Electrospray Applications for Applying CNT Solutions

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Introduction and Mechanism

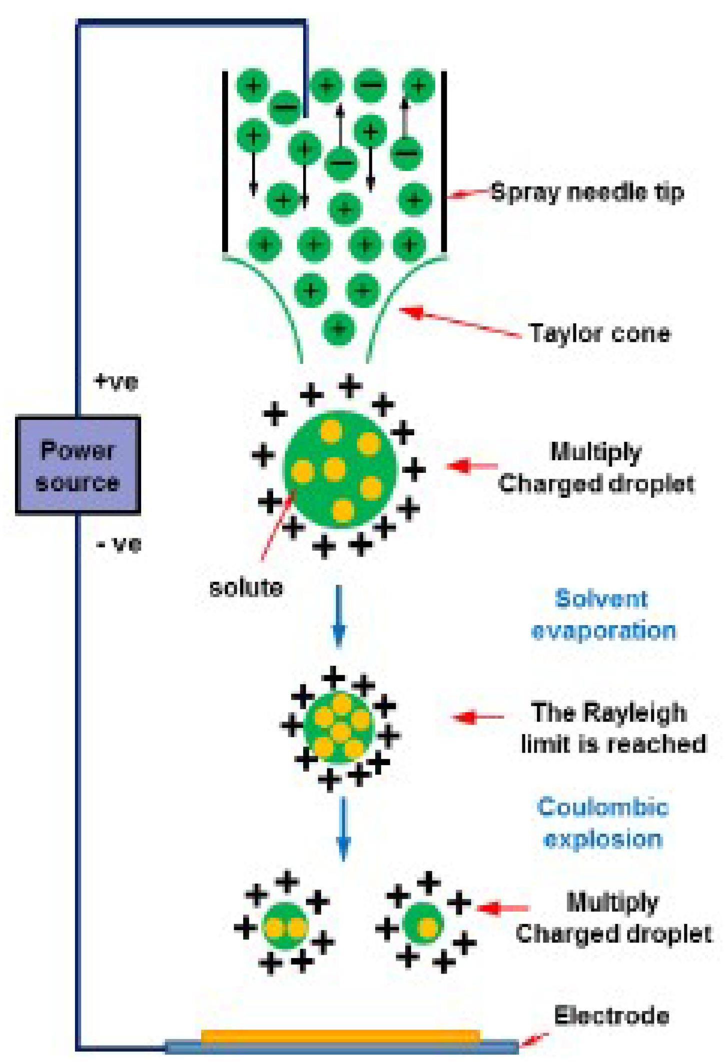

Fig.1: A conceptual vertical setup of electrospray

- **Electrospray operates by pumping an electrolyte through a capillary and forming a very fine tip of conductive solution, called a Taylor Cone, by applying a high voltage between the capillary containing the conductive liquid and a substrate. The applied electric field induces forces (surface tension and viscoelastic forces) on the fluid that help to retain the hemispherical shape of the droplet. Once the voltage breaches a threshold value the surface tension is overwhelmed, and a charged jet emerges from the Taylor cone. It has been observed that low viscosity fluids break up into particles when an electric field is applied and leave the capillary as very fine mist in electrospray.**

Fig. 2, 3: Formation of Taylor cone as the electromagnetic attraction overcomes the surface tension of the CNT solution.

CNT Solution

The solution used with the electrospray platform was composed of Carbon nanotubes (CNTs), polyaromatic moieties, and the presence of a strong acid. Carbon nanotubes (CNTs) are an allotrope of carbon that is rolled into cylinders that can be used for a variety of purposes as shown below in figure 4. A free-flowing solution of CNT nanoparticles was created using noncovalently bonding polyaromatic moieties that are further functionalized using either fuming sulfuric acid or chlorosulfonic acid. The acid and the polyaromatic moieties are used together to minimize the presence of London Dispersion Forces (LDF) between the CNTs, diminishing the clumping of the nanotubes. In addition, the conjunction of moieties and a strong acid allows for the mechanical flexibility and electrical properties of the CNTs to be unaffected, creating a solution with a high amount of resistance to be developed. The free-flowing properties of the CNT films allow for uniform distribution on large surfaces.

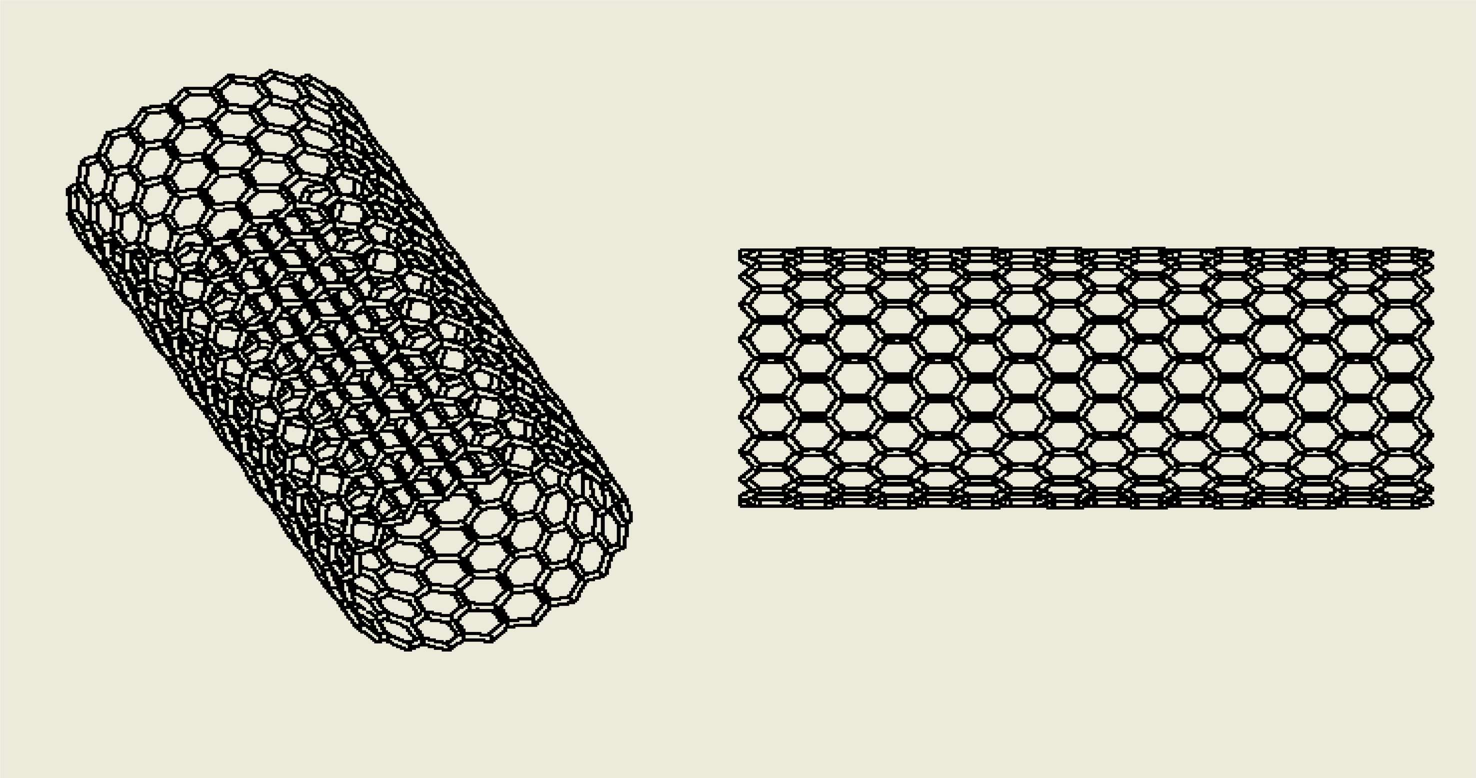

Fig.4: The basic structure of a single walled carbon nanotube (SWCNT)

Results

By varying flow rate and applied voltage the electrospray phenomena was achieved using a ring with the needle that acted like a focusing lens. The ring was placed just at the tip of the needle as to avoid spray getting on the ring. We tested the H2SO4 solution filled with dispersed CNTs and we sprayed them at different flow rate settings increasing the voltage until achieving a Taylor cone, and thus electrospray. The two figures below represent the data collected and the observation made during the trials. To achieve a finer spray the flow rate was decreased with a set interval of 0.2 ml/mm. The voltage was adjusted accordingly to form the Taylor cone. A decreasing linear trend was found between voltage and small flow rates.

Left: 0.6 ml/min   Middle: 0.02 ml/min   Right: 1 ml/min

Fig.5: Samples collected after electrospraying on a PET substrate at different flow rate and voltage.

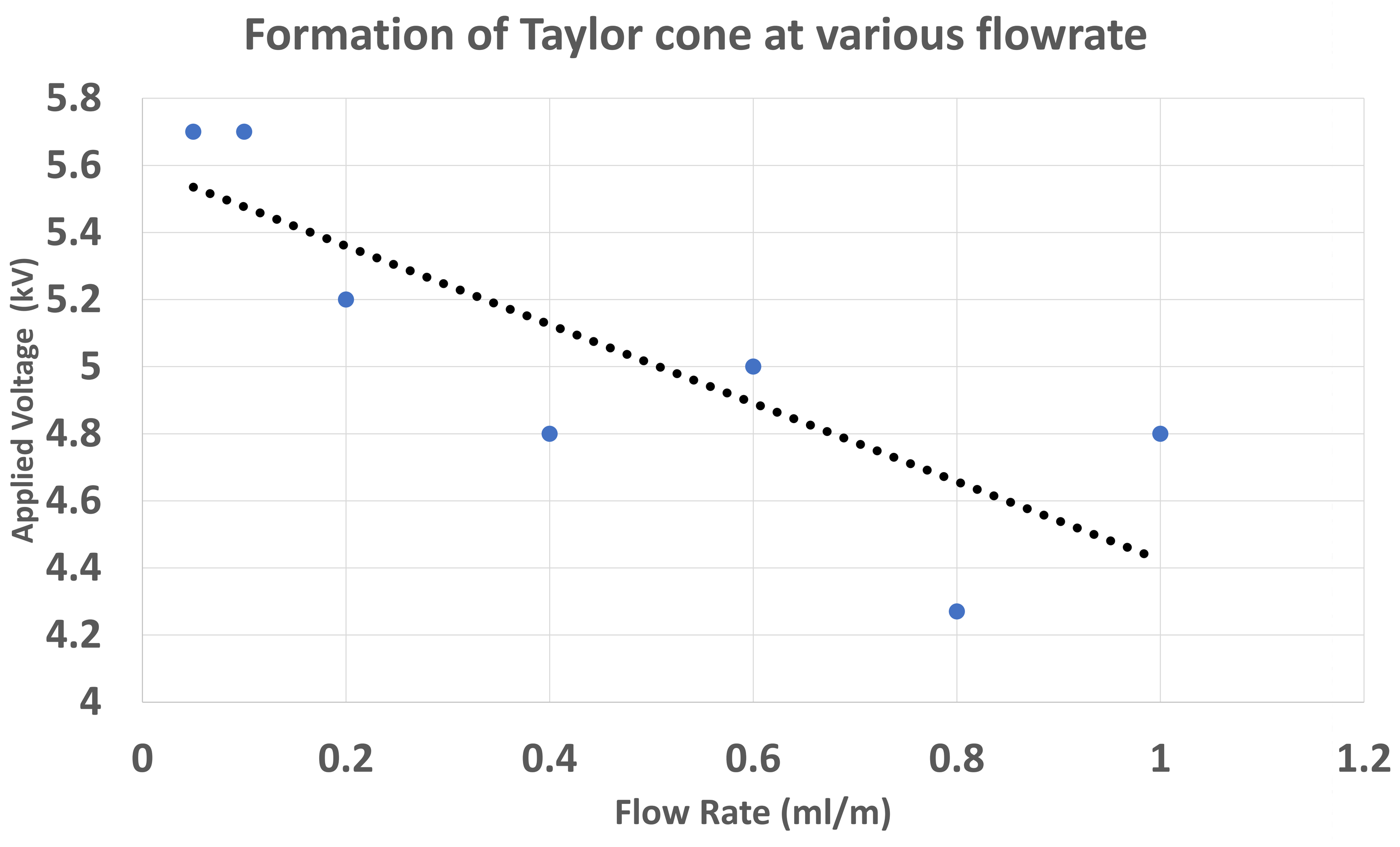

Fig.6: Data collected during the experiments. The point represent the voltage and flow rate at which Taylor cone formed.

Conclusion

In conclusion, electrospray is a proven concept. We look next to improving upon the concept by experimenting further with the needle size as well as the changing the voltage and flow rate of our experiment setup to improve the quality of our spray. We wish to improve upon this to the point where we can apply our concept to larger scale applications and start testing out coatings themselves for resistivity..

References and Acknowledgements

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