

Chapter 7

Hydrogen Peroxide (H_2O_2) Decomposition as Green Propellant: Overview of Synthesized Catalysts

Hajar Jabri

Faculty of Sciences, University of Chouaib Doukkali, Morocco

Abdelaziz Sahibeddine

Faculty of Sciences, University of Chouaib Doukkali, Morocco

Rachid Amrousse

 <https://orcid.org/0000-0002-2905-602X>

Faculty of Sciences, University of Chouaib Doukkali, Morocco

ABSTRACT

Space propulsion technology facilitates the launch and maneuvering of spacecraft. Different propulsion systems are present, like electric, chemical, and those using pressure. Chemical reactions are primarily used for thrust in current space launches, with ongoing advancements. Hydrazine is widely employed due to its performance and stability, despite its toxicity. The hazardous nature of hydrazine necessitates rigorous safety protocols. Consequently, research aims to create “green propellants” that are less toxic yet effective. Owing to its remarkable traits, hydrogen peroxide (H_2O_2) is regularly chosen for being both effective and safe. Its catalytic decomposition can be enhanced with catalysts, producing energy for space missions while ensuring stability.

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I. INTRODUCTION

Hydrogen peroxide (H_2O_2) is a promising eco-friendly propellant for space propulsion systems due to its ecological nature and safer synthesis compared to traditional methods. Hydrazine, a traditional propellant, is highly toxic and poses risks to handling and the environment. On the other hand, H_2O_2 is less hazardous and decomposes into harmless water and oxygen (Ogo et al., 2023). H_2O_2 possesses a notable density of approximately 1.43 g cm^{-3} , thereby enabling its storage at high concentrations, particularly suitable for utilization in space propulsion aimed at low and medium thrust scenarios. Despite H_2O_2 exhibiting a specific impulse of roughly 186 seconds, which falls short by 20% in comparison to hydrazine (Remissa et al., 2023). In this chapter, the different types of propulsion systems utilized in space will be examined, encompassing liquid, solid, and hybrid systems. An analysis will be conducted on the propellants available, such as hydroxyammonium nitrate (HAN) (Amrousse et al., 2015, 2016, 2017; Amrousse, Hori, et al., 2012; Amrousse, Katsumi, Bachar, et al., 2013; Amrousse, Katsumi, et al., 2012; Amrousse, Katsumi, Niboshi, et al., 2013; Amrousse & Katsumi, 2012; Katsumi et al., 2015; Agnihotri & Oommen, 2018; Atamanov et al., 2018; Mansurov et al., 2020; Amrousse et al., 2022; Chai et al., 2022; Souagh et al., 2022; Amrousse et al., 2024), ammonium dinitramide (ADN) (Harimech et al., 2023; Harimech et al., 2022; Amrousse et al., 2011; Amrousse et al., 2024), hydrazinium nitroformate (HNF) (Schoeyer et al., 2000), and nitrous oxide (N_2O) (Amrousse, Chang, et al., 2013; Amrousse, Katsumi, et al., 2012; Amrousse, Tsutsumi, et al., 2013), emphasizing their specific functions and benefits. In particular, an investigation will assess H_2O_2 as an eco-friendly liquid propellant, focusing on its physical and chemical attributes. Furthermore, an evaluation will be carried out on the various propellants tailored for H_2O_2 and, notably, an examination will be made on the synthesized catalysts crucial for enhancing its decomposition process. These catalysts play a vital role in facilitating the generation of oxidizing gases necessary for space missions, while ensuring prolonged stability. The objective of this study is to present a comprehensive summary of the progress made in the utilization of H_2O_2 and its associated catalysts, and to evaluate the potential impact of these advancements on space propulsion technology. Through a thorough analysis of these factors, the intent is to provide recommendations that can steer future advancements and foster a more sustainable outlook for space exploration.

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