Chelated Flavonol Co-ordination in Flavonolatobis(triphenylphosphine)copper(I)

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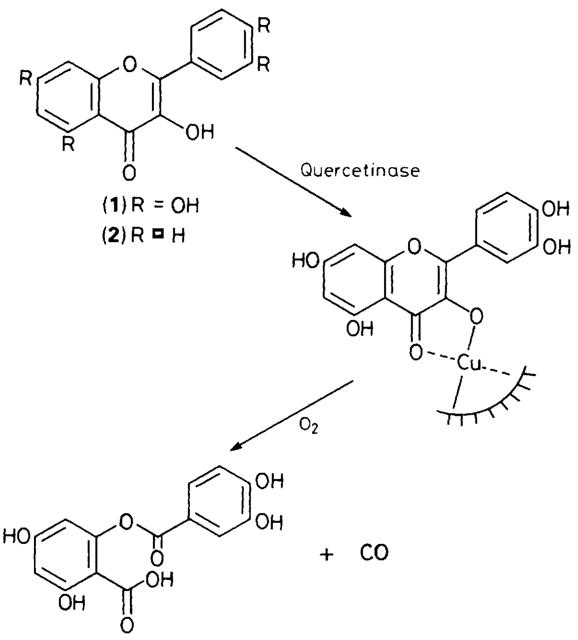
3-Hydroxyflavone co-ordinates to copper(I) by its 3-hydroxy and 4-carbonyl groups together with two triphenylphosphines to form a distorted tetrahedron with a high electron delocalization on the flavonolate ligand, as shown by an *X*-ray crystal structure determination.

In the microbial metabolism of rutin by *Aspergillus* or *Pulmalaria* species quercetin (3′,4′,5,7-tetrahydroxyflavonol) (**1**) is degraded into a depside (phenolic carboxylic acid ester) and carbon monoxide.[1—3] Quercetinase, a Cu^{II}-containing dioxygenase responsible for the enzymatic reaction, has been purified and characterized.[4] The formation of a Cu chelate of quercetin is postulated as the key intermediate (Scheme 1). Quercetin is known to form a stable Cu^{II} chelate presumably by co-ordination at the 3-hydroxy and 4-carbonyl groups.[5] In model catalytic oxygenations copper(II) compounds have been used successfully.[6]



The aim of this project is to determine the mode of co-ordination of flavonol (Hfla) (**2**) to copper which may give relevant information for the enzyme–quercetin interaction. To a stirred solution of flavonol (10 mmol) in anhydrous tetrahydrofuran (100 ml) sodium (10 mmol) was added under an inert atmosphere. After dissolution of the sodium, triphenylphosphine (20 mmol) and CuCl (10 mmol) were added. The mixture was stirred for 1 h, solvent evaporated off *in vacuo*, and the residue treated with ether and then recrystallized from ether to give orange crystals of Cu(fla)(PPh$_3$)$_2$. The complex shows bands in the UV-VIS region at 232 (log ε 4.89), 272 (4.54), and 426 (3.88) nm and a strong IR absorption at 1560 cm^{-1}. This can be assigned to ν(CO), showing a decrease of *ca.* 40 cm^{-1} compared to flavonol [ν(CO) 1602 cm^{-1}] due to chelation and formation of a stable five-membered ring.[7]

The crystal structure of Cu(fla)(PPh$_3$)$_2$† is shown in Figure 1. The complex has a distorted tetrahedral geometry around copper(I) with the flavonol chelating through the 3-hydroxy and 4-carbonyl groups. Copper–oxygen bond distances are surprisingly longer [Cu–O(2) 2.051(4); Cu–O(3) 2.167(5) Å] than those found in [Cu$_4$(OBu^t)$_4$] [Cu–O$_{av.}$ 1.854(9) Å][8] and in [Cu$_2$Cl$_2$(OMe)$_2$(py)$_2$] [1.932(4) and 1.940(6) Å; py = pyridine].[9] The P(1)–Cu–P(2) angle [124.5(1)°] is larger and the O(1)–Cu–O(3) angle [79.2(3)°] much smaller than expected for tetrahedral geometry around the copper atom. Owing to the distortion of the tetrahedron the two phosphorus atoms are non-equivalent but this could not be detected by ^{31}P NMR spectroscopy owing to line broadenings caused by paramagnetic impurities. The differences in the Cu–O distances provide evidence for a partial delocalization of π-electrons indicating a somewhat stronger bonding in Cu–O(2) than in Cu–O(3).

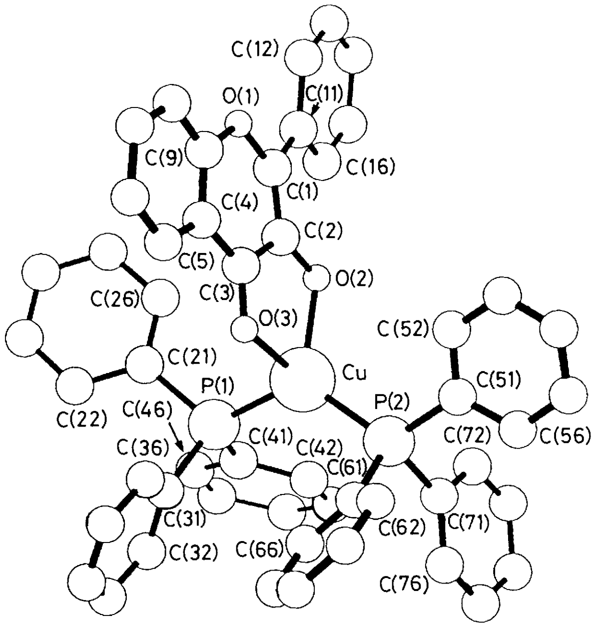


Figure 1. Structure of Cu(fla)(PPh$_3$)$_2$. Relevant bond lengths (Å) and angles (°): Cu–P(1) 2.280(2), Cu–P(2) 2.238(2), Cu–O(2) 2.051(4), Cu–O(3) 2.167(5), O(2)–C(2) 1.286(7), O(3)–C(3) 1.250(7); P(1)–Cu–P(2) 124.5(1), P(1)–Cu–O(2) 109.9(2), P(1)–Cu–O(3) 100.7(2), P(2)–Cu–O(2) 120.7(2), P(2)–Cu–O(3) 109.1(2), O(2)–Cu–O(3) 79.2(3).

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† *Crystal data*: $C_{51}H_{39}CuO_3P_2$, M = 825.37, orthorhombic, space group $P2_12_12_1$, a = 9.588(1), b = 17.364(3), c = 24.378(3) Å, U = 4059(2) Å^3, Z = 4, D_c = 1.35 g cm^{-3}, μ(Cu-K_α, λ = 1.54184 Å) = 18.3 cm^{-1}, F(000) = 1712. Data were collected on an Enraf-Nonius CAD-4 diffractometer using Cu-K_α radiation, and 3358 independent intensities with $3 \leqslant 2\theta \leqslant 150°$, were measured; 2263 unique reflections with $I \geqslant 3\sigma(I)$ were used to solve (Patterson method) and refine (full-matrix least-squares) the structure. Final R = 0.046 and R_w = 0.051, $w = 4F_o^2/\sigma^2(F_o^2)$. Number of refined parameters 514, maximum residual electron density 0.47(6) e Å^{-3}. Atomic co-ordinates, bond lengths and angles, and thermal parameters have been deposited at the Cambridge Crystallographic Centre. See Notice to Authors, Issue No. 1.

The diamagnetic, solid compound is highly stable, and its solutions fairly stable towards molecular oxygen. This is due to the stabilizing effect on Cu^{I} of the phosphines. Oxygenation studies are in progress to determine the nature of quercetinase-type reactions.

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