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Synthesis of Acridinyl- and Fluorenylidenehydrazido Derivatives of *p-tert*-Butylcalix[4]arene

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Abstract—*p-tert*-Butylcalix[4]arenes substituted at the lower rim by acetic acid hydrazide residues reacted with methoxy(ethoxy)acridine and fluoren-9-one derivatives to give a series of calixarenes containing *N*'-fluorenylidene- and *N*'-acridinylacetohydrazide residues. It was found that modification of the hydrazide moiety does not affect the conformation of the initial macroring and that it can lead in some cases to unsymmetrically substituted calixarenes.
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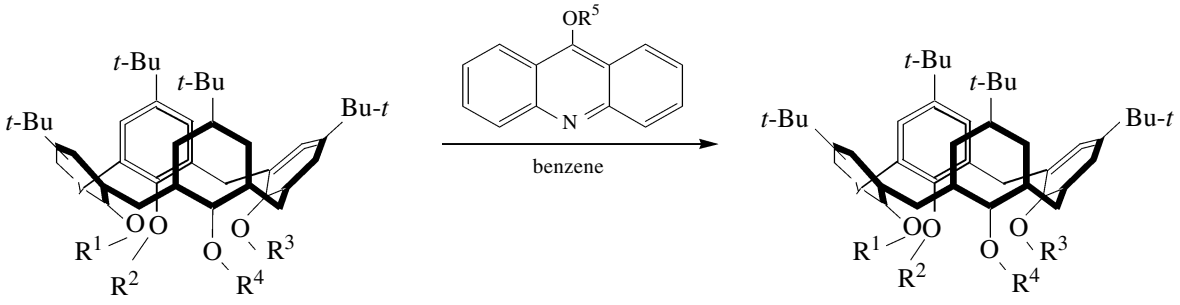
Numerous studies on functionalization of calix[*n*]arenes and complexing ability of their various derivatives [1] revealed that their complexing power and selectivity to metal cations, as well as the stability of the resulting complexes, depend not only on the nature of substituents in the macroring but also on their topology and conformation of the calixarene framework. Calixarene derivatives in which the substituents possess various donor centers, in particular oxygen and nitrogen atoms [2–4], attract considerable interest from the viewpoint of synthesizing ligands capable of binding metal cations. It is known that the presence of nitrogen-containing fragments in calixarene molecules enhances their extraction ability toward lantanides and actinides [4–6]. In addition, the presence of aromatic moieties in functional groups increases the quantum yield of 4*f* luminescence.

With a view of searching for new complexing agents in the series of calix[4]arenes, we examined reactions of hydrazide derivatives of *p-tert*-butylcalix[4]arene (**I**) with 9-alkoxyacridine, fluoren-9-one, and hydroxy-substituted fluoren-9-ones. As starting compounds we selected mono-, bis-, and tetrakis[(hydrazinocarbonyl)methoxy]-*p-tert*-butylcalix[4]arenes **II**–**IV** which were synthesized according to the procedure described in [7, 8]. Acridinyl-containing *p-tert*-butylcalix[4]arenes were obtained by heating the corresponding hydrazide and 9-methoxy- or 9-ethoxyacridine in benzene in the presence of a



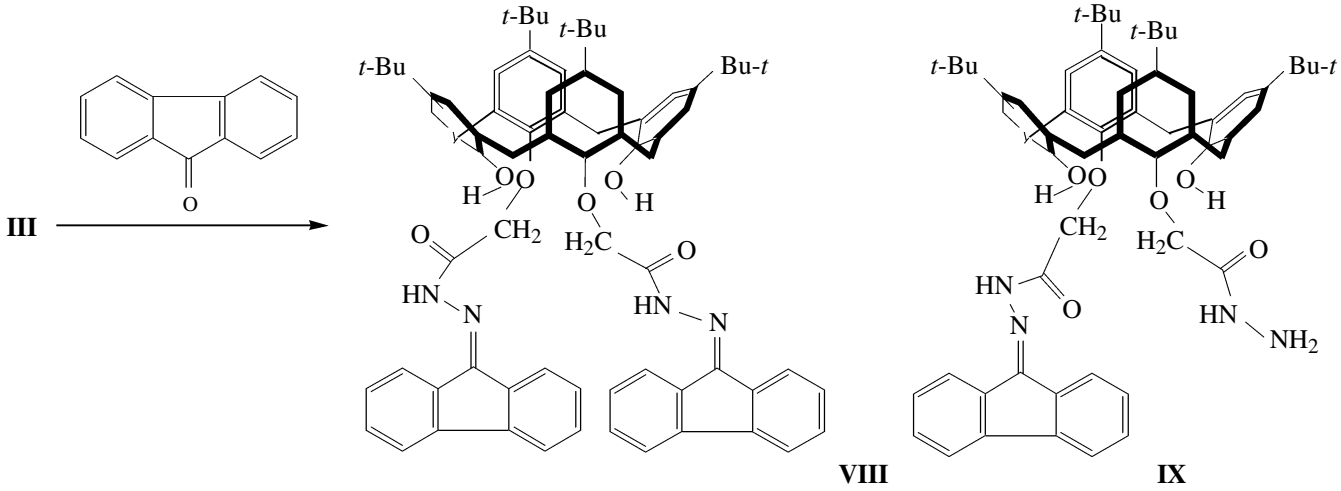
II–**IV** **V**–**VII**

II, $R^1 = CH_2CONHNH_2$, $R^2 = R^3 = R^4 = H$; **III**, $R^1 = R^3 = CH_2CONHNH_2$, $R^2 = R^4 = H$; **IV**: $R^1 = R^2 = R^3 = R^4 = CH_2CONHNH_2$; **V**, $R^1 = CH_2CONHNHAcr$, $R^2 = R^3 = R^4 = H$, $R^5 = Me$; **VI**: $R^1 = R^3 = CH_2CONHNHAcr$, $R^2 = R^4 = H$, $R^5 = Me$; **VII**: $R^1 = R^3 = CH_2CONHNHAcr$, $R^2 = R^4 = CH_2CONHNH_2$, $R^5 = Et$; Acr = acridin-9-yl.

catalytic amount of methanol. (*N*'-Acridinylhydrazinocarbonyl)methoxy-*p*-*tert*-butylcalix[4]arenes **V**–**VII** were isolated by column chromatography and preparative thin-layer chromatography on silica gel using benzene–methanol–triethylamine as eluent. The yields of **V**–**VII** were 50–65%; these compounds are yellow high-melting crystalline substances.

It should be noted the reaction of tetrahydrazide **IV** with ethoxyacridine leads to a mixture of several products, the major of which being compound **VII** containing two acridinylhydrazide groups and two unsubstituted hydrazide fragments. A probable reason is steric hindrances arising from addition at the lower rim of such bulky fragments as acridine. Analysis of the resonance pattern of protons in the *tert*-butyl and methylene groups and aromatic fragments in compounds **V**–**VII** showed that their molecules adopt mainly *cone* conformation.

The reaction of calixarene **III** with fluoren-9-one at a ratio of 1 : 10 (5 equiv of carbonyl functionality per hydrazide group) was carried out by heating the reactant mixture in benzene in the presence of a catalytic amount (10 mol%) of acetic acid. From the reaction mixture we isolated compounds **VIII** and **IX**. Change of the calixarene-to-fluorenone ratio to 1 : 2 or 1 : 4 led to the formation of monofluorenylidene-substituted derivative **IX** as the major product.



We failed to effect analogous transformations of hydrazide **III** with 2-hydroxy- or 2,7-dihydroxyfluoren-9-one. Monosubstituted calixarene was isolated in 10% yield only in the reaction of **III** with 2-hydroxyfluoren-9-one. Presumably, the presence of hydroxy groups in the fluorenone molecule affects the reaction course in acidic medium. Using 2-propoxy-, 2,7-dipropoxy-, and 2-hydroxy-7-propoxyfluoren-2-ones instead of hydroxy derivatives (reactant ratio 1 : 10), we obtained the corresponding disubstituted propoxyfluorenylidenehydrazinocarbonylmethoxy-*p*-*tert*-butylcalix[4]arene **X**, a mixture of mono- and disubstituted dipropoxyfluorenylidenehydrazinocarbonylmethoxy-*p*-*tert*-butylcalix[4]arenes **XI** and **XII** in an overall yield of 65%, and monopropoxyhydroxyfluorenylidene-substituted hydrazide **XIII** in 35% yield.

It should be noted that the products formed along the entire transformation sequence bis(methoxycarbonylmethoxy)-*p*-*tert*-butylcalix[4]arene → hydrazide **III** → compounds **VIII**–**XIII** contained potassium cations. The formation of a calixarene complex with potassium cation is possible at the stage of alkylation of *p*-*tert*-butylcalix[4]arene, which is performed in the presence of potassium carbonate as a base. The presence of potassium followed from the mass spectra (FAB) of both initial calixarene containing two ester groups and its hydrazide derivative **III**, which displayed a strong peak from the $[M + K]^+$ ion (*m*/*z* 831). The other hydrazino derivatives also showed the corresponding $[M + K]^+$ ion peaks in the mass spectra. In the ^{1}H NMR spectra of complex–free ligand mixtures of both hydrazides and fluorenylidenehydrazides we observed characteristic averaging of signals from protons on the nitrogen atoms. For example, the ^{1}H NMR spectrum of **XI** contained signals from the hydrazide protons as a doublet and a broadened singlet for the free ligand and two broadened signals in a weaker field for the complex. The spectral pattern is similar for compounds **VIII**–**X** and **XIII**.

Thus we have demonstrated one more way of modifying the hydrazide group at the lower rim of calixarenes; in some cases, it ensures synthesis of unsymmetrically substituted macrorings and preparation of various calix[4]arene derivatives with the same conformation of the macroring as in the initial compound.

EXPERIMENTAL

The ^{1}H NMR spectra were recorded on a Varian VXR-300 spectrometer (300 MHz) from ~10% solutions in $CDCl_3$ using TMS as internal reference. The mass spectra (fast atom bombardment, Xe, 8 keV) were obtained on a VG 70-70EQ mass spectrometer. Analytical thin-layer chromatography was performed using Silufol UV-254 plates.

Reaction of calixarene II with 9-alkoxyacridines *(general procedure).* A solution of 1 mmol of compound **II** in 50 ml of anhydrous benzene containing 0.1 ml of methanol was heated to reflux, and a solution of 15 mmol of 9-methoxy- or 9-ethoxyacridine in 15 ml of benzene was added over a period of 20 min. The mixture was refluxed for 2 h under continuous stirring and cooled, the solvent was removed under reduced pressure, and the residue was treated with boiling heptane to remove excess alkoxyacridine. The crude product was purified by column chromatography on silica gel using benzene–methanol–triethylamine (2 : 0.5 : 0.1) as eluent.

25-[*N*'-(Acridin-9-yl)hydrazinocarbonylmethoxy]-5,11,17,23-tetra-*tert*-butyl-26,27,28-trihydroxycalix[4]arene (V). Yield 65%, mp 270–272°C. Mass spectrum: *m/z* 884 $[M + 1]^+$. ^{1}H NMR spectrum, δ, ppm: 1.01 s [9H, $(CH_3)_3C$], 1.20 s [18H, $(CH_3)_3C$], 1.21 s [9H, $(CH_3)_3C$], 3.02 d (2H, ArCH_2Ar, J = 13 Hz), 3.1 d (2H, ArCH_2Ar, J = 14.6 Hz), 4.22 d (2H, ArCH_2Ar,), 4.33 d (2H, ArCH_2Ar), 4.74 s (2H, CH_2CO), 6.94 d (2H, H_{arom}, J = 2.3 Hz), 7.00 d (2H, H_{arom}), 7.1 s (2H, H_{arom}), 7.12 s (2H, H_{arom}), 7.14–8.21 m (8H, Acr), 8.6 s (1H, NH), 9.4 br.s (2H, OH), 9.6 s (1H, NH), 10.01 s (1H, OH).

25,27-Bis[*N*'-(acridin-9-yl)hydrazinocarbonylmethoxy]-5,11,17,23-tetra-*tert*-butyl-26,28-dihydroxycalix[4]arene (VI). Yield 57%, mp 279–281°C. Mass spectrum: *m/z* 1119 $[M + 1]^+$. ^{1}H NMR spectrum, δ, ppm: 1.18 s [18H, $(CH_3)_3C$], 1.19 s [18H, $(CH_3)_3C$], 3.4 d (2H, ArCH_2Ar, J = 13 Hz), 4.27 d (2H, ArCH_2Ar, J = 14 Hz), 4.42 d (2H, ArCH_2Ar), 4.45 d (2H, ArCH_2Ar), 4.8 s (4H, CH_2CO), 6.98 s (4H, H_{arom}), 7.13 s (4H, H_{arom}), 7.14–8.22 m (16H, Acr), 8.4 s (2H, NH), 9.2 s (2H, NH), 9.4 s (2H, OH).

25,27-Bis[*N*'-(acridin-9-yl)hydrazinocarbonylmethoxy]-5,11,17,23-tetra-*tert*-butyl-26,28-bis(hydrazinocarbonylmethoxy)calix[4]arene (VII) was isolated by column chromatography on silica gel using benzene–methanol–triethylamine (2 : 0.4 : 0.1) as eluent. Yield 50%, mp 295–297°C. Mass spectrum: *m/z* 1263 $[M + 1]^+$. ^{1}H NMR spectrum, δ, ppm: 1.1 s [18H, $(CH_3)_3C$], 1.15 s [18H, $(CH_3)_3C$], 3.36 d (2H, ArCH_2Ar, J = 14.3 Hz), 4.25 d (2H, ArCH_2Ar), 4.38 s (4H, CH_2CO), 4.42 s (4H, CH_2CO), 6.8 s (4H, H_{arom}), 7.12 s (4H, H_{arom}), 7.12–8.22 m (16H, Acr), 8.4 s (2H, NH), 8.6 s (4H, NH), 9.2 s (2H, NH), 9.45 s (2H, NH).

Synthesis of calixarene derivatives containing fluorenylidenehydrazide fragments *(general procedure).* A suspension of 0.45 mmol of calixarene **III**, 1.8 mmol of the corresponding fluorenone, and 0.18 mmol of acetic acid in 20 ml of benzene was heated for 15 h under reflux with vigorous stirring. The mixture was cooled, the solvent was removed under reduced pressure, and the crude product was purified by recrystallization first from heptane and then from ethanol.

5,11,17,23-Tetra-*tert*-butyl-26,28-bis[*N*'-(fluoren-9-ylidene)hydrazinocarbonylmethoxy]-25,27-dihydroxycalix[4]arene (VIII). mp 110–112°C. Mass spectrum: *m/z* 1155 $[M + K]^+$. ^{1}H NMR spectrum, δ, ppm (hereinafter, the data for a sample containing no potassium cation are given): 1.05 s [18H, $C(CH_3)_3$], 1.27 s [18H, $C(CH_3)_3$], 3.44 d (4H, ArCH_2Ar), 4.11 d (4H, ArCH_2Ar, J = 11.45 Hz), 4.64 s (4H, CH_2CO), 6.94 s (4H, H_{arom}), 7.08 s (4H, H_{arom}), 7.79 br.s (2H, OH), 7.4–8.4 m (14H, Flu), 10.4 br.s (2H, NH).

5,11,17,23-Tetra-*tert*-butyl-26-[*N*'-(fluoren-9-ylidene)hydrazinocarbonylmethoxy]-28-(hydrazinocarbonylmethoxy)-25,27-dihydroxycalix[4]arene (IX). mp 156–158°C. Mass spectrum: *m/z* 993 $[M + K]^+$. ^{1}H NMR spectrum, δ, ppm: 1.1 s [9H, $C(CH_3)_3$], 1.23 s [18H, $C(CH_3)_3$], 1.25 s [9H, $C(CH_3)_3$], 3.3 d (2H, ArCH_2Ar, J = 13.2 Hz), 3.5 d (2H, ArCH_2Ar), 4.02 d (2H, ArCH_2Ar), 4.2 d (2H, ArCH_2Ar, J = 13.2 Hz), 4.3 s (2H, CH_2CO), 4.39 s (2H, CH_2CO), 6.97 s (2H, H_{arom}), 7.04 s (2H, H_{arom}), 7.05 d (2H, H_{arom}), 7.09 d (2H, H_{arom}, J = 2.3 Hz), 7.28–8.1 m (7H, Flu), 8.3 d (2H, NH_2), 9.4 br.s (1H, NH), 9.6 br.s (1H, NH), 10.1 br.s (2H, OH).

5,11,17,23-Tetra-*tert*-butyl-25,27-dihydroxy-26,28-bis[*N*'-(2-propoxyfluoren-9-ylidene)hydrazinocarbonylmethoxy]calix[4]arene (X). mp 240–243°C. Mass spectrum: *m/z* 1109 $[M + K]^+$. ^{1}H NMR spectrum, δ, ppm: 0.8–1.2 m (10H, C_3H_7), 1.15 s [18H, $C(CH_3)_3$], 1.2 s [18H, $C(CH_3)_3$], 2.25 m (4H, C_3H_7), 3.5 d (2H, ArCH_2Ar, J = 13.2 Hz), 4.35 d (2H, ArCH_2Ar), 4.45 d (2H, ArCH_2Ar), 4.6 d (2H,

ArCH_2Ar, J = 14.0 Hz), 4.7 s (4H, CH_2CO), 6.82 s (4H, H_{arom}), 7.78 s (4H, H_{arom}), 7.3–8.15 m (14H, Flu), 9.1 s (2H, OH), 10.8 s (2H, NH).

5,11,17,23-Tetra-*tert*-butyl-26-[*N*'-(2,7-dipropoxyfluoren-9-ylidene)hydrazinocarbonylmethoxy]-28-(hydrazinocarbonylmethoxy)-25,27-dihydroxycalix[4]arene (XI). mp 210–211°C. Mass spectrum: *m/z* 1387 $[M + K]^+$. ^{1}H NMR spectrum, δ, ppm: 0.9–1.1 m (10H, C_3H_7), 1.01 s [9H, $C(CH_3)_3$], 1.20 s [18H, $C(CH_3)_3$], 1.21 s [9H, $C(CH_3)_3$], 2.5 m (4H, C_3H_7), 3.02 d (2H, ArCH_2Ar), 3.1 d (2H, ArCH_2Ar, J = 13.1 Hz), 4.22 d (2H, ArCH_2Ar), 4.33 d (2H, ArCH_2Ar, J = 14.6 Hz), 4.5 s (2H, CH_2CO), 4.52 s (2H, CH_2CO), 6.94 d (2H, H_{arom}), 7.00 d (2H, H_{arom}), 7.02 s (2H, H_{arom}), 7.04 s (2H, H_{arom}), 7.38–8.3 m (6H, Flu), 8.4 d (2H, NH_2), 9.52 br.s (1H, NH), 10.0 br.s (1H, NH), 10.2 br.s (2H, OH).

5,11,17,23-Tetra-*tert*-butyl-25,27-dihydroxy-26,28-bis[*N*'-(2,7-dipropoxyfluoren-9-ylidene)hydrazinocarbonylmethoxy]calix[4]arene (XII). mp 235–237°C. Mass spectrum: *m/z* 1109 $[M + K]^+$. ^{1}H NMR spectrum, δ, ppm: 0.8–1.2 m (20H, C_3H_7), 1.18 s [18H, $C(CH_3)_3$], 1.19 s [18H, $C(CH_3)_3$], 2.3 m (8H, C_3H_7), 3.4 d (2H, ArCH_2Ar, J = 13.0 Hz), 4.27 d (2H, ArCH_2Ar), 4.42 d (2H, ArCH_2Ar), 4.45 d (2H, ArCH_2Ar, J = 14.0 Hz), 4.8 s (4H, CH_2CO), 6.98 s (4H, H_{arom}), 7.99 s (4H, H_{arom}), 7.4–8.23 m (12H, Flu), 9.2 s (2H, OH), 11.0 br.s (2H, NH).

5,11,17,23-Tetra-*tert*-butyl-28-(hydrazinocarbonylmethoxy)-25,27-dihydroxy-26-[*N*'-(7-hydroxy-2-propoxyfluoren-9-ylidene)hydrazinocarbonylmethoxy]calix[4]arene (XIII). mp 250°C. Mass spectrum: *m/z* 1067 $[M + K]^+$. ^{1}H NMR spectrum, δ, ppm: 0.9–1.1 m (5H, C_3H_7), 1.2 s [9H, $C(CH_3)_3$], 1.21 s [18H, $C(CH_3)_3$], 1.24 [9H, $C(CH_3)_3$], 2.3 m (2H, C_3H_7), 3.3 d (2H, ArCH_2Ar, J = 14 Hz), 3.45 d (2H, ArCH_2Ar), 4.2 d (2H, ArCH_2Ar), 4.35 s (2H, CH_2CO), 4.5 d (2H, ArCH_2Ar, J = 14.3 Hz), 4.56 s (2H, CH_2CO), 6.86 d (2H, H_{arom}), 7.01 d (2H, H_{arom}), 7.1 s (2H, H_{arom}), 7.14 s (2H, H_{arom}), 7.4–8.34 m (6H, Flu), 8.5 d (2H, NH_2), 9.6 br.s (1H, NH), 10.2 br.s (2H, OH), 10.34 br.s (1H, OH), 11.0 br.s (1H, NH).

REFERENCES

1. Asfari, Z., Bohmer, V., Harrowfield, J., and Vicens, J., *Calixarenes 2001,* Dordrecht: Kluwer, 2001.
2. Dominik, A., Roth, H.J., Schierbaum, K.D., and Göpel, W., *Supramol. Sci.,* 1994, vol. 1, p. 111.
3. Liu, Yu, Wang, H., Wang, L.-H., and Zhang, H.-Y., *Thermochim. Acta,* 2004, vol. 414, no. 1, p. 65.
4. Ogden, M.I., Skelton, B., and White, A.H., *C.R. Chim.,* 2005, vol. 8, no. 1, p. 181.
5. Ulrich, G., Ziessel, R., Manet, I., Guardigli, M., Sabbatini, N., Fraternali, F., and Wipff, G., *Chem. Eur. J.,* 1997, vol. 3, no. 11, p. 1815.
6. Deligoz, H., Ozen, O., Cilgi, K.G., and Cetisli, H., *Thermochim. Acta,* 2005, vol. 426, no. 2, p. 33.
7. Alekseeva, E.A., Bacherikov, V.A., Gren', A.I., Mazepa, A.V., Gorbatyuk, V.Ya., and Krasnoshchekaya, S.P., *Russ. J. Org. Chem.,* 2000, vol. 36, no. 9, p. 1321.
8. Alekseeva, E.A., Krasnoshchekaya, S.P., and Gren', A.I., *Russ. J. Gen. Chem.,* 2002, vol. 72, no. 1, p. 157.