

行政院國家科學委員會專題研究計畫報告
電子效應與主客化學(2/2)
Electronic Effects and Host-Guest Chemistry (2/2).

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一、中文摘要

本研究計畫為期兩年，主題為電子效應與主客化學。我們承續過去對2,5-雙取代金剛烷衍生物的系列研究，推展至2,4-雙取代金剛烷衍生物的合成，針對含羰基的化合物如2,4-雙羰基、4-羰基-2-亞甲烯基、以及4-羰基-2-硫酮基金剛烷衍生物(6-8)進行還原反應。針對含亞甲烯的化合物如7, 10進行Carbene addition反應、MCPBA氧化反應。對含fulvene的化合物如12, 13進行Diels-Alder addition反應以及1,3-偶極環化加成反應。部分成果已經在2000年八月份的ACS Meeting發表，目前正在整理詳細資料投稿Full Paper中。

在主客化學上：合成上緣與下緣分別有不同取代的 Calixarenes：例如含偶氮及含硫取代的 Calixarenes 的合成。在上緣取代的 Calixarenes 之合成上，我們已利用丙烯基的重排及其反應多樣性，與Nitriloxides行1,3-偶極環化加成反應，製備了一系列上緣含 isoxazolinomethyl 取代基的 Calixarenes。除了已成功合成單 isoxazolinomethyl 取代的 Calixarene 之外，也合成了 5,11-, 5,17- 雙取代的 Calixarenes，並利用氫核磁共振光譜技術探討此系列宿主對於四級銨鹽錯合的效用。已經發表一篇著作於周大紓教授紀念

專輯 (*J. Chinese Chem. Soc.* **2000**, *47*, 173-182).

與中研院趙依嫻博士合作，我們也針對環糊精宿主中所進行的狄亞士-阿德反應之高度方位選擇性進行理論計算，尋找出其控制因素。計算之結果發現親雙烯醌類與雙烯環合反應之過渡態，在環糊精中只有淺淺的結合，並沒有深入孔洞中。狹窄的環糊精一級側邊，對反應過渡態有較佳的選擇性。靜電力與凡得瓦爾力共同扮演了主客錯合的關鍵角色。此結果也已經投稿一篇審查中。

未來我們對於上述1,3-偶極環化加成反應所獲得的不同取代之Calixarenes將進行各種開環反應：包括Raney Nickel 還原反應，TiCl₃ 偶合反應等嘗試。此外也將研究它們在金屬錯合或環境保護應用上的可能性。這些研究可以利用NMR, UV/VIS, Fluorescence等各種光譜法來分析。與清大儲三陽教授及高醫蘇明德教授合作，我們也利用密度泛函理論計算針對Nitrile Ylide的1,3-偶極環化加成反應進行理論計算，結果發表於*Int. J. Quantum Chem.* **2001**, *83*, 3318-323。

關鍵詞: 2,4-雙取代金剛烷衍生物、1,3-偶極環化加成反應、Isoxazolinomethyl-

calix[4]arenes

Abstract

This is a two-year's project which we focused on two areas: The electronic effects and Host-Guest chemistry. We have extended our work to the syntheses of 2,4-disubstituted Adamantanes and their application in face selectivity study. For example, we have carried out reduction reactions on the carbonyl-containing compounds **6-8**, carbene addition and MCPBA oxidation reactions on the methylene-containing compounds **7** and **10**. To fulvene-containing compounds we have studied their face selectivity in Diels-Alder reaction and 1,3-dipolar cycloaddition reactions. Good progress is obtained in this area and we have presented part of the results in the Washington ACS meeting, in the year of 2000. We are writing up a full paper and will submit it for publication soon.

In the Host-Guest chemistry: We have also extended our syntheses of upper-rim and lower-rim modified calix[4]arenes. For example, sulfur- and azo-containing calixarenes. In the upper-rim modification of calix[4]arenes, we used the Claisen rearrangement of allyl-group and its 1,3-dipolar cycloaddition reaction with nitrileoxides to furnish a series of isoxazolinomethyl containing calixarenes. Preliminary test of these hosts in the complexation of quaternary ammonium salts was studied using ^1H nmr spectroscopy. A paper has been published in the memorial issue of Prof. Ta-Shue Chou in J. Chinese Chem. Soc. **2000**, *47*, 173-182.

In collaboration with Dr. Ito Chao and W-S. Li, we have also carried out a computational study on the regioselectivity in a cyclodextrin mediated Diels-Alder reactions. The original work was published in J. Chem. Soc. Chem. Commun. **1995**, 971, however, we were intrigued by the dramatic effects cyclodextrins have played. From this study, we found that: (1) only shallow binding with CD is necessary for the regio-selectivity and multiple binding geometries are possible; (2) the narrow bottom rim of the CD binds both regio-transition states better than at the wider top rim; (3) structural clustering analyses of the CD-TS configurations has enabled us to evaluate the binding energies of the different binding configurations. A full paper has been submitted for these results.

We shall keep studying the ring-opening reactions of those mono-, 5,11- and 5,17-diisoxazolomethylcalix[4]arenes, which includes: Raney nickel reduction and TiCl_3 coupling reactions. Besides, we shall also explore the application of these upper and lower rim modified calix[4]arenes in metal ion complexation studies. These types of research can be studied by NMR, uv/vis and fluorescence spectroscopy methods. In collaboration with Prof. S.-Y. Chu (National Tsing-Hua University) and M.-D. Su (Kaohsiung Medical University), we have also carried out a Density Functional Study on the 1,3-dipolar cycloaddition of nitrile ylide with disubstituted ethylenes, and the results have been published in *Int. J. Quantum Chem.* **2001**, *83*, 318-323.

Key words: 2,4-disubstituted adamantanes, 1,3-dipolar addition、isoxazolinomethyl-calix[4]arenes °

二、緣由與目的

本研究是主持人持續進行的一個領域，而電子效應的探討在國內外也仍是個非常熱門的主題，因為其進行機制仍有許多不清楚之處待釐清。

三、結果與討論

經由本研究我們獲得面向反應的過渡態能量差異與電荷分布差異，使得吾人對電子效應的機制更加清楚了解，特別是在沒有立體障礙差異的金剛酮系列，相對於靜電場效應來說過渡態超共軛理論扮演非常重要角色。詳見本人回顧性文章：*Chem. Review* **1999**, 99, 1387-1413。

四、計劃成果自評

本計劃成果豐碩兩年來已發表論文六篇，分別是：(1) *J. Org. Chem.* **1999**, 64, 1099-1107, (2) *J. Org. Chem.* **1999**, 64, 2673-2679, (3) *J. Org. Chem.* **1999**, 64, 6710-6716, (4) *Chem. Review* **1999**, 99, 1387-1413, (5) *J. Chinese Chem. Soc.* **2000**, 47, 173-182, (6) *Int. J. Quantum Chem.* **2001**, 83, 318-323。另外上有兩篇文章投稿送審之中。

understanding the electronic factors in face selection. The studies of a variety of reactions indicate that the reagent prefers to attack the face antiperiplanar to the more electron-rich vicinal bonds, and the results can be reconciled with Cieplak's transition-state hyperconjugation model. °

4. Self-Evaluation

Most of our work is fulfilled as originally proposed, and the results from two year's project have been sum up to **six** original publications, plus two submitted articles: (1) *J. Org. Chem.* **1999**, 64, 1099-1107, (2) *J. Org. Chem.* **1999**, 64, 2673-2679, (3) *J. Org. Chem.* **1999**, 64, 6710-6716, (4) *Chem. Review* **1999**, 99, 1387-1413, (5) *J. Chinese Chem. Soc.* **2000**, 47, 173-182, (6) *Int. J. Quantum Chem.* **2001**, 83, 318-323. °

2. Purposes and Objectives

The study of electronic effects in various sterically unbiased trigonal carbon centers continues to attract considerable theoretical and experimental attention. Among the many models, transition-state hyperconjugation and electrostatic field interaction are the two most popular explanations for the face selectivity results to be found in the literature.

3. Results and Discussion

The effects of *p*-substitution of benzonitrile oxides (**5-Y**) on the face selectivity of 1,3-dipolar cycloaddition have been studied. 5-Substituted adamantan-2-ones and their derivatives have proven to be useful probes in research aimed at