Title: Using Chemistry to Manipulate Contact Electrification and Electrical Discharges.

Extended Abstract: This talk will describe mechanistic investigations and applications of space-charge electrets generated by contact electrification, the mechanisms of which remain a subject of active controversy at the atomic/molecular level. Using a tool that we described previously,[1] we can observe in real-time the dynamics of charging and discharging due to a sphere rolling on a planar electrically insulating surface. Consistent with previous reports concerning the effect of ionizable groups on the polarity of charge separation during tribocharging,[2] we observed that materials with surface-bound ionic functional groups develop the same sign of charge as the formal charge associated with the covalently-bound functional group; this observation is consistent with an ion-transfer mechanism for contact electrification. In many cases, the data show linear accumulation of charge on the two contact bodies as function of time. Sharp discontinuities, which we have attributed to dielectric breakdown of the surrounding gas, interrupt the accumulation of charge. The maximal amount of charge that the rolling sphere could attain was in agreement with the known dielectric strength of air. Also, the maximal charge on the sphere in other gases correlated with their published dielectric strengths.

As an application of these intuitive and readily predictable relationships between chemical structure and polarity of charge separation, we fabricated surfaces that resist charging by contact electrification comprised of a pattern of oppositely charging ionic. We used the techniques of soft lithography to create surfaces patterned in a hexagonal array. The distribution of oppositely charging groups, which we could control through the geometry of the pattern, determined the rate of charge separation. Appropriately patterned surfaces did not discharge. Rates of contact electrification between two insulators showed similar behavior: this approach to anti-static materials does not require that one of the surfaces be conductive.

We have developed a method for determining quantitatively the location of discharges that occurred between the rolling sphere and the electrically insulating surface. The method is based on the distance-dependant sensitivity of an electrode that measures the charge on the sphere by induction. We infer from the shape of the data around each discontinuity the approximate location of the discharge relative to the position of the measuring electrode. By modeling the sensitivity of the electrode to the sphere as a function of angular displacement, we can quantitatively determine the position of the discharge. We can use multiple electrodes to increase the accuracy of the location of the discharge along the entire path of the sphere. Manipulation of surface chemistry can influence where electrical discharges occur. These examples demonstrate that a more developed understanding of electrets in general, and of the mechanisms and physical-organic chemistry of contact electrification in particular, can lead to new applications for space-charge electrets.

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2 (a) McCarty, L. S.; Whitesides, G. M. *Angew. Chem. Int. Ed.* **2008**, *47*, 2188–2207. (b) Diaz, A. F. *J. Adhes.* **1998**, *67*, 111–122.