

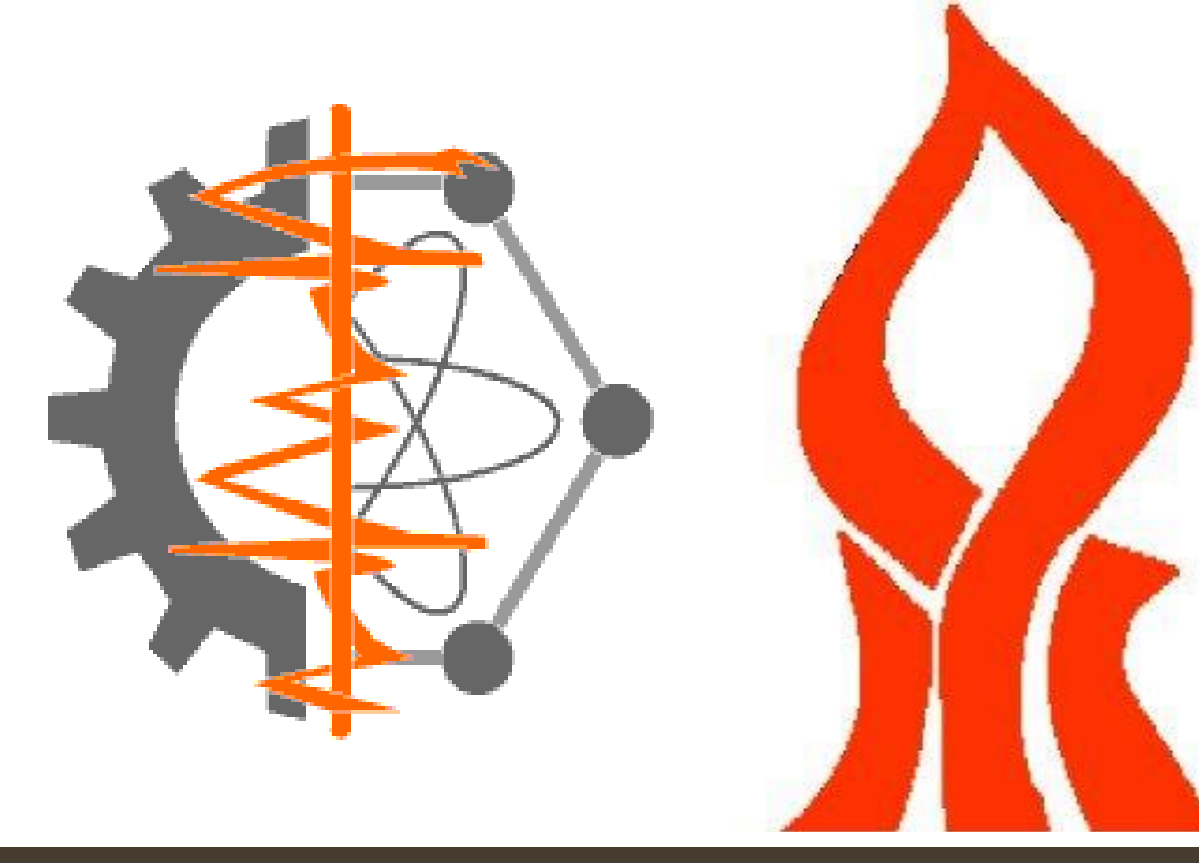


Measurements of the adhesion forces between explosive particles and various substrates

Yevgeny Zakon^a, Paz Elia^a and Yehuda Zeiri^{a,b}

^a Biomedical Engineering, Ben-Gurion University, Beer-Sheva 84105, Israel

^b Department of Chemistry, NRCN, P.O. Box 9001 Beer-Sheva 84190, Israel
yehuda@bgu.ac.il



Abstract

Most of the military and improvised explosive used by terrorists have low vapor pressure. Therefore, the detection of these explosives is based on sampling of particles mostly by swab materials (cloth). This study is based on force measurements between explosive particles and substrates using the Atomic Force Microscope (AFM). A particle is glued to the tip on a cantilever. This process is performed under an optical microscope as shown in Fig. 1 below. Once the particle is attached to the cantilever the force between the particle and a substrate can be obtained by moving the particle towards the surface while recording the cantilever deflection. If the force constant associated with the cantilever is known the adhesion force can be obtained. Typical force curve is shown in Fig. 2.

Relevance

The detailed understanding of the forces that act between explosive particle and various substrates is essential to the design of efficient swab materials. There are two main aspects associated with this, the first is the optimized morphology to be used and the other is related to the chemical nature of the swab material surface. Additional issues that may be crucial are influence of humidity and other types of substrate wetting (such as finger prints) on the particle-substrate adhesion strength. The results reported here constitute a first step towards detailed understanding of the explosive particle-substrate interaction. This type of information will allow us to design more efficient swab materials.

Technical Approach



Fig. 1: Device used to glue particles to the cantilever.

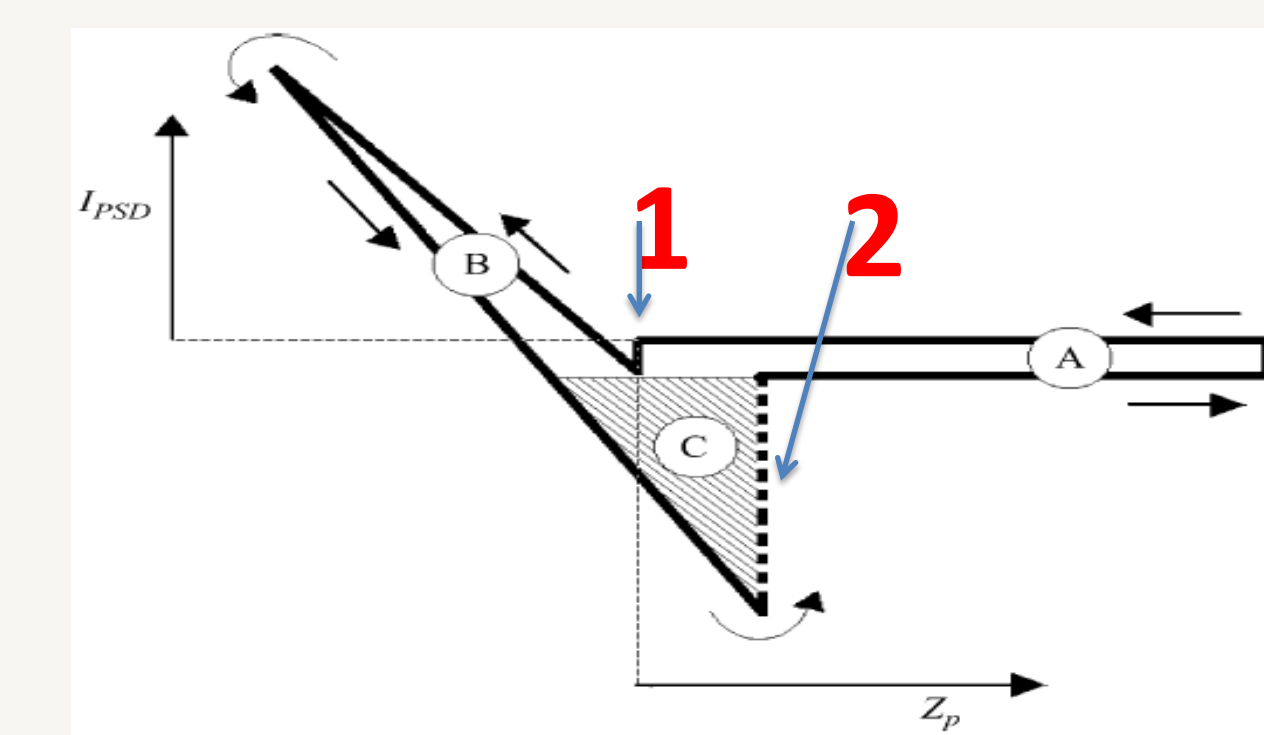


Fig. 2: Typical force curve. The "jump-to-contact" at point 1 used to obtain Hamaker constants while the "detachment jump" at point 2 used to estimate the adhesion forces.

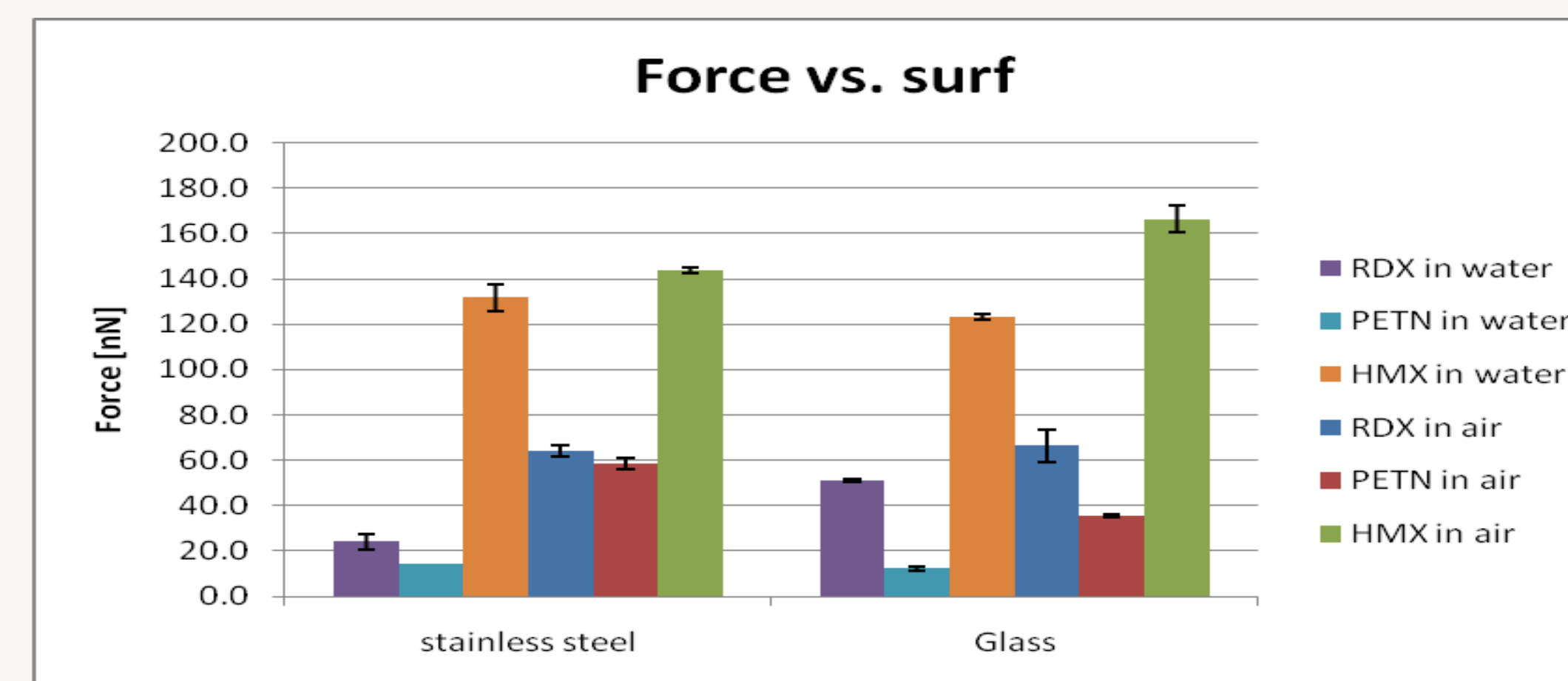


Fig. 3: Adhesion force of RDX, HMX and PETN particles to glass and stainless steel surfaces. Force measurements carried out in air and under water.

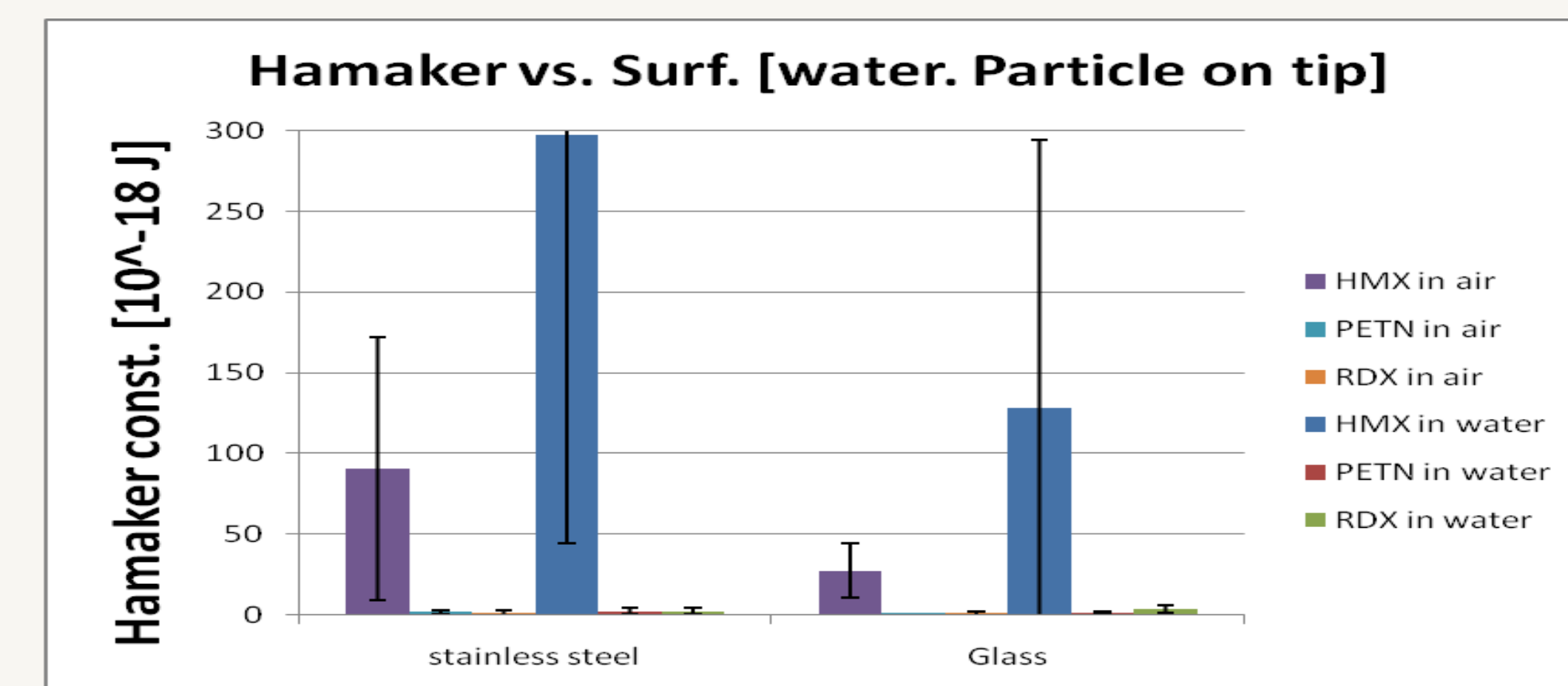


Fig. 4: Hamaker constants for RDX, HMX and PETN particles at glass and stainless steel surfaces. Force measurements carried out in air and under water.

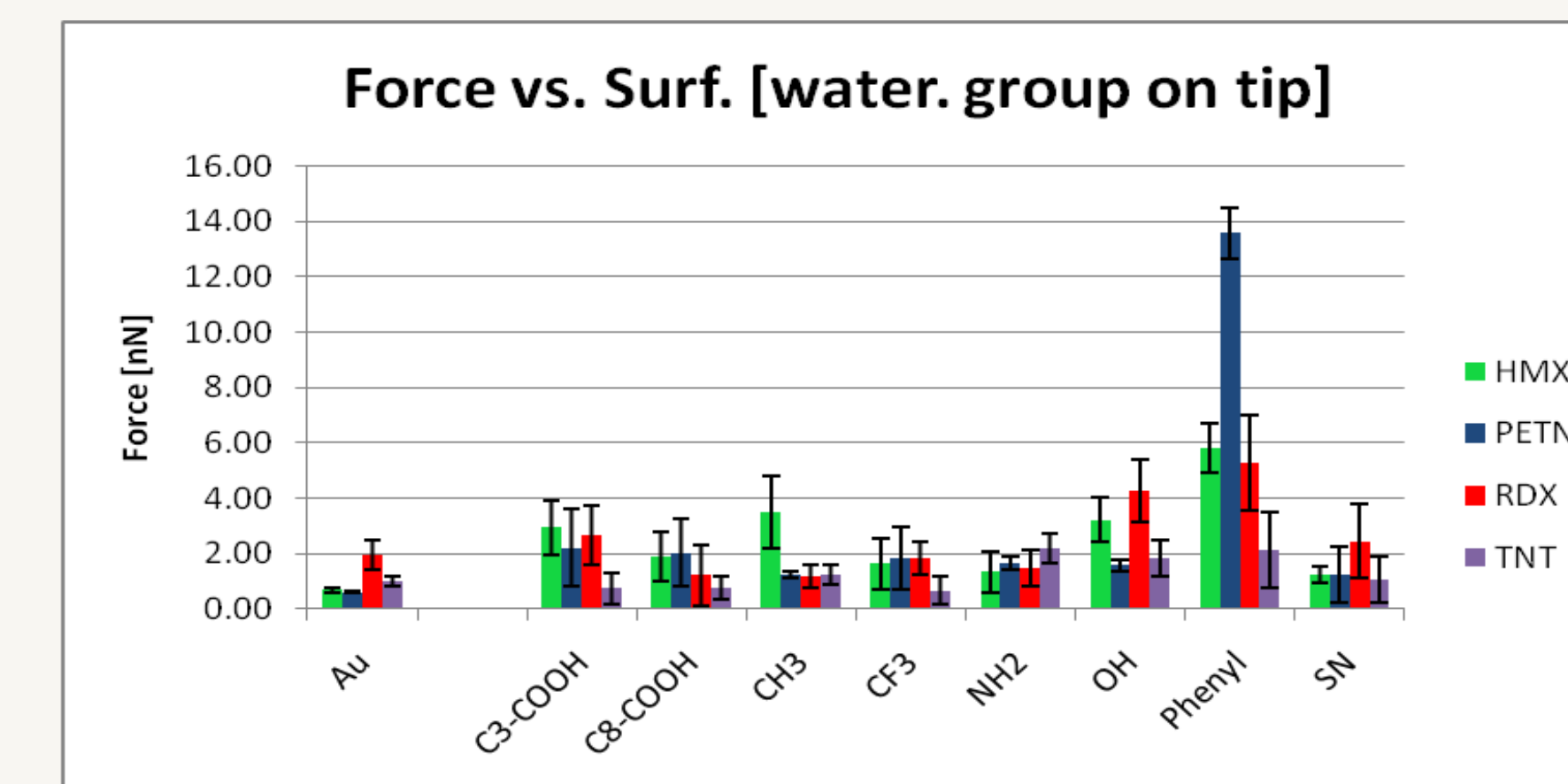


Fig. 5: Adhesion force measurements between a gold plated tip covered with a monolayer of molecules with different end groups. The horizontal axis describes the different molecular-end groups examined. Measurements under water eliminate contributions of capillary forces.

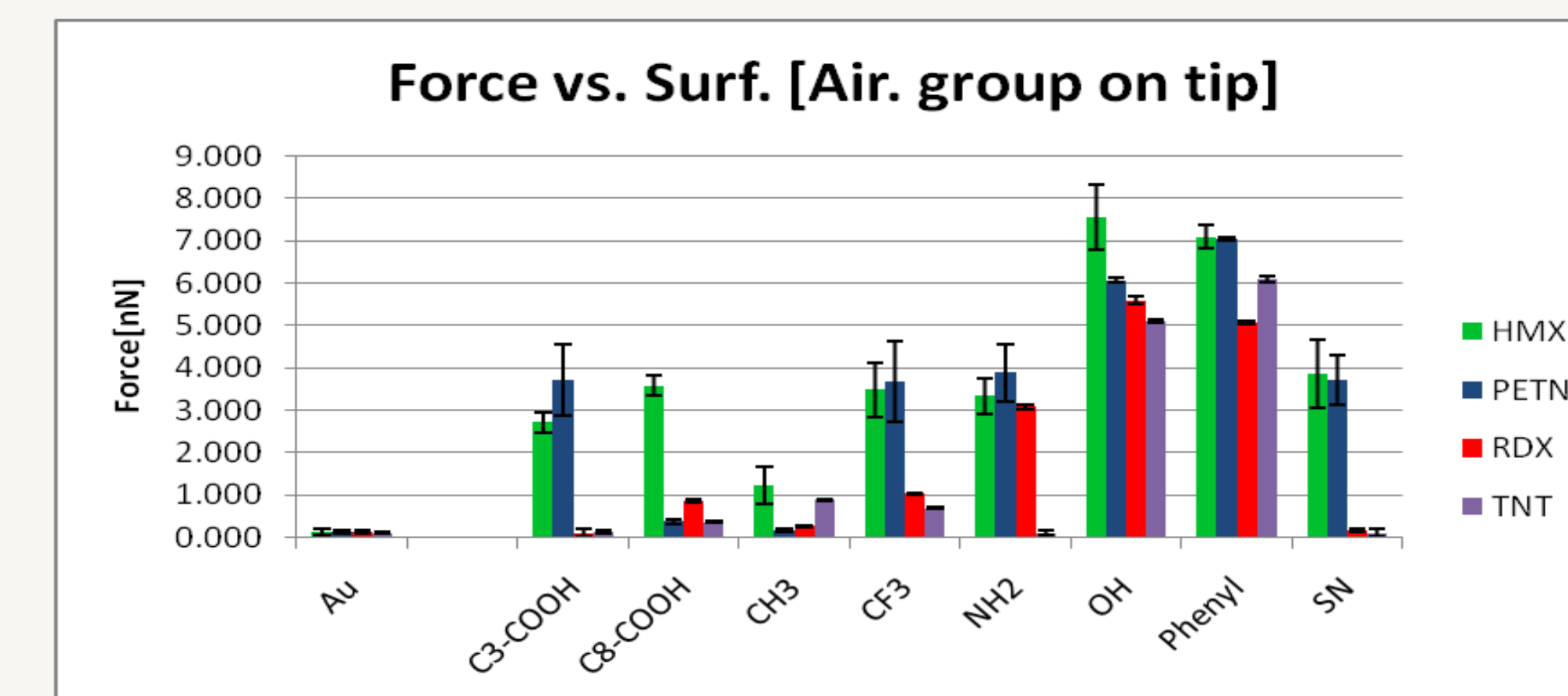


Fig. 6: Measurements in air correspond to forces due to dispersion interactions as well as contributions from forces related to capillary condensation.

Accomplishments Through Current Year

Large fraction of the results reported here were measured during the last year. The force measurements between explosive particles and different end groups of monolayer were carried out for the first time to the best of our knowledge.

Future Work

Presently we are performing electronic structure calculations to rationalize the force measurements between explosive particles and various end groups (Figs. 5 and 6 above). In addition, the force measurements will be extended to other substrates both hard (such as rubber and various plastic) and soft (including various cloth and if possible human skin)

Opportunities for Transition to Customer

Some of the findings of this study suggest that different end groups might interact more strongly than others with explosive particles. One can use this type of information to device functionalization processes for swab materials that will enhance adhesion to explosive particles. Such development is our goal for the future.

Patent Submissions

No patents were registered so far.

Publications Acknowledging DHS Support

A M.Sc. Thesis has been written by Yevgeni Zakon and submitted a few weeks ago. A full paper summarizing the results presented here together with additional data is being written at present and will be submitted for publication soon.

Other References

A good review of adhesion force measurements using AFM can be found in:
Hans-Jürgen Butt Brunero Cappella and Michael Kappl, Surf. Sci. Rep. **59** 1-152 (2005)