Rain power - Triboelectric Nanogenerators

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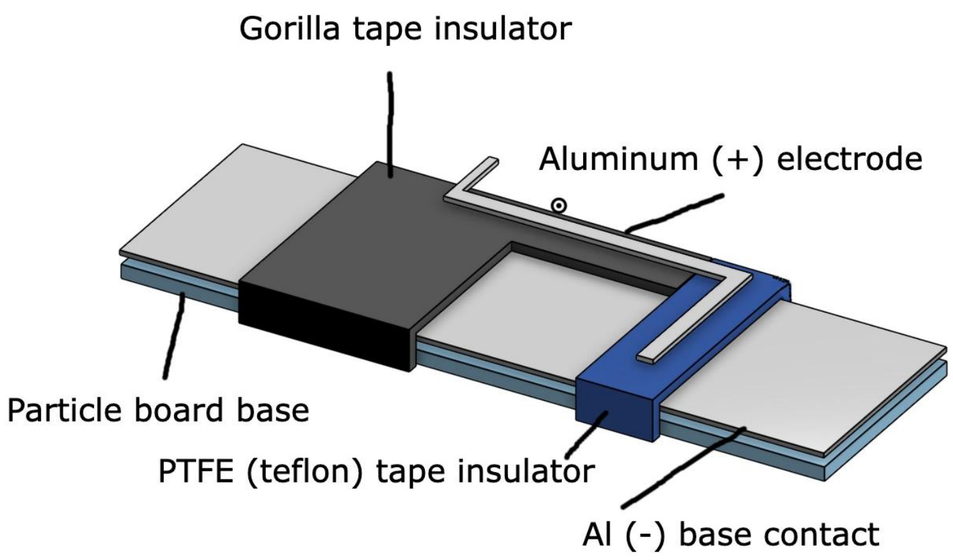
- As of 2022, 770 million people worldwide lack access to electricity, and declines in global accessibility rose from 74% pre-pandemic to 77% in Sub-Saharan Africa's populations recently (6)
- The call for action to limit carbon emission has incentivized the development of renewable energy. However, cost and space limitations still surround wind and solar energy generation (1)
- Our research seeks to explore an alternative that is more cost-effective and local to the Vancouver area – triboelectric nano generators utilizing rainfall. A TENG converts mechanical energy into electrical energy using the triboelectric effect. When two materials with different electronegativities come into contact and then separate, the electrons transfer from one material to the other, creating an electric potential difference (2).
- While TENGs currently exist, they can be costly and are not as readily available. In our experiment, we test different materials of varying triboelectric series to produce the most cost-effective, efficient, and environmentally friendly TENGs to provide universal, clean energy for all.

Experimental Procedures

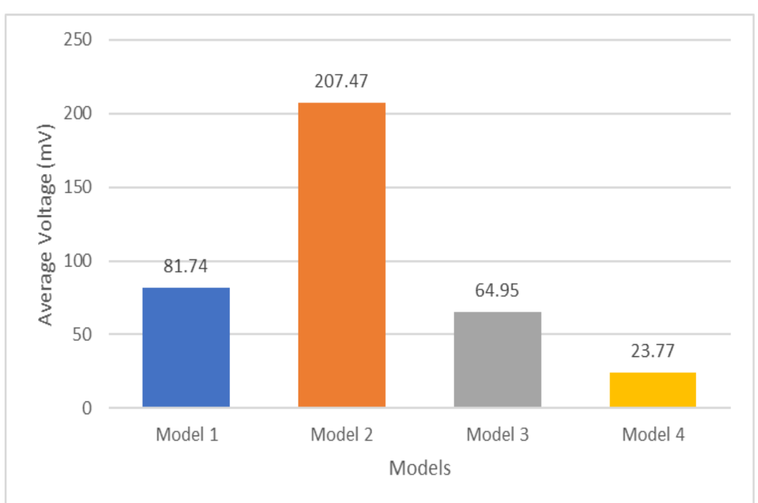
Cut and label four particle boards with 1, 2, 3, and 4 and adhere aluminum foil atop each, then insulate with Gorilla Tape strip layer ~2 cm from the middle of aluminum layer, separating electrodes. Add conductive paint between larger half of aluminum for models 2 and 3 and polytetrafluoroethylene tape for models 1 and 2. Paint models 3 and 4 with polyurethane.

Set up a burette on a ring stand and place a beaker with soldering helping hands beside it, clamping the experimental TENG in one hand at 30-45°, around 4 cm below the burette tip. Using a multimeter and alligator clips, connect the black lead from "COM" to the TENG's negative electrode and the read lead from "V" to the positive end for voltage measurements. The multimeter was set to 200mV (Direct Current), and we turned the stopcock open to allow a frequency of two water droplets per second to drip on the TENG to test voltage output. Calculate the average voltage output over 15 seconds after stable water flow is achieved. We recorded the data on our laptop spreadsheet and repeated procedure for each trial and the other models.



Model	Name	Material
1	Robert Murray Smith, Youtube (5)	Polytetrafluoroethylene (PTFE)
2	Cayrex, Youtube (6)	Carbon Conductive Paint, PTFE
3	Robert M. Smith (Modified)	Carbon Conductive Paint, Polyurethane (PU)
4	Custom TENG	Aluminum, PU

Figure 1: Average voltage output (mV) from water droplets contacting TENG models for 15 seconds upon stable water flow achieved. Note: all average voltages magnitudes are *absolute values*.



Results – continuous voltage

- Models 2 and 3 read negative voltage values and are recorded as "absolute voltages."
- Negative voltages were not read for Models 1 and 4 which were made of different materials
- From time (t) = 11-15 s, the magnitudes of each models' voltages are similar, whereas from t = 1-10 s, the voltage magnitude of Model 2 progressively decrease, while the magnitude of Model 3 progressively increases until t = ¬> 11 s where both models remain consistent with each other
- Of the four models tested, Model 1 (PTFE) had the highest average voltage output at 81.74 mV, and Model 4 (PU & aluminum) had the lowest non-negative average voltage at 23.77 mV

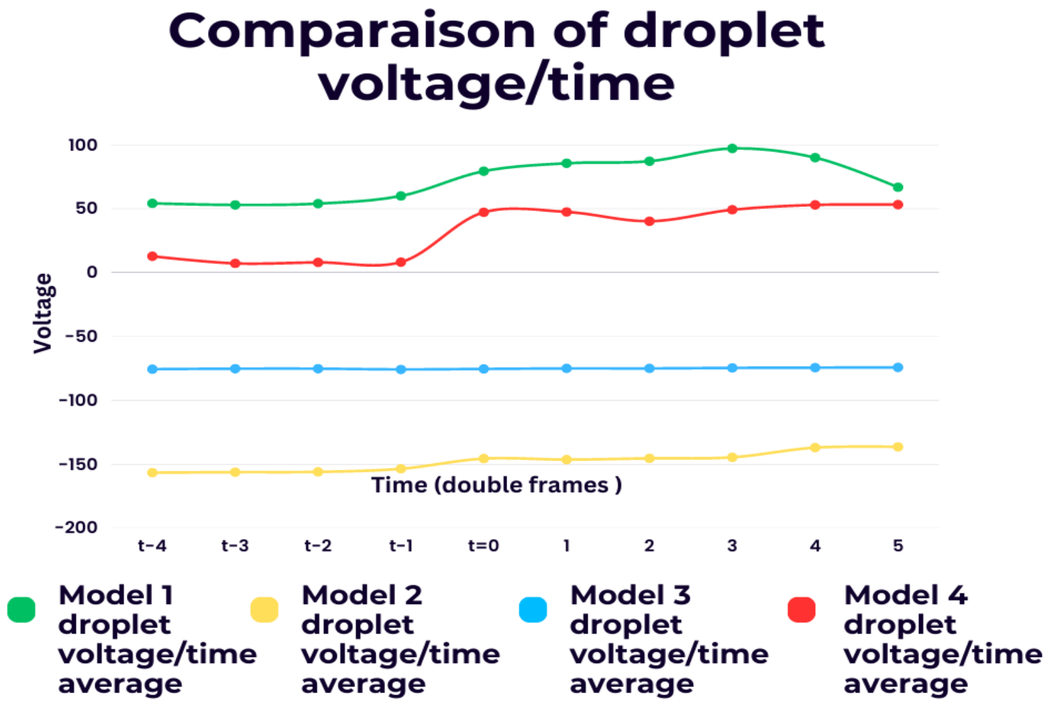


Figure 2: Data is shown over time relative to when each water droplet hits the generator's surface. T-0 represents the time when each droplet passed the (+) Al contact. Data points are separated by 2 frames (1/15 sec)

Discussion

- While all TENG models generated electricity, it is unlikely that all of them were generating energy using triboelectricity: models 2 & 3 should be disqualified as they produced a continuous voltage regardless of droplet timing as shown in figure 2. Their voltage produced was opposite in polarity to what should be expected given traditional triboelectric behaviour.
- Altogether, our experiments show Model 1 (PTFE) having the highest voltage output, it is perhaps not the ideal option for a clean and affordable energy source as it contains chemicals that harm the environment and is relatively expensive (11)
- Despite Model 4 having lower voltage output than Model 1, aluminum & PU is more affordable, sustainable, & safe for energy production in large quantities, especially suitable for rainy climates such as Vancouver (12, 13)

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