THE EXPERIMENTAL EVIDENCE OF O_3 GENERATION IN MARTIAN ATMOSPHERE BY DUST EVENT RELATED ELECTROSTATIC DISCHARGE PHENOMENON.

Zhongchen Wu[1*], Fabao Yan[2]. Zongcheng Ling[1], Xiaoling Ye[1], Minliang Zhang[1], Ling Xu[1], Lei Zhang[1], Jiayi Chen[1]. [1]Institute of Space Science, Shandong University, Weihai 264209, China (z.c.wu@sdu.edu.cn); [2]School of Mechanical, Electrical & Information Engineering, Shandong University, Weihai 264209;

Introduction: Mars has remarkable dust storms and dust devils. Due to the temperature, pressure and topographic conditions, regional dust events are much stronger and occur more frequently on the Martian surface than those on Earth. Mars also has global dust storms lasting for several months.

Martian dust events are electrostatic because of static friction between mineral particle matters[1]. Electrostatic discharge (ESD) is also expected to occur when a local E-field accumulates beyond the break-down electric field threshold (BEFT). The Mars' BEFT(~ 20-25 kv/m)[2] is ≤ 1% of Earth's BEFT (~ 3000 kv/m)[3]. This indicates that ESD may occur much more easily on Mars than on Earth. During ESD, electrons collide with Martian atmospheric molecules, and cause molecular ionization or dissociation, resulting in positive and negative ions, and new neutral gas species.

Experiments: In this study, several ESD experiments were conducted in a low temperature plasma generator using CO_2 as working gas. Two neutral O atom emission lines at 777.2nm and 844.7nm were detected in dry CO_2 gas plasma in addition to various CO_2^+ bands in the UV band[4]. Oxygen atoms are known to be extremely reactive and unstable. They readily interact among themselves and with surrounding materials which could play a key role in transforming CO_2 to O_3 and O_2.

For identification of new generated gas species, infrared(IR) absorption spectrum of CO_2 ESD reaction gas was detected, analyzed and shown in **Fig.1**. The typical absorption bands of O_3 (~1059 cm^{-1} and ~1029cm^{-1}) and CO (~2171 cm^{-1} and ~2119 cm^{-1}) were clearly observed. This is the experimental evidence of O_3 generation in CO_2 plasma which indicates that O_3 and O_2 (decomposed from O_3) can be spontaneously generated in ESD process of Martian dust events. The absorption band of CO_2 (~2400 cm^{-1} and ~671 cm^{-1}) also appeared in **Fig.1** resulting from the residual CO_2 gas of this plasma reaction. Two absorption peaks near ~1349cm^{-1} , ~1380 cm^{-1} were not identified which perhaps were due to other intermediate gas species.

Result and Discussion: As known, the reaction yield of new reaction products in plasma reaction depends strongly on the reaction parameters which were also investigated in this CO_2 ESD experiment.

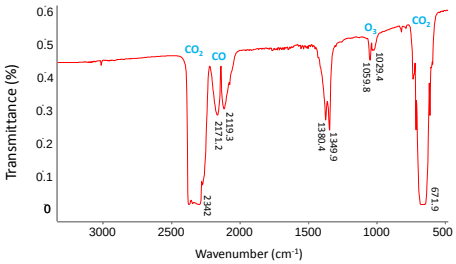

Fig.1 The IR absorption spectrum of CO_2 plasma dissociation reaction product.

We directly observed (1) the instantaneous generation of O,CO and O_3 in ESD plasma, detected by UV emission and IR absorption spectroscopy; (2) The plasma temperature has direct effect on the concentration variation of O_3 because of temperature-related instability; However, the plasma temperature almost has no effect on new generated CO gas; (3) The reaction yield of CO is linear with the discharge voltage of input of ESD generator in range of 40V-230V. However, the voltage of 170V was found for maxim yield of O_3 because of high temperature degradation at higher discharge voltage; (4) The yield of O_3 and CO varied with the CO_2 gas flow rate. The CO_2 gas flow rate for the highest yield of O_3 and CO is 0.4 L/min within flow rate of 0.2 L/Min -2.0L/Min; (5) The detection distant from CO_2 plasma generator to IR/UV absorption cell has no effect on the concentration variation of O_3 and CO.

Conclusion: Our study gave a preliminary experimental evidence for O_3 generated in Martian atmosphere by dust event related electrostatic discharge phenomenon. Meanwhile, due to thin CO_2 atmosphere, Mars has excellent conditions for plasma reforming. Our experiment also offers a twofold solution for a manned mission to Mars. Not only would it provide a reliable supply of oxygen, but as source of fuel as well, since CO can be used as a propellant mixture in rocket vehicles.

References:[1]Forward, K.M. et al.(2009), *Geophys.Res.Lett*,36,L13201;[2]Melnik O. et al.(1998), *J.Geophys.Res.*103,29107-29117.[3] Farrell, W.M. (2015) *Icarus*, 254,333-337; [4] WU et al.(2018) *EPSL*,504,94–105.

Acknowledgement: This work was supported by Natural Science Foundation of China (41573056).