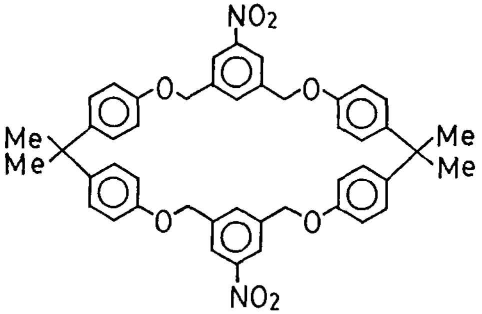
Tetrahedron Letters,Vol.26,No.10,pp 1325-1328,1985 0040-4039/85 $3.00 + .00

SYNTHESIS AND COMPLEXATION OF A NOVEL CYCLOPHANE

Kazuhiko Saigo,* Masataka Kubo, Ru-Jang Lin, Akira Youda, and Masaki Hasegawa
Department of Synthetic Chemistry, Faculty of Engineering
The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113, Japan

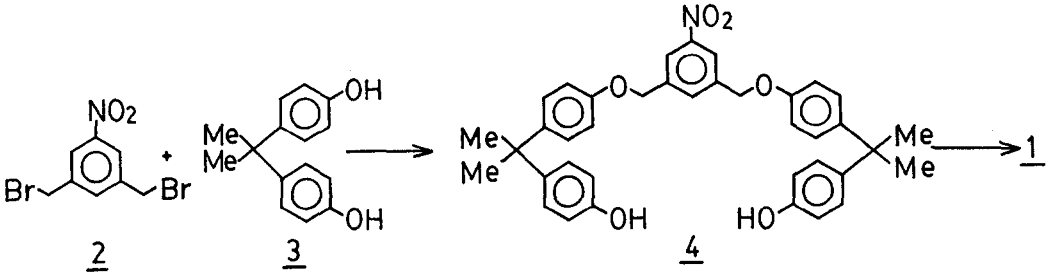
Abstract: *A novel cyclophane, 17,17,40,40-tetramethyl-7,30-dinitro-1,10,24,33-tetraoxa[2.2.1.2.2.1]metaparaparametaparaparacyclophane, was synthesized by 2:2 cyclization of 3,5-bis(bromomethyl)nitrobenzene, derived from 3,5-dimethylnitrobenzene, and bisphenol A. The cyclophane was found to form 1:1 complex with benzene.*

Synthetic host molecules having cavities capable of accomodating molecular guests are of current interest as a structural basis for constructing enzyme-like catalysts.[1)] Several compounds have been reported to form inclusion complexes with neutral organic molecules.[2)] In our efforts to synthesize neutral organic cavities, we isolated a novel compound, of which the starting materials (3,5-dimethylnitrobenzene and bisphenol A) are readily available. In this communication we report the synthesis and complexation behavior of the novel cyclophane, 17,17,40,40-tetramethyl-7,30-dinitro-1,10,24,33-tetraoxa[2.2.1.2.2.1]metaparaparametaparaparacyclophane (1).



1

The synthesis was carried out as shown in the Scheme. One step preparation of the 2:2 cyclized cyclophane **1** from equimolar amounts of 3,5-bis(bromomethyl)nitrobenzene[3)] (**2**) and bisphenol A (**3**) resulted in a low yield (4%). The synthesis of the 2:2 cyclized cyclophane **1** was performed by stepwise cyclization *via* the U-shaped precursor (**4**). The diphenol **4** was prepared in 80% yield by the reaction of **2** with a large excess of **3** in EtOH using NaOEt as a base [Mp 74-77°C; IR (KBr) 3420, 1527, 1510, 1228, 1180, and 830 cm^{-1}; ^1H-NMR ($CDCl_3$) δ 1.60 (s, 12H), 5.08 (s, 4H), 6.6-7.2 (m, 16H), 7.79 (s, 1H), and 8.20 (s, 2H)]. The 1:1 cyclization between **2** and **4** in the presence of *t*-BuOK by the high dilution method, followed by precipitation with benzene, gave 35% yield of the cyclic dinitro compound **1** accompanying benzene in the molar ratio of 1:1.



Complex formation between **1** and benzene was suggested by ^1H-NMR spectrum (a part of it is shown in Fig. 1a) of crystals deposited from a chloroform-benzene (10:1 v/v) mixed solvent [Mp 280°C (decomp); IR (KBr) 1526, 1510, 1350, 1240, 1220, and 1180 cm^{-1}; ^1H-NMR ($CDCl_3$) δ 1.62 (s, 12H), 5.11 (s, 8H), 6.75 (d, 8H, J=9 Hz), 7.06 (d, 8H, J=9 Hz), 7.31 (s, 6H), 7.71 (s, 2H), and 8.13 (s, 4H)]. The integral ratio revealed the crystal is the 1:1 complex of **1** with benzene. From TG-DSC curves the crystal morphology of the complex seemed to change on heating (Fig. 2). Between 135°C and 170°C the weight of the sample decreased about 9.2% endothermically. In the NMR spectrum of the

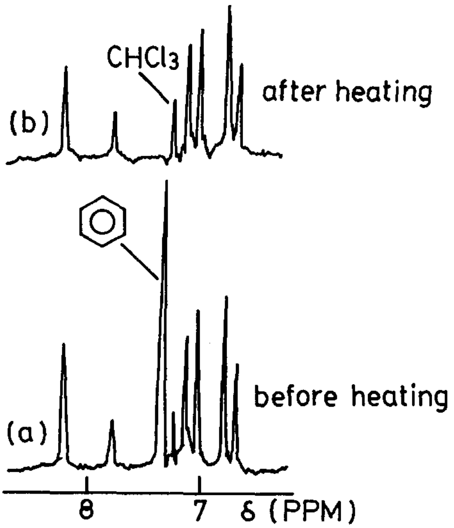


Fig. 1 NMR spectral change

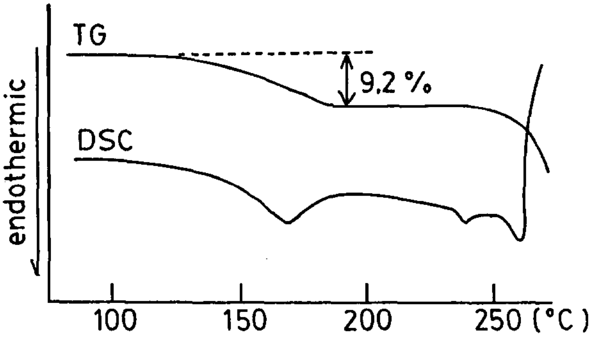


Fig. 2 TG-DSC curves of 1·benzene complex

sample heated up to 180°C, the peak of benzene (δ 7.31) disappeared completely (Fig. 1b). Therefore the decrease of the weight should correspond to the evolution of benzene from the complex (theoretical weight loss: 9.4%). At 245°C a new crystal form appeared, of which melting point is the same as that of the free cyclophane **1** (280°C decomp.). Moreover, the solubility of the complex quite differed from that of the free cyclophane **1**. These experimental results indicate that the interaction between benzene and the cyclophane exsists in the crystalline state.

The structure of the complex was determined by X-ray crystallography.4) As shown in Fig. 3 the complexed host molecules adopt piled "chair"-like conformation. The cavities are created not only by the packing of the host molecules but also by the host molecules themselves. Benzene guest is fixed in the channel formed by two host molecules, that is, the host molecules pack up one above the other resulting in the formation of the cavity in which the guest, benzene molecule, is located. This structural arrangement is similar to that observed for the complexation of 1,4-dioxane with tetraazaparacyclophane.2h)

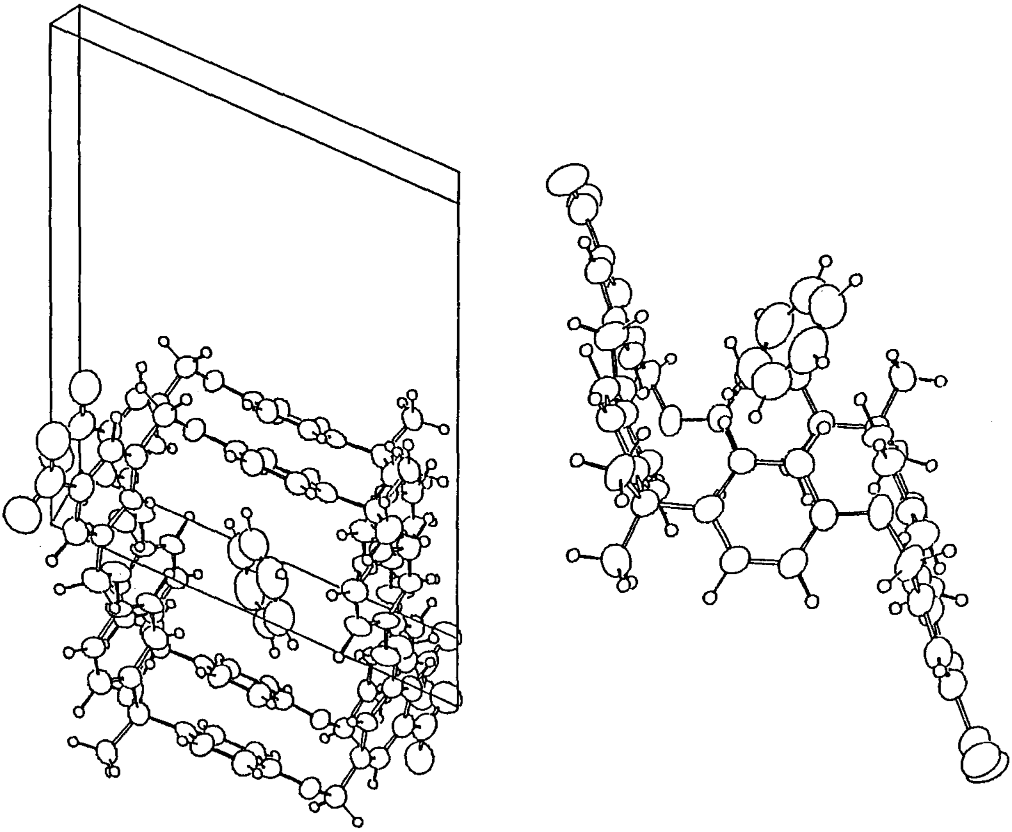


Fig. 3 Perspective drawing of **1**·benzene complex

Acknowledgment. The X-ray structual work was accomplished by Dr. Kazuhide Kamiya and Dr. Yoshikazu Wada, Takeda Chemical Industries Ltd, whom the authors gratefully acknowledge.

References

1) (a) J.-M. Lehn and C. Sirlin, *J. Chem. Soc., Chem. Commun.*, **1978**, 949. (b) G. L. Trainor and R. Breslow, *J. Am. Chem. Soc.*, **103**, 154 (1981). (c) D. J. Cram, G. M. Lien, T. Kaneda, R. C. Helgeson, C. B. Knobler, E. Maverick, and K. N. Trubelood, *J. Am. Chem. Soc.*, **103**, 6228 (1981). (d) E. T. Jarvi and H. W. Whitelock, Jr., *J. Am. Chem. Soc.*, **104**, 7196 (1982). (e) K. J. Takeuchi, D. H. Busch, and N. Alcock, *J. Am. Chem. Soc.*, **105**, 4261 (1983).

2) (a) Y. Murakami, J. Sunamoto, H. Okamoto, and K. Kawanami, *Bull. Chem. Soc. Jpn.*, **48**, 1537 (1975). (b) I. Tabushi, Y. Kuroda, and Y. Kimura, *Tetrahedron Lett.*, **1976**, 3327. (c) I. Tabushi, H. Sasaki, and Y. Kuroda, *J. Am. Chem. Soc.*, **98**, 5727 (1976). (d) G. D. Andreetti, R. Ungaro, and A. Pochini, *J. Chem. Soc., Chem. Commun.*, **1979**, 1005. (e) K. Odashima, A. Itai, Y. Iitaka, and K. Koga, *J. Am. Chem. Soc.*, **102**, 2504 (1980). (f) K. Odashima, A. Itai, Y. Iitaka, Y. Arata, and K. Koga, *Tetrahedron Lett.*, **21**, 4347 (1980). (g) T. Soga, K. Odashima, and K. Koga, *Tetrahedron Lett.*, **21**, 4351 (1980). (h) S. J. Abbott, A. G. M. Barrett, C. R. A. Godfrey, S. B. Kalindjian, G. W. Simpson, and D. J. Williams, *J. Chem. Soc., Chem. Commun.*, **1982**, 796. (i) F. Vögtle, H. Puff, E. Friedrichs, and W. M. Müller, *J. Chem. Soc., Chem. Commun.*, **1982**, 1389. (j) F. Diederich and K. Dick, *Tetrahedron Lett.*, **23**, 3167 (1982). (k) F. Toda, K. Tanaka, G. Ulibarri Daumas, and Ma. C. Sanchez, *Chem. Lett.*, **1983**, 1521. (l) F. Toda, K. Tanaka, and C. W. Mak, *Tetrahedron Lett.*, **25**, 1359 (1984). (m) S. P. Miller and H. W. Whitelock, Jr., *J. Am. Chem. Soc.*, **106**, 1492 (1984). (n) I. Tabushi, K. Yamamura, H. Nonoguchi, K. Hirotsu, and T. Higuchi, *J. Am. Chem. Soc.*, **106**, 2621 (1984). (o) J. Canceill, J. Gabard, L. Lacombe, and A. Collet, The 3rd International Symposium on Clathrate Compounds and Molecular Inclusion Phenomena, Tokyo, Japan (1984), Abstract 1010.

3) S. A. Sherrod, R. L. daCosta, R. A. Barnes, and V. Boekeiheide, *J. Am. Chem. Soc.*, **96**, 1565 (1974).

4) Crystal data: triclinic; $P\bar{1}$; a=14.606(4), b=13.220(6), c=6.419(2) Å; α=100.42(4), β=104.78(3), γ=66.41(3)°; Z=1; V=1093.9(8) Å^3; R=0.082.

(Received in Japan 4 December 1984)