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Development of the Conductive Composite Thread and the Evaluation of Sensing Performance of Human Body Signals for the Textile-type Electrodes

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1. Introduction

This study aimed to manufacture the conductive composite thread, which is applicable to embroidery, sewing or knitting and is a source material used in textile-type electrodes and circuits, by various twisting condition used by the textured polyester yarn and Ag coated polyamide yarn. The performance of the manufactured samples was analyzed through morphology, tensile property and electrical property. Then, the applicability was confirmed by manufacturing textile-type electrodes for electromyography (EMG) measurement using them.

2. Experimental

Table 1 shows the twisting conditions for manufacturing conductive thread and the corresponding sample code. In this study, a type of commercially available silver-coated conductive yarn (Soitex, Seoul, Korea) and textured PET yarn were used to manufacture conductive thread, and samples were prepared using twisting machine (TY370, TexTex, China). To manufacture the conductive thread, first, 2 plies of PET yarn were fixed to the twisting jig and then twisted with the "S" twist (1st twisting) at 100, 200, 250, 500, and 1,000 TPM. Afterwards, the twisted PET yarn and 1 ply of conductive yarn were again fixed to the twisting jig, and then it was produced with the "Z" twist (2nd twisting) at 100, 200, 250, 500, and 1,000 TPM. At this time, the initial load was 2 cN, and twisted conductive thread was heat-set at 60°C for 30 min to obtain the final sample. The manufactured composite threads were analyzed for tensile property and linear resistance, and the size of 15 mm^2 electrode was fabricated using the DT/CY-5S/5Z sample to measure sheet resistance.

Table 1. Sample code and twist factor for manufacturing twisted conductive thread

Sample code	1st twisting		2nd twisting		Sample code	1st twisting		2nd twisting	
	Twisting direction & Used yarn	TPM (Turns per Meter)	Twisting direction & Used yarn	TPM (Turns per Meter)		Twisting direction & Used yarn	TPM (Turns per Meter)	Twisting direction & Used yarn	TPM (Turns per Meter)
***DT/**CY-1S/1Z**	S, PET	100	Z, Ag coated PA	100	**DT/CY-5S/1Z**	S, PET	500	Z, Ag coated PA	100
DT /CY-1S/2Z				200	**DT /CY-5S/2Z**				200
DT /CY-1S/5Z				500	**DT /CY-5S/5Z**				500
DT /CY-1S/10Z				1,000	**DT /CY-5S/10Z**				1,000
DT/CY-2S/1Z		200		100	**DT/CY-10S/1Z**		1,000		100
DT /CY-2S/2Z				200	**DT /CY-10S/2Z**				200
DT /CY-2S/5Z				500	**DT /CY-10S/5Z**				500
DT /CY-2S/10Z				1,000	**DT /CY-10S/10Z**				1,000

*DT: Draw Texture Yarn **CY: Conductive Yarn

3. Results and discussion

It was confirmed that the modulus decreased as the TPM in the 1st twists increased, and TPM in the 2nd twists did not significantly affect it. On the other hand, tenacity and elongation tended to increase as the TPM of 1st and 2nd twists increased up to 500 TPM. Accordingly, DT/CY-5S/5Z showed the best performance with modulus, tenacity, and elongation of 11.23 gf/den, 4.21 gf/den, and 48.3 %, respectively. In the electrical properties, the samples with 1000TPM increased by about 1.5 times compared to the case of 100TPM. In this study, as a result of measuring the sheet resistance of a textile-type electrode manufactured using DT/CY-5S/5Z samples with excellent tensile and electrical properties, it was confirmed that had a low resistance of 1.58 ± 0.35 ohm/sq. Additionally, the EMG signal of the textile electrode using this was also well detected.

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