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Optimization of Knitted Structures for E-Textiles Applications †

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Abstract: The findings of this research attempt to evaluate the electrical and compression features of electrically conductive yarns (ECY) as well as the structure of sensor systems, such as single jersey and double jersey knit designs, for healthcare applications and wearing technologies. The tensile properties and electrical properties of conductive yarns were optimized basis of the findings. Owing to the knit-tuck stitches arrangement, which gives density to the fabric, the double lacoste, popcorn, and milano ribs were proven to have adequate compressive resilience. The developed knitted structures kinds of sensors were noticed and may easily be applied to global smart socks manufacture as well as other technologies.

Keywords: silver-coated yarns; pressure sensor; electrical properties; compression properties; e-textiles

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1. Introduction

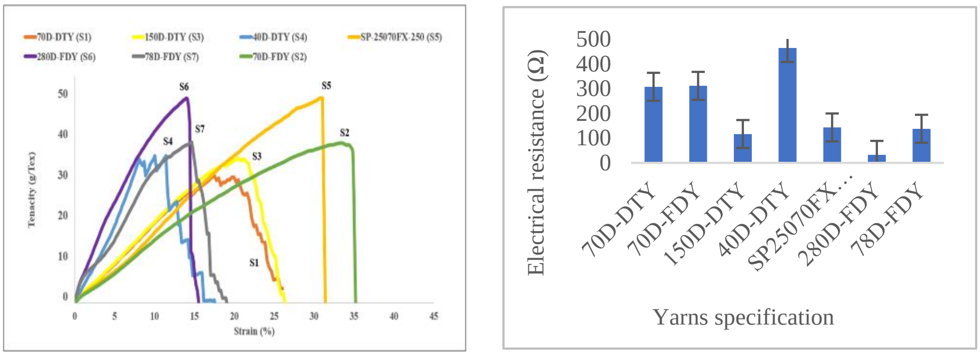
By recognizing and responding to a sensory input, smart textiles response to the environment with various components of electronics in the form of yarns or textiles [1] integration of various patterns and composition of woven, non-woven, and knitted structures [2].

2. Results and Discussion

The conductive yarns 280D-FDY and SPFX25070-FX were selected based on the results shown in Figure 1a, and the electrical characteristics of the conductive yarns were seen in Figure 1b. The Kawabata evaluation system (KES FB-03) had been used to test pressure sensors such as double lacoste, popcorn, and milano rib compression properties, with the findings reported in Table 1. Figure 2 and Table 2 show the pressure electrical resistance curve for an optimized knitted structure. The decrease in electrical resistance when subjected to varying loads indicates well for the insertion of such designs into socks for counting calories and other health-related applications in the field of e-textiles. Furthermore, the sensors utilized in health monitoring systems are extremely adaptable, allowing for a natural interface with the human body [3].

Table 1. Compression results for optimized knitted pressure sensors.

Compression Characteristics	Double Lacoste	Popcorn	Milano Rib
Linearity of compression (LC)	0.560 ± 0.036	0.570 ± 0.026	0.550 ± 0.050
Work of compression (WC) gf. cm/cm^2	1.467 ± 0.108	1.850 ± 0.050	2.157 ± 0.137
The resilience of compression (RC) %	44.000 ± 1.375	45.557 ± 0.407	49.55 ± 0.918
Thickness at the max load (To) mm	3. 550 ± 0.050	3.490 ± 0.066	4.666 ± 0.015
Thickness at the pressure 0.5 g. f/cm^2 (Tm) mm	2.447 ± 0.186	1.550 ± 0.050	1.550 ± 0.05



(**a**) (**b**)

Figure 1. (**a**) Tenacity-strain curve for conductive yarns; (**b**) electrical resistance (Ω) of conductive yarns.

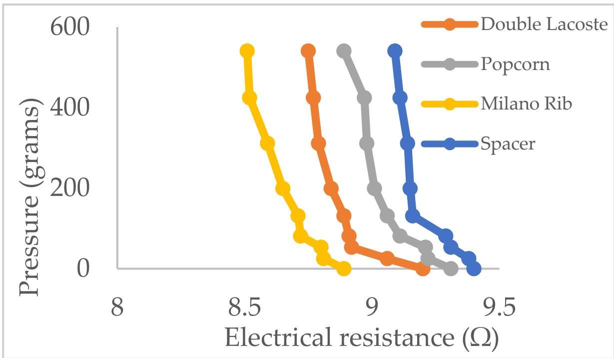


Figure 2. Pressure-electrical resistance curve for an optimized knitted pressure sensor.

Table 2. Electrical resistance measurement for the selected knitted structures to identify the pressure sensing properties.

Sr. #.	Pressure (Grams)	Double Lacoste Resistance (Ω)	Popcorn Resistance (Ω)	Milano Rib Resistance (Ω)	Spacer Resistance (Ω)
1	0	9.20 ± 0.21	9.31 ± 0.32	8.89 ± 0.39	9.40 ± 0.41
2	25	9.06 ± 0.23	9.22 ± 0. 29	8.81 ± 0.32	9.38 ± 0.41
3	53	8.92 ± 0.23	9.21 ± 0.22	8.80 ± 0.29	9.31 ± 0.29
4	81	8.91 ± 0.25	9.11 ± 0.22	8.72 ± 0.31	9.29 ± 0.28
5	131	8.89 ± 0.28	9.06 ± 0.19	8.71 ± 0.29	9.16 ± 0.31
6	199	8.84 ± 0.22	9.01 ± 0.23	8.65 ± 0.33	9.15 ± 0.33
7	311	8.79 ± 0.23	8.98 ± 0.28	8.59 ± 0.35	9.14 ± 0.41
8	424	8.77 ± 0.25	8.97 ± 0.26	8.52 ± 0.41	9.11 ± 0.39
9	540	8.75 ± 0.22	8.89 ± 0.33	8.51 ± 0.29	9.09 ± 0.36

3. Conclusions

Based on their compressional properties, this research work sought to select/optimize the best practicable knitted structures from both single and double jersey knitted structures. Double lacoste and popcorn were reported to have better compressional behavior in case of single jersey knitted structures. The only structure in a double jersey is the milano rib, which offers a higher compressive value due to the structure design and the best pressure sensing properties. Smart textiles are seen as the industry's future, with numerous new items being developed in various stages of life in response to demand [4]. Miniaturization of health monitoring systems is progressing to manage complicated computing and efficient information sensing [5]. Several studies [6,7] have been done to improve the sensing characteristics of textile constructions made from electrically conductive yarns.

Author Contributions: S.U. contributed to original draft preparation, methodology and investigation. K.S. helped in supervision and formal analysis. S.T.A.H. contributed to conceptualization supervision, project administration and funding acquisition. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: Not applicable.

Informed Consent Statement: This study was conducted to measure the calories burnt during human activities like running, jumping, walking etc., and to get the actual quantities consumed. The purpose of this study was to manufacture a textile-based structure for E-Textiles applications along with good features of comfortability and breathability.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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