INTRODUCTION

[3+2] Cycloadditions (32CA) of three atom components (TAC) to substituted methyl E-cinnamates and diethyl arylidene malonates have been investigated. [3+2] Cycloadditions of cinnamates yielded mixtures of cycloadducts, the major products being the 3,4-trans-4,5-trans-2,3,5-triaryl-4-carbomethoxy products originating from the endo-carbonyl-exo-aryl meta channel approach of the cinnamate component. [3+2] Cycloadditions to diethyl arylidene malonates furnished single cycloadducts-3,5-trans-2-methyl-3,5-diaryl-4,4-dicarbethoxy isoxazolidines by a endo-aryl meta channel approach of the 2π-component.

Keywords: [3+2] Cycloadditions, Methyl E-Cinnamate, Diarylidene malonate, Nitrone, Isoxazolidine, XRD.
out using neutral alumina (Qualigens), silica gel (Qualigens 60-120 mesh, Spectrochem 100-200 mesh) and silica gel G (Merck), respectively. Spots on TLC chromatograms were visualized with iodine vapour. Anhydrous sodium sulphate was used for drying extracts. Analytical samples were routinely dried over anhydrous CaCl₂ in vacuo at room temperature.

IR spectra were recorded in KBr discs on Perkin-Elmer FT-IR model RX-9. UV spectra were recorded with a Hitachi UV-vis-NIR model U 3501. ¹H NMR and ¹³C NMR spectra were recorded with Bruker AM-300L and Avance 300 instruments at 300 MHz and 75.5 MHz and DRX 500 instruments at 500 MHz and 125.5 MHz respectively. Chemical shifts for NMR were recorded with Bruker AM-300L and Avance 300 instruments at 300 MHz and 75.5 MHz and DRX 500 instruments at 500 MHz and 125.5 MHz respectively. Chemical shifts for NMR are reported in ppm, downfield from TMS, ¹H-¹H coupling constants are given in Hz. ¹³C NMR assignments were confirmed by DEPT spectra. COSY and DQF-COSY experiments were performed to unravel ¹H-¹H coupling information.

All chemicals were from Merck, India. They were purified by recrystallization or by fractional distillation under reduced pressure. The purities of starting materials were verified from comparison of their melting points or boiling points with those recorded in literature as well as from their IR and ¹H NMR spectra.

Preparation of dipolarophiles: The cinnamic acid methyl esters (5.6,7) were prepared by esterification of the corresponding acids (0.4 mol) by refluxing with anhydrous methanol (162 mL)/concentrated sulphuric acid (6 mL) for 5 h. On cooling crystals of methyl 4-chlorocinnamate, m.p. 74-76 °C (yield 71.5 g, 91 %), methyl 4-nitrocinnamate, m.p. 162 °C (yield 114 mg (6 %). IR (KBr, 4 cm⁻¹): 2952, 2852, 1730, 1635, 1595, 1506, 1490, 1400, 1395, 1091 & 1013 (aryl Cl), 826 (1,4-disubstituted benzene ring), 755 & 692 (mono-substituted benzene ring). ¹H NMR (300 MHz, CDCl₃): δ 9.48 (d, J = 10.2 Hz, H3), 7.37 (br. t, J = 9.9 Hz, H4), 5.72 (d, J = 9.6 Hz, H5), 3.30 (s, OCH₃), 6.94-7.01 (m, ovl, A/H-2,6), 7.20-7.28 (m, ovl, A/H-3,4,5, 7.30-7.45 (m, ovl, B,C/H-2,3,5,6); ¹³C NMR (75.5 MHz, CDCl₃): δ 71.2 (C3), 66.2 (C4), 82.0 (C5), 170.2 (CO), 150.1 (A/C-1), 114.6 (A/C-2), 127.9, 128.1, 128.9, 129.15, 129.05 (A/C-3, 5, B/C-2,3,5,3), 122.4 (A/C-4), 139.5 (B/C-1), 134.6, 133.7 (B/C-4), 135.5 (C/C-1). Anal. calcd. (found) (%) for C₂₃H₁₉NO₃Cl₂: C, 64.5 (64.2); H, 4.5 (4.3); N, 3.3 (3.1).

3,4-cis-4,5-trans-2-Phenyl-3,5-di(4’-chlorophenyl)-4-carbomethoxy isoxazolidine (9b): From later hexane eluates, a mixture of (9a) and (9b) were obtained, which were resolved further by rechromatography and PTLC using benzene/hexane (4:1) as developing solvent, with double development; pale yellow solid, m.p. 66 °C, m.f.: C₂₃H₁₉NO₃Cl₂; yield 114 mg (6%). IR (KBr, 4 cm⁻¹): 2954, 2874, 1730 (ester CO), 1635, 1595, 1491, 1398, 1091 & 1010 (aryl Cl), 826 (1,4-disubstituted benzene ring), 755 & 695 (mono-substituted benzene ring).

¹H NMR (300 MHz, CDCl₃): δ 4.98 (d, J = 10.2 Hz, H3), 7.37 (br. t, J = 9.9 Hz, H4), 5.72 (d, J = 9.6 Hz, H5), 3.30 (s, OCH₃), 6.94-7.01 (m, ovl, A/H-2,6), 7.20-7.28 (m, ovl, A/H-3,4,5, 7.30-7.45 (m, ovl, B,C/H-2,3,5,6); ¹³C NMR (75.5 MHz, CDCl₃): δ 71.2 (C3), 61.0 (C4), 79.5 (C5), 52.6 (OCH₃), 168.8 (CO), 149.1 (A/C-1), 116.1 (A/C-2, 6), 127.9, 128.2, 127.5, 129.6, 129.2 (A/C-3, 5, B/C-2,3,6,3,5), 122.7 (A/C-4), 139.5 (B/C-1), 134.6, 134.2 (B/C-4), 136.1 (C/C-1). Anal. calcd. (found) (%) for C₂₃H₁₉NO₃Cl₂: C, 64.5 (64.3); H, 4.5 (4.6); N, 3.3 (3.1).

Detected by ¹H NMR in crude reaction mixture: Region-isomeric 3,4-trans-4,5-trans-2-phenyl-3,4-di(4’-chlorophenyl)-5-carbomethoxy isoxazolidine (9c): δ 8.41, (d, J = 7.5 Hz, H3), 4.07 (dd, J = 7.5, 8.5 Hz, H4), 4.49 (d, J=8.5 Hz, H5).

Reaction of C-(4-nitrophenyl)-N-phenyl nitrone (2) (0.655 g, 0.0027 mol) with methyl 4-chlorocinnamate (6) (1.59 g, 3 × 0.0027 mol): Reaction time 12 h. 300 MHz ¹H NMR analysis revealed three products formed: total conversion ~ 92 %; ratio 10a:10b:10e = 89:7:4.

3,4-trans-4,5-trans-2-Phenyl-3-(4’-nitrophenyl)-5-(4’-chlorophenyl)-4-carbomethoxy isoxazolidine (10a): yellow solid, m.p. 62 °C, m.f.: C₂₃H₂₃NO₃Cl₂; yield 0.85 g (72 %), isolated from hexane eluates, Rf 0.62 (benzene). IR (KBr, 4 cm⁻¹): 3069, 2924, 2854, 1736 (ester CO), 1598, 1491, 1521 & 1346 (nitro), 1091, 1013 & 520 (aryl Cl), 825 (1,4-disubstituted benzene ring), 755 & 692 (mono-substituted benzene ring) cm⁻¹. ¹H NMR (300 MHz, CDCl₃): δ 5.41 (d, J = 6.0 Hz, H3), 3.54 (dd, J = 6.0, 9.0 Hz, H4), 5.45 (d, J = 9.0 Hz, H5), 3.73 (s, OCH₃), 7.02-7.07 (m, ovl, A/H-2,6), 7.33 (br. t, J = 8.0 Hz, A/H-3,5), 7.79 (d, J = 8.7 Hz, B/H-2,6), 8.28 (d, J = 8.7 Hz, B/H-3,5), 7.28-7.49 (m, ovl, C/H-2,3,5,6); ¹³C NMR (75.5 MHz, CDCl₃): δ 72.7 (C3), 65.9 (C4), 82.1 (C5), 52.8 (OCH₃), 170.2 (CO), 150.1 (A/C-1), 114.4 (A/C-2,6), 127.4 (A/C-3,5), 122.7 (A/C-4), 147.6 (B/C-1), 128.1 (B/C-2,6), 124.2 (B/C-3,5), 148.5 (B/C-4), 134.8, 134.7 (C/C-1,4), 129.0, 129.2 (C/C-2,6,3,5). Anal. calcd. (found) (%) for C₂₃H₂₃NO₃Cl₂: C, 62.9 (62.6); H, 4.4 (4.5); N, 6.4 (6.2).

Detected by ¹H NMR in crude reaction mixture. 3,4-cis-4,5-trans-2-Phenyl-3-(4’-nitrophenyl)-5-(4’-chlorophenyl)-4-carbomethoxy isoxazolidine (10b): δ 5.14 (d, J = 9.0 Hz, H3).
3.70 (obs., overlapped with methoxy signals), 5.74 (d, J = 9.0 Hz, H5); 3.4-trans-4,5-trans-2-phenyl-3-(4'-nitrophenyl)-4-(4'-chlorophenyl)-5-carboxymethoxy isoxazolidine (11c): δ 4.83 (d, J = 6.0 Hz, H3), 4.07 (t, J = 6.0 Hz, H4), 4.67 (d, J = 6.0 Hz, H5).

Reaction of C,N-diphenyl nitrite (3) (0.591 g, 0.003 mol) with methyl 4-chlorocinnamate (6) (1.77 g, 3 × 0.003 mol); yield 0.94 g, 60 % isolated from hexane eluates, Rf 0.57 (petroleum ether: benzene 1:1). H NMR (300 MHz, CDCl3); δ 5.11 (d, J = 6.8 Hz, H3), 3.45 (dd, J = 6.8 Hz, 8.4, H4), 5.28 (d, J = 8.4 Hz, H5), 3.66 (s, OCH3), 0.693 (s, J = 8.8 Hz, A/H-2,6), 7.13 (t, J = 6.8 Hz, A/H-3,5), 6.85 (t, J = −7.3 Hz, A/H-4), 7.12−7.31 (m, ovl, B/C-2,3,5,6); 13C NMR (75.5 MHz, CDCl3); δ 73.9 (C3), 66.3 (C4), 81.2 (C5), 52.5 (OCH3), 170.7 (CO), 150.9 (A/C-1,114.5 (A/C-2,6), 126.5 (A/C-3,5), 122.3 (A/C-4,140.9 (B/C-1), 128.9, 128.3 (B/C-2,6,3,5), 127.9 (B/C-4), 135.7 (C/C-1), 129.0, 129.1 (C/C-2,6,3,5), 134.5 (C/C-4). Anal. calcd. (found) (%) for C23H21NO3Cl: C 70.1 (69.8); H 5.1 (4.9); N 3.6 (3.4).

Detected by 1H NMR in crude reaction mixture. 3,4-cis-4,5-trans-2,3-Diphenyl-5-(4'-chlorophenyl)-4-carboxymethoxy isoxazolidine (11b): δ 4.85 (d, J = 10.4 Hz, H3), 3.68 (br. t, J = −9.9 Hz, H4), 5.61 (d, J = 9.6 Hz, H5); 3,4-trans-4,5-trans-2,3-Diphenyl-4'(4'-chlorophenyl)-5-carboxymethoxy isoxazolidine (11c): δ 4.81 (d, J = 6.6 Hz, H3), 4.19 (br. t, J = −7.0 Hz, H4), 4.51 (d, J = 7.1 Hz, H5).

Reaction of C-(4-chlorophenyl)-N-phenyl nitrite (1) (1.02 g, 0.0044 mol) with methyl 4-nitrocinamate (7) (2.73 g, 3 × 0.0044 mol); Reaction time 23 h. 300 MHz H NMR analysis revealed three products formed: total conversion ~72 %; ratio 12a:12b:12c = 88:9:3.

3,4-trans-4,5-trans-2-Phenyl-3-(4'-chlorophenyl)-5-(4'-nitrophenyl)-4-carboxymethoxy isoxazolidine (12a): Pale yellow waxy solid, m.p.: C23H21NO3Cl; yield 1.10 g (58 %) isolated from petroleum ether eluates, Rf 0.57 (petroleum ether:benzene 1:1). IR (KBr, v_max, cm−1): 3070, 3033, 2951, 1731 (ester CO), 1400, 1091, 1016 & 511 (aryl Cl), 826 (1,4-disubstituted benzene ring), 762 & 683 (mono-substituted benzene ring). 1H NMR (300 MHz, CDCl3); δ 5.13 (d, J = 6.9 Hz, H3), 3.53 (dd, J = 6.8, 8.8 Hz, H4), 5.32 (d, J = 8.8 Hz, H5), 3.71 (s, OCH3), 6.98 (d, J = 7.8 Hz, A/H-2,6), 6.87 (t, J = 7.5 Hz, A/H-3,5), 7.03 (t, J = 7.3 Hz, A/H-4), 7.15−7.40 (m ovl, B/C-2,3,4,5,6), 7.49 (d, J = 7.2 Hz, C/H-2,6); 13C NMR (75.5 MHz, CDCl3); δ 73.7 (C3), 66.0 (C4), 82.7 (C5), 51.9 (OCH3), 170.5 (CO), 150.9 (A/C-1,114.1 (A/C-2,6), 126.6, 126.1 (A/B/C-5,121.6 (A/C-4,141.1 (B/C-1), 128.7, 128.3, 128.7 (B/C-2,6), 127.9 (B/C-4), 137.3 (C/C-1), 128.6 (C/C-4). Anal. calcd. (found) (%) for C25H23NO3Cl: C 76.9 (76.6), H 5.9 (5.7), N 3.9 (3.7).

Detected by 1H NMR in crude reaction mixture. 3,4-cis-4,5-trans-2,3,5-Triphenyl-4-carboxymethoxy isoxazolidine (13b): δ 4.89 (d, J = 10.3, H3), 3.65 (obsd. ovl, methoxy signal, H4), 5.67 (d, J = 9.7, H5); 3,4-trans-4,5-trans-2,3,4-Triphenyl-5-carboxymethoxy isoxazolidine (13c): δ 4.72 (d, J = 6.7 Hz, H3), 4.01 (br. t, J = −7.0 Hz, H4), 4.45 (d, J = 7.5 Hz, H5).

Reaction of C-(4-nitrophenyl)-(N)-(4'-chlorophenyl)nitrite (14) (1.217 g, 0.0044 mol) with methyl cinamate (8) (2.14 g, 3 × 0.0044 mol); Reaction time 16 h. 300 MHz H NMR analysis revealed three products formed: total conversion ~75 %, ratio 13a:13b:13c = 91:7:2.

3,4-trans-4,5-trans-2-(4'-Chlorophenyl)-3-(4'-nitrophenyl)-5-phenyl-4-carboxymethoxy isoxazolidine (15b): δ 5.13 (d, J = 10.1 Hz, H3), 3.66 (br. t, J = −9.7 Hz, H4), 5.68 (d, J = 9.4 Hz, H5); 3,4-trans-
4.5-trans-2-(4′-Chlorophenyl)-3-(4′-nitrophenyl)-4-phenyl-5-carbethoxy isoxazolidine (15c): δ 4.96 (d, J = 6.1 Hz, H3), 4.12 (br, t, J = ~ 6.6 Hz, H4), 4.47 (d, J = 7.1 Hz, H5).

Reaction of C (4′-chlorophenyl)-N-methyl nitrore (16) (0.746 g, 0.0044 mol) with diethyl (4-nitrophenyl) methyl malonate (18) (3.86 g, 3 × 0.0044 mol): Reaction time 18 h.

3,5-trans-2-Methyl-3-(4′-chlorophenyl)-5-(4′-nitrophenyl)-4,4-dicarbethoxy isoxazolidine (21): Pale yellow crystals, m.p. 106-108 °C; m.f.: C22H24NO5Cl; yield 1.70 g (88 %), isolated from hexane eluates, Rf 0.59 (benzene).

IR (KBr, νmax, cm⁻¹): 2983, 1726 (ester CO), 1602, 1524 & 1354 (aromatic CO₂), 1093, 1043 & 502 (aromatic Cl), 859 (1,4-disubstituted benzene ring), 750 & 692 (mono-substituted benzene ring). 1H NMR (500 MHz, CDCl₃) revealed only one product.

Table 1: Crystal data and structure refinement for cycloadduct 22.

| Formula | C₂₂H₂₄NO₅Cl |
|---------|-------------|
| m.w.    | 417.87      |
| Temperature | 150°(2) K |
| Radiation | Mo Kα | 0.7107 Å |
| Crystal system, space group | Orthorhombic, Pca2₁ |
| Cell parameters | a = 16.582(6) Å; b = 10.482(4) Å; c = 25.442(10) Å; α = β = γ = 90° |
| Volume | 422(3) Å³ |
| Z, Calculated density | 8.1255 Mg/m³ |
| Absorption coefficient | 0.204 mm⁻¹ |
| F(000) | 1760 |
| Crystal size | 0.02 × 0.16 × 0.09 mm |
| θmax - θmin | 1.60 - 18.44° |
| Limiting indices | -14 ≤ h ≤ 14, -9 ≤ k ≤ 9, -22 ≤ l ≤ 22 |
| Reflections collected/unique | 14738/3232 [R(int) = 0.1284] |
| Completeness to q | 99.3 % |
| Refinement method | Full-matrix least-squares on F² |
| Data/parameters | 3232/530 |
| Goodness-of-fit on F² | 1.032 |
| Final R indices [I>2σ(I)] | R1 = 0.0510, wR2 = 0.1026 |
| R indices (all data) | R1 = 0.0827, wR2 = 0.1185 |
| Largest diff. peak and hole | 0.162 and -0.172 e Å⁻³ |
RESULTS AND DISCUSSION

32CA of C,N-diaryl nitrones to substituted methyl E-cinnamates: The 32CA of four differentially substituted nitrones (1-4) to various substituted methyl E-cinnamates are reported (Scheme-I). Additionally, the reaction of C-(4-nitrophenyl)-N-(4'-chlorophenyl) nitrone (14) with 8, reported earlier [19], was repeated to obtain further amounts of the resultant cycloadducts 15a-c.

The following reactions were carried out in refluxing anhydrous toluene with three-fold molar excess of the cinnamates:

(a) nitrones 1, 2, 3, 4 with 6; (b) nitrone 4 with 5; (c) nitrone 1 with 7; (d) nitrone 3 with 8; (e) nitrone 14 with 8 (repetition of earlier work) [19].

The reactions were monitored by TLC and 300 MHz 1H NMR analysis of aliquots taken from time to time. Work-up involved removal of the solvent under reduced pressure in a rotary evaporator, followed by 1H NMR analysis of the post-reaction mixture for total overall yield and product ratios. The reaction mixture was then chromatographed over neutral alumina to isolate the products. Reactions of 4 with 5 and 6 did not proceed satisfactorily as evident from 1H NMR monitoring of the reaction mixtures-extensive decomposition was observed. The results of the other 32CA reactions are summarized in Scheme-I. All the reactions gave 3,4-trans-4,5-trans-2,3,5-triaryl-4-carboxmethyloxazolidine (series a) as major products, the corresponding diastereoisomeric 3,4-cis-4,5-trans-2,3,5-triaryl-4-carboxmethyloxazolidine (series b) were obtained as minor products, the regioisomeric 3,4-trans-4,5-trans-2,3,4-triaryl-5-carboxmethyloxazolidine (series c) were obtained in even lesser quantity. All the major products (9a, 10a, 11a, 12a, 13a) were isolated by chromatography in pure state. Of the minor compounds, only 9b could be isolated in the pure state. The other diastereoisomeric products (10b to 13b) and regioisomeric products (9c to 13c) were detected by 1H NMR of the crude reaction mixture. All the isolated products (9a-13a, 9b) showed IR bands (1736-1730 cm⁻¹) characteristic of unconjugated ester; other characteristic bands could be assigned to substituted aromatic rings, aryl Cl and aryl nitro substituents.

Structure elucidation of the products were achieved by spectroscopic analysis, particularly by 300 MHz 1H NMR and 75.5 MHz 13C NMR and comparison of the values with those of the oxazolidines generated by 32CA of nitrones to α,β-unsaturated amides [9-12]. We reported earlier that the 32CA of C-(4-nitrophenyl)-N-(4'-chlorophenyl) nitrone (14) with methyl cinnamate (8) furnished 15a as the major compound; this on mild hydrolysis afforded the corresponding acid 15d. XRD analysis of 15d established the structure as 3,4-trans-4,5-trans-
2-(4′-chlorophenyl)-3-(4′-nitrophenyl)-5-phenyl-4-carboxy isoxazolidine. The characteristic 1H NMR and 13C NMR signals relating to isoxazolidine ring of 15a and 15d are given in Tables 2 and 3. The chemical shifts and coupling constants of the isomeric cycloadducts (9a, 9b, 9c) are given in Table-2.

The signals in 9a were similar to the corresponding signals of 15a with small changes attendant upon changes in aromatic substituents which affect the 1H- and 13C NMR chemical shifts in the benzylic 3- and 5-positions. Hence cycloadduct 9a was 3,4-trans-4,5-trans-2-phenyl-3,5-di(4′-chlorophenyl)-4-carboxymethoxy isoxazolidine belonging to series a type of cycloadducts, arising out of meta-channel endo-carbonyl-exo-aryl approach of 6 to the nitrone [2].

The positions of attachment of aryl rings at C-3 and C-5 were confirmed from COSY-LR assignments of 9a and 9b which showed long range couplings of H-3 and H-5 with H-4 in the region δ 5.19-5.41, H-5 in the region δ 3.43-3.54, H-4 in the region δ 4.07 (dd, 7.5, 8.5). All three 13C-signals moved upfield: C-3 by ~0.2 ppm, C-4 by ~0.6 ppm, and C-5 by ~0.3 ppm in 9b compared to 9a. J3,4 and J4,5 coupling constants were enhanced to ~9.5-10.5 Hz in this series.

The proton shifts of 9c were markedly different from those of 9a – H-5 moved significantly upfield (~0.9 ppm) while H-4 moved downfield by ~0.6 ppm, consequent upon the interchange of the substituents between C-4 and C-5. The magnitude of J3,4 and J4,5 (7.5 and 8.5Hz) suggested a 3,4-trans-4,5-trans configuration in 9c. In the other members of the regioisomeric series (10c-13c,15c), the 1H- and 13C NMR characteristics of the isoxazolidine ring carbons and protons were similar to those of compound 9c.

In the diastereoisomeric series (9b-13b, 15b), the H-4 and H-5 signals were more differentiated with respect to each other, H-3 moving ~0.2 ppm upfield and H-5 ~0.3 ppm downfield; H-4 shifted ~0.2 ppm downfield. All three 13C-signals moved upfield: C-3 by ~2 ppm, C-4 by ~6 ppm and C-5 by ~2.5 ppm in 9b compared to 9a. J3,4 and J4,5 coupling constants were enhanced to ~9.5-10.5 Hz in this series.

The reactions carried out were (i) 16 with 18, 19, 20; (ii) 17 with 19, 20. Reactions were carried out with a three-fold molar excess of the aryldiene malonates in refluxing anhydrous toluene with 1H NMR and TLC monitoring. Work-up was similar to that described earlier. 1H NMR analysis of the post reaction mixture showed the presence of a single cycloadduct; no other products were detected within limits of NMR detection (~ 0.5 %). Conversions were nearly quantitative.

A remarkable increase in regio- and stereoselectivity compared to cinnamic acid esters was observed leading to the exclusive formation in the reactions of the trans-3,5-diaryl-4,4-dicarboxethoxy isoxazolidines. These were obtained by meta-channel exo-aryl approach of the aryldiene malonates to the nitrene. NMR monitoring of reactions (both 16 and 17 with 19) showed that these reactions with aryldiene malonates bearing the electron-releasing substituent methoxy were not

**Scheme-II:** 32CA of C-aryl-N-methyl nitrones to diethyl aryldiene malonates
successful extensive decomposition was observed. These were not followed up.

IR spectra of the cycloadducts exhibited bands corresponding to non-conjugated esters (~1730 cm⁻¹), 300 MHz ¹H NMR spectra showed two singlets corresponding to H-3 and H-5 (δ 4.64 and δ 5.96 respectively for 22), thus confirming the regiochemistry of these cycloadducts. Both these protons showed long range coupling with the ortho-protons of aryl rings attached to C-3 and C-5.

Both these protons showed long range coupling with the ortho-protons of aryl rings attached to C-3 and C-5 (Fig. 1; DQF-COSY of 21). Two carbethoxyl groups are attached to the diastereotopic centre C-4. Consequently the methylene protons and the methyl protons in the ethyl ester units are differentiated. Further, within each methylene group the two protons are differentiated, the mutual relationships of which were confirmed by reference to the DQF-COSY of cycloadduct 21. The relative stereochemistry of the N-methyl cycloadduct 22 and hence of the other cycloadducts was confirmed by XRD studies. Earlier we had reported the XRD analysis of N-phenyl cycloadduct having the same relative configuration [12].

Compound 22 was recrystallized from methanol to obtain single crystals. Diffraction data were recorded on a Brucker Smart Apex II CCD area detector diffractometer operating the MoKα radiation (λ = 0.7107 Å). Crystals were orthorhombic (space group Pca21) with cell parameters a = 16.582(6) Å; b = 10.482(4) Å; c = 25.442(10) Å; α = β = γ = 90°. The X-ray crystallographic study showed an all trans-configuration: H-3 and H-5 were trans-oriented, additionally the N-lone pair was trans- to H-3. Two optical antipodes were present in the unit cell which had a two-fold alternating axis of symmetry. The ORTEP projection is shown in Fig. 2. The numberings of structures as given in these projections are those provided in the X-ray crystallographic analysis outputs.

**Conclusion**

The results of 32CA reactions between four differently substituted C,N-diarly nitrones with four methyl E-cinnamates, bearing different aryl substituents, were investigated. The results can be summarized as follows: (i) The reactions proceeded with high regioselectivity to give mainly 2,3,5-triaryl isoxazolidine adducts; (ii) the major product belonged to the 3,4-trans-4,5-trans series, obtained by the meta-channel, endo-carbonyl-exo-aryl approach of the methyl cinnamate; (iii) stereoselectivity overwhelmingly favoured the 3,4-trans-4,5-trans adducts (meta-channel, endo-carbonyl-exo-aryl approach of the methyl E-cinnamate) over the 3,4-cis-4,5-trans adducts (meta-channel, exo-carbonyl-endo-aryl approach); (iv) the regioisomeric isomers (ortho-channel) were obtained only in slight amounts; (v) the product ratios of cycloadducts of series a:b:c were 88:91:7:9; 2:4; (vi) product ratios were essentially similar even with changes of substituents on either of the reactants. This is in contrast to 32CAs of α,β-unsaturated amides to C,N-diaryl nitrones [12,16], where changes in aryl substituents affected the regioselectivities.

32CA reactions of C-aryl-N-methyl nitrones with diethyl arylidene malonates were investigated, as these had not been investigated earlier. A remarkable increase in regio- and stereoselectivity compared to cinnamic acid esters was observed leading to the exclusive formation in the reactions of the trans-3,5-diaryl-4,4-dicarboxyl oxazolidines by an endo-aryl meta channel approach of the 2π component.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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