A comparative analysis on properties of retroreflective materials for road traffic warning clothing

Soonja Park, Changwoo Choi*

Dept. of Home Economics Education, *Center for Glocal Multicultural Education Professional Development, Inha University, Incheon, Republic of Korea

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Recently, South Korea became more committed to road traffic safety and has also strengthened education on safety clothing, whilst the worldwide trend imposes stricter regulations that make its wear mandatory in some countries. As of now, the study on retroreflective material conducted in Korea apply mainly to life jackets; as to road traffic working clothing, there are studies safety vests but not overalls. Therefore, in order to develop warning clothing with enhanced visibility of motion and comfort that meet international standards, retroreflective materials, which are main components of safety clothing, are examined and compared.

In this study, the retroreflective properties of the sample materials are compared. The samples consist of plain type from 3M (S1), grid (S2) and plain (S3) types from a Korean company R, and another plain type (S4) with no specified manufacturer of Korea. ISO 150-J01 (1997) and ISO 20471 (2013) methods were used to measure the chromaticity and retroreflective property respectively. General, 12′ observation angle, and 5° incidence angle retroreflection were measured under 5 conditions: after abrasion (1), bending (2), bending at low temperature (3), alternating temperature (4), and washing 5 times (5). Finally, scanning electron micrographs (SEMs) of the surface and the cross section were taken at a magnification of ×300.

The resulting measurements and the SEMs are shown below. Although there were slight differences, the four types of materials were generally in accordance with ISO 20471. The chromaticity is regarded as luminance. All of the four samples are silver tones, and a higher value in Table 1 indicate better luminance.

Table 1. Chromaticity measurement values of 4 samples

	S1	S2	S3	S4
Luminance Factory	0.16	0.17	0.09	0.21
Coordinate x	0.311 2	0.310 7	0.299 4	0.311 0
Coordinate y	0.329 1	0.330 4	0.323 5	0.329 1

CIE-D65, 2˚, 45/0 method using Black Underlay. Measuring device: Spectrophotometer CM-2500c (Konica Minolta)

For the general retroreflective property outlined in Table 2, the smaller angles 12′ (~0.2°) and 20′ represent the angle of reflected headlight observed by the driver of a standard vehicle (sedan), whereas 1° 30’ represent the angle of reflection affecting larger vehicles(truck). ε = 0° and 90° on the left column represent frontal and lateral reflection. All of the 4 samples chosen for the study exhibit measurements above the ISO 20471 standard, showing suitability.

Table 2. General retroreflective property measured at 0° (horizontal) and 90°

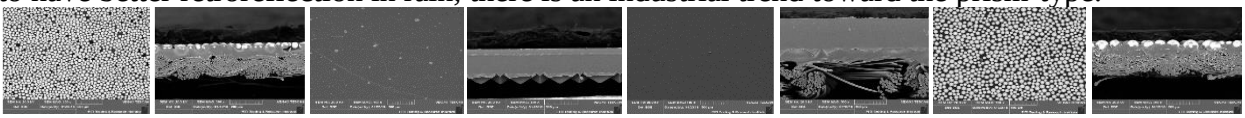
-	Obs. Angle	Incid. Angle	Reflective Property (cd/lx·m²)				-	Obs. Angle	Incid. Angle	Reflective Property(cd/lx·m²)			
			S1	S2	S3	S4				S1	S2	S3	S4
ε = 0°	12′	5°	473.3	411.9	1009.5	550.7	ε = 90°	12′	5°	471.0	383.5	746.1	446.4
		20°	463.6	315.4	810.3	559.4			20°	438.3	312.5	525.5	532.6
		40°	287.8	145.5	302.0	475.5			40°	191.1	140.0	238.4	466.6
	20′	5°	334.6	463.7	576.0	346.7		20′	5°	331.8	404.5	366.7	287.6
		20°	329.0	245.9	469.6	344.8			20°	321.6	228.3	221.0	324.6
		40°	238.0	90.8	196.5	298.8			40°	166.7	86.5	118.4	292.0
	1° 30′	5°	22.2	25.1	10.3	16.0		1° 30′	5°	22.4	26.8	18.2	16.6
		20°	21.8	17.6	10.6	16.8			20°	20.7	19.4	9.2	16.3
		40°	9.9	13.5	9.6	16.7			40°	17.3	15.7	12.2	15.1

Table 3 includes measurements of retroreflective property measured at observation and incidence angles of 12′ and 5° under the 5 conditions outlined above. As a bigger number in Table 3 also indicates higher retroreflection, the prism-type S3 exhibited the highest retroreflection as well as the largest deviation, while S1 showed the smallest deviation. The sample with the highest retroreflective property under all 5 conditions was S3.

Table 3. Reflective properties at 12′ observation angle and 5° incidence angle under 5 conditions

-	Observation Angle	Incidence Angle				
			S1	S2	S3	S4
Condition 1	12′	5°	436.8	319.6	799.4	390.1
Condition 2			433.0	343.0	822.9	418.1
Condition 3			444.4	350.1	834.1	431.6
Condition 4			450.1	361.9	859.3	450.6
Condition 5			363.1	283.3	686.4	277.8

Figure 1 shows SEM photos of surface (a) and cross-section (b) of each sample. It is obvious that S1 and S4 are bead-types while S2 and S3 are prism-types. A comparison of S1 and S4 will show that more homogeneous beads produce better retroreflection. As prism-types tend to have better retroreflection in rain, there is an industrial trend toward the prism-type.



a b a b a b a b

S1 S2 S3 S4

Figure 1. SEM of surface (a) and cross-section (b) of samples (S1, S2, S3, S4)

Reference

Park, S.J. Analysis of the Current Wearing Status, Point of Improvement, and Satisfaction of Warning Clothing for Road Cleaner and Traffic Workers. Journal of the Korean Society of Clothing & Textiles (Proceeding/Autumn), 2017.

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