Textile based Triboelectric Nanogenerators with Balanced Electrical and Wearable Performance

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Introduction: Triboelectric Nanogenerators (TENGs) depend on the triboelectric effect and electrostatic induction to convert mechanical energy into electricity.[1] They have been demonstrated as energy harvesters and self-powered sensors for wearable applications, converting human movement into electrical outputs at conversion efficiencies reaching 50%.[1] However, most TENG designs are constructed using flexible plastic sheets via lab-scale fabrication methods, hence, simultaneously achieving both electrical and wearable properties is significantly challenging.[2] This work investigates the applicability of common textile materials (yarns, knitted fabrics) and industrial textile manufacturing techniques (yarn coating, dip coating, screen printing) to produce textile TENGs with balanced electrical and wearable performance.

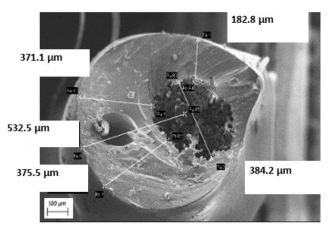
TENG Fabrication: TENG Layer 1

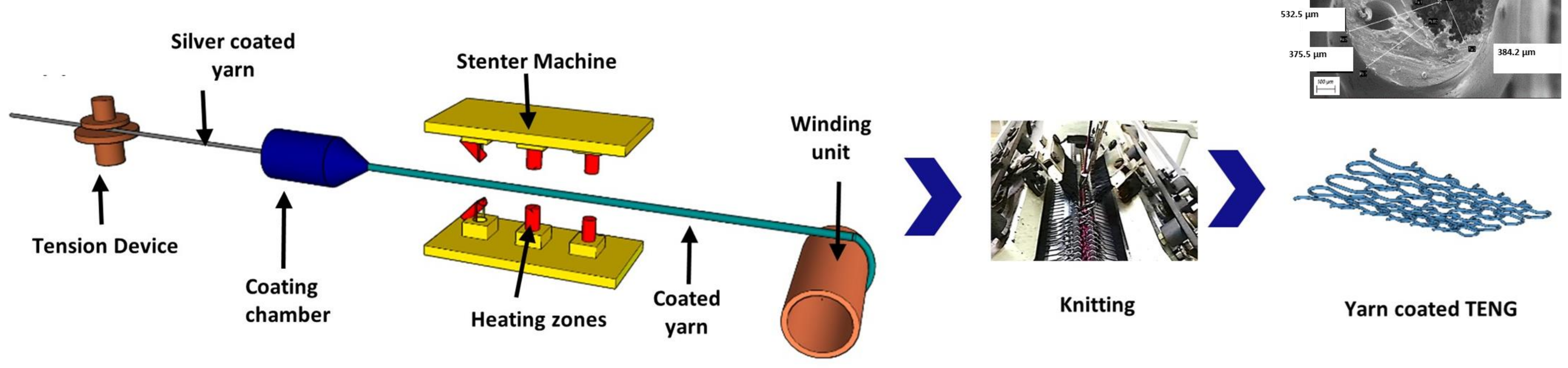
Substrate Material: Silver Plated Nylon Yarn (875 dTex)

Triboelectric Coating: Polydimethylsiloxane (PDMS)

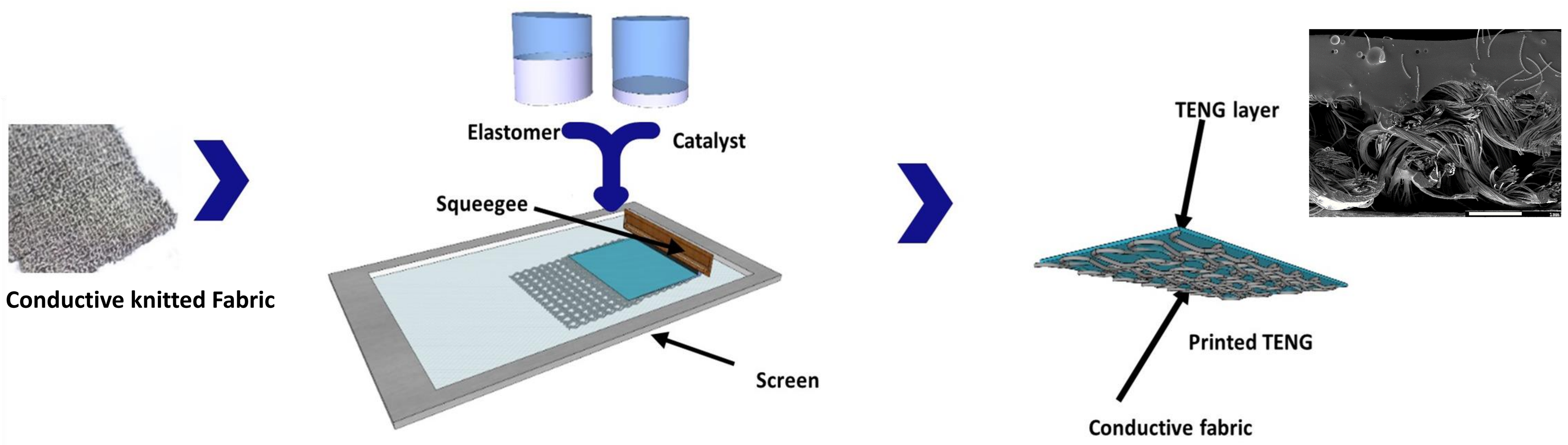
Fabrication Methods: Yarn Coating, Screen Printing, Dip Coating

Method 1: Yarn Coating

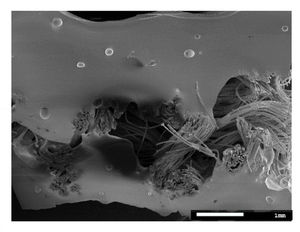


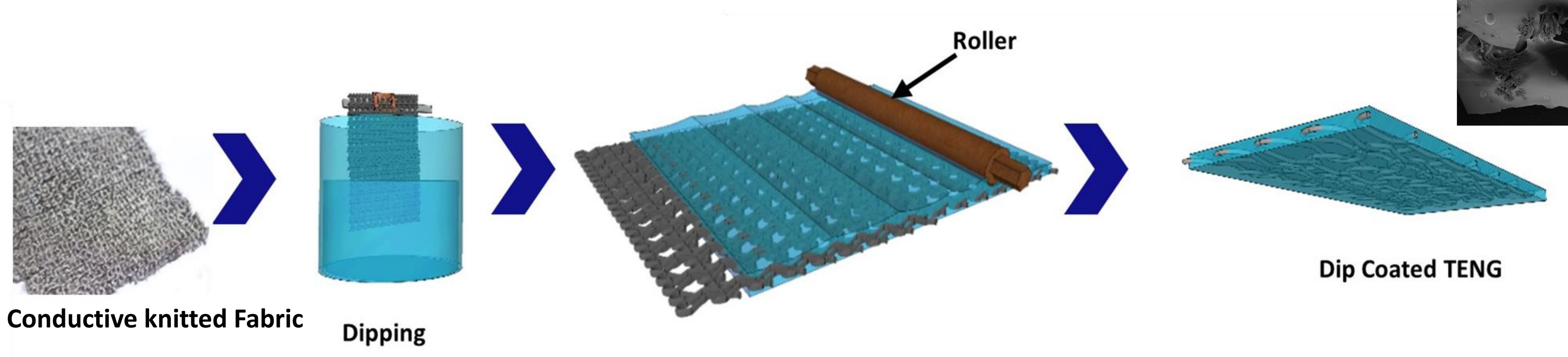


Method 2: Screen Printing



Method 3: Dip Coating



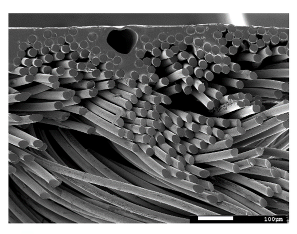


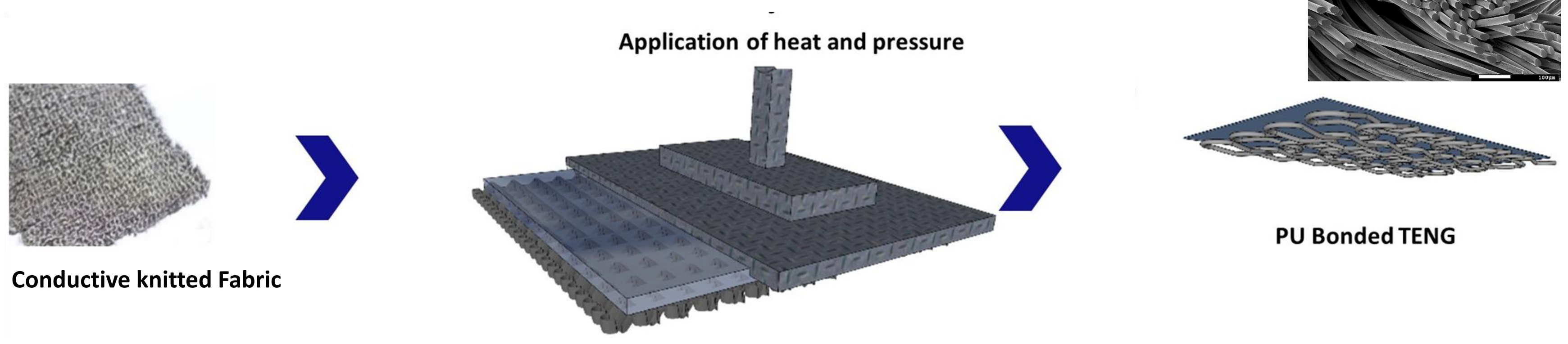
TENG Layer 2

Substrate Material: Silver Plated Nylon Yarn (875 dTex)

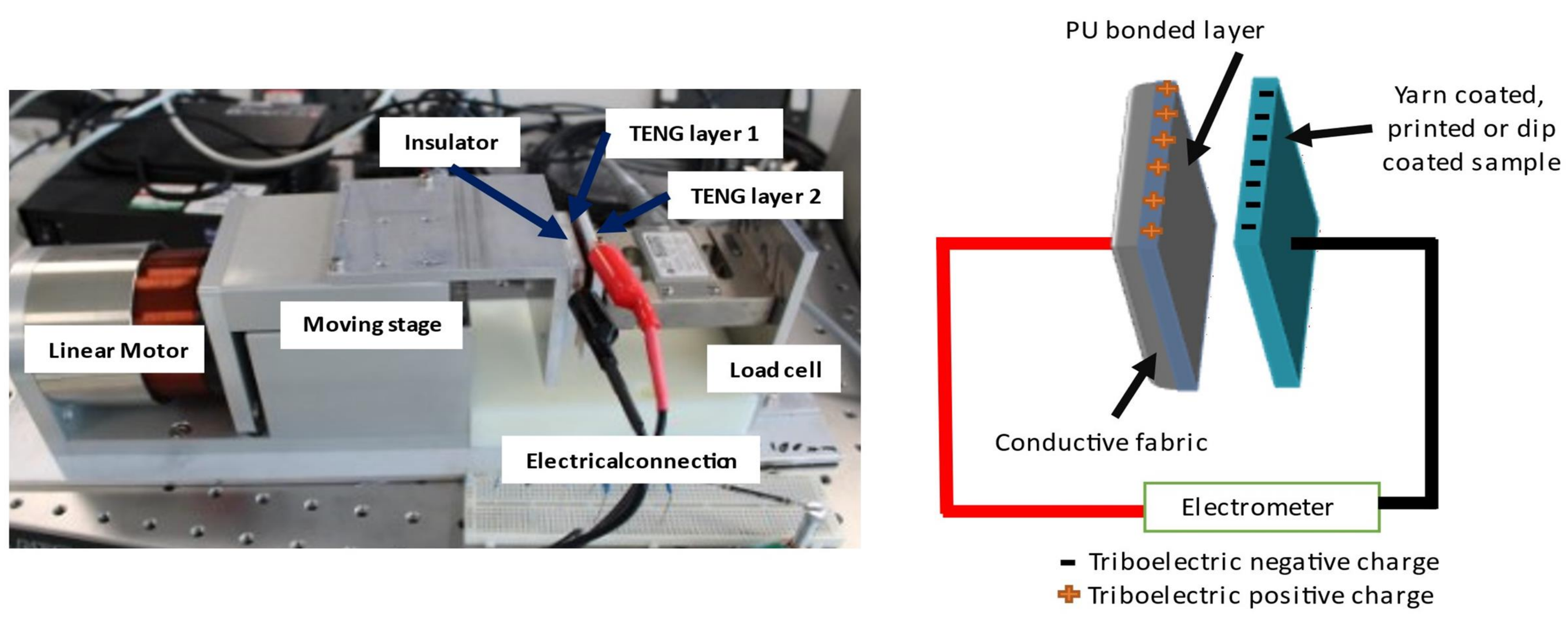
Triboelectric Coating: Polyurethane (PU)

Fabrication Methods: Heat Bonding





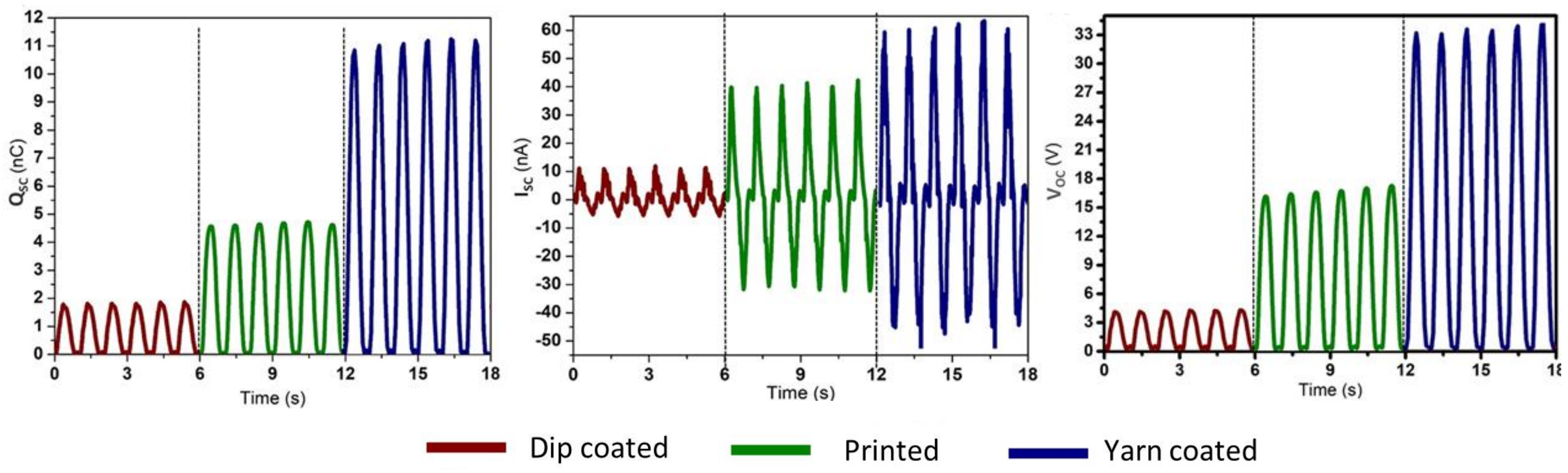
Electrical Characterization



Electrical outputs (Experimental)

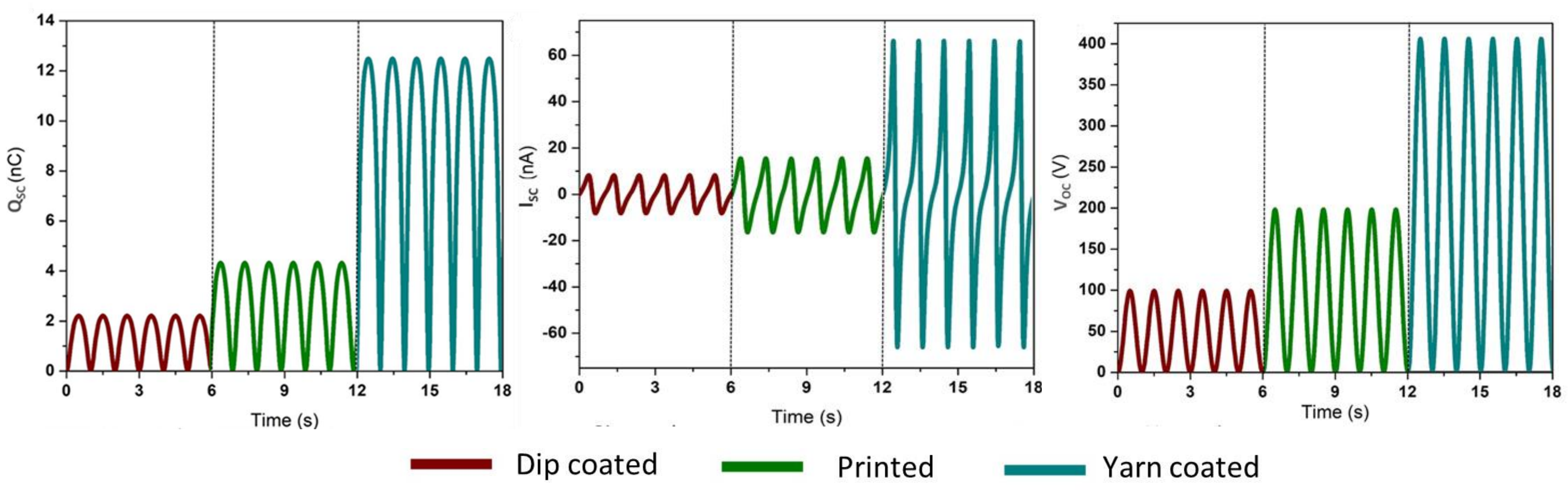
Sample size: 5 cm* 5 cm

Excitation: sinusoidal (1 mm amplitude, 1 Hz) with maximum contact force of 10 N

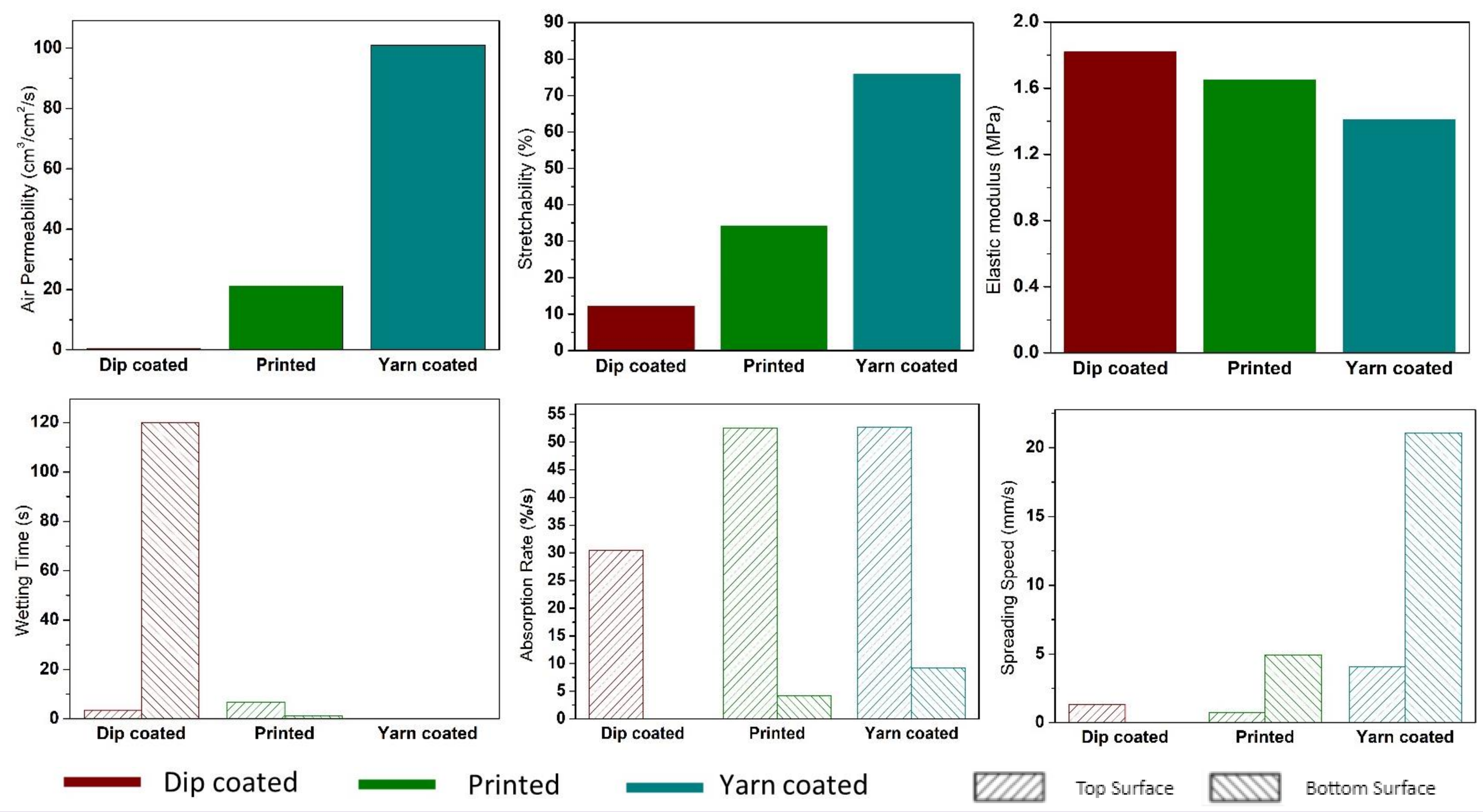


Electrical outputs (Theoretical)

Theoretical platform: Distance Dependent Electric Field (DDEF) model[3]



Wearable Characterization



Conclusions: The yarn coated TENG provides the best electrical and wearable performances, followed by the screen printed and dip coated TENG devices. Textile properties such as fabric porosity, loop mobility, evenness of the triboelectric coating and low coating thickness, which are prominent features of the yarn coated TENG, plays a key role in these performance enhancements. This technique, therefore, can be used as a scalable technique for wearable TENG applications to obtain balanced performance between wearable and electrical characteristics.

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References:

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