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REVIEW ARTICLE

Environmental Control of Vanadium Haloperoxidases and Halocarbon Emissions in Macroalgae

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Abstract

Vanadium-dependent haloperoxidases (V-HPO), able to catalyze the reaction of halide ions (Cl^-, Br^-, I^-) with hydrogen peroxide, have a great influence on the production of halocarbons, which in turn are involved in atmospheric ozone destruction and global warming. The production of these haloperoxidases in macroalgae is influenced by changes in the surrounding environment. The first reported vanadium bromoperoxidase was discovered 40 years ago in the brown alga *Ascophyllum nodosum*. Since that discovery, more studies have been conducted on the structure and mechanism of the enzyme, mainly focused on three types of V-HPO, the chloro- and bromoperoxidases and, more recently, the iodoperoxidase. Since aspects of environmental regulation of haloperoxidases are less well known, the present paper will focus on reviewing the factors which influence the production of these enzymes in macroalgae, particularly their interactions with reactive oxygen species (ROS).

Keywords Haloperoxidases · Macroalgae · Halocarbons · Bromoperoxidases · Iodoperoxidase · Algal biotechnology

Introduction

Halogenated natural products are widespread in the environment, and the halogen atoms are typically key to their bioactive properties. Halogenated compounds are known to have many industrial applications, including their use as biopharmaceuticals. Marine organisms (including macroalgae, sponges, and worms) are known to be good sources of halogenated organic compounds for such purposes. Until recently, research interests have focused on complex halogenated molecules, their metabolic pathways, and their possible industrial applications (Laturnus et al. 2000), but it is now recognized that small/simpler halogenated compounds play significant roles in the biology of marine organisms and in climate change.

Central to the biological synthesis of halogenated compounds is the activity of a group of enzymes known as haloperoxidases (HPOs) (Leblanc et al. 2006; Wever and Hemrika 2001). Algae produce HPO as part of their physiological responses to the environment, and this group of enzymes has attracted the attention of many researchers. There are three types of HPOs based on their cofactor requirements, namely cofactor-free haloperoxidases (HPOs), vanadium-dependent haloperoxidases (V-HPOs), and heme iron-dependent haloperoxidases (HI-HPOs), and three types of halogenating enzymes, namely nonheme iron-dependent halogenases (NI-HG), flavin-dependent halogenases (F-HG), and S-adenosyl-L-methionine (SAM)-dependent halogenases (S-HG) (Blasiak and Drennan 2009; Pang et al. 2015). Despite having similar biological functions, their structure variance suggests that they may have evolved independently. Based on phylogenetic and structural analyses, HPO, V-HPO, HI-HPO, NI-HG, F-HG, and S-HG enzyme families may have

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