IN VIVO MÖSSBAUER SPECTROSCOPY OF IRON UPTAKE AND FERROMETABOLISM IN ESCHERICHIA COLI

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Abstract

Iron limited growth of microbes results in derepression of siderophore receptor- and transport-systems which can be utilized for controlled and specific siderophore mediated $^{57}\text{Fe}$ incorporation, yielding a suitable resonance nuclide concentration inside the cell. We have employed in vivo Mössbauer spectroscopy to analyze $^{57}\text{Fe}$ siderophore uptake and to monitor time-dependent processes of microbial iron metabolism in $E.\text{coli}$. The cell spectra display the course of siderophore uptake and ferric ion metabolization with a time resolution which is merely limited by the time required for sample preparation. Since iron is present in many metabolic processes, the in vivo analysis of selected metabolites after siderophore uptake seems to be extremely tedious at a first glance. Surprisingly, only few components of iron metabolism are visible in the Mössbauer spectra, thus enabling their analysis. The intracellular distribution pattern of the main iron metabolites observed by this method differs from that derived from biochemical analyses. Based on the spectroscopic results, two hitherto unknown Fe$^{2+/3+}$ high-spin proteins have been isolated. Additional Mössbauer experiments suggest that the novel iron proteins are not restricted to $E.\text{coli}$. Rather, similar components are detectable in several bacterial and fungal systems, thus pointing to a general importance. The function of these proteins is currently being analyzed.

1. Introduction

Most Mössbauer studies in the area of biological systems have been performed with isolated iron containing enzymes. Mössbauer spectroscopy is a powerful tool for analyzing the electronic states of iron in such molecules [1]. Some groups have investigated tissues of patients with iron-overload diseases [2,3]. In addition, intact microbial [4-6], plant [7] and animal cells [8-10] have been isolated from $^{57}\text{Fe}$-enriched cultures, the metal being added in large excess. This procedure is satisfactory for the analysis of iron storage compounds in vivo. We have developed an alternative
technique which allows us to monitor by in vivo Mössbauer spectroscopy the time-
dependent iron accumulation in microbial cells and the transfer to iron requiring
functions inside the cell [11-15].

Under conditions of iron starvation, most microorganisms excrete low
molecular mass iron complexing agents which are able to mobilize iron from minerals
or other organic substrates. These iron complexing agents are called siderophores
(fig. 1). Siderophores are able to bind Fe\(^{3+}\) with extraordinary high complex forma-