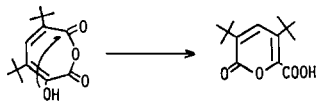


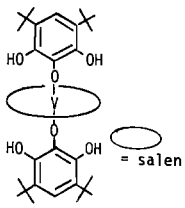
(2)

5 *2*

oxygenation of the pyrogallol *1* proceeds via the Hamilton intermediate similarly to oxygenation of 3,5-di-*tert*-butylcatechol [1].

Reaction of *1* with VO(salen) under nitrogen atmosphere gave a complex (*6*) as a black brown powder (mp 135–40 °C, dec.) which showed a similar catalytic activity for the oxygenation of *1* to that of VO(salen) [see eqn. (3)]. Based on the elemental analyses, IR, and ESR spectra, the structure of *6* was proposed as shown in Fig. 1. Thus,

$$VO(salen) + 2 \cdot 1 \rightarrow 6 \qquad (3)$$



6

Fig. 1. Structure of *6*.

the complex *6* can be regarded as a model complex for the enzyme-substrate complex. Coordination of the pyrogallol monoanion to the metal ion leading to the activation of the substrate is essential for the oxygenation of *1*.

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N9

$[Cu_4(SR)_6]^{2-}$, a Model approach for the Copper Binding Centre of Yeast Cu–Thionein

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Unlike aliphatic mercaptanes, thiophenol and $[Cu(CH_3CN)_4]ClO_4$ form crystalline complexes of the type $[Cu_4S_6]X_2$. Me_4N^+, Et_3NH^+ or Bu_4N^+ served as the respective suitable cation X. The copper to sulphur ratio was close to 1:1.5.

A comparison of the IR spectra of the free and the complexed ligand clearly demonstrates the disappearance of the characteristic ν(SH) vibration at 2570 cm^{-1} and supports the copper thiolate binding. From both the integration of the ^1H NMR spectra and the elemental analyses a metal to ligand ratio of 1:1.5 has been found.

The Cu_4S_6 cluster would nicely fit an adamantane-type structure as earlier described [1] (Fig. 1).

Cu-thionein from baker's yeast has a $[Cu(SR)_2]_4$ centre. According to EXAFS spectroscopy [2] each copper is tetrahedrally surrounded by four cysteine sulphurs. The best guess for arranging four $Cu(SR)_2$-units was a cubane type structure (Fig. 2).

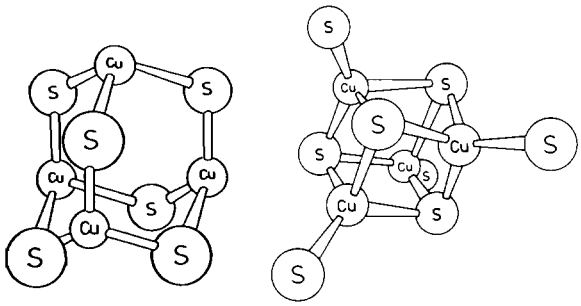

Fig. 1. Adamantane arrangement of $[Cu_4S_6]X_2$.

Fig. 2. The proposed Cu_4S_8 binding centre of yeast Cu–thionein.

At present the above mentioned low molecular weight $[Cu_4S_6]$ species are the closest models for the Cu–thionein metal binding centre. Of course a ratio of 1 Cu per 2 thiolate sulphurs would most successfully mimic the copper binding in this protein.

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N10

Active Centre Models for Non Heme Iron Dioxygenases

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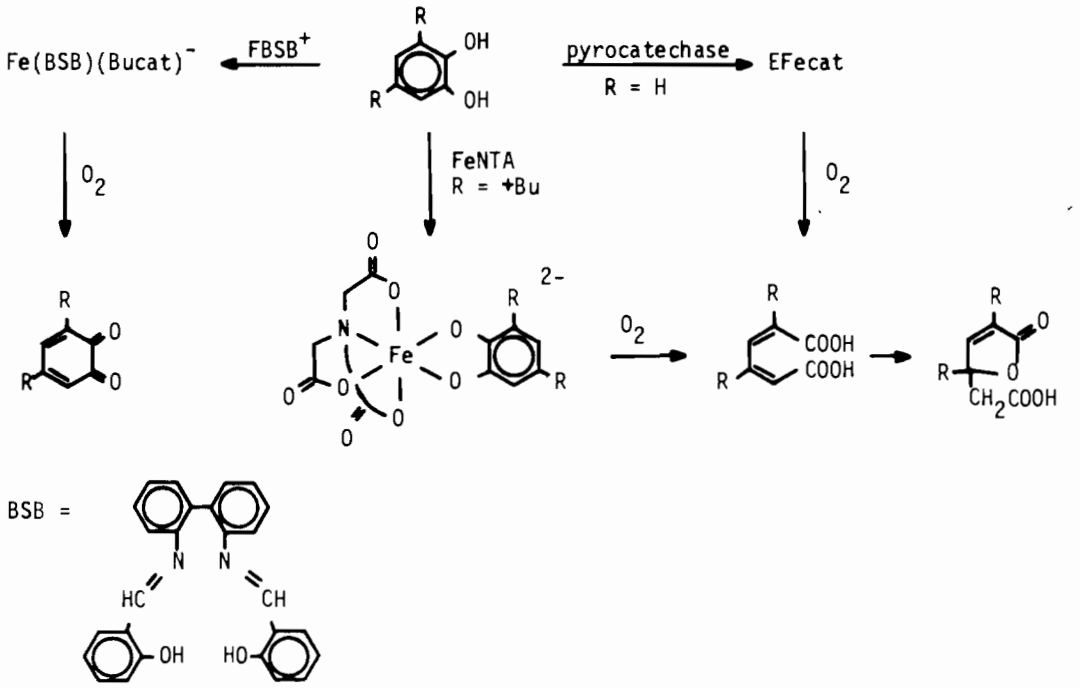
In pyrocatechase, a non heme ferric dioxygenase, the substrate catechol is coordinated to the ferric centre, and subsequently cleaved by O_2 to give muconic acid (scheme) [1, 2]. Hitherto, this catalytic action could not be mimicked with model systems [2].

Resonance Raman data demonstrated the Fe(III) to the bound to phenolate groups of pyrocatechase



Scheme.

tyrosines [2]. Models using phenolic ligands, *i.e.* salen [3], or N,N'-bis(salicylidene)-1,1'-biphenyl-2,2'-diamine (BSB; scheme), however, failed to yield the enzymatic ring cleavage of catechols in mixed ferric complexes. *E.g.*: $[Fe(BSB)(Bucat)]^-$ ($BucatH_2$ = 3,5-di-t-butylcatechol), upon exposure to O_2, was found to undergo rapid oxidation to form 3,5-di-t-butylquinone. In this system, $[FeBSB]^+$ (identified by nmr and Raman Resonance spectra; C. Ruh, M. G. Weller and U. Weser, to be published) acts as an effective catalyst for catechol oxidation, but in a way different from the one characteristic for pyrocatechase.

The dioxygenase action is, however, exhibited by ferric nitrilotriacetate (FeNTA). We have isolated the mixed complex $Fe(NTA)(Bucat)^{2-}$ as its piperidinium salt [4]. With O_2, this system yields ring cleavage of the bound catechol, and it does so catalytically (scheme). Apparently, the coordinated catechol is attacked by dioxygen to form muconic acid, the latter then separates from the ferric centre, and another catechol enters the complex to undergo oxidation. Spontaneous cyclization of the muconic acid finally gives the lactone that is isolated as the reaction product.

A typical example: A mixture of FeNTA and $BucatH_2$, molar ratio 1:100, in aqueous DMF with borate buffer pH 8, after 7 days at room temperature, yields 80% lactone, together with traces (2%) of quinone and some unreacted catechol, *i.e.* a turnover of 80 mol catechol per mol Fe^{3+}. Without NTA present, with Fe^{3+} aq only, quinone is the oxidation product found.

Both for the epr and visible spectra of $[Fe(NTA)(Bucat)]^{2-}$ and for its reactivity towards O_2, ferric nitrilotriacetate can be viewed as an active centre analogue of pyrocatechase.

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N11

Spectroscopic Evidence for Metal–Thiolate Clusters in Complexes of Cd(II) with Dithiol Hexapeptides and in Cd–Metallothionein

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Metallothioneins constitute a novel family of widely occurring metal–thiolate proteins which are engaged in the metabolism and the detoxification of posttransitional metal ions (Zn(II), Cd(II), Cu(I),