

# Solid State Reactions of Hemin with Basic Substances: Formation of bis and Mixed Complexes

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Received April 23, 2002; revised November 11, 2002; accepted November 13, 2002

The solid state reactions of hemin with KCN,  $\text{Na}_2\text{S} \cdot x\text{H}_2\text{O}$ , arginine, imidazole, 1-methylimidazole, 2-methylimidazole, benzimidazole, and mixtures of these basic reagents were monitored using IR, Mössbauer, and XRD techniques. All these basic substances react at the peripheral propionic acid group of hemin-forming salts. Binary mixtures of KCN, arginine, imidazole, 1-methylimidazole, 2-methylimidazole, and benzimidazole were found to form complexes with mixed ligands at the iron site of hemin. According to the structural information obtained for these mixed complexes, mechanisms for their formation are proposed. The solid state synthesis and the properties of the obtained products reveal the specificities of the involved ligands.

**KEY WORDS:** Hemin; hemin complexes; mechanochemistry; Mössbauer; infrared.

## INTRODUCTION

The determination of the ferric iron coordination state and the nature of the bound ligands is a central problem in porphyrin bioinorganic chemistry. Vast information about the binding sites between the prosthetic group and the globular part of many hemoproteins has been obtained from the study of the interactions between ferriporphyrins and various amino acids. Complexes of ferriporphyrins with imidazole have been used as models to elucidate the binding between the histidine residue of the globin and the hemin in hemoglobin [1, 2]. Complexes of hemin have been used in the treatment of porphyria patients [3]. All the studies on hemin complexes have been carried out on samples prepared from solutions.

In a recent study [4], we have shown that two hemin–imidazole complexes can be synthesized by milling the reagents in the solid state. This mechanochemical synthesis in the absence of solvent has advantages over the synthesis in solution. The peripheral hemin–imidazole complex, not obtained in solution, can be prepared in the solid

state. The solid state reaction of hemin with fluorides has also revealed the advantages of this preparative route [5]. In the present work, the solid state reaction of hemin with a variety of basic substances is used to prepare bis and mixed complexes in order to obtain information on the specificities and reactivity of the involved ligands. This solid state synthesis facilitates the structural characterization of the obtained products using IR, XRD, and Mössbauer techniques. The spectroscopic data provide information on the spin state of the iron(III) cation and the type of binding of the ligand to the hemin molecule.

## EXPERIMENTAL

The samples of hemin chloride,  $\text{Na}_2\text{S} \cdot x\text{H}_2\text{O}$ , KCN, arginine, imidazole, benzimidazole, 2-methylimidazole, and 1-methylimidazole were analytical-grade commercial reagents (from Sigma Chemical Co). Their purity was tested by IR, XRD, and Mössbauer techniques. The studied samples were prepared with different molar ratios of hemin to ligands. They were milled in an agate mortar for 10–20 min to a paste and then stored in a desiccator in the dark. In the preparation of hemin complexes with mixed ligands at the iron site, appropriate ternary mixtures of hemin and the basic reagents were milled, considering the ability of these reagents to form complexes with iron.

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