# Chapter 8
# Catalytic Materials for Space Propulsion Applications: Hydroxylammonium Nitrate (HAN) and Hydrogen Peroxide (H2O2) Decompositions

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## ABSTRACT

*This chapter explores the critical role of catalytic materials in advancing the utilization of environmentally friendly propellants for space propulsion applications. Specifically, it focuses on the thermal decomposition and compositions of hydroxylammonium nitrate (HAN) and hydrogen peroxide (H2O2) as green propellants, highlighting their potential for sustainable propulsion systems. The chapter reviews innovative catalysts developed to enhance the thermal decomposition and combustion processes of these propellants, shedding light on the catalytic mechanisms involved. Furthermore, it discusses the practical implementation of HAN and H2O2 as thrusters, demonstrating their feasibility and efficiency in space missions. Through*

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*a comprehensive analysis of catalytic materials and their impact on propellant performance, this chapter contributes to the advancement of eco-friendly propulsion technologies, essential for the future of space exploration.*

## 1. INTRODUCTION

Artificial satellites are man-made satellites that orbit the Earth or other celestial bodies to carry out various missions. Since the Soviet Union launched the first artificial satellite, Sputnik 1, in 1957, satellites have played a crucial role in many civil, military, scientific, and commercial applications. Artificial satellites can be classified into different types according to their main functions: communication, navigation, Earth observation, meteorological and scientific research satellites; spy or reconnaissance satellites. On the other hand, propellants are high-powered fuels used to power rockets, missiles, and launch vehicles (Sutton & Biblarz, 2001). These are energetic materials that, when burned (or decomposed), produce very hot gases that are ejected through the propulsion unit's nozzle to generate the desired thrust. Pure hydrazine and its derivatives are propellants commonly used in space missions, in particular to monitor the orbit and orientation of satellites. What's more, hydrazine decomposes extremely exothermically, making it possible to increase the temperature by up to 1000 °C (Amstrong et al., 1964). Hydrazine is used as a monopropellant fuel in liquid rockets, which has the advantage of eliminating oxidants. Uses of hydrazine as monergol in rocket and satellite propulsion systems have been carried out in the presence of catalysts that spontaneously and reproducibly trigger the decomposition of monergol. This material can be decomposed in a controlled manner with the liberation of heat and energy when it comes into contact with the catalyst, making it possible to produce gases to drive turbines and operate altitude control jets for rockets and spacecraft (Jang et al., 2012; Eckart Walter Schmidt, 2001). The possible reactions to describe the spontaneous decomposition of hydrazine are as follows:

$3N_2H_4\ (l) \rightarrow 4NH_3\ (g) + N_2\ (g)$ Eq. 1

$2NH_3\ (g) \rightarrow N_2\ (g) + 3H_2\ (g)$ Eq. 2

$3N_2H_4\ (l) \rightarrow 2NH_3\ (g) + 2N_2\ (g) + 3H_2\ (g)$ Eq. 3

But its high toxicity means that the cost of handling and preparing it is high. Consequently, the search for alternatives is a necessity. An effective monopropellant to substitute hydrazine must be both chemically and thermally stable so that it can