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On the Feasibility for Mining the Hydrogen Peroxide (H_2O_2) of Mars as Monopropellant Rocket Fuel

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Abstract

Already since the 1970s, hydrogen peroxide (H_2O_2) has been suggested as a possible oxidizer of the Martian surface, but until only three decades latter it was finally detected. So far, the interest aroused by planetary scientist on H_2O_2 is because it could be the key catalytic chemical that controls Mars atmospheric chemistry. However, from the point of view of a rocket scientist hydrogen peroxide is a rocket fuel, and indeed it is the most simple monopropellant rocket fuel known, therefore, it could play an important role for Mars exploration. Here, consideration is given to the feasibility of mining the hydrogen peroxide from the regolith or atmosphere of Mars to be used as monopropellant rocket fuel.

1. Introduction

Despite hydrogen peroxide H_2O_2 has been suggested as a possible oxidizer of the Martian surface since the Viking mass spectrometer failed to detect organics on the surface of Mars in 1976, , [1], nevertheless the search for H_2O_2 on Mars was unsuccessful for three decades and only in 2003, hydrogen peroxide was finally detected using two ground-based independent techniques,[2]. Since then, research on hydrogen peroxide on Mars by planetary scientist community has been intensified mostly motivated by the fact that it could be the key catalytic chemical that controls Mars atmospheric chemistry.[3]. However, from the point of view of a rocket scientist, hydrogen peroxide is a rocket fuel, and indeed it is the most simple monopropellant rocket fuel known and hence it could play an important role for the exploration of Mars.

• Hydrogen peroxide on Mars and its feasibility as rocket fuel

The generation of H_2O_2 on Mars is believed to be mostly by atmospheric photochemical process which is consistent with the discovery in the last decade of H_2O_2 at 20-40 parts per billion volume on Mars, [4], nevertheless the soil reactivity implied by the Viking results indicate levels ranging from at least 1 part per millon, [5] up to ∼250 parts per millon,[6]. One additional source of hydrogen peroxide is by atmospheric electrical discharges during dust storms, [7]. This hypothesis seems plausible in view of the last years laboratory studies, desert fields tests , and numerical simulations which indicate that the aeolian dust transport can generate atmospheric electricity by contact electrification (triboelectricity), [8]. Therefore, to be in the conservative side and preliminary calculations, a lower and upper limit of 20 ppb and 40 ppb can be taken, respectively.

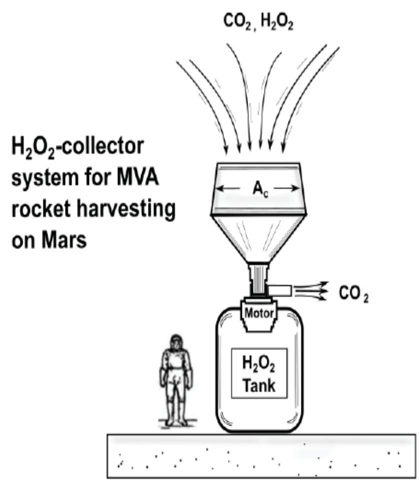

Figure 1: Atmospheric H_2O_2 removal system.

Assuming that the atmosphere is an infinite reservoir of H_2O_2 with a constant concentration n_a, the total net flux in an atmospheric H_2O_2 removal-collector system (as sketched in Fig.1), J_c, is given by

$$J_c = n_a v_t \quad (1)$$

where n_a is the atmospheric concentration of H_2O_2 and v_t is the pumping velocity. Taking into account that the pumping power W is given by

$$W = \frac{\rho v_t^3 A_c}{2} \quad (2)$$

where ρ is the density of the atmosphere; and A_c the area of the collector. By inserting Eq.(2) into Eq.(1) one obtains,

$$J_c = n_a \sqrt[3]{\frac{2W}{\rho A_c}} \quad (3)$$

The total number of particles of hydrogen peroxide N_p crossing the collector is obtained by integrating the flux expression of Eq.(3) over the cross section area A_c and with the time

$$N_p = J_c \times t_c \times A_c$$

$$= n_a t_c \sqrt[3]{\frac{2WA_c^2}{\rho}} \quad (4)$$

where t_c and A_c are the collection time and the area of the collector, respectively.

•Discussion and conclusions

To obtain some idea of the pumping power required as function of the mass of the spacecraft for a surface-to-LMO transfer, we assume some typical values of the parameters: atmospheric concentrations of H_2O_2 from 20-40 parts per billion volume on Mars; $\rho = 10^{-2}$ kg/m^3; $t_c = 455$ days, for Hohmann orbital rendezvous; area of collector $A_c = 10$ m^2, H_2O_2 with specific impulse 160-sec ISP, [9]; a spacecraft with acceleration $3g$. The resulting curves are shown in Fig. 2. It is seen that for a Mars Ascent Vehicle (MAVs) with 0.5 tons to 1 ton of weight, it will require a power source around 10 W to 100 W which can be easily obtained either by solar power or from a radioisotope thermoelectric generator.

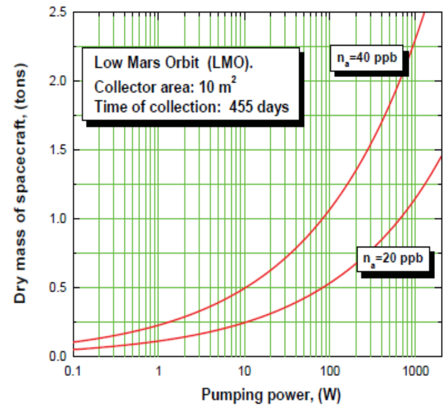

Figure 2: Mass of the Mars Ascent Vehicle (MVA) to Low ars Orbit (LMO) as function of pumping power and atmospheric concentrations of H_2O_2 40 ppb and 20 ppb

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