8.00 (s, 1H), 7.77-7.47 (m, 3H), 7.46-7.35 (dd, 1H), 7.33-7.26 (s, 1H), 7.25-7.20 (s, 1H), 7.19-7.15 (m, 3H), 7.14-7.01 (t, 2H), 6.89-6.82 (d, 2H), 6.14 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 136.56, 135.19, 128.34, 126.36, 124.94, 123.37, 122.02, 119.97, 119.32, 111.34, 35.55. IR ($CHCl_3$) υ 3417, 3178, 3065, 2921, 2834, 2167, 1978, 1818, 1463, 1420, 1361, 1158, 1131, 1018, 844, 810, 748, 704.

3,3'-(propane-2,2-diyl) bis(1H-indole) (10d):

Yield, 99%; yellow colour solid; m.p. 165-168^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 7.87-7.63 (d, 2H), 7.58-7.40 (d, 2H), 7.29-7.21 (d, 2H), 7.11-7.03 (d, 2H), 6.91-6.88 (dd, 1H), 6.50 (s, 1H), 1.18 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 137.13, 136.57, 130.63, 126.92, 126.36, 124.27, 121.31, 120.62, 119.24, 118.90, 111.15,

102.56, 37.20, 29.79. IR ($CHCl_3$) υ 3402, 3178, 3065, 2986, 1708, 1595, 1478, 1427, 1384, 1260, 1119, 1049, 998, 895, 818, 771, 717, 681.

3,3'-(1-(4-nitrophenyl) ethane-1,1-diyl) bis(1H-indole) (10e):

Yield, 99%; yellow colour solid; m.p. 246-248^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 8.24 (s, 1H), 8.00-7.94 (m, 3H), 7.61-7.60 (s, 1H), 7.48-7.45 (dd, 1H), 7.28-7.20 (m, 3H), 7.10-6.93 (t, 2H), 6.56-6.51 (d, 2H), 2.61 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.44, 136.81, 130.53, 130.02, 126.90, 123.97, 122.49, 121.51, 120.79, 119.80, 118.93, 111.58, 102.57, 37.14, 29.88. IR ($CHCl_3$) υ 3479, 3369, 2995, 2237, 1717, 1533, 1427, 1365, 1244, 1134, 1032, 951, 895, 852, 807, 697.

3,3'-(naphthalen-1-ylmethylene) bis(1H-indole) (10f):

Yield, 85%; red colour solid; m.p. 251-253^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 8.35 (s, 1H), 8.16-8.00 (t, 2H), 7.99-7.75 (m, 3H), 7.74-7.65 (dd, 1H), 7.65-7.52 (m, 4H), 7.52-7.37 (m, 3H), 7.19-7.01 (dd, 1H), 6.66-6.57 (s, 1H), 5.29 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.58, 139.84, 136.82, 134.57, 131.77, 128.53, 128.06, 126.31, 125.74, 124.54, 122.01, 120.01, 119.26, 114.93, 110.95, 35.87. IR ($CHCl_3$) υ 3389, 3037, 2983, 2885, 2361, 1987, 1739, 1599, 1494, 1443, 1384, 1299, 1240, 1181, 1126, 1060, 1010, 931, 852, 790, 748, 689.

3,3'-(anthracen-9-ylmethylene) bis(1H-indole) (10g):

Yield, 83%; black colour solid; m.p. 265-267^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 8.61-8.50 (d, 2H), 8.43-8.31 (s, 1H), 7.82-7.80 (dd, 1H), 7.76-7.64 (m, 3H), 7.63-7.55 (s, 1H), 7.53-7.50 (s, 1H), 7.40-7.27 (m, 3H), 7.26-7.12 (m, 3H), 7.11-7.09 (s, 1H), 6.87-6.72 (m, 3H) 5.49-5.29 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.36, 139.90, 138.92, 136.66, 134.71, 131.96, 129.22, 127.29, 124.75, 124.06, 121.80, 120.07, 119.10, 113.40, 110.94, 44.32. IR ($CHCl_3$) υ 3414, 3191, 3034, 2896, 2158, 2029, 1458, 1176, 1111, 1041, 1005, 942, 841, 751, 704.

3,3'-(pyren-1-ylmethylene) bis(1H-indole) (10h):

Yield, 81%; dark red colour solid; m.p. 316-319^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 8.47-8.43 (d, 2H), 8.35-8.33 (d, 2H), 8.32-8.29 (d, 2H), 8.28-8.26 (m, 3H), 8.24-8.19 (dd, 1H), 8.13-8.11 (d, 2H), 8.03-7.90 (m, 3H), 7.80-7.73 (s, 1H), 7.43-7.25 (d, 2H), 6.98-6.85 (d, 2H), 6.58-6.52 (s, 1H) 5.82-5.75 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.15, 135.68, 131.41, 130.90, 127.39, 126.68, 125.89, 124.42, 123.15, 122.91, 122.13, 119.87, 119.67, 111.36, 36.32. IR ($CHCl_3$) υ 3417, 3178, 3045, 2910, 2862, 2299, 2162, 1995, 1849, 1545, 1455, 1415, 1330, 1247, 1154, 1080, 1010, 937, 852, 759, 697.

tri(1H-indol-3-yl) methane (10i):

Yield, 90%; yellow colour oil; m.p. 163-165^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 8.35-8.28 (s, 1H), 8.24-8.15 (s, 1H), 7.90-7.83 (d, 2H), 7.66-7.65 (dd, 1H), 7.51-7.50 (dd, 1H), 7.37-7.31 (m, 3H), 7.30-7.17 (m, 3H), 7.12-7.02 (d, 2H), 6.99-6.78 (s, 1H), 6.56 (s, 1H), 6.17 (s, 1H), 5.30 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 136.71, 127.45, 124.50, 123.23, 121.60, 120.79, 120.05, 118.95, 111.56, 39.76. IR ($CHCl_3$) υ 3369, 3178, 3014, 2784, 2158, 2018, 1635, 1561, 1455, 1435, 1317, 1235, 1114, 1075, 1013, 974, 911, 807, 728, 689.

3,3'-((5-methoxy-1H-indol-3-yl) methylene) bis(1H-indole) (10j):

Yield, 87%; light black colour solid; m.p. 206-209^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 7.90-7.80 (d, 2H), 7.78-7.73 (s, 1H), 7.73-7.63 (dd, 1H), 7.63-7.51 (dd, 1H), 7.51-7.35 (t, 2H), 7.35-7.28 (d, 2H), 7.21-7.17 (d, 2H), 7.17-7.11 (t, 2H), 7.11-7.01 (t, 2H), 6.94-6.84 (s, 1H), 6.75-6.65 (d, 2H), 6.18 (s, 1H), 3.88 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.06, 144.65, 136.82, 129.04, 127.10, 126.05, 124.46, 123.64, 122.27, 120.11, 119.33, 115.28, 110.96, 56.22, 31.35. IR ($CHCl_3$) υ 3445, 3378, 3034, 2955, 2851, 2175, 2014, 1829, 1623, 1579, 1482, 1438, 1361, 1263, 1190, 1134, 1088, 998, 942, 825, 771, 731, 672.

2-chloro-3-(di(1H-indol-3-yl) methyl)-8-methylquinoline (10k):

Yield, 82%; yellow colour solid; m.p. 216-218^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 8.00 (s, 1H), 7.87-7.81 (d, 2H), 7.51-7.48 (dd, 1H), 7.47-7.39 (m, 3H), 7.38-7.31 (dd, 1H), 7.29-7.28 (s, 1H), 7.26-7.19 (d, 2H), 7.18-7.03 (d, 2H), 6.74-6.64 (d, 2H), 6.41 (s, 1H), 3.65 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.72, 146.06,

140.71, 137.99, 136.75, 133.59, 129.89, 127.91, 125.50, 124.04, 122.26, 119.62, 117.66, 36.96, 17.84. IR ($CHCl_3$) υ 3448, 3378, 3070, 2913, 2865, 2366, 2167, 2037, 1807, 1702, 1607, 1536, 1458, 1435, 1350, 1271, 1150, 1106, 1072, 985, 864, 810, 743, 692.

3,3'-((3,4,5-trimethoxyphenyl) methylene) bis(1H-indole) (10l):

Yield, 99%; pale pink colour solid; m.p. 202-204^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 8.03 (s, 1H), 7.42-7.35 (d, 2H), 7.34-7.31 (dd, 1H), 7.30-7.26 (s, 1H), 7.25-7.13 (m, 3H), 7.10-7.03 (d, 2H), 6.68 (s, 1H), 6.59 (s, 1H), 5.81 (s, 1H), 3.93 (s, 4H), 3.83 (s, 1H), 3.70 (s, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.02, 140.03, 136.60, 126.99, 123.84, 121.98, 119.89, 119.09, 111.10, 106.87, 106.06, 60.95, 56.53. IR ($CHCl_3$) υ 3378, 3217, 3062, 2991, 2952, 2831, 2366, 2135, 1970, 1739, 1592, 1502, 1451, 1402, 1322, 1235, 1193 1083, 1049, 985, 849, 720, 672.

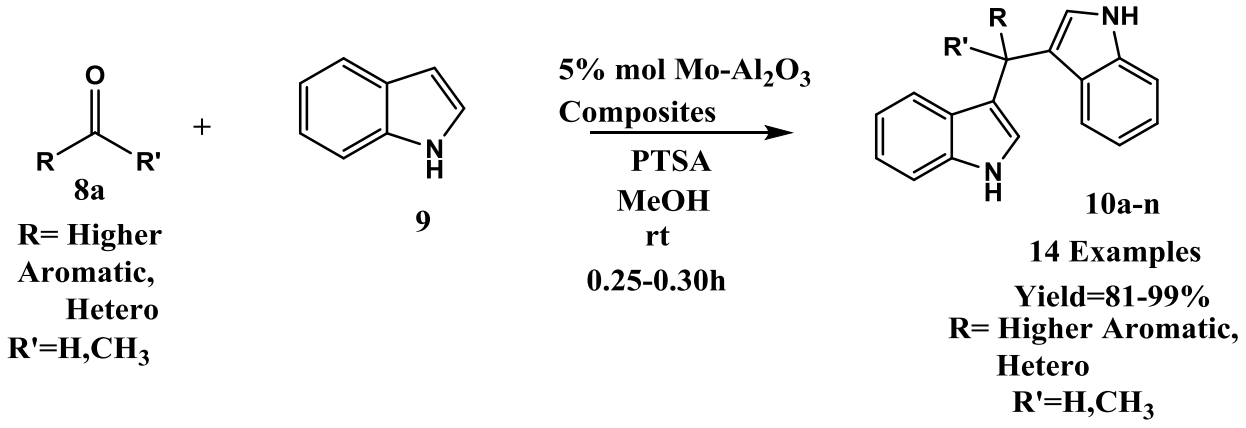
4-(di(1H-indol-3-yl) methyl) phenol (10m):

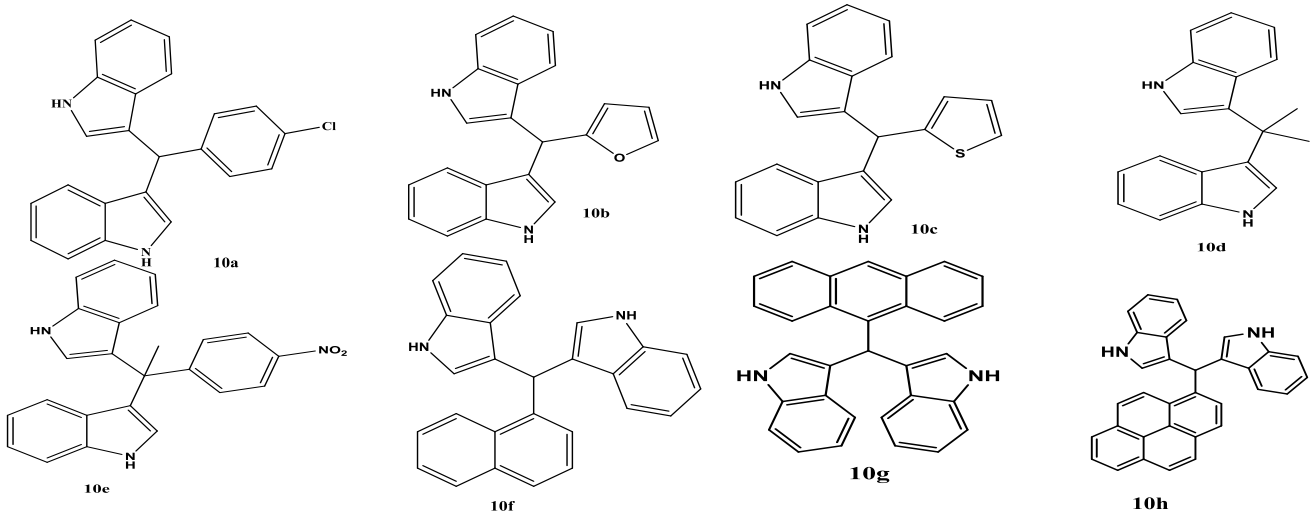
Yield, 99%; orange colour solid; m.p. 312-314^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 7.91 (s, 1H), 7.39-7.36 (m, 3H), 7.35-7.21 (m, 4H), 7.17-7.15 (d, 2H), 6.99-6.75 (d, 2H), 6.73-6.65 (d, 2H), 5.83 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.46, 136.52, 136.24, 129.72, 126.81, 123.52, 121.65, 120.02, 119.04, 115.11, 110.88, 39.52. IR ($CHCl_3$) υ 3402, 3195, 3062, 2929, 2842, 2338, 2181, 2014, 1913, 1772, 1604, 1502, 1458, 1435, 1314, 1252, 1209, 1176, 1083, 998, 892, 821, 740, 704.

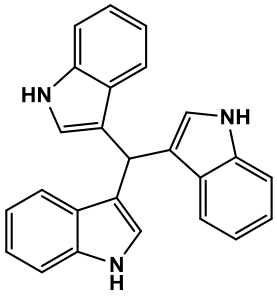
3,3'-(1-(naphthalen-1-yl) ethane-1,1-diyl) bis(1H-indole) (10n):

Yield, 99%; yellow colour solid; m.p. 266-268^{0}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ ppm: 8.40 (s, 1H), 7.99-7.89 (s, 1H), 7.88-7.85 (dd, 1H), 7.63-7.52 (m, 3H), 7.46-7.36 (dd, 1H), 7.36-7.25 (d, 2H), 7.25-7.22 (d, 2H), 7.22-7.10 (m, 3H), 6.86 (s, 1H), 6.50 (s, 1H), 6.45 (s, 1H), 2.65 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.88, 137.36, 135.89, 134.56, 133.55, 132.47, 130.52, 129.49, 128.59, 127.11, 123.77, 122.25, 121.81, 120.51, 119.84, 119.19, 111.43, 103.00, 43.94, 26.66. IR ($CHCl_3$) υ 3428, 3070, 2980, 2662, 2338, 2142, 1967, 1843, 1612, 1572, 1455, 1407, 1334, 1286, 1209, 1119, 1010, 951, 872, 798, 748, 708.

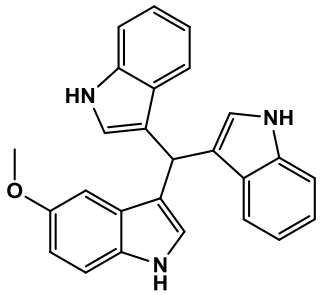
Scheme I



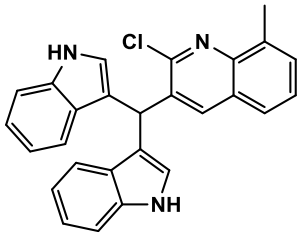




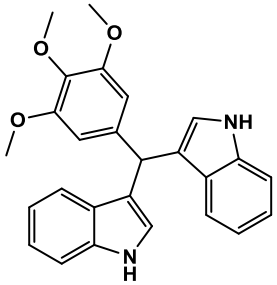
10i



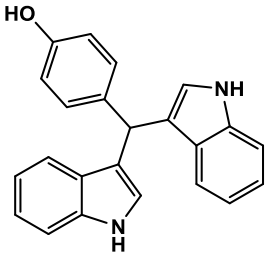
10j



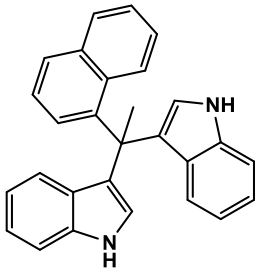
10k



10l

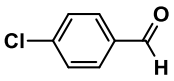
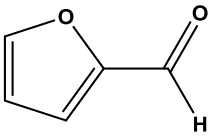
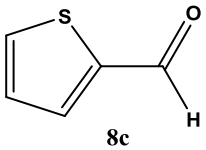


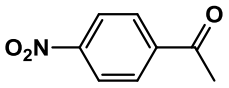
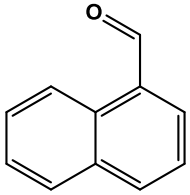
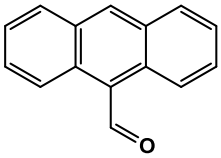
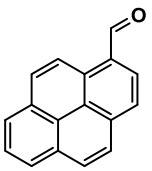
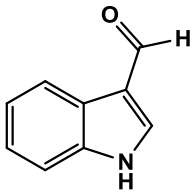
10m

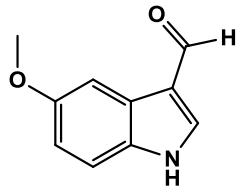
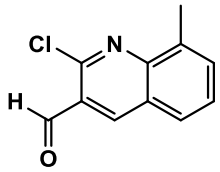
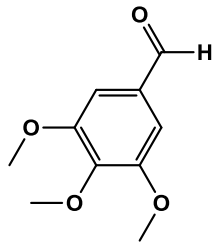
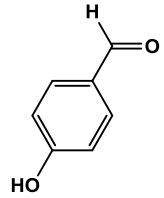
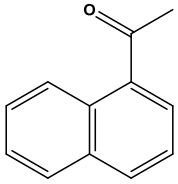


10n

Table-1:

S.No	Aldehyde/Ketone	Indole	Time(h)	Product	Yield(%)
1	 8a	9	0.25	10a	99
2	 8b	9	0.25	10b	92
3	 8c	9	0.25	10c	91
4	 8d	9	0.25	10d	99

5	 **8e**	**9**	**0.25**	**10e**	**99**
6	 **8f**	**9**	**0.30**	**10f**	**85**
7	 **8g**	**9**	**0.30**	**10g**	**83**
8	 **8h**	**9**	**0.30**	**10h**	**81**
9	 **8i**	**9**	**0.25**	**10i**	**90**

10	 **8j**	**9**	**0.30**	**10j**	**87**
11	 **8k**	**9**	**0.30**	**10k**	**82**
12	 **8l**	**9**	**0.25**	**10l**	**99**
13	 **8m**	**9**	**0.25**	**10m**	**99**
14	 **8n**	**9**	**0.25**	**10n**	**99**

3. Results and Discussion:

3.1. Optimization of the catalyst:

Begining the synthesis, Indole (9) is reacted with 1-napthaldehyde (8f) on different temperatures and times using the various catalysts affording 3,3'-(naphthalen-1-ylmethylene) bis(1H-indole) (10f) as a reference

reaction. we experimented with a variety of solvent conditions like CH_2Cl_2, DMF, THF, DMSO, MeOH and Toulene. We found that the reaction Indole (9) with 1-napthaldehyde (8f) at room temperature (30^0 C) in the presence of Mo-Al_2O_3 composites in *p*-TSA in Methanol (Table 2, entry 9) as the solvent afforded 3,3'-(naphthalen-1-ylmethylene) bis(1H-indole) (10f) in the high yields (Table 2, entry10). Without a catalyst, no reaction is seen and the initial ingredients are recovered and unchanged (Table 2, entry1). The results are showed in (Table 2).

Entry	Catalyst	Solvent	Temp(^{0}C)	Time (h)	Yield (%)
1	no catalyst added	Methanol	rt	4h	nr
2	HCl	H_2O	rt	4h	nr
3	H_2SO_4	THF	80^0C	4h	nr
4	$ZnCl_2$	Toulene	100^0C	4h	nr
5	Al_2O_3	CH_2Cl_2	rt	4h	nr
6	$(NH4)_2MoO_3$+Al_2O_3	CH_2Cl_2	rt	4h	nr
7	p-TSA	CH_2Cl_2	rt	4h	<5
8	Al_2O_3/p-TSA	Methanol	rt	4h	8
9	CH3COOH	Ethanol	80^0C	4h	2
10	**Mo-Al_2O_3 composites in *p*-TSA**	**Methanol**	**rt**	**0.3h**	**99**

Table 2

3.2. Optimization of the solvent:

The direct Indole reaction catalysed by 5 mol% Mo-Al_2O_3 composites in *p*-TSA catalyst in different solvents were observed and (Table 3) gives the best solvent for the reaction.

Table 3

Entry	Solvent	Time (h)	Yield (%)
1	no solvent added	8h	nr
2	H_2O	8h	nr
3	DMSO	8h	nr
4	DMF	8h	nr
5	CH_2Cl_2	8h	nr
6	$CHCl_3$	8h	nr
7	Toulene	8h	nr
8	THF	8h	nr
9	EtOH	8h	81
10	**MeOH**	**0.3h**	**99**

3.3. Loading of the catalyst:

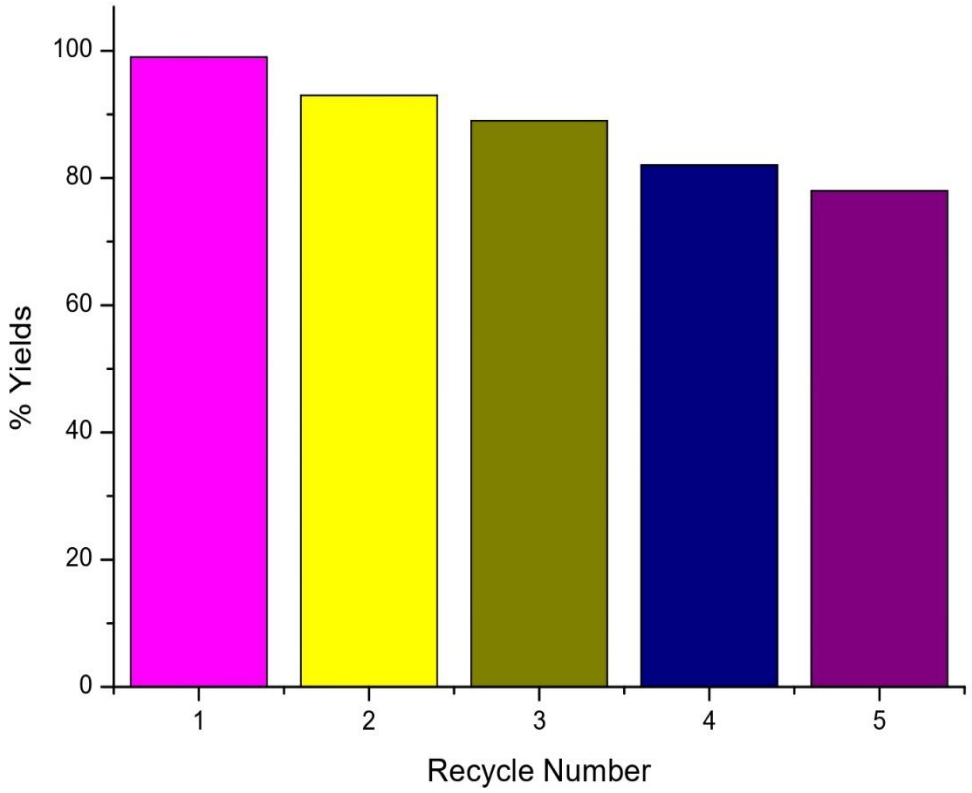
The reaction was carried out with various mol% of the catalyst and the outcomes were reported in (Table 4). For preparation of Mo-Al_2O_3 composites we have taken $(NH_4)_2MoO_3$ and Al_2O_3 in 1:2 ratios in methanol. Lower ratios (0.5:1, 0.1:1, etc.) are not successful to conduct for this reaction. The below table gives the yields of the reaction with different mol% of catalyst.

Table 4

Entry	Catalyst mol(%)	Temperature(T)	Time (h)	Yield[a] (%)
1	1.0	rt	4h	20
2	2.0	rt	4h	32
3	**5.0**	**rt**	**0.3h**	**99**
4	8.0	rt	4h	75

3.4. Reusability of the catalyst:

By reacting of Indole (9) with 1-napthaldehyde (8f) for 0.5h in presence of 5% of Mo-Al_2O_3 /*p*-TSA catalyst at room temperature. The Mo-Al_2O_3 /*p*-TSA catalyst is recovered and reused for five consecutive reactions with the product in 78-75% yields. The recovered catalyst can be reused because it does not lose its activity.



Catalyst recycling of Mo-Al_2O_3/*p*-TSA catalyst for Schiff base reaction. Reaction condition: 1-napthaldehyde (8f): Indole (9), 1:2 (5 mmole ratio), Mo-Al_2O_3/*p*-TSA (0.25 mmol,0.11 g) at room temperature (30^0C).

4. Conclusion

In conclusion, Indole electrophilic substitution reaction of, various higher aromatic and hetero aldehyde (8a-n) is reacted with Indole (9) are efficiently catalysed by Mo-Al_2O_3/*p*-TSA catalyst in methanol. This process of reported method has the advantages of (a) gentle method; (b) solid, air-free catalyst; (c) less cost and minimum workup; (d) the reusability of the catalyst. Moreover, this method is applicable for synthesis of a wide range of Bis and Tris Indolyl methanes.

Supplementary Information (SI)

Experimental and analytical data are provided in the Supporting Information.

Acknowledgements

The authors are thankful to Annamalai University for NMR, IR instrumentation facility and thanks to UGC, India.

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Graphical Abstract

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A new divergent organo catalyst for the synthesis of Bis Indolyl methanes with Higher and Hetero Aldehydes and with Ketones.

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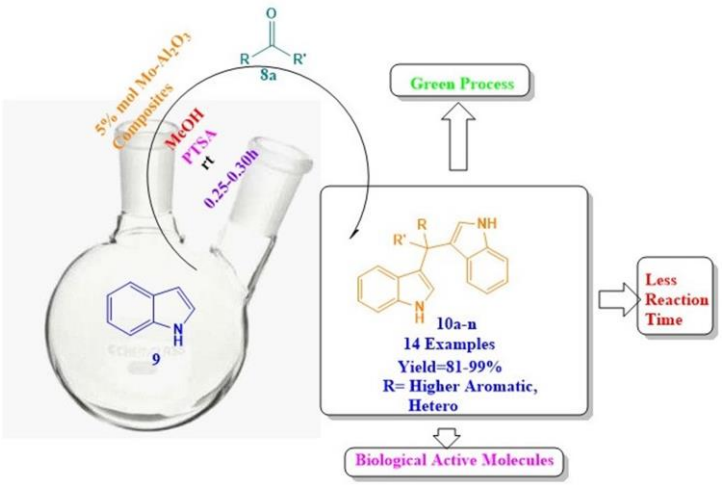
Koteswara Rao Anam and Ganesamoorthy Thirunarayanan*



Highlights

- Synthesis of Important Bis and Tris Indolyl methanes of Higher Aromatic, Hetero Aromatic Aldehydes and Ketones at room temperature.
- Solid Catalyst which is easy to handle and less work-up procedure.
- Fast Reaction time.
- High Yields with Recrystallization Process.
- The reaction has wide range of applications for the synthesis of various Bis and Tris Indolyl methanes.