Chromium(III) Complexes with Sugars

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The biological role of chromium as an essential trace element was suggested when it was found that rats on a chromium deficient diet developed an impaired tolerance for intravenous glucose [1]. More recently an insulin potentiating factor containing chromium has been isolated [2]. This so-called glucose tolerance factor (GTF) was found to contain chromium(III) and nicotinic acid as well as glycine, cysteine and glutamic acid [3] – the latter three being the constituents of the tripeptide glutathione. The mechanism by which glucose tolerance is improved is unknown but evidence suggests that GTF somehow potentiates insulin activity. In all the samples of GTF isolated, nicotinic acid has been present, thus considerable research effort has been directed towards examining the reactions of chromium(III) with nicotinic acid. This has resulted in the isolation of a number of both nitrogen and oxygen donor complexes [4].

The chromium content of a number of foodstuffs has been determined [5] and a significant relationship was found between the alcohol extractable chromium and biological activity. It is of interest that an alcohol extraction is often the first step in the isolation of GTF. This raises the possibility that the active chromium could be in a non-aqueous environment *in vivo*. Little is known of the complexing ability of chromium(III) with naturally occurring ligands in non-aqueous media. In particular it is of interest to see if such chromium(III) will complex with sugars in such media as no stable complexes are found in aqueous solution.

Experimental

The starting complex chromium(III) trichloride tripyridine was prepared by the method of Taft *et al.* [6]. The complexes were prepared in solution by refluxing for four hours a 1:3 mixture of the chromium(III) trichloride tripyridine and the required ligand in dried methanol. In every case colour changes were observed within a few minutes of the start of the refluxing. Complex formation was detected in solution by changes in UV–Vis spectra and the appearance of Cotton effects corresponding to the transition of chromium(III). All the ligands used – glucose, galactose, mannose, ribose, arabinose, xylose, sorbose, sucrose, lactose – were optically active.

Results

All the ligands reacted to give chromium(III) complexes with UV–Vis absorption peaks around 440 and 605 corresponding to the $^4A_{2g} \rightarrow {}^4T_{1g}$ and $^4A_{1g} \rightarrow {}^4T_{1g}$ transitions of octahedral chromium(III). The results are shown in Table I.

Discussion

The above results show that all of the sugars examined reacted fairly rapidly with chromium(III) to produce optically active complexes. The smell of pyridine (confirmed by HPLC) suggested that the pyridine was being replaced rather than the chloride. None of the complexes prepared were likely to be *fac* in terms of sugar hydroxy groups since, if this was the case, stronger and better defined Cotton effects would have been expected for those sugars which could give rise to this structure com-

TABLE I. UV–Vis and CD Spectra of Chromium(III) Sugar Complexes

Sugar	UV–Vis ($^4A_{2g}(F) \rightarrow$)			CD (nm)				
	$^4T_{1g}(P)$	$^4T_{1g}(F)$	$^4T_{2g}(F)$					
Glucose	350	440	615		−430	+580	−700	
Ribose	380	445	620		−420	−534	−700	
Arabinose	350	440	605		+440	+580	+670	
Xylose	340	430	600	−400	+470	−551	+646	
Galactose	350	440	610	−385	−444	−577	+665	
Mannose	350	440	605	+404	+470	−560	+650	+670
Sorbose	360	450	608	+368		+550		
Sucrose	370	430	601	−414	−490	−540	−680	
Lactose	310	440	620	−400	+454	−570	+660	

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pared to those which could not [7]. Thus bidentate complexing seems likely. However, no solid complexes were isolated to confirm this suggestion. Thus if the nicotinic acid found in GTF is bound to chromium through the nitrogen of the pyridine, then given suitable conditions, replacement by glucose may facilitate either glucose transport or metabolism.

References

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