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CIRCULAR DICHROISM—LXIV[1]

ON THE CHIROPTICAL PROPERTIES OF SICCANIN DERIVATIVES AND THE ABSOLUTE CONFIGURATION OF SICCANOCHROMENE-A

S. NOZOE and K. HIRAI[a]
Institute of Applied Microbiology, University of Tokyo, Bunkyo-ku, Tokyo, Japan

and

F. SNATZKE and G. SNATZKE*
Lehrstuhl für Strukturchemie, Ruhr-Universität Bochum (D), West Germany

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Abstract—The $^1B_{2u}$-band CD of siccanin (3) and some of its derivatives obeys the known rules for the benzene chromophore with the appropriate substitution pattern. The CD spectrum of the chromanone **8** is better resolved than that of related flavanones, the band between 300–320 nm is most probably the $^1B_{2u}$-band of this chromophore. The non-planar styrenes **10–12** symmetrically substituted in the benzene ring with respect to the "pivot" bond follow *Crabbé's* rule, and the absolute configuration of siccanochromene-A (**13**) in the chromene ring follows from its CD to be *S*.

Zusammenfassung—Der CD der $^1B_{2u}$-Bande von Siccanin (3) und einigen seiner Derivate folgt den bekannten Regeln für den Benzol-Chromophor des entsprechenden Substitutions-musters. Das CD-Spektrum des Chromanons **8** ist besser aufgelöst als das verwandter Flavanone, die Bande zwischen 300–320 nm ist wahrscheinlich die $^1B_{2u}$-Bande dieses Chromophors. Die nichtkoplanaren Styrole **10–12**, die im Benzolring symmetrisch in Bezug auf die "zentrale" Bindung substituiert sind, folgen der Regel von *Crabbé* und die absolute Konfiguration von Siccanochromen-A (**13**) im Chromenring lässt sich aus dem CD zu *S* bestimmen.

Siccanin (3) is a prenylphenol whose structure (including absolute configuration) has been determined by X-ray analysis.[2] In spite of *cis*-fusion of the nonaromatic rings only one conformation is possible for this molecule, and also for those derivatives in which the dihydropyrane ring is opened. The analysis of the chiroptical data of **3–12** is thus not complicated by conformational mobility.

Siccanin and other chromanes. Siccanin (3) contains as the only chromophore the substituted benzene ring, for which three to four CD-bands may be expected (260–280 nm: $^1B_{2u}$; 210–230 nm: $^1B_{1u}$ with admixture of some $n_0 \rightarrow \pi_{ar}$-CT; couplet between 180–210 nm: $^1E_{1u}$).[3] For a tetralin or related compound the sign of the first of these can be correlated quite safely with the preferred chirality of the nonaromatic ring if one takes into account the substitution pattern of the benzene ring (*cf* Fig 1). For chromanes or flavanes the contribution of a benzylic polar group like OH may, however, outweigh the effect of ring conformation: **1** gives a positive, **2** a negative Cotton effect at appr. 280 nm.[5]

As seen from molecular models the dihydropyrane ring of siccanin (3) and its derivatives **4–7** adopts *M*-helicity which according to the corresponding rule[3,6] for this substitution pattern must lead to a positive Cotton effect for the band at 260–280 nm. This is indeed the case for all of them and the rotational strength is bigger for **3** than for **5**; most probably this is due to the complete rigidity of the dihydropyrane ring in **3**, whereas in **5** (and its derivatives) some flattening of this ring will reduce its chirality.

Augmentation of this Cotton effect is also obtained by changing the substitution at the benzene ring, e.g. by acylation of the phenolic hydroxy group. For siccanin acetate (4) $\Delta\epsilon_{max}$ is three times that of **3**, and the CD of the mesylate (**6**) and tosylate (**7**) of **5** is nearly ten times as big as that of the phenol **5**.

A distinct $^1B_{1u}$ CD-band is seen only in the spectrum of **3**, and the strong negative Cotton effect around 205–215 nm is already the first peak of the $^1E_{1u}$-couplet.

The chromanone **8**. CD spectra of flavanones have been investigated by different groups (e.g.[7-10]) and the band at longest wavelengths which is as-

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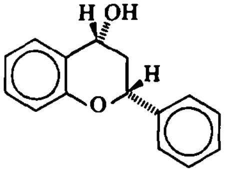
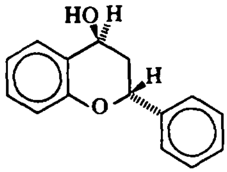
[a] Present address: Central Research Laboratories, Sankyo Co., Ltd. Hiromachi, Shinagawa-ku, Tokyo, Japan.



1



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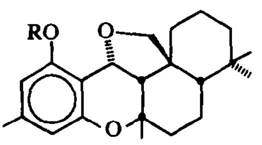
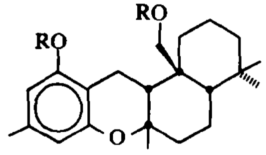
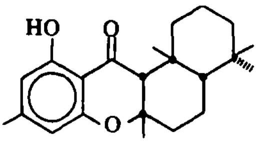


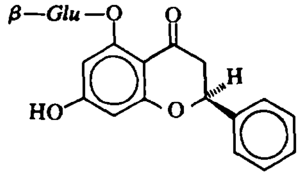
3: R = H (Siccanin)
4: R = Acetyl



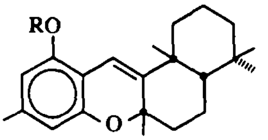
5: R = H
6: R = Mesyl
7: R = Tosyl



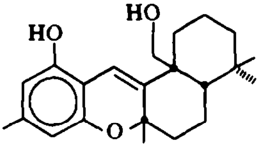
8



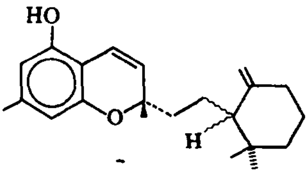
9: (−)-Naringenin-β-D-glucoside



10: R = H
11: R = Acetyl



12: Siccanochromene-E



13: Siccanochromene-A

sumed to be due to an $n \rightarrow \pi^*$-transition can be correlated with the preferred conformation of the dihydropyrane ring using the rule proposed for the acetophenone type chromophore.[7] Fig 2 shows the CD spectrum of the chromanone **8** prepared from siccanin, and for comparison also that of (−)-naringenin glucoside (**9**)§ having a similar substitution pattern in the aromatic ring. In the preferred conformation of **9** the *para*-hydroxy phenyl ring will adopt the equitorial position so the chirality of the dihydropyrane ring must be enantiomeric to that of ketone **8**. Indeed the band at longest wavelengths for the latter is negative whereas the corresponding CD-band of **8** is positive. The CD spectrum of **8** shows altogether four bands between 200 and 360 nm, that of **9** apparently only three. A more careful inspection of this CD spectrum and comparison with that of **8** (Fig 2) reveals, however, a shoulder approximately at 290 nm in the CD spectrum of **9** whose position corresponds to the strong UV-max ascribed[11] to the "conjugation band". The 300–320 nm band may then correspond to the $^1B_{2u}$-transition whose CDs are again of oppo-

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§We thank Prof. R. Hänsel, Berlin also here for providing us with a sample of **9**.

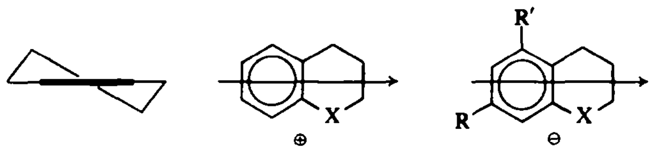

Fig 1. *P*-helicity of the nonbenzoid ring (projection in direction of the arrow) leads to positive CD within the $^1B_{2u}$-band for tetralins or analogous compounds not further substituted in the benzene ring, but to negative CD if substituted as indicated in the right formula[3] (X = CR_2 or O).

site signs for the two compounds **8** and **9**. The CD within the conjugation band seems to be strongly influenced (sign inversion) by the substituent in *para*-position to the carbonyl group which is OH in case of **9** but methyl in case of **8**.

The chromene chromophore. The chromene structure forms essentially a styrene chromophore, for which Crabbé[12] has proposed the rule, that a negative torsion angle between the C=C double bond and that side of the benzene ring which is nearer to it gives rise to a positive Cotton effect around 260–290 nm. The substitution pattern of the benzene ring is not taken into account, which has been questioned, however.[3] The three chromenes **10–12** give indeed a positive Cotton effect as predicted by Crabbé's rule[12] and here it is easily explained why the substituents on the benzene ring have no influence upon the sign of the CD. The methyl group is in *para*-position to the bond connecting the phenyl ring with the C=C-bond ("pivot bond"), and is thus collinear with it. The two oxygen functions (the OH-group and the chromene ring oxygen) are both *ortho*-positioned with respect to the same pivot bond so on symmetry arguments

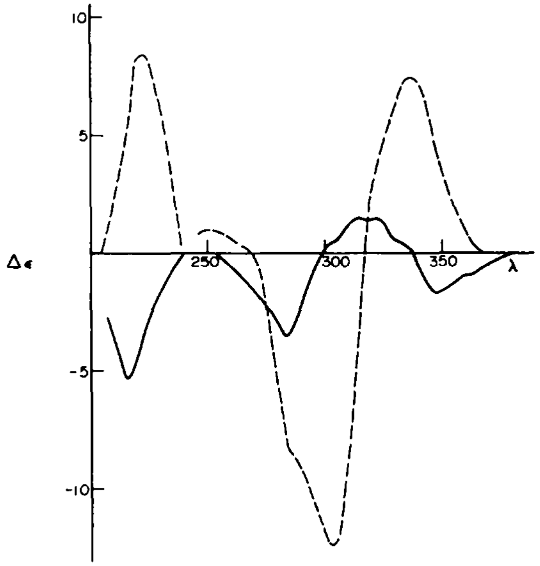

Fig 2. CD spectrum of **8** (—, in acetronitril) and **9** (------, in ethanol).

Table 1. CD-maxima of siccanin (**3**) and related compounds

Compound	Solvent[a]	CD-maxima given as λ_{max} ($\Delta\epsilon$)
Siccanin **3**[2,14]	A	283(+1·43), 276sh(+1·13), 236(−1·55) 213(−8·0)
Siccanin acetate **4**[14]	A	281(+3·21), 278(+2·88), 207(−30·0)
5[14]	A	281(+0·23), 275sh(+0·13), 214(−5·8)
6[14]	A	281(+1·88), 277sh(+1·79), 234(−0·5)
7[14]	A	283(+1·74), 277sh(+1·48), 271(+0·72), 265(−0·22), 236(−4·17), 225(+5·0)
8[14]	A	364sh(−0·85), 348(−1·66), 335sh(+0·28), 322(+1·46), 312(+1·42), 303sh(+0·56), 284(−3·70), 217(−5·4)
9	E	335(+7·6), 302(−12·6), 286sh(−8·6), 250(+1·2), 220(+8·7)
10[14]	A	336sh(+0·43), 315sh(+1·21), 286(+4·31) 236(−9·39), positive below 210 nm
11[14]	A	315(+0·64), 283(+1·81), 275(+1·89), 232(−3·26)
Siccanochromene-E **12**[15]	A	314(−1·96), 282(+1·92), 222(−9·34), 202(+9·0)
Siccanochromene-A **13**[16,17]	A	321(+0·10), 312(−0·18), 289sh(+2·18), 277(+2·82), 210(+5·1)

[a] A: acetonitril, E: ethanol.

the Me group can have no influence at all, those of the two oxygen functions must compensate each other.

With these CD spectra of the compounds **10–12** at hand one can determine the hitherto unknown absolute configuration of the chiral center in the chromene ring of siccanochromene-A (**13**). If one makes the reasonable assumption that the bigger of the two geminal substituents in the chromene ring will adopt the equatorial conformation then the styrene chromophore of **13** is also not coplanar. As the Cotton effects around 280 nm are positive for all four compounds **10–13** the chirality of the styrene chromophore has to be the same, too. This can only be achieved if siccanochromene-A (**13**) has *S*-configuration at the chiral center in the chromene ring. Of course no conclusions can be drawn from the CD spectra about the absolute configuration at the second chiral center within the cyclohexane ring.

The CD between 300 and 360 nm of **10** and its acetate **11** is positive, whereas it is negative for siccanochromene-E (**12**). In this region the $^1B_{2u}$-CD-band is expected and it is interesting to notice the pronounced influence of an OH-group relatively far away upon the sign of these bands in such styrenes. Around 200 nm strong positive CD-bands could be observed for **12** and **13**, unfavourable g-factors[13] prevented similar measurements for **10** and **11**.

CD spectra were recorded with a Jouan-Roussel dichrograph II at 20° and at concentrations of appr. 1 mg/ml in cells of 0·01–1·00 cm thickness. "sh" refers to a shoulder.

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