

MARS DUST: CHARACTERIZATION OF PARTICLE SIZE AND ELECTROSTATIC CHARGE DISTRIBUTIONS. M. K. Mazumder¹, D. Saini¹, A. S. Biris¹, P. K. Srirama¹, C. Calle², and C. Buhler², ¹University of Arkansas at Little Rock, Applied Science Department ETAS 575, 2801 South University Ave, Little Rock, AR 72204 Tel: 501-569-8007, Fax: 501-569-8020, mkmazumder@ualr.edu, ²Electrostatics and Materials Physics Laboratory, YA-C2-T, NASA, Kennedy Space Center, FL 32899.

Introduction: Some of the latest pictures of Mars surface sent by NASA's Spirit rover in early January, 2004, show very cohesive, "mud-like" dust layers. Significant amounts of dust clouds are present in the atmosphere of Mars [1-4]. NASA spacecraft missions to Mars confirmed hypotheses from telescopic work that changes observed in the planet's surface markings are caused by wind-driven redistribution of dust. In these dust storms, particles with a wide range of diameters ($< 1 \mu\text{m}$ to $50 \mu\text{m}$) are a serious problem to solar cells, spacecraft, and spacesuits. Dust storms may cover the entire planet for an extended period of time [5]. It is highly probable that the particles are charged electrostatically by triboelectrification and by UV irradiation.

Experimental Plan for Characterization of Size and Charge Distributions: To analyze the size and charge distributions of the Mars dust cloud, a miniature version of the ESPART analyzer [6] is being developed, and tested using a simulated Martian dust, JSC Mars-1 [7]. In order to study the triboelectrification of the Mars simulant dust caused by erosion of the dust in a storm and resulting suspension over millions of years in a dry atmosphere, experiments are being performed to characterize the particle size (PSD) and electrostatic charge (Q/M)D distributions. Approximately 20 grams of simulant dust sample was contained in a small plastic jar and was shaken for three minutes to allow the dust to acquire electrostatic charge by friction against itself and by contact with the wall of the plastic jar. Since the wall surface was comparatively negligible compared to the large surface area of the dust particles, and since the container wall was insulating, it was assumed that tribocharging was primarily due to particle-particle collisions.

Simultaneous Measurement of Particle Size and Electrostatic Charge Distribution by ESPART Analyzer: The ESPART analyzer [6] has been used in the toner industry for many years to measure toner particle charge distribution. Its principles of operation and performance characteristics have been well documented in the literature. In an ESPART analyzer, measurements are performed by oscillating particles in an acoustic or electric field or by simultaneous application of both

acoustic and electric fields. The motion of the particle is measured in real time through the application of Laser Doppler Velocimetry (LDV) or by using image analysis as shown in Fig. 1. One of the characteristics of the ESPART analyzer is that the range of particle size measured by the instrument depends upon the frequency of excitation (either acoustic or electric). In the toner industry, the ESPART is used at a drive frequency of 1 kHz. However, in order to cover a much wider range of particle size, it is necessary to drive the particles at multiple frequencies. Presently under development is a miniature, digitally-controlled ESPART analyzer where the AC drive frequency can be varied depending upon the particle size and electrostatic charge distributions to cover particle size from 0.5-30 μm and the electrostatic charge from zero to the saturation charge level which depends upon the particle size and the environmental condition. Fig. 2 shows an expanded view of the ESPART analyzer.

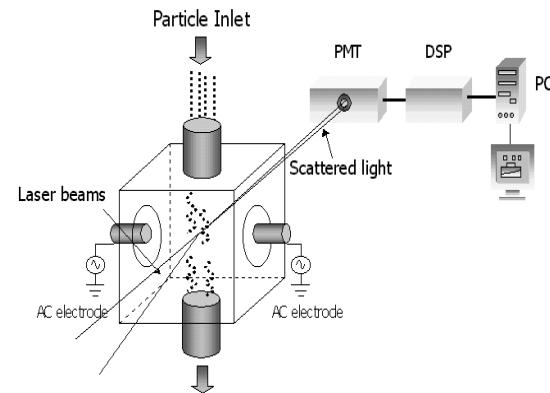


Fig. 1. Basic schematic of the ESPART analyzer. The particles are oscillated by an AC drive and the signal is detected by a photomultiplier tube (PMT) and analyzed by a digital signal processor (DSP) for PSD and (Q/M)D.

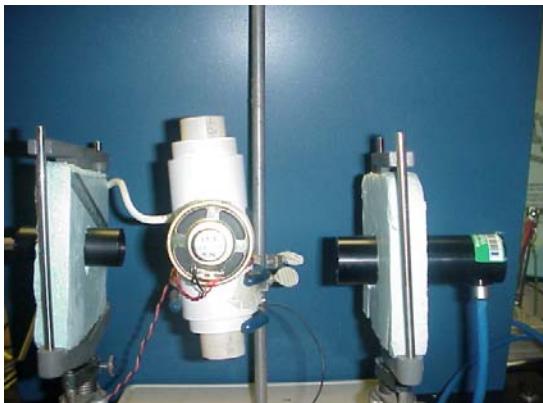


Fig. 2. Photograph of the ESPART Analyzer showing an expanded view of the instrument. The integrated version of the instrument will be housed in a small plastic box for its installation within a vacuum chamber for testing it under a simulated Martian atmosphere.

A miniature ESPART analyzer is being developed for its potential planetary mission to analyze the particle size and electrostatic charge distribution of Mars dust. The experimental data presented in Fig. 3 shows preliminary results performed in a laboratory environment at 40% relative humidity and at atmospheric pressure. The results demonstrate the possible application of the instrument in a future planetary mission. An electrodynamic screen is also being developed to protect the ESPART optical windows from dust deposition.

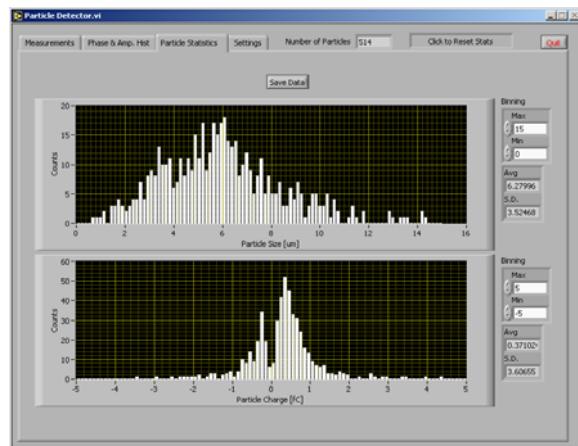


Fig. 3. The two histograms show the particle size (top) and electrostatic charge (bottom) distributions of Mars simulant dust. The dust CMAD was 6.27 μm , with a standard deviation of 3.52. The net Q/M was 0.37 $\mu\text{C/g}$ with a bipolar charge distribution.

Conclusion: Tribocharging of Mars dust particles can contribute to strong adhesion of particles to solar panels and to optical windows. The

amount and polarity of charge depends upon surface composition of the particles and contacting materials. Understanding charging mechanisms and size and charge distributions can contribute to selection and design of materials and devices that can be used to remove dust particles from equipment. The ESPART analyzer is miniaturized so that the instrument can be used on the surface of Mars for characterizing the PSD and (Q/M)D of Mars dust. The development of the instrument will be carried out by testing it in a vacuum chamber that simulates Martian atmosphere, except for the gravitational force. Particle charging can be caused both by (1) UV irradiation, and (2) particle-to-particle collision in a dust storm. Tribocharging occurs when two dissimilar solids come in contact and separate, exchanging charges throughout the contact area. Electron transfer occurs due to difference in work functions between the two materials ($\Phi_1 - \Phi_2$), at the point of contact, even when the bulk chemical composition of the particles coming in contact is the same.

Acknowledgement: The work reported here is supported by a NASA NRA grant awarded to the University of Arkansas at Little Rock and to NASA Kennedy Space Center.

References: [1] McLaughlin, D., "Volcanism and aeolian deposition on Mars", *Bull. Of the Geol. Soc. Of Amer.*, 65, pp. 715-717 (1954). [2] Kuiper, G. P., "Visual observations of Mars", *Astrophys. Jour.*, 125, pp. 307-317 (1957). [3] Sagan, C. and J. B. Pollack, "Windblown dust on Mars", *Nature*, 223, pp. 791-794 (1969). [4] Haberle, R. M., "Interannual variability of global dust storms on Mars", *Science*, 234, pp. 459-461 (1986). [5] Zurek, R. W. and Martin, L. J., "Interannual variability of planet-encircling dust storms on Mars", *Jour. Of Geophys. Res.*, 98, pp. 3247-3259 (1993). [6] Mazumder, M. K. et al., "Measurement of particle size and electrostatic charge distributions on toners using E-SPART analyzer", *IEEE Trans. And Indust. Appl.*, 27, No. 4, pp. 611-619 (1991). [7] Allen, C. et al., "JSC Mars-1: A Martian Soil Simulant", *Proc. Of the Conf. Of Amer. Soc. Of Civil Eng.*, Albuquerque, NM, pp. 469-476 (1998).