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Norcubanes From Cubanes
Novel Reaction Of Amidocubanes With Oxalyl Chloride

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Summary: Amidocubanes react with oxalyl chloride via a ring opening-addition process to give substituted norcubanes.
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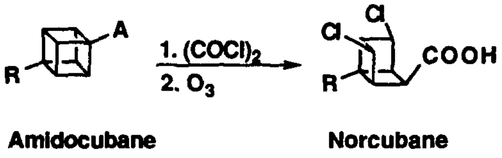
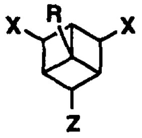
Recently we reported photochemical reaction of carboxy- and nitrocubanes with oxalyl chloride.[1] Many interesting t_d-substituted cubanes were obtained and their use in the area of combinatorial chemistry,[2] materials[3] and explosives is being explored.[4,5]

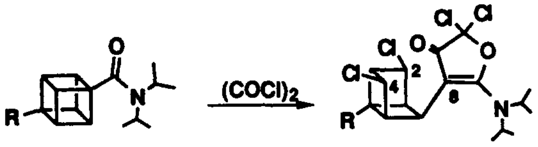
We now report synthesis of another tetrahedrally substituted cage system, tricycloheptane(norcubane),[6] by unusual reactions of 1,4-disubstituted amidocubanes with oxalyl chloride.





In the extension of our studies on the effects of functional groups on the regioselectivity of chlorocarbonylation, some interesting results were obtained. Reaction of diisopropylamidocyanocubane (**1**) with oxalyl chloride at room temperature gave a tetra-substituted tricycloheptane(**2**) in >90%

yield.[7] The structure of compound **2** was unequivocally determined by X-ray crystallography.[8]

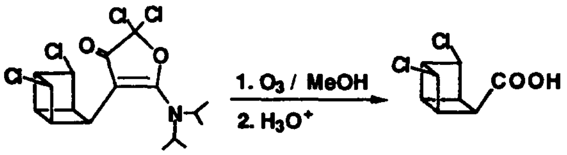


1 R= CN
3 R= H
5 R= CON(i-Pr)$_2$

2 R= CN
4 R= H
6 R= CON(i-Pr)$_2$

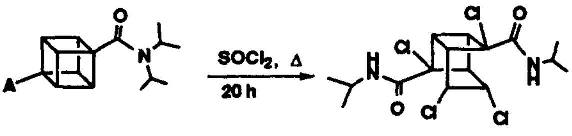
The ^{1}H NMR of compound **2** is quite simple and shows only four resonances at 4.35(s, 2H), 4.19(t, 1H), 3.66(dd, 2H) and 3.38(t, 1H) ppm for the cage protons and two resonances at 3.77(sept, 2H) and 1.42(d, 12H) for the isopropyl hydrogens. The furanone ring is invisible by ^{1}H NMR because of its perchlorination.[9]

An interesting feature of compound **2** is the formation of a substitution pattern at alternate positions of the tricycloheptane ring. Single crystal X-ray of compound **2** shows two chlorine atoms occupying exo positions relative to the tricycloheptane skeleton. Of particular interest is that the distances from carbon atoms C_2 and C_4 to C_8 are 3.10 Å and 3.13 Å, shorter than the non-bonded Van der Waals contact distance which usually ranges from 3.20 Å to 3.40 Å. This close proximity of the C_2 and C_4 to C_8 could lead to the construction of very desirable molecules such as azacubanes via the transformation of the furanone ring to a carboxy and then to an amino group. In fact, the dichlorofuranone ring was simply converted to a carboxy group by ozonolysis in methanol followed by acidic hydrolysis of the ester. The yield of **7** (mp. 144-145 °C) from **4** was 41%.



4 **7**

Reaction of oxalyl chloride with 1,4-diamidocubane (**5**) was completed within one hour to give compound **6** (mp. 190-191 °C) in 86% yield. In this reaction, both bond breakages on the cubane skeleton occur simultaneously at one amido site without participation of the other amido substituent. This is the first example in which adjacent cubane carbon-carbon bonds are broken to give a substituted tricycloheptane ring system. In similar cases, usually, two non-neighboring bonds are cleaved.[10] For example, reaction of 1,4-diamidocubane **5** with thionyl chloride results in the more stable configuration, nortwistbrendane(**8**) (mp. 163-166 °C) in 46% yield.



5 **8**

Novel reaction of oxalyl chloride with amidocubanes opens up a new approach for construction of interesting cage systems. These unique carbocyclic rings are potential core molecules for use in combinatorial chemistry, dendrimers, liquid crystals and energetic materials. The extension of this work as well as the mechanistic aspects of these transformations are under study.

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7. In a typical experiment, 1.0 g of amidocubane**(3)** was treated with 20.0 ml of oxalyl chloride at room temperature for 30 min.(^{1}H NMR). The reaction mixture was concentrated, diluted with methylene chloride and successively washed with aqueous(5%) NaHCO$_3$ and brine. The organic layer was dried over anhydrous Na$_2$SO$_4$ and concentrated. The solid residue was triturated with ether to give compound **4**(mp. 169-171 °C) in 94% yield.
8. Crystals of **2** from hexanes are in monoclinic space group P2$_1$/n. Unit cell: a = 13.809(1), b = 8.929(1), c = 18.427(1) Å, b = 98.906(3), Z = 4 at -50 °C. R= 0.0407, wR2=0.0895 for 2463 unique reflections with I>2sig(1). Details of the X-ray structure analysis are available from the Director of the Cambridge Crystallographic Data Center,12 Union Road, Cambridge CB2 1EZ(UK).
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