Deposition of Single Walled CNTs Through Electrospray

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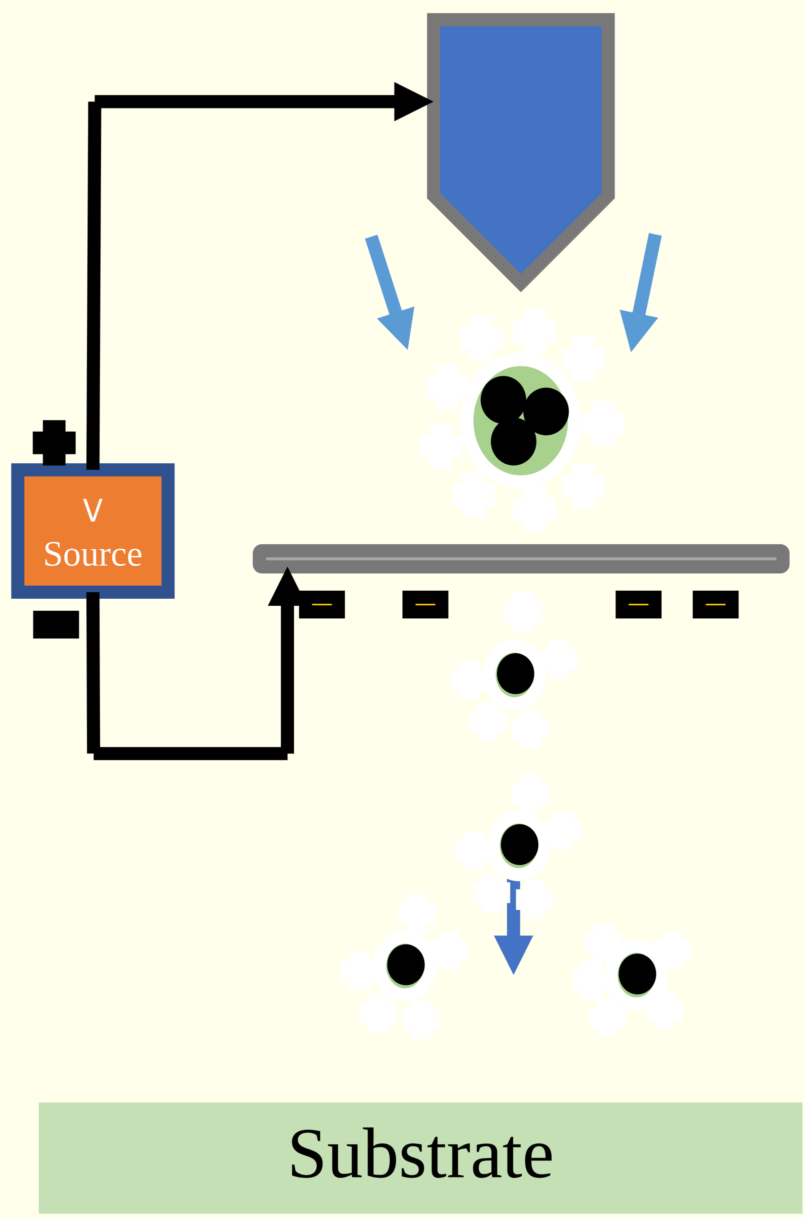
Introduction and Mechanism



Schematic Diagram

Experimental Setup

Fig:1 Electrospray setup used for the experiment.

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.

Voltage Off

Voltage On

Fig:2 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 Singled Walled 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. Concentration of CNT 1.2 mg/mL

Fig:3 Single walled Carbon Nanotube (SWCNT solution

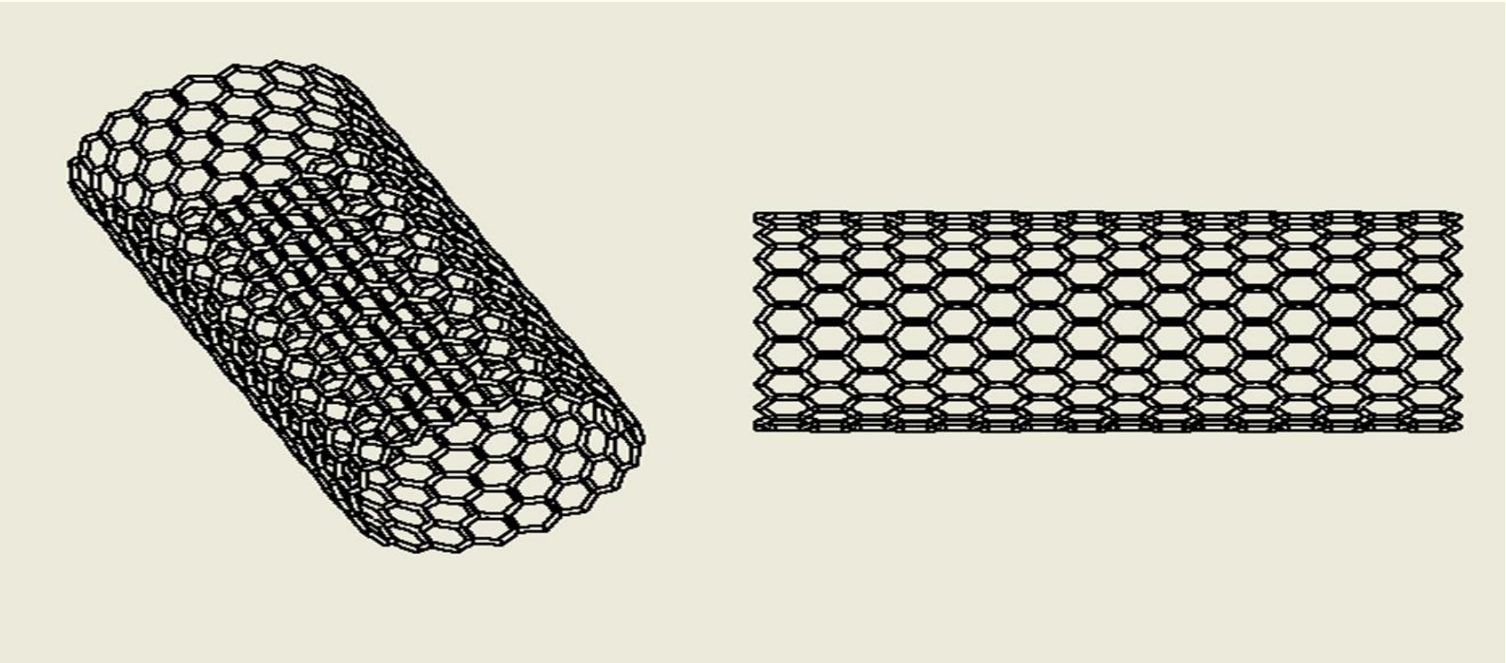


Fig:4 Basic nanostructure of a SWCNT

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.

Flow rate: 1.0 mL/min
Voltage: 4.8 ± 0.1 kV

Flow rate: 0.05 mL/min
Voltage: 5.7 ± 0.1 kV

Flow rate: 0.6 mL/min
Voltage: 5.0 ± 0.1 kV

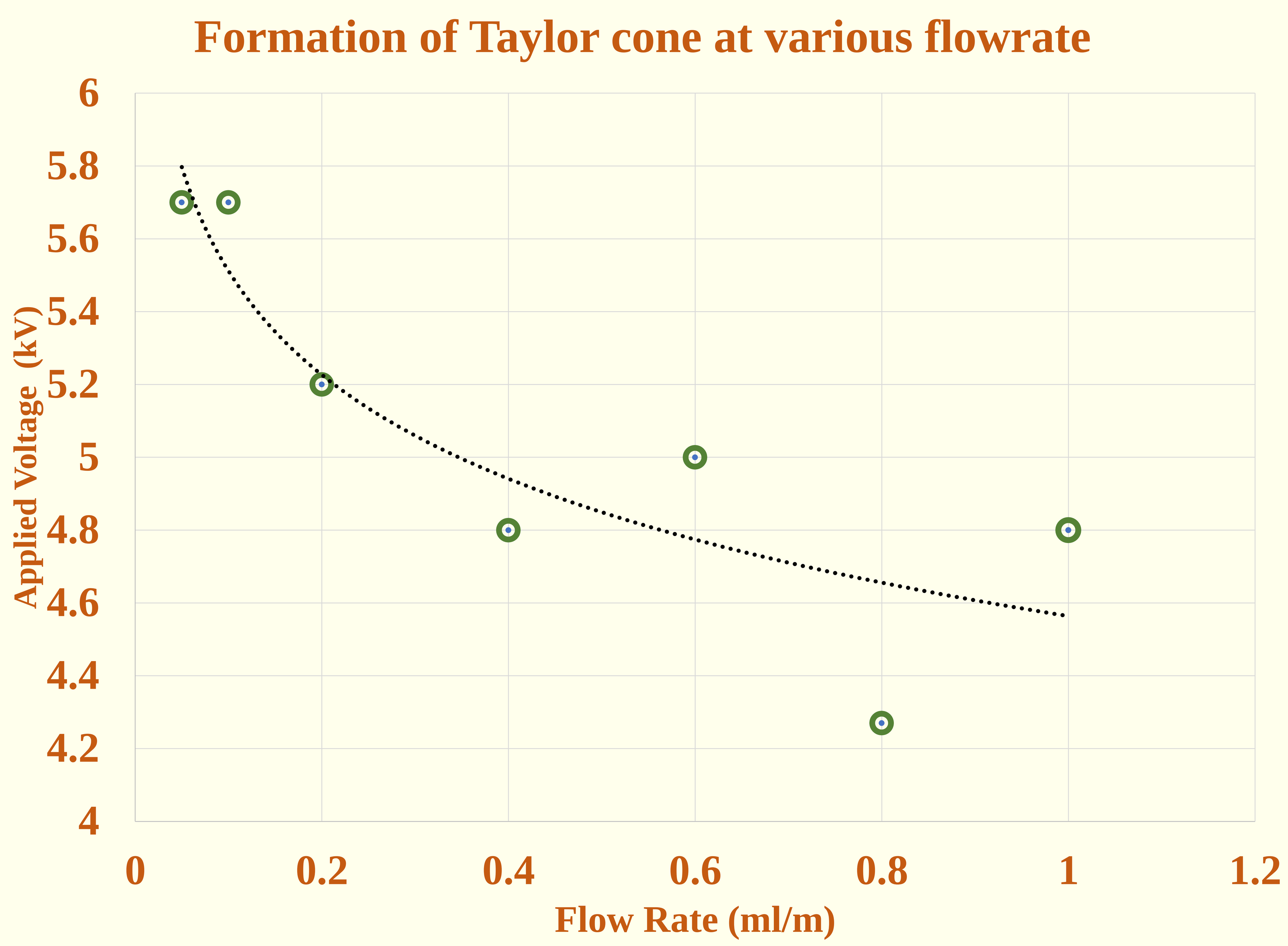


Fig.6: Data collected during the experiments. The point represent the voltage and flow rate at which Taylor cone formed.

Discussion

For the given conditions of the concentration of the SWCNTs, the distance between the needle and the ring, the Taylor Cone formation the experiment suggests the need of low voltage at higher flow rate. The voltage of 5.7 ± 0.1 kV required to form a Taylor cone at 0.05 mL/min as compared to 4.8 ± 0.1 kV for 1.0 mL/min.

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 to apply our concept to larger scale applications.

References and Acknowledgements

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Acknowledgements: We thank the financial support by Office of the undergraduate research, Embry Riddle Aeronautical University, Daytona Beach, FL 32114