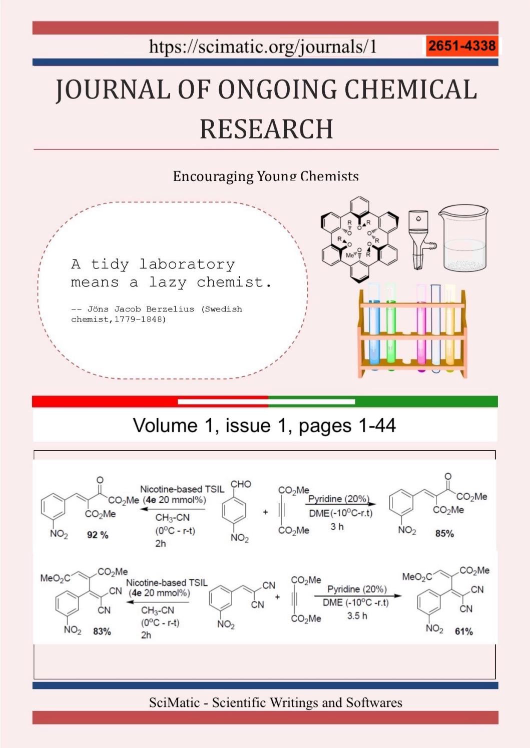
SYNTHESIS AND STRUCTURAL CHARACTERIZATION OF MONO ACID-TYPE *PARTIAL CONE* CONFORMATION AZOCALIX[4]ARENE



JOURNAL OF ONGOING CHEMICAL RESEARCH

2022
Volume: 6
Issue: 1
Pages: 24-28
Document ID: 2022JOCR57
DOI: 10.5281/zenodo.6526076
Manuscript Submitted: 2022-05-07 06:58:50
Manuscript Accepted: 2022-05-07 07:00:52

J Ong Chem Res, 2022, **6**(1): 24-28, Document ID: 2022JOCR57, doi:10.5281/zenodo.6526076

Research Article

Synthesis and Structural Characterization of Mono Acid-type *partial Cone* Conformation Azocalix[4]arene

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Abstract

The synthesis of chromogenic mono acid-type azocalix[4]arene derivatives is described in this study. From p-*tert*-butylcalix[4]arene, which was made with p-*tert*-butylphenol as a starting material, a new family of azocalix[4]arene monocarboxylic acid derivatives (**5a-d**) were synthesized. Four azocalix[4]arenes (**3a-d**) were produced by attaching 4-methoxy-, 4-ethyl-, 4-chloro-, and 4-bromoaniline to 25,26,27,28-tetrahydroxycalix[4]arene through a diazo-coupling reaction. To obtain partial cone conformation acid derivatives, their mono ester units were synthesized with ethyl bromoacetate and hydrolyzed in a basic media (**5a-d**). Products were obtained in suitable (79-92 %) yields, with 25-(carboxymethoxy)-26,27,28-trihydroxy-5,11,17,23-tetra(4-methoxyphenyl)azocalix[4]arene (**5a**) being the product with the highest yield (92 %). FT-IR and ^{1}H-NMR spectroscopy approaches, as well as elemental analysis techniques, were used to elucidated the synthesized products.

Keywords: Structural Properties, Azocalix[4]arene, Calix[n]arene, Diazo-coupling Reaction, Partial Cone Conformation

INTRODUCTION

After crown ethers and cyclodextrins, calix[n]arenes are the third most commonly used host molecules for supramolecules [1]. They're also built on macrocyclics, which can form stable and selective complexes with cations, anions, or neutral molecules [2]. Calix[n]arenes, which are cyclic oligomers of phenolic groups connected in the ortho position, are an intriguing supramolecular structure. Chemical reactions take place on the compound's top and lower rims. pH sensor, host–guest chemistry, chemical sensor, hazardous metals, drug nanocarrier, transition metal ion complexes, liquid crystal, and colorimetric detection are just few of the applications [3–10].

Many sensor experiments for diverse objectives have been reported throughout the previous decade [11, 12]. These research [13, 14] incorporate many calix[n]arene-derived sensors. To achieve their goals, several authors have focused on the invention of new calixarene derivatives such as alcohols esters, amines, amides, imines, ethers, crown ethers, azo, azocrown ethers, schiff bases, vic-dioximes, and carboxylic acids [15-17]. For metal and ligand interaction, this type of supramolecular study has incorporated simplicity, high sensitivity, selectivity, and high detection limits.

Azocalix[4]arene is one of the calixarene derivatives with one or two azo units integrated into the lower rim of a calix[4]arene skeleton, and it is well documented because to their excellent selectivity toward metal ions [18-20]. The lower rim and higher rim of calix[n]arene in the form of monooxime, vic-dioxime, polymeric, Schiff base, and azo groups have been the focus of many of our laboratory studies in this area [21, 22]. Spectrophometric research have improved the extraction, transport, thermal behavior, and stability constant of the azocalix[4]arene. These compounds have strong ionophoric characteristics for cations, with several exhibiting excellent selectivity within metal groups [1, 16].

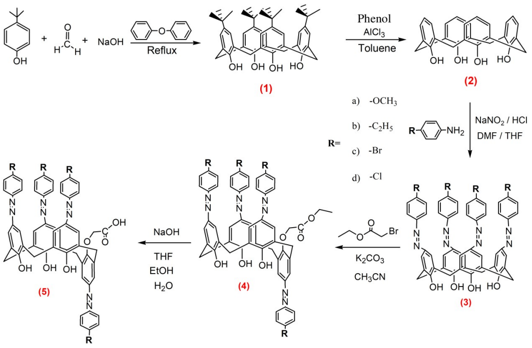

Figure 1. Synthesis of azocalix[4]arene acids (**5a-d**).

In the literature, there exist acid-derived calix[n]arene compounds produced by various techniques. They've been employed for a variety of things, including enantiorecognition characteristics, environmental friendliness, and brnsted acid [23-25].

In this study, FT-IR, ^{1}NMR, and elemental analysis were used to examine the structures of mono partial cone conformation acid derivatives of calix[4]arene with tetraazo groups (Figure 1).

RESULTS AND DISCUSSION

The azocalix[n]arenes that were sought were easily produced utilizing the synthetic approach outlined in Figure 1. Derivatization is one of the goals of the synthetic approach. To achieve the desired result, we used a base catalyzed condensation reaction to produce p-tert-butylcalix[4]arene (**1**) as a starting material, followed by a deterbutylation reaction to obtain calix[4]arene (**2**) in $AlCl_3$ / phenol medium. A diazo-coupling process was used to bind 4-methoxy, 4-ethyl, 4-chloro, and 4-bromoaniline to calix[4]arene, yielding azocalix[4]arenes (**3a-d**). The esterification of calix[4]arenes (**3a-d**) and ethyl bromoacetate in K_2CO_3 medium yielded mono ethyl ester azocalix[4]arene derivatives (**4a-d**), which were subsequently hydrolyzed in basic medium to yield partial cone conformation acid derivatives (**5a-d**) [26, 28, 29].

IR, ^{1}H-NMR, melting point, and elemental studies were used to determine the structure and conformation of new mono acid azocalix[4]arene (**5a-d**) derivatives. In the form of disintegrating, the melting points of derivatives were 250, 227, 257, and 265 °C, respectively.

The absorption bands observed at 1451, 1450, 1470, and 1467 cm^{-1} respectively in the IR spectrum can be assigned to the azo group stretching $\upsilon_{(-N=N-)}$ while the absorption bands at 1735, 1739, 1735, and 1732 cm^{-1} can be attributed to $\upsilon_{(-C=O-)}$ carbonyl group.

According to ^{1}H-NMR spectrum of **5a,** methylene peaks were observed at 3.67, 3.70, 4.30 and 4.60 ppm as four doublet peaks signified *partial cone* conformation as methylene protons of this kind of compounds are not equivalent [26, 28, 29]. The ^{1}H-NMR spectrum showed three singlets at δ 3.74 ppm (3H), δ 3.78 ppm (3H), δ 3.82 ppm (6H) for methoxy protons as shown in figure 2, which supported the acid conformation.

^{1}H-NMR spectrums of other compounds (**5b-d**) showed the methylene peaks as follows: in compound **5b,** methylenes were observed at 3.82, 3.87, 4.43 and 4.55 ppm. In **5c**, they were observed 3.73, 3.76, 4.36 and 4.54 ppm while in **5d**, they were found at 3.77, 3.81, 4.37 and 4.56 ppm. Each of the four peaks showed us that the structures were in *partial cone* conformation.

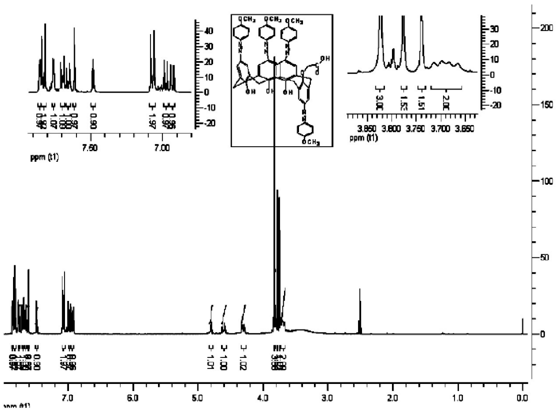

Figure 2. ^{1}H-NMR spectra of (**5a**)

The aromatic protons of the compounds were detected in the ^{1}HNMR spectrum in the region of 6.92 ppm to 7.96 ppm in response to 24 protons.

The ester group's triplet peak at 1.45 ppm and quartet peak at 4.48 ppm in compound **4a**, from which compound **5a** is derived, vanished [30]. In addition, the carbonyl peak in the infrared spectrum changed from 1740 cm^{-1} to 1735 cm^{-1}.

EXPERIMENTAL

General

Merck and Aldrich provided the chemicals utilized in this research. All of the reactions took place in a nitrogen-rich environment. The products were purified using chromatography (column) and silica gel (0.040-0.063 nm). Before use, all organic solvents were analytical grade and dried using standard techniques.

A model 2400 Perkin Elmer elemental analysis instrument was used to do elemental analysis (C, H, and N). The products' melting points were determined using an Electrothermal IA9100 digital melting point device in nitrogen-sealed capillaries. Shimadzu 1601 UV-Vis recording spectrophotometer was used to obtain UV-Vis spectra. Perkin Elmer's ATR-IR spectrometer was used to capture IR spectra. The ^{1}H-NMR spectra were acquired at room temperature

(DMSO / $CDCl_3$) using a Bruker FT-400 MHz spectrometer.

Preparation of the ligands

p-tert-Butylcalix[4]arene (**1**), calix[4]arene (**2**), azocalix[4]arene derivatives (**3a-d**), mono esters (**4a-d**), were synthesized as described previously [26, 27].

Preparation of 25-(Carboxymethoxy)-26,27,28-*tri*hydroxy-5,11,17,23-*tetra*(4-methoxyphenyl)azocalix[4]arene (5a)

In 3 mL water, 17 mL ethanol, and 50 mL THF, a combination of the mono ester (**4a**) 1.00 g (0.96 mmol) and 0.50 g (12.50 mmol) NaOH was mixed and refluxed for 3 hours. TLC was used to monitor the reaction's progress. The medium was acidified with 0.5 M HCl three hours later, and solvents were extracted using the rotary evaporator. The flask medium was filled with 100 mL water, and the crude product at the balloon was filtered, washed with water, and dried. With 25 mL chloroform and 75 mL ethanol, the crude product was crystallized. The dark brown crystalline that results (yield, 0.90 g (92 %), mp. 250 °C (decomposed)). [Found: C: 68.27%; H: 5.01%; N: 10.92%]; $C_{58}H_{50}N_8O_{10}$ requires C: 68.36%; H: 4.95%; N: 11.00%. FT-IR υ: 1451 cm^{-1} (-N=N). 1735 cm^{-1} (-C=O). ^{1}H-NMR (DMSO-*d6*, 25°C) d_H: 3.67 (d, *J*=6.79 Hz, 2H, Ar**CH$_2$**Ar), 3.70 (d, *J*=6.79 Hz, 2H, Ar**CH$_2$**Ar), 3.74 (s, 3H, O-**CH$_3$**), 3.78 (s, 3H, O-**CH$_3$**), 3.82 (s, 6H, O-**CH$_3$**), 4.30 (d, *J*=13.19 Hz, 2H, Ar**CH$_2$**Ar), 4.60 (d, *J*=13.19 Hz, 2H, Ar**CH$_2$**Ar), 4.80 (s, 2H, O-**CH$_2$**-COOH), 6.92-7.86 (m, 24H, Ar**H**).

Preparation of 25-(Carboxymethoxy)-26,27,28-*tri*hydroxy-5,11,17,23-*tetra*(4-ethylphenyl)azocalix[4]arene (5b)

Azocalix[4]arene **5b** was prepared as described for **5a** using **4b** and sodium hydroxide, which was filtered, washed with water and dried. The resulting solid was recrystallized from $CHCl_3$ / C_2H_5OH (100 mL, 1:4, v/v) mixture that gave us a orange product (yield, 0.82 g (% 84), mp. 227 °C (decomposed)). [Found: C: 73.62%; H: 5.80%; N: 11.98%]; $C_{62}H_{58}N_8O_6$ requires C: 73.64%; H: 5.78%; N: 11.08%. FT-IR υ: 1275 cm^{-1} (-C-O). 1450 cm^{-1} (-N=N). 1739 cm^{-1} (-C=O). ^{1}H-NMR (DMSO-*d6*, 25°C) d_H: 1.11-1.23 (m, 12H, CH$_2$-**CH$_3$**), 2.57-2.70 (m, 8H, **CH$_2$**-CH$_3$), 3.82 (d, *J*=6.63 Hz, 2H, Ar**CH$_2$**Ar), 3.87 (d, *J*=6.63 Hz, 2H, Ar**CH$_2$**Ar), 4.43 (d, *J*=13.24 Hz, 2H, Ar**CH$_2$**Ar), 4.55 (d, *J*=13.24 Hz, 2H, Ar**CH$_2$**Ar), 4.90 (s, 2H, O-**CH$_2$**-COOH), 7.22-7.92 (m, 24H, Ar**H**).

Preparation of 25-(Carboxymethoxy)-26,27,28-*tri*hydroxy-5,11,17,23-*tetra*(4-chlorophenyl)azocalix[4]arene (5c)

Azocalix[4]arene **5c** was prepared as described for **5a** using **4c** and sodium hydroxide, which was filtered, washed with water and dried. The resulting solid was recrystallized from $CHCl_3$ / C_2H_5OH (100 mL, 1:4, v/v) mixture that gave us a dark orange product (yield, 0.77 g (% 79), mp. 257 °C (decomp.)). [Found: C: 62.48%; H: 3.62%; N: 10.78%]; $C_{54}H_{38}Cl_4N_8O_6$ requires C: 62.56%; H: 3.69%; N: 10.81%. FT-IR υ: 1274 cm^{-1} (-C-O). 1470 cm^{-1} (-N=N). 1735 cm^{-1} (-C=O). ^{1}H-NMR ($CDCl_3$, 25 °C) d_H: 3.73 (d, *J*=6.83 Hz, 2H, Ar**CH$_2$**Ar), 3.76 (d, *J*=6.84 Hz, 2H, Ar**CH$_2$**Ar), 4.36 (d, *J*=13.31 Hz, 2H, Ar**CH$_2$**Ar), 4.54 (d, *J*=13.30 Hz, 2H, Ar**CH$_2$**Ar), 5.05 (s, 2H, O-**CH$_2$**-COOH), 7.37-7.44 (m, 8H, Ar**H**), 7.69-7.80 (m, 16H, Ar**H**).

Preparation of 25-(Carboxymethoxy)-26,27,28-*tri*hydroxy-5,11,17,23-*tetra*(4-bromophenyl)azocalix[4]arene (5d)

Azocalix[4]arene **5d** was prepared as described for **5a** using **4d** and sodium hydroxide, which was filtered, washed with water and dried. The resulting solid was recrystallized from $CHCl_3$ / C_2H_5OH (100 mL, 1:4, v/v) mixture that gave us a light orange product (yield, 0.74 g (% 76), mp. 265 °C (decomp.)). [Found: C: 53.46%; H: 3.21%; N: 9.14%]; $C_{54}H_{38}Br_4N_8O_6$ requires C: 53.40%; H: 3.15%; N: 9.23%. FT-IR υ: 1275 cm^{-1} (-C-O). 1467 cm^{-1} (-N=N). 1732 cm^{-1} (-C=O). ^{1}H-NMR (DMSO-*d6*, 25°C) d_H: 3.77 (d, *J*=6.88 Hz, 2H, Ar**CH$_2$**Ar), 3.81 (d, *J*=6.86 Hz, 2H, Ar**CH$_2$**Ar), 4.37 (d, *J*=13.41 Hz, 2H, Ar**CH$_2$**Ar), 4.56 (d, *J*=13.38 Hz, 2H, Ar**CH$_2$**Ar), 4.85 (s, 2H, O-**CH$_2$**-COOH), 7.58-7.96 (m, 24H, Ar**H**).

CONCLUSION

To summarize, this article described the synthesis and characterisation of a series of acid base azocalix[4]arene compounds (**5a-d**). In reasonable yields, four new acid derivatives of calix[4]arene were synthesized. Using IR and ^{1}H-NMR spectroscopic methods, I synthesized and studied new azocalix[4]arene derivatives. All of these new compounds were studied in partial cone conformation.

One of the most notable characteristics of these acid compounds is their ease of conversion to acyl chloride compounds. As a result, these novel compounds are simple to obtain, and they can be used in a variety of sensor experiments. These newly synthesized compounds (**5a-d**) have the advantage of containing only one acid unit, making the compounds obtained from here easier to identify.

Acknowledgements

The author would like to thank Afyon Kocatepe University for its support.

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