

Research Journal

Zixuan Chen · March–October 2026

A retrospective journal of three connected projects: an electrostatic broom, a personal dust-removal device, and charged-mist dust control. These dates mark progress discussions, rather than the exact dates of every experiment or design change.

Where the questions began

The starting point was construction-site dust. Early work explored electric fields, spraying, and particle motion before the three projects took more distinct directions.

March 29, 2026

Defining the problem and the comparison

Progress The early discussion revisited electrostatic nozzles and collecting plates, including how droplets acquire charge and how electrostatic spraying differs from electrospinning.

Question Nozzle materials, liquid conditions, cost, and a useful measure of dust removal still needed to be defined. A promising mechanism alone would not show whether a practical system worked.

Next step The proposed approach was to examine published operating conditions, hold some variables fixed, and compare natural settling with electric-field and spray-assisted cases. Time to reach a specified removal level was considered as a possible comparison metric.

June 20, 2026

Simplifying the model—and questioning the particle source

Progress After struggling to solve a four-column construction-site model, I simplified it to one column. I obtained steady-state electric and flow fields, including velocity plots and tables. This was an early field model around a metal column and surrounding walls, rather than a model of the later mist nozzle.

Question Particle tracing was still not working correctly, so I could not yet calculate how many particles reached the column or walls. I also noticed a mismatch: releasing particles downward from the upper boundary did not represent dust rising from construction work below.

Next step I planned to revise the release position and initial velocity, then resolve the trajectories before discussing collection. The single-column model could help me reason about the larger layout, but it did not validate the four-column case. I was also preparing interview questions to understand workers' exposure and existing dust-control practices.

The electrostatic broom

Could static electricity help collect light debris? I explored how bristle material, charging method, and contact with the floor might affect the answer.

August 19, 2026

Looking beyond the patent sketches

Progress I reviewed Chinese patents and questioned how much their electrostatic stages contributed beyond ordinary sweeping or suction.

Question I was concerned that charge could escape when the brush touched the floor, or through discharge at high voltage. These were technical questions to test, rather than reasons to assume that every proposed design would fail.

Next step I wanted to compare frictional charging, direct high-voltage connections, and charging insulating bristles with negative ions. I also began separating two tasks: lifting debris from the floor and keeping it inside a collector.

October 6, 2026

An initial effect, with more work ahead

Progress The broom had not progressed much beyond an initial observation. I had not yet developed that observation into a systematic investigation.

Reflection At this point, I could describe an attraction effect, but I could not claim a measured cleaning result.

October 29, 2026

A prototype—and a clearer limit

Progress I had made a broom prototype and was preparing to film it. Hair and other light material seemed easier to attract than larger particles or debris strongly attached to the floor. I also compared ordinary plastic bristles with softer bristles.

Question I had not counted repeated hair-pickup trials, and I could not directly measure its effect on PM2.5 or PM10. The observations showed an effect, but did not establish a pickup rate or fine-particle cleaning efficiency.

Next step I planned to record the prototype and test a fixed amount of hair repeatedly, so I could move from an impression of success to a counted pickup result.

A more comfortable dust mask

This personal dust-removal concept grew from a difficult balance: moving enough air through a small device while giving particles enough opportunity to be captured.

August 19, 2026

Rethinking the air curtain

Progress I was reconsidering a simple air curtain. Fine particles could follow the airflow, while a compact electrostatic stage offered limited collecting area and short particle residence time. In an earlier bottle experiment with cigarette smoke, an ion generator, and wire mesh, I had noticed yellow-brown deposits and an apparent reduction in escaping smoke. Parts including a helmet, fan, battery, and high-voltage module had arrived, but the complete device was not assembled.

Question The smoke observation was qualitative; it did not establish filtration efficiency or suitability for breathing. Outdoor wind and dust buildup could also change performance. I still needed to understand how airflow, capture, and the physical layout would work together.

Next step I considered moving the air outlet from the helmet brim toward the neck and adding a prefilter and electrostatic stage. The idea was shifting from blocking dust with an air curtain toward supplying treated air, but the airflow and capture figures remained design estimates.

October 29, 2026

Making the design clearer before building further

Progress The complete personal device was still unbuilt. I had design images and was considering how to bring the design and simulation work together.

Question A design concept could explain the idea, but it could not establish filtration, comfort, or respiratory safety.

Next step My immediate plan was to organize the design images into a poster and prepare the simulation results for presentation. Further prototype work remained a task for the following months.

Charged mist, closer questions

I explored whether charged droplets could help control construction dust, and what a model or prototype would need to demonstrate before claiming an improvement.

August 19, 2026

Narrowing the construction-site question

Progress I revisited the different constraints facing well-equipped construction sites and smaller sites, alongside the need for personal protection. For the spray concept, I considered how charged droplets might disperse, interact with dust, and eventually deposit. I also questioned whether direct attraction to metal plates would have enough range to be useful.

Question Water savings and reduced resuspension were still hypotheses. I was unsure how to model the system in sufficient detail or whether I could build the proposed high-voltage nozzle.

Next step I planned to define a more manageable modeling question, clarify the hardware approach, and develop a report around the work.

October 6, 2026

Bringing the calculations into a draft

Progress I had brought the calculations together into a research draft that was close to completion, and I was using COMSOL alongside this work.

Question I was trying to explain the different behavior of PM_{2.5} and PM₁₀ through gravitational settling and time spent airborne. I recognized that the PM₁₀ calculations might be inaccurate. My conclusions about fine-particle removal and water use still depended on the model assumptions; they were not measured device performance.

Next step I planned to share the draft for feedback and work toward a final version over the next few days.

October 29, 2026

From purchased parts to a testable spray system

Progress I had bought a water pump and an agricultural electrostatic spray gun, with the aim of connecting them into a charged-mist setup.

Question I understood the basic connection, but I was still unsure how to measure dust removal and water use fairly. I was also concerned that the simulated benefit might be unrealistically large.

Next step I hoped to assemble the setup shortly and work out an appropriate evaluation method. Assembly and measured performance were still ahead of me.