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Novel approach to bis(indolyl)methanes using nickel nanoparticles as a reusable catalyst under solvent-free conditions

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Abstract: A nanosized Nickel as catalyst has been developed for the electrophilic substitution reactions of indole with various aromatic aldehydes under solvent-free conditions to afford the corresponding bis(indolyl)methanes in high to excellent yields. The described method has promising features such as no hazardous organic solvents or catalysts, short reaction time, high product yields, simple work-up procedure, reusable catalyst and easy product separation without further purification with coulmn chromatography.

Keywords: indole; aldehyde; electrophilic substitution; Ni.

INTRODUCTION

The efficiency of heterogeneous catalysis in organic synthesis can be improved by employing nanosized catalysts because of their extremely small size and large surface to volume ratio. It has been recently demonstrated that Ni nanoparticles as catalysts offer great opportunities for a wide range of applications in organic synthesis and chemical manufacturing processes including the chemoselective oxidative coupling of thiols[1], reduction of aldehydes and ketones[2-4], hydrogenation of olefins[5], and supports for hydrogen adsorption[6]. Thus, the remarkable catalytic activity and easy synthesis, simplicity and reusability of the Ni nanoparticles encouraged us to utilize this as a catalyst for the synthesis of bis(indolyl)methanes (BIM).

Development of bis(indolyl)alkane (BIA) derivatives has been of considerable interest in organic synthesis because of their wide occurrence in various natural products possessing biological activity[7] and usefulness for drug design. BIM are substances found in cruciferous that exhibit activity promoting

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beneficial estrogen metabolism and inducing apoptosis in human cancer cells[8]. Consequently, a number of synthetic methods for preparation of BIA derivatives have been reported in the literature by reaction of indole with various aldehydes and ketones in the presence of either a Lewis acid or a protic acid[9-16]. In recent years, environmentally safer synthetic methods have received considerable attention and some solvent-free protocols have been developed. Synthesis of BIM under solvent-free conditions may be carried out using catalysts such as using I_2[17] and $ZrOCl_2 \cdot 8H_2O$/silica gel[18]. These previous methods involved generally difficult handling, stoichiometric amount of catalyst may be needed, and require tedious aqueous work-up, along with the use of environmentally harmful organic solvents.

In view of the importance of BIA derivatives, we report herein the use of nanosized nickel[19] as catalyst in the reaction of indole with aromatic aldehydes under solvent-free conditions. As such, our method provides the product via easy work-up and is also in accord with green sustainable chemistry principles.

EXPERIMENTAL

All commercially available chemicals and reagents were used without further purification. Melting points were determined with an Electrothermal model 9100 apparatus and are uncorrected. IR spectra were recorded on a Shimadzu 4300 spectrophotometer. The ^{1}H and ^{13}C NMR spectra were recorded in DMSO-d_6 on Bruker DRX-500 Avance spectrometers. Chemical shifts (δ) are reported in parts per million and are referenced to the NMR solvent. Mass spectra of the products were obtained with an HP (Agilent Technologies) 5937 mass selective detector. Elemental analyses were carried out by a CHN–O–Rapid Heraeus elemental analyzer (Wellesley, MA).

*General procedure for the synthesis of bis(indolyl)methanes **3***

To a mixture of indole (2 mmol) and aromatic aldehyde (1 mmol) was added nickel nanoparticle powder (10 mol %). The reaction mixture was magnetically stirred on a preheated oil bath at 80 °C for the appropriate time as indicated in Table 1. After completion of the reaction, as indicated by TLC, the reaction mixture was cooled to room temperature. Then, ethanol (5 mL) was added. Nanoparticles were recovered by centrifuging the organic layer and reutilized for the same reaction. The solution was poured into water (50 mL). The precipitate that formed was filtered, washed with water and dried. The crude product was stirred for 5 min in boiling *n*-hexane and the resulting precipitate was filtered. The product **3** thus obtained was found to be pure upon TLC examination.

3-((1H-Indole-3-yl)(phenyl)methyl)-1H-Indole (3a). IR (KBr, cm^{-1}): 3416, 1630, 1460, 1371, 1090, cm^{-1}; ^{1}H NMR (500 MHz, DMSO-d_6) δ: 5.68 (s, 1H, *methine-H*), 6.67-7.22 (m, 15H, *Ar-H*), 10.71 (s, 2H, *indole-NH*); ^{13}C NMR (125 MHz, DMSO-d_6) δ: 40.58, 112.33, 118.91, 119.03, 119.94, 121.73, 124.39, 124.66, 126.64, 127.48, 128.89, 129.15, 137.44, 145.83.

3-((1H-Indole-3-yl)(4-nitrophenyl)methyl)-1H-Indole (3b). IR (KBr, cm^{-1}): 3425, 1590, 1456, 1340, 1229, cm^{-1}; ^{1}H NMR (500 MHz, DMSO-d_6) δ: 5.89 (s, 1H, *methine-H*), 6.72-8.01 (m, 14H, *Ar-H*), 10.79 (s, 2H, *indole-NH*); ^{13}C NMR (125 MHz, DMSO-d_6) δ: 40.35, 112.46, 117.55, 119.29, 119.78, 121.97, 124.28, 124.73, 127.24, 130.32, 137.47, 146.63, 154.00.

3-((1H-Indole-3-yl)(3-nitrophenyl)methyl)-1H-Indole (3c). IR (KBr, cm^{-1}): 3405, 1525, 1458, 1351, 1045, cm^{-1}; ^{1}H NMR (500 MHz, DMSO-d$_6$) δ: 5.92 (s, 1H, *methine-H*), 6.72-8.30 (m, 14H, *Ar-H*), 10.77(s, 2H, *indole-NH*); ^{13}C NMR (125 MHz, DMSO-d$_6$) δ: 39.97, 112.46, 117.82, 119.29, 119.79, 121.92, 121.98, 123.47, 124.75, 127.23, 130.46, 135.97, 137.49, 148.27, 148.67.

3-((1H-Indole-3-yl)(2-nitrophenyl)methyl)-1H-Indole (3d). IR (KBr, cm^{-1}): 3415, 1574, 1461, 1350, 1227, cm^{-1}; ^{1}H NMR (500 MHz, DMSO-d$_6$) δ: 6.41 (s, 1H, *methine-H*), 6.77-7.87 (m, 14H, *Ar-H*), 10.92 (s, 2H, *indole-NH*); ^{13}C NMR (125 MHz, DMSO-d$_6$) δ: 34.93, 112.51, 116.83, 119.37, 119.43, 122.03, 124.80, 124.99, 127.19, 128.39, 131.41, 133.38, 137.47, 138.55, 150.39.

3-((1H-Indole-3-yl)(2-chlorophenyl)methyl)-1H-Indole (3e). IR (KBr, cm^{-1}): 3414, 1602, 1445, 1336, 1110; ^{1}H NMR (500 MHz, DMSO-d$_6$) δ: 6.10 (s, 1H, *methine-H*), 6.63-7.33 (m, 14H, *Ar-H*), 10.74 (s, 2H, *indole-NH*); ^{13}C NMR (125 MHz, DMSO-d$_6$) δ: 37.02, 112.46, 117.39, 119.27, 119.55, 121.90, 124.88, 127.38, 127.84, 128.60, 130.10, 131.09, 133.57, 137.52, 142.73.

3-((1H-Indole-3-yl)(4-chlorophenyl)methyl)-1H-Indole (3f). IR (KBr, cm^{-1}): 3412, 1610, 1487, 1455, 1012; ^{1}H NMR (500 MHz, DMSO-d$_6$) δ: 5.84 (s, 1H, *methine-H*), 6.82-7.36 (m, 14H, *Ar-H*), 10.91 (s, 2H, *indole-NH*); ^{13}C NMR (125 MHz, DMSO-d$_6$) δ: 22.94, 31.83, 112.38, 118.41, 119.11, 121.80, 124.49, 127.35, 128.85, 130.98, 131.14, 137.48, 144.89.

3-((1H-Indole-3-yl)(4-bromophenyl)methyl)-1H-Indole (3g). IR (KBr, cm^{-1}): 3409, 1600, 1468, 1409, 1335, 1225, 1100; ^{1}H NMR (500 MHz, DMSO-d$_6$) δ: 5.69 (s, 1H, *methine-H*), 6.68-7.31 (m, 14H, *Ar-H*), 10.8 (s, 2H, *indole-NH*); ^{13}C NMR (125 MHz, DMSO-d$_6$) δ: 39.90, 112.39, 118.30, 119.10, 119.61, 119.87, 121.79, 124.50, 127.33, 131.41, 131.76, 137.47, 145.34.

3-((1H-Indole-3-yl)(4-hydroxyphenyl)methyl)-1H-Indole (3h). IR (KBr, cm^{-1}): 3410, 1608, 1484, 1420, 1339, 1215, 1088; ^{1}H NMR (500 MHz, DMSO-d$_6$) δ: 5.57 (s, 1H, *methine-H*), 6.50-7.20 (m, 14H, *Ar-H*), 8.99 (br, 1H, *OH*), 10.61 (s, 2H, *indole-NH*); ^{13}C NMR (125 MHz, DMSO-d$_6$) δ: 39.47, 112.25, 115.63, 115.79, 118.93, 119.55, 120.05, 121.64, 124.25, 127.54, 130.00, 130.12, 136.07, 137.47, 156.14.

3-((1H-Indole-3-yl)(4-methylphenyl)methyl)-1H-Indole (3i). IR (KBr, cm^{-1}): 3403, 1600, 1457, 1218, 1090; ^{1}H NMR (500 MHz, DMSO-d$_6$) δ: 5.64 (s, 1H, *methine-H*), 6.66-7.21 (m, 14H, *Ar-H*), 10.64 (s, 2H, *indole-NH*); ^{13}C NMR (125 MHz, DMSO-d$_6$) δ: 21.49, 40.58, 112.28, 118.97, 119.08, 120.00, 121.68, 124.34, 127.50, 129.05, 129.46, 135.42, 137.46, 142.82.

3-((1H-Indole-3-yl)(4-chlorol-3-nitrophenyl)methyl)-1H-Indole (3j). Yellow solid; Anal. calcd for $C_{23}H_{16}ClN_3O_2$: C, 68.74, H, 3.98, N, 10.46; found C, 68.83, H, 3.90, N, 10.51. IR (KBr, cm^{-1}): 3400, 1574, 1471, 1350, 1225, cm^{-1}; ^{1}H NMR (500 MHz, DMSO-d$_6$) δ: 5.88 (s, 1H, *methine-H*), 6.74-7.87 (m, 13H, *Ar-H*), 10.80 (s, 2H, *indole-NH*); ^{13}C NMR (125 MHz, DMSO-d$_6$) δ: 39.46, 112.49, 117.41, 119.36, 119.72, 122.03, 123.23, 124.82, 125.86, 127.13, 132.25, 134.57, 137.47, 147.25, 148.24.

3-((1H-Indol-3-yl)(2-hydroxy-5-nitrophenyl)methyl)-1H-indole (3k). Yellow solid; Anal. calcd for $C_{23}H_{17}N_3O_3$: C, 72.06, H, 4.43, N, 10.96; found C, 71.96, H, 4.52, N, 11.01. IR (KBr, cm^{-1}): 3412, 1588, 1491, 1333, 1275, 1205 cm^{-1}; ^{1}H NMR (500 MHz, DMSO-d$_6$, δ / ppm): δ: 6.05 (s, 1H, methine-H), 6.68-7.86 (m, 13H, Ar-H), 10.74 (s, 2H, indole-NH), 11.30 (br, 1H, OH); ^{13}C NMR (125 MHz, DMSO-d$_6$, δ / ppm): 32.64, 112.46, 116.28, 117.57, 119.20, 119.51, 121.87, 124.47, 124.66, 125.78, 127.40, 133.21, 137.54, 140.24, 162.29; MS (m/z): 383 (M)$^+$, 265, 139, 130, 118, 117, 89.

3-((1H-Indol-3-yl)(5-bromo-2-hydroxyphenyl)methyl)-1H-indole (3l). Pink solid; Anal. calcd for $C_{23}H_{17}BrN_2O$: C, 66.18, H, 4.07, N, 6.71; found C, 66.24, H, 4.00, N, 6.80; IR (KBr, cm^{-1}): 3407, 1612, 1479, 1413, 1338, 1212, 1094; ^{1}H NMR (500 MHz, DMSO-d_6, δ / ppm): 6.14 (s, 1H, methine-H), 6.76-7.35 (m, 13H, Ar-H), 9.76 (s, 1H, OH), 10.77 (s, 2H, indole-NH); ^{13}C NMR (125 MHz, DMSO-d_6, δ / ppm) δ: 32.50, 110.74, 112.36, 118.10, 118.15, 119.08, 119.64, 121.78, 124.45, 127.53, 130.15, 132.30, 134.75, 137.45, 154.64; MS (m/z): 418 (M+2)$^+$, 416 (M)$^+$, 300, 298, 245, 243, 220, 117, 97.

3-((1H-Indol-3-yl)(2-chloro-6-flourophenyl)methyl)-1H-indole (3m). Pink solid; Anal. calcd for $C_{23}H_{16}ClFN_2$: C, 73.69, H, 4.27, N, 7.47; found: C, 73.53, H, 4.35, N, 7.40; IR (KBr, cm^{-1}): 3410, 1608, 1452, 1343, 1100; ^{1}H NMR (500 MHz, DMSO-d_6, δ / ppm): 6.40 (s, 1H, methine-H), 6.88-7.37 (m, 13H, Ar-H), 10.89 (s, 2H, indole-NH); ^{13}C NMR (125 MHz, DMSO-d_6, δ / ppm): 36.45, 114.67, 117.58, 118.61, 118.79, 121.33, 121.52, 124.00, 126.82, 126.85, 128.87, 129.63, 131.92, 132.00, 133.14, 133.26, 136.52,139.30; MS (m/z): 376 (M+2)$^+$, 374 (M)$^+$, 337, 243, 222, 194, 117, 90, 89.

3-((1H-Indol-3-yl)(2-benzyloxyphenyl)methyl)-1H-indole (3n). White solid; Anal. calcd for $C_{30}H_{24}N_2O$: C, 84.11, H, 5.60, N, 6.54; found C, 84.17, H, 5.65, N, 6.48.IR (KBr, cm^{-1}): 3411, 1589,1447, 1340, 1221, 1091; ^{1}H NMR (500 MHz, DMSO-d_6, δ / ppm): 5.14 (s, 2H, O-CH_2-), 6.34 (s, 1H, methine-H), 6.79-7.38 (m, 19H, Ar-H), 10.79 (s, 2H, indole-NH); ^{13}C NMR (125 MHz, DMSO-d_6, δ / ppm): 34.99, 72.40, 114.52, 115.45, 120.88, 121.22, 122.01, 123.40, 123.91, 126.79, 129.89, 130.03, 130.22, 130.59, 131.29, 132.23, 136.39, 139.70, 140.50, 158.38; MS (m/z):428 (M)$^+$, 337, 243, 130, 117, 92, 91.

RESULTS AND DISCUSSION

In continuation of our work on the development of solvent-free conditions in one-pot, multi component reactions [20-24], we observed that the treatment of indole with aromatic aldehydes in the presence of nickel catalyst under solvent-free conditions afforded the corresponding BIM derivatives. As a model reaction, the reaction of indole (2 mmol) with benzaldehyde (1 mmol) was initially examined at 70-120 ^{o}C in the presence of nanosized Nickel powder (10 mol %) as catalyst under solvent-free conditions. Our investigation demonstrated that the best result was obtained when temperature was fixed at 80 ^{o}C and the reaction was completed in 1 hour. Thereby, an excellent yield of bis(indolyl)phenylmethane (**3a**) was obtained (95%). To determine the appropriate concentration of the catalyst Ni nanoparticles, we have investigated that the model reaction of benzaldehyde and indole at different concentrations of Ni nanoparticles. This indicated that 10 mol % of nanosized Ni produces the best results with respect to product yield (Table I).

In order to show the general applicability of the method for other substrates and derivatives, the same reaction conditions can be applied. Reactions of 2 equiv indole and 1 equiv aromatic aldehydes **2** in the presence of nickel nanoparticle catalyst under solvent-free conditions at 80 ^{o} C in appropriate times (see Table II) directly afforded BIM derivatives (**3a-n**) with good to excellent yields (Scheme). The reaction times and yields of the synthesized BIM derivatives have been shown in Table 2. As shown in Table 2, yields are almost quantitative in most cases.

We found that aromatic aldehydes with electron donating and electron withdrawing groups were converted to the corresponding products within some hours. We have examined the recovery and reusability of the catalyst. The catalyst was recovered by a simple work-up using the centrifugation method and reused during four consecutive runs without any apparent loss of activity for the same reaction. It is noteworthy that the yield of the product in the second, third, and fourth uses was almost the same as that in the first run.

All products were well characterized by ^{1}H NMR, ^{13}C NMR, FTIR, mass spectra, elemental analyses and melting point. To the best of our knowledge, synthesis of compounds **3j-n** has not previously been reported in literature. The ^{1}H NMR spectra of compounds **3j-n** are shown a sharp singlet for the indole-NH at about δ 10.80 ppm. The methine protons appeared as singlet at about δ 6.20 and aromatic protons displayed in the region of 6.68-7.86 ppm. Hydroxyl protons in the compounds **3k** and **3l** were observed at δ 11.30 and 9.76 ppm, respectively. The ^{13}C NMR, FTIR, mass spectra and elemental analyses confirmed the structures of synthesized compounds.

CONCLUSIONS

In summary, we have found for the first time that Ni in the form of nanoparticles, is a potential alternative to the use of noble-metal-based catalysts for the synthesis of BIM derivatives. Compared to the other previously reported procedures in literature, the present method provides some advantages such as omitting organic solvent, efficient and experimental simplicity, compatibility with various functional groups, generality, clean, easy work-up and high yields. Moreover, there is no need for dry solvents or protecting gas atmospheres. Product purification by column chromatography is not necessary and catalyst can be easily recovered from the reaction mixture by simple centrifugation.

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ИЗВОД

НОВ ПРИСТУП СИНТЕЗИ БИС(ИНДОЛИЛ)МЕТАНА УПОТРЕБОМ НАНОЧЕСТИЦА НИКЛА КАО КАТАЛИЗАТОРА БЕЗ ПРИСУСТВА РАСТВАРАЧА

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Развијене су наночестице никла које су употребљене као катализатор у реакцији електрофилне супституције индола и различитих ароматичних алдехида у одсуству растварача. Дибијени су одговарајући бис(индолил)метани у добром до одличном приносу. Предности ове методе су одсуство органских растварача, кратко реакционо

време, висок принос производа реакције, једноставан поступак обраде реакционе смеше, олакшано изоловање производа и могућност регенерације и вишеструке упоптребе катализатора.

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REFERENCES

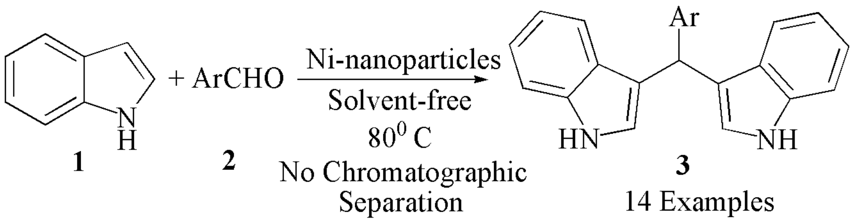
1. A. Saxena, A.Kumar, S. Mujumdar, *J. Mol. Catal. A: Chem.* **269** (2007) 35
2. F. Alonso, P. Riente, M. Yus, *Tetrahedron* **64** (2008) 1847
3. F. Alonso, P. Riente, M. Yus, *Tetrahedron Lett.* **49** (2008) 1939
4. F. Alonso, P. Riente, M. Yus, *Synlett* (2008) 1289
5. A. Dhakshinamoorty, K. Pitchumani, *Tetrahedron Lett.* **49** (2008) 1818
6. L. Zank, J. Zielinsky, *Appl. Catal. A: Gen.* **334** (2008) 268
7. R. Bell, S. Carmeli, N. Sar, *J. Nat. Prod.* **57** (1994) 1587
8. X. Ge, S. Yannai, G. Rennert, N. Gruener, F. A. Fares, *Biochem. Biophys. Res. Commun.* **228** (1996) 153
9. B. V. Gregorovich, K. Liang, M. Clugston, S. Macdonald, *Can. J. Chem.* **46** (1968) 3291
10. A. Chatterjee, S. Manna, J. Benerji, C. Pascard, T. Prange, J. Shoolery, *J. Chem. Soc. Perkin Trans. 1* (1980) 553
11. W. E. Noland, M. R. Venkiteswaran, . G. Richards, *J. Org. Chem.* **26** (1961) 4241
12. G. Babu, N. Sridhar, P. T. Perumal, *Synth. Commun.* **30** (2000) 1609
13. H. Firouzabadi, N. Iranpoor, A. A. Jafari, *J. Mol. Catal. A: Chem.* **244** (2005) 168
14. M. A. Zolfigol, P. Salehi, M. Shiria, *Phosphorus Sulfur Silicon* **179** (2004) 2273
15. P. Srinivasan, J. Amalraj, *J. Mol. Catal. A: Chem.* **242** (2005) 168
16. M. Chakrabarty, A. Mukherji, S. Karmakar, S. Arima, Y. Harigaya, *Heterocycles* **68** (2006) 331
17. S. J. Ji, S. Y. Wang, Y. Zhang, T. P. Loh, *Tetrahedron* **60** (2004) 2051
18. H. Firouzabadi, N. Iranpoor, M. Jafarpour, A. Ghaderi, *J. Mol. Catal. A: Chem.* **253** (2006) 249
19. S. H. Wu, D. H. Chen, *J. Colloid Interface Sci.* **259** (2003) 282
20. A. Shockravi, M. Sadeghpour, A. Olyaei, *Synth. Commun.* **39** (2009) 2347
21. A. Shockravi, M. Sadeghpour, A. Olyaei, *J. Chem. Res.* (2009) 556
22. A. Olyaei, E. Chehrehgosha Parashkuhi, S. Raoufmoghaddam, M. Sadeghpour, *Synth. Commun.* **40** (2010) 3609
23. A. Olyaei, B. Shams, M. Sadeghpour, F. Gesmati, Z. Razaziane, *Tetrahedron Lett.* **51** (2010) 6086
24. A. Olyaei, S. Raoufmoghaddam, M. Sadeghpour, B. Ebadzadeh, *Chin. J. Chem.* **28** (2010) 825
25. Z. C. Ma, Z. H. Zhang, *Synth. Commun.* **35** (2005) 1997
26. G. Penieres-Carrillo, J. G. Garcia-Estrada, J. L. Gutierrez-Ramirez, C. Alvarez-Tolendano, *Green Chem.* **5** (2003) 337
27. R. Tayebee, F. Nehzat, E. Rezaei-Seresht, F. Z. Mohammadi, E. Ezzat Rafiee, J. Mol. Cat. A: Chem. **351** (2011) 154
28. S. M. Vahdat, S. Khaksar, S. Baghery, *World Appl. Sci. J.* **15** (2011) 877

TABLE I. Comparison of the amount of Ni and yields for the synthesis of BIM.

Entry	Catalyst/ mol %	Time/ min	Yield, %
1	1	90	55
2	2.5	90	65
3	5.0	90	70
4	7.5	60	84
5	10	60	95

TABLE II. Ni nanoparticles-catalyzed synthesis of BIM under solvent-free conditions at 80 ° C.

Entry	Ar	Products	Time/ min	Yield/ %	M.P (°C) Found	Reported [Lit.]
1	C_6H_5	**3a**	60	95	148-150	149-150 [25]
2	4-$NO_2C_6H_4$	**3b**	20	92	220-22	217-220 [25]
3	3-$NO_2C_6H_4$	**3c**	30	89	264-265	265-566 [26]
4	2-$NO_2C_6H_4$	**3d**	60	88	137-139	139-141 [27]
5	2-ClC_6H_4	**3e**	20	91	74-75	70-71 [25]
6	4-ClC_6H_4	**3f**	100	90	80-82	76-77 [25]
7	4-BrC_6H_4	**3g**	100	88	116-117	110-112 [28]
8	4-OHC_6H_4	**3h**	120	85	136-137	122-124 [25]
9	4-$CH_3C_6H_4$	**3i**	90	85	96-97	93-94 [25]
10	4-Cl-3-$NO_2C_6H_3$	**3j**	70	89	183-184	-
11	2-OH-5-$NO_2C_6H_3$	**3k**	20	94	194-196	-
12	2-OH-5-BrC_6H_3	**3l**	110	88	141-142	-
13	2-Cl-6-FC_6H_3	**3m**	60	92	94-95	-
14	2-$OCH_2PhC_6H_5$	**3n**	70	88	206-208	-



Scheme. Synthesis of bis(indolyl)methanes.