Particle removal measurements using the aerodynamic approach and Explosive particles evaporation rate measurements

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Abstract

We present here results of two different (but related) experimental studies. The first is related to investigation of particle removal efficiency using the aerodynamic approach. Here, a short pulse of inert gas is directed toward the particle covered substrate. The experiment is carried out under an optical microscope. The particle-substrate system is photographed before and after the gas pulse. Comparison between the two photographs allows us to measure the removal efficiency as a function of the substrate nature and the pressure used to generate the gas pulse (over pressure). The data shown correspond to six substrates: cotton fabric, rubber, stainless steel, glass and two car paint coupons, a white (WP) and black (BM).
The other experiments reported here are related to the measurement of sublimation rate of explosive particles. The evaporation rate was measured using a quartz crystal microbalance. The explosive particles were deposited on the quartz substrate by precipitation from a solution in acetonitrile.

Relevance

The two studies reported here are tightly connected to the sampling of explosive particles. The aerodynamic approach is being used for the removal and collection of explosive particles in gates positioned in air ports and borders. The data reported here give an insight into the removal process and the influence of various environmental conditions on the removal efficiency. This and similar results (see future work) will be very helpful in the design of new gates and to maximize the particle collection.
The second types of experiments reported here allows one to determine the “life time” of an explosive particle at different conditions. This is important to estimate the duration one can sample explosive particles following their deposition on a substrate. This data can also be used as a simple route to obtain an estimate of the temperature dependent vapor pressure of explosives.

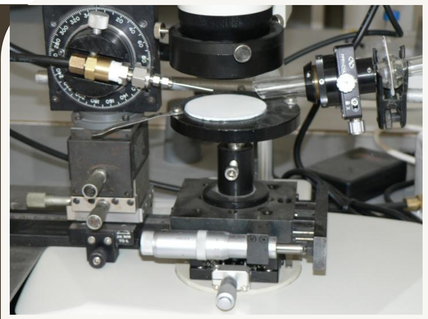

Fig.1: Set up of the aerodynamic system for particle removal measurements

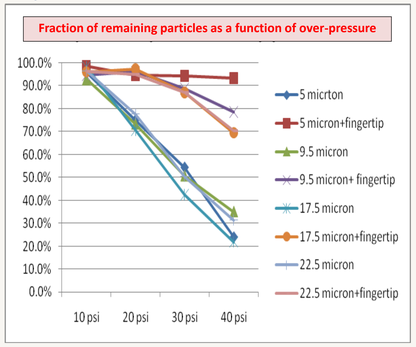

Fig.2: Particle removal efficiency as function of over pressure from clean glass substrate and glass substrate with finger prints.

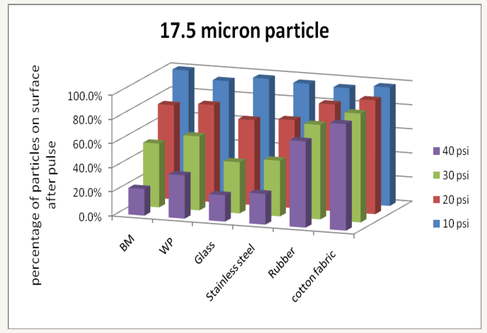

Fig.3: Particle (17.5 μm) removal efficiency from different substrates (see text) as a function of over pressure.

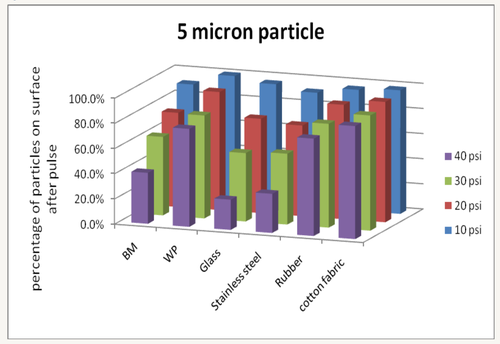

Fig.4: Particle (5 μm) removal efficiency from different substrates (see text) as a function of over pressure.

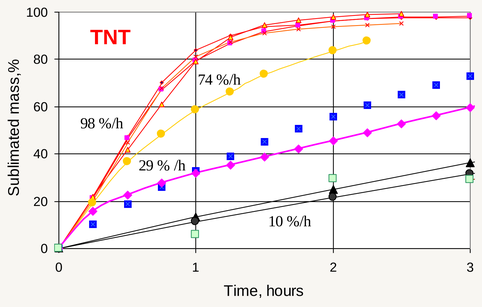

Fig.5: Evaporation rate of TNT particles at different temperatures measured using quartz microbalance.

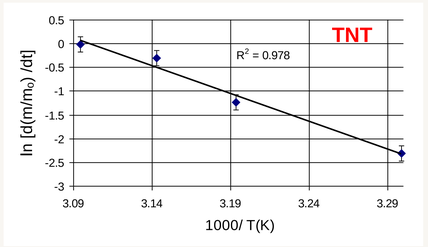

Fig.6: Arrhenius plot obtained using the data in Fig. 5. The activation energy of evaporation is: **96 kJ/mol**

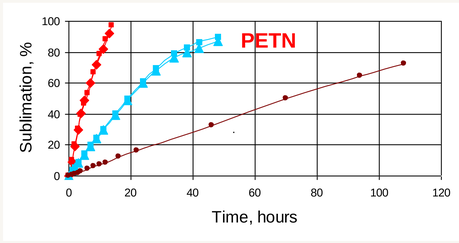

Fig.7: Evaporation rate of PETN particles at different temperatures measured using quartz microbalance.

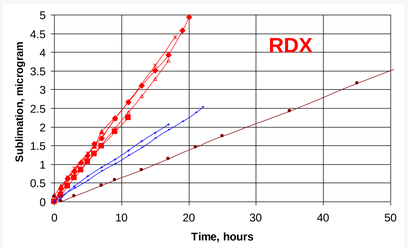

Fig.8: Evaporation rate of RDX particles at different temperatures measured using quartz microbalance.

The activation energies obtained from the data in Figs. 7 and 8 for the sublimation temperature dependence are:
125 kJ/mol for PETN and 114 kJ/mol for RDX.

Accomplishments Through Current Year

- The data obtained this year related to particle removal using air jets shows clearly a marked particle size dependence. Small particles is harder to remove.
- Existence of finger prints reduces markedly the particle removal efficiency.
- Explosive particle sublimation rate are found to be limited by their diffusion in the air.

Future Work

- In the case of particle removal we shall extend the study to more substrates and to sub micron size particles.
- Similar studies will be performed using particles made of explosive replacement materials (to be developed).
- Influence of exposure to UV on explosive particle sublimation rate.

Opportunities for Transition to Customer

- The aerodynamic method is used for particle sampling in gates at airports and borders. The study here helps to optimize the sample collection procedure.
- The sublimation rates of explosives help to define the life time of various size explosive particles in real environment conditions.

Patent Submissions

No patent requests were submitted based on the data presented here.

Publications Acknowledging DHS Support

1. Arcady P. Gershanik and Yehuda Zeiri "Sublimation Rate of TNT Microcrystals in Air" J. Phys. Chem. A, **114**, 12403–12410 (2010).
2. A paper summarizing the particle removal measurements data is being written at present.

Other References

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2. G. T. Smedley, D. J. Phares, R. C. Flagan, Experiments in Fluids **26** (1999) 116
3. G. T. Smedley, D. J. Phares, R. C. Flagan, Experiments in Fluids **30** (2001) 135

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