

Reaction of 1, 5-diphenylcarbazide with aqueous glyoxal; identification of the product structure by use of spectroscopic analyses and computational methods

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Reaction of 1,5-diphenylcarbazide and aqueous glyoxal at reflux condition in the presence of hydrochloric acid catalyst in ethanol (as solvent) led to the precipitation of a white solid. TLC analysis of the solid suggested that it consisted of one component. On the basis of spectroscopic analyses and computational methods, the solid structure was established as 2,2'-diphenyl-5,5'-bis(phenylamino)-2,2',3,3',5,5'-hexaazabicyclo-pentyl-4,4'-dione (1).

INTRODUCTION

Reaction of amides and amines with aqueous formaldehyde and aqueous glyoxal gives a variety of products depending upon the nature of amide, amine and the reaction conditions [1-10]. In 1992, Nielsen and co-workers reported the cyclocondensation reaction of benzylamine, glyoxal and formaldehyde to produce various products, including imidazolidines [1]. They suggested that glyoxal diimine was an important intermediate in this reaction. A similar strategy was also utilized to synthesis of some nitrogen containing five-membered saturated heterocycles [2-3]. It should be noted that nitrogen containing five-membered heterocyclic compounds are important building blocks in biologically active compounds and carriers of pharmacologically active carbonyl compounds [11-12].

RESULTS AND DISCUSSION

Reaction of 1,5-diphenylcarbazide and aqueous glyoxal at reflux condition in the presence of hydrochloric acid catalyst in ethanol (as solvent) affords a white precipitate. TLC analysis indicates the presence of one product. IR, ¹³C-NMR and ¹H-NMR spectral analyses of the product show that the existing data are consistent with three different structures: 2,2'-diphenyl-5,5'-bis(phenylamino)-2,2',3,3',5,5'-hexaazabicyclo-pentyl-4,4'-dione (1), cis- or trans-2,7-diphenyl-5,10-bis(phenylamino)-

2,3,5,7,8,10-hexaazabicyclo[4,4,0]deane-4,9-dione (2 and 3) (Figure 1). Despite the numerous attempts, we failed to prepare single crystals of the product.

The ¹H-NMR spectrum of the product shows a sharp singlet for the methine moieties localized at about $\delta = 5.7$ ppm (2H). The protons on the nitrogen atoms adjacent to phenyl groups (NH-Ph) and phenyl protons appear as a multiplet (22H) at about $\delta = 6.5 - 7.3$ ppm. The signal of amidic protons (NH-CO) appear as a singlet at $\delta = 9.00$ ppm (2H). Upon addition of D₂O to the NMR sample, the signal at 9 disappears and in the region 6.5 – 7.3, the integration for 22 protons is reduced to 20 protons. In the IR spectrum, the carbonyl group gives a sharp absorption band at 1697 cm⁻¹. NH band appears at 3330 cm⁻¹. In ¹³C-NMR spectrum, carbonyl carbon and methine carbons appear at $\delta = 159$ and 75 ppm, respectively. The 7 peaks between 114 and 147 are attributed to phenyl carbons, the observed intense peak at 129 may result from overlapping of two closely spaced peaks.

The semi-empirical PM3 method was employed to perform a detailed analysis of C=O stretching vibrations in the above-mentioned structures (1-3). The computations show that in both 2 and 3, C=O stretches appear as two intense bands, and they are of approximately equal intensity. But in structure 1, the C=O stretch appears as one intense band.

Comparing computational results with experimental IR spectrum which shows only one stretching vibration band for C=O group, presents that the experimental data are consistent with structure 1.

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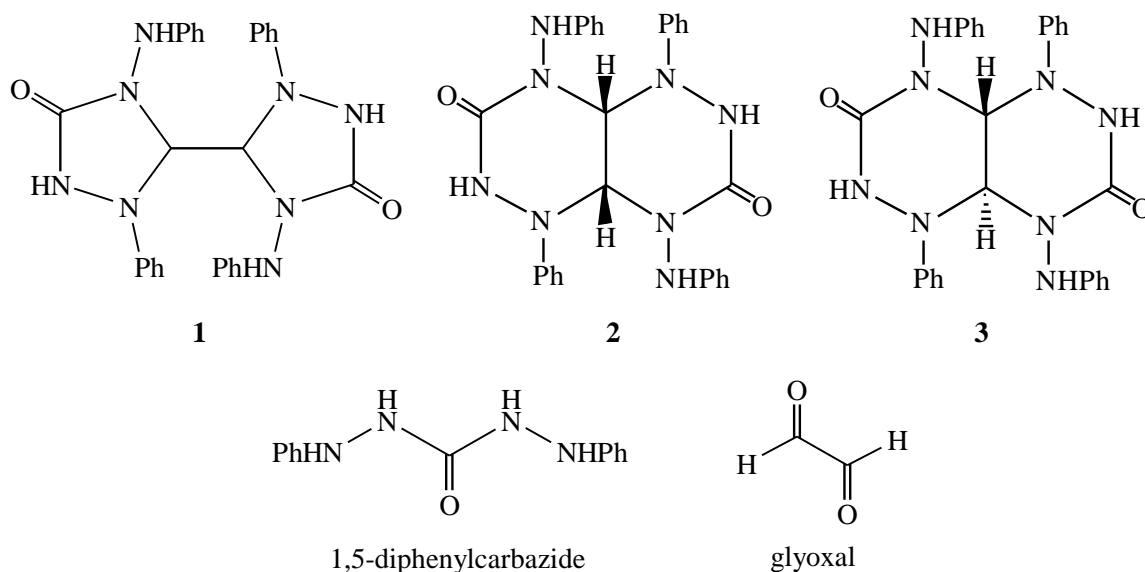


Fig. 1. Structures of 1-3.

EXPERIMENTAL

2,2'-diphenyl-5,5'-bis(phenylamino)-2,2',3,3',5,5'-hexaazabicyclopentyl-4,4'-dione. Hydrochloric acid (0.2 g of 37% aqueous solution, 2 mmol) and glyoxal (0.08 g of 40% aqueous solution, 0.5 mmol) were added slowly to a stirring solution of 1,5-diphenylcarbazine (0.25 g, 1mmol) in ethanol (50 ml). The solution was refluxed for 6h and then cooled. Water (50 ml) was added to the reaction mixture. On standing over night, a white solid (57 %) was formed and then filtered .M.p. 270-271°C.

IR (KBr) cm^{-1} : 1697 (C=O), 3330 (NH). $^1\text{H-NMR}$ (80 MHz, CDCl_3) δ : 5.68 (s, 2H, CH), 6.54-7.33 (m, 22H, Ph-H and Ph-NH-N), 9.00 (s, 2H, NH-CO). $^1\text{H-NMR}$ (80 MHz, $\text{CDCl}_3 + \text{D}_2\text{O}$) δ : 5.70 (s, 2H, CH), 6.52 – 7.5 (m, 20H, Ph-H). $^1\text{H-NMR}$ (80 MHz, DMSO-d_6) δ : 6.05 (s, 2H, CH), 6.41- 7.27 (m, 22H, Ph-H and Ph-NH-N), 9.06 (s, 2H, NH-CO). $^{13}\text{C-NMR}$ (80 MHz, CDCl_3) δ : 75, 114, 116, 121, 122, 129, 146, 147, 159 (CO).

Anal. Calcd. for $\text{C}_{28}\text{H}_{26}\text{O}_2\text{N}_8$: C, 66.4; N, 22.1; H, 5.1. Found: C, 65.9; N, 22.1; H, 5.1.

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