Influence of Plasma Treatment on Total Hand Value and Adhesion Properties of Bi-Fabrics of Fused Interlining and Wool Fabrics

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Abstract: Plasma treatment to wool fabrics is effective to the shrink-resistant performance without using chlorination and dyeing performance. The adhesive property between fabrics is growing by the treatment when we make two-layer fabric from face fabric and fusible interlining. During the process of apparel making, interlining fabric is fused on the rear side of the face fabric to make and keep a beautiful silhouette of garments. In this study plasma effects on adhesive strength between face and interlining fabrics are measured objectively. Fabric mechanical properties are investigated, and adhesion properties of bi-fabrics structure of fused interlining and wool fabrics are also discussed. Three types of face fabric are treated by argon-plasma and fusible interlining is adhered on them respectively. Interlining used in this study is polyester plain weave with polyamide adhesive resin. Interlining and face fabrics are bonded together using Flatbed type press machine. Face fabric samples used in this experiment are basket weave, twill and hound's-tooth wool fabrics. Bending, shearing and compression properties and air permeability are measured by KES measurement instruments [1]. Peeling strengths of the bonded fabrics were measured using KES FB1 tensile tester. The results show that adhesion property enhances by the plasma treatment. In the next stage, we study how adhesion bond impregnate with fibers and yarns and what is the difference in penetration between treated and untreated fabrics. Finally we study the influence of plasma treatment on total hand value of bi-fabrics.

Keywords: Bi-fabric, plasma treatment, fusible interlining, adhesion property, mechanical property

1. INTRODUCTION

Wool has many excellent characters as to elastic, stain ability, moisture absorbency, warm, moisture retain, water repellency and fire retardancy because of the fiber mechanisms. And at the end of fabric it goes back to the earth. Wool fabrics make beautiful and comfortable appearance of garments. But some reasons, as to feeding damage by insect and felting property, make it difficult to be convenient apparel materials like polyester. Felting is one of superior character and it makes beautiful texture of wool fabrics. But, as for the easy care performance for daily garment like underwear and T-shirt, it becomes a weak point of wool. Wet chlorination has been used as anti-felting methods traditionally, but it needs much toxic chemical matters and much energy, in addition sewage should be treated. Some research works against anti-felting treatment of wool without chlorination has been developed [2]. Plasma treatment is understood to be effective as a non- chlorination system for the anti-felting of wool. Mori mentioned the mechanical property and anti-felting property of wool fabric treated with low temperature plasma [3] and its' dyeing properties [4]. Mechanism of anti-felting by plasma treatment is discussed by Mori, Tahara [5], Dai [6] and Molina [7]. Plasma treatment gives wool not only anti-felting character but also good dyeing performance and mechanical properties changes. In addition it is estimated that bonding performance between treated wool fabric and fusible interlining becomes strong. Fusible interlining makes an important role to the beautiful silhouette and its retaining of jacket. But high fusing temperature and pressing force cause fabric shrinkage. Lower temperature, pressing force and shorter pressing time are preferred. In this study influence of plasma treatment on adhesion and mechanical properties, hand values (HV) and total hand value (THV) of bi-fabrics of fused interlining and wool fabrics.

2. EXPERIMENTAL

2.1. Fabric Samples

Three types of face fabric were treated by the low temperature plasma and fusible interlining is adhered on the rear side of face fabrics respectively. Untreated face fabrics are also prepared for comparison. Interlining used in this study was polyester plain weave with polyamide adhesive resin, which is used widely in the front part of jacket. Face fabric and interlining were placed on the flat bed type press machine and bonded under the conditions of 140^{o}C and 125g/cm^2 for 10 seconds. Face fabric samples used in this experiment are basket weave, twill and hound's-tooth wool fabrics. Constructional details of fabric samples are provided in Table 1.

Plasma reactor used in this study is a type DSSO-422 (Daia Sinku Co., Ltd.). The discharge frequency was fixed at 13.56 MHz. Plasma treatment was carried out by the following procedures. The fabric sample was placed in the reactor, and the reactor was evacuated to 0.001 Torr (0.13 Pa). Then argon (Ar) was fed into it at a volumetric flow rate of 10 mL/min. The electric power for plasma discharge was fixed at 100 W. The internal pressure of the reactor was maintained at 0.1 Torr (13.3Pa) during a plasma-treatment time of 300 s. The treated fabric samples were finally rinsed with water and dried by air, and then subjected to property measurements.

Table 1 Fabric Samples Used in This Study and Their Symbol

Fabric Symbol	Fiber	Fabric	Density(/cm) Ends	Density(/cm) Picks	Thickness (mm)	Weight (mg/cm^2)
Face Fabric BR	Wool	Basket Weave	33.8	29.0	0.85	26.45
Face Fabric WH	Wool	2/2 Twill	28.3	26.0	0.52	20.41
Face Fabric HT	Wool	Hound Tooth	30.5	25.7	0.73	23.55
Interlining	Polyester	Plain Weave			0.36	3.72

2.2. Measurement of Mechanical Properties

Fabric mechanical properties, bending, shearing, compression and tensile properties, surface properties and air permeability were measured by KES measurement instruments under the atmospheric conditions of 20±2^{o}C and 65%RH. Parameters and conditions of mechanical properties are summarized in Table 2.

Peeling strengths of the bonded fabrics were measured using KES FB1 tensile tester. Figure 1 shows a photograph of peeling test. One end of peeled face fabric is clutched on the fixed grip and another peeled interlining fabric end is clutched, loaded and peeled. Sample width for peeling test is 2.5cm. Peeling speed is 0.2mm/sec and 2.0cm of samples were peeled.

Table 2 Details of Fabric Mechanical Properties

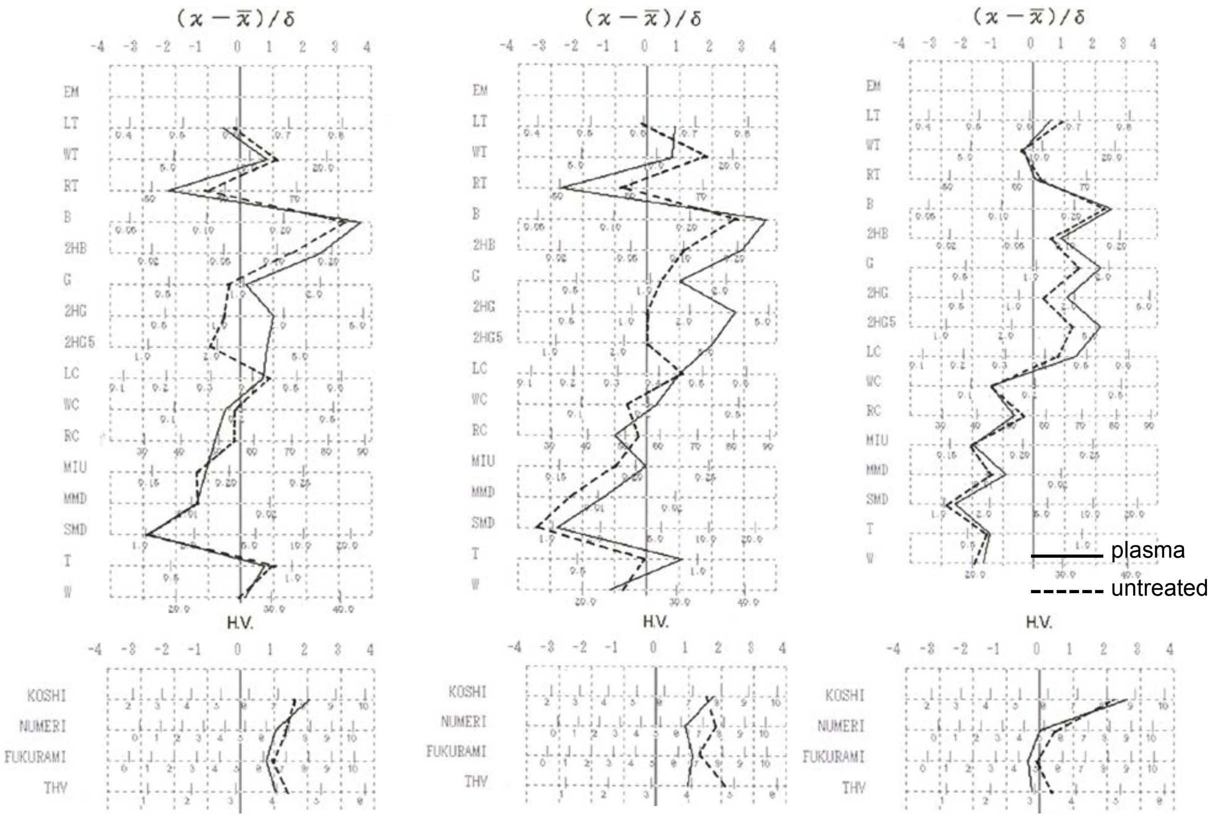
Property Block	Symbol	Details of Property	Unit
Tensile	LT	Linearity in tensile stress and strain	non
	WT	Energy in tensile	gf・cm/cm^2
	RT	Resilience in tensile	%
Bending	B	Bending rigidity	gf・cm^2/cm
	2HB	Bending hysteresis	gf・cm/cm
Shearing	G	Shear rigidity	gf/cm・deg.
	2HG	Shear hysteresis at 0.5 deg. of shear angle	gf/ cm
	2HG5	Shear hysteresis at 5 deg. of shear angle	gf/ cm
Compression	LC	Linearity in compression	non
	WC	Energy in compression	gf・cm/cm^2
	RC	Resilience in compression	%
Surface	MIU	Mean frictional coefficient μ	non
	MMD	Mean deviation of MIU	non
	SMD	Surface roughness	non
Thickness	T	Fabric thickness under the load of 0.5 gf/cm^2	mm
Weight	W	Fabric weight per unit area	mg/ cm^2

3. RESULTS AND DISCUSSION

3.1. Fabric Mechanical Properties,Hand Values and Total Hand Value

Fig. 1, Fig. 2 and Fig. 3 shows plotted mechanical properties on the data chart of men' winter suit [1] of bi-fabrics with interlining and face fabric HT, BR and WH respectively. Solid and dotted lines show plasma treated and untreated face fabrics respectively.

Most remarkable differences between plasma treated and untreated bi-fabrics were bending and shearing properties. Bending rigidity, B, and hysteresis, 2HB, shear rigidity, G, shear hysteresis, 2HG and 2HG5 were larger in plasma treated bi-fabrics compared with untreated ones. These



(a) Face fabric BR (b) Face fabric HT (c) Face fabric WT

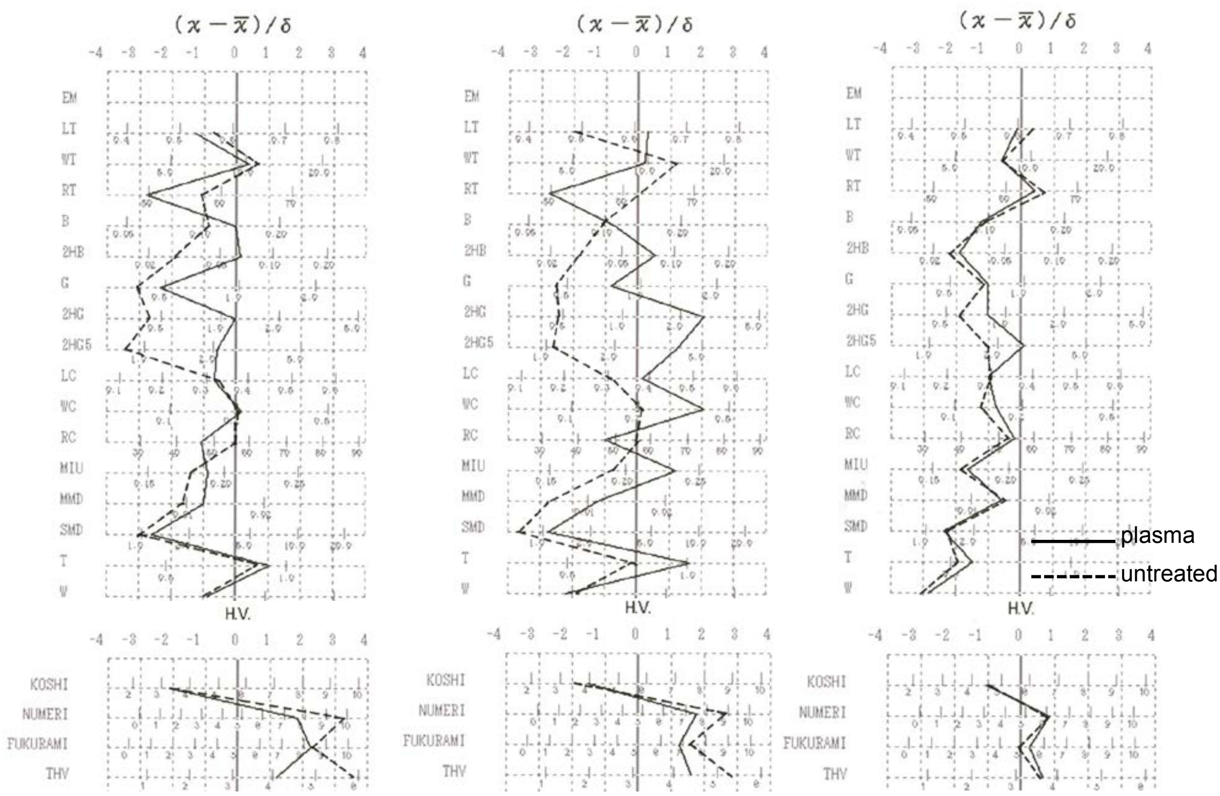
Fig.1 Mechanical Properties, HVs and THV [1] of Bi-Fabrics with Face fabrics

changes were shown the face fabrics shown in Fig.2. In tensile property, RT values were smaller in plasma treated bi-fabrics compared with untreated ones. The degree of the change in maximum elongations at 500gf/cm became smaller in plasma treated bi-fabrics were differ in three face fabrics, while RT values became in all samples. And WT values were smaller in HT and BR bi-fabrics and almost same value in WH. In plasma treated bi-fabrics resin penetrate deeply to the face fabric and hold yarns strongly, which might be a reason of the change of RT values. As for the compression property, linearity, LC, and compression energy, WC were differ from samples. But as for the compression resilience, RC values were smaller in all plasma treated bi-fabrics.

In the cases of two fabrics BR and WT, there were almost no changes in the fabric thickness between untreated and treated conditions, while treated fabric became thicker than untreated in fabric HT. Table 3 shows the weave density and thickness of face fabrics under the conditions of untreated and plasma treated. For the fabric HT, shrinkage along weft direction might occur during

Table 3 Changes of Fabric Structural Factors before and after Plasma Treatment

Fabric	Density Ends/Picks (/cm)		Thickness (mm)	
	Untreated	Treated	Untreated	Treated
BR	33.8 / 29.0	34.1 / 29.1	0.520	0.567
WH	28.3 / 26.0	28.7 / 27.1	0.848	0.908
HT	30.5 / 25.7	28.1 / 25.4	0.723	1.015



(a) Face fabric BR (b) Face fabric HT (c) Face fabric WT

Fig.2 Mechanical Properties, HVs and THV[1] of Face fabrics

plasma radiation.

Hand values of KOSHI, NUMERI and FUKURAMI and Total Hand Value (THV) [1] are shown in the figures in Fig.1. Fig.2 shows mechanical properties, HVs and THV of three face fabrics. In these figures properties of plasma treated fabrics (solid line) are compared with untreated (dotted lines) ones. HVs and THV are calculated using equation KN-101-winter for men’s winter suiting fabrics [1]. For face fabrics BR and HT, when fabrics are plasma-irradiated, hand value of NUMERI and THV are reduced compared with original ones. As for the bi-fabric, increase of KOSHI value and decrease of NUMERI and FUKURAMI values are observed and consequently derive the little decrease of THV values. For face fabric, the degree of THV change by the plasma radiation is different from its type. As for the change of HVs and THV by plasma irradiation, there were small. But shearing and bending properties were changed, which are acting to be stiffer. The influence for tailor-ability and comfort to wear of this change must be considered.

3.2. Peeling Strength

Fig.3 shows an example of measurement of peeling strength using KES-FB1 tensile tester in sample BR. After chucking the both sides of peeled face and interlining fabrics, load was applied to fabrics until peeled length arrived 2.0cm, and then loaded side returned to the original position, while peeling of two fabrics peeling force was detected. Under the same conditions of bonded process peeling strength, that is, bonding strength is different between plasma treated and untreated face fabrics, that of plasma treated is larger than untreated one. In this experiment, mean peeling strength during peeling is measured visually. Fig. 4 shows the results of three face fabrics. Red and blue data show the peeling strengths in plasma treated and untreated respectively, and

Fig. 3-1 Peeling Strength Test Using KES FB1 Tensile Tester

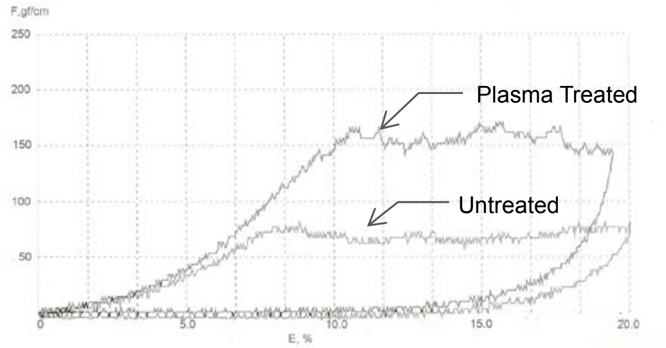


Fig. 3-2 Example of Measurement of Peeling Strength Using KES-FB1 Tensile Tester

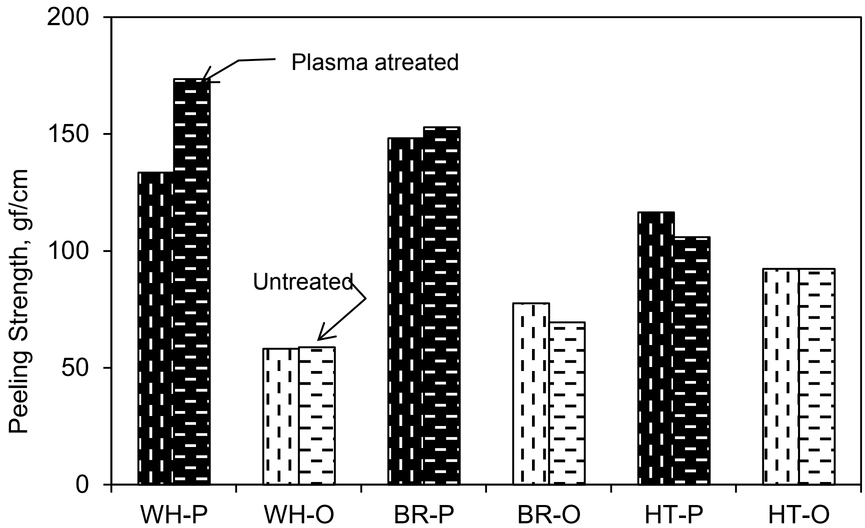


Fig. 4 Peeling Strength for Three Fabric Samples (Warp and Weft Directions)

solid and dotted data show along warp and weft directions respectively. In cases of face fabric sample WH, 2/2 twill weave, and BR, basket weave, different of peeling strengths between plasma treated and untreated, over two times larger in treated than untreated. In case of face fabric HT, peeling strength of plasma treated bonding fabric is larger than untreated, but the difference between them is rather small.

Mori et al. concluded that chemical and structural changes of the wool surfaces by the plasma treatment were investigated using XPS and SEM and thin layer of 36 nm thickness was removed from the surface of wool fiber, which suggested that most of the epi-cuticle layer at the outermost surface of the fiber was etched away [2]. In this experiment the reason why bonding force is increase in plasma treated face fabrics is related with the etching of fiber surface wool. Mori also mentioned the implantation effect of plasma treatment on wool fiber [2]. Wool fiber can react easily with oxygen in the air because of a generation of oxidative sulfurs as to S, SO_2 and SO_3 which were formed as a result of keratin resolution by plasma treatment. As results of etching and implantation effect penetration of binding resin is increasing in plasma treatment and as a result of penetration bonding strength is enhanced. Fig.5 show photos of cross section of bi-fabric with face fabric HT (hound-tooth fabric). In case of bi-fabric with plasma treated face fabric bonding resin penetrates into face fabric, while in case of untreated face fabric resin lays on the face fabric. This result means that smaller volume of bonding resin, lower dot density of resin, can make proper bonding strength

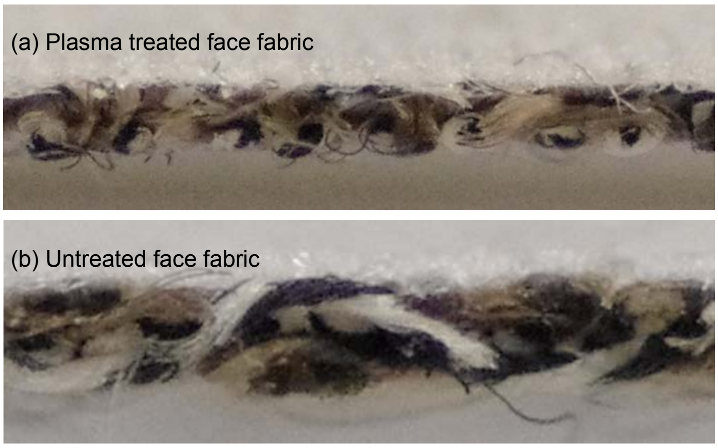


Fig.5 Cross-Section of Bi-Fabrics (a) Plasma Treated Face Fabric, (b) Untreated

for the plasma treated face fabric and interlining, which can prepare softer handle of bonded bi-fabric.

4. CONCLUSION

In this study the bonding performance of plasma treated wool fabrics with fusible interlining was discusses. Plasma treatment on wool fibers and fabrics are effective to the anti-felting performance as an environmentally-friendly method. And at the same time binding strength between treated face fabric and fusible interlining was predicted to be stronger compared with untreated one. In this study, this prediction was resulted experimentally. That is, bi-fabrics of plasma treated face fabric and interlining showed strong peeling strength compared with untreated bi-fabrics under the same bonding conditions. Bi-fabrics play an important role to the formation of beautiful shape. From this study we can use lower dots density of adhesive resin on the interlinings than useal for the plasma treated face fabrics. Lower dots of adhesive resin affect softer handle of face fabrics. This rsult that when we make up the garment like jacket, we can get not only easy care performance but also softer handle bi-fabrics for the plassma treated fabrics. On the other hand, mechanical properties as to B, 2HB, G, 2HG were change to the stiffer region.

In the next stage we will examine the effects of dots density of adhesive resin on plasma treated face fabrics and fusible interlining from the points of bonding strength and the change of mechanical properties to find the optimum conditions of strong and soft bi-fabrics for garments.

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BIOGRAPHY

Machiko Murakami

Machiko Murakami graduated the master course of Nara Women's University in 1978 and belonged 1) Kobe Gakuin Women's College (1978-1979), 2) Mimasaka Women's University (1978-1983) and has belonged 3) Gifu City Women's College (1988-at present) and has been professor since 2007. Her major research areas in scientific achievement are 1) mechanical properties and handle estimation of clothing fabrics, 2) objective evaluation of clothing materials and 3) mechanical properties of bi-fabrics related to clothing silhouette.

Masukuni Mori

Dr. Mori, professional engineer had been working and studying about textile technology, dying, fabric handling and mechanical properties of wool fabrics since 1950, having got a job at Tsuyakin Kogyo Co. Ltd. up to 1996, retiring the company. he joined the " Hand Evaluation and Standardization Committee, Textile Machinery Society of Japan", established by former Professor Dr. Kawabata, Kyoto University and former Professor Dr. Masako Niwa, Nara Women's University in 1973. His knowledge and experience about textile, especially in dyeing and finishing of wool fabrics, have been absolutely imperative still now. After 1996, he has been working as a consultant of textile engineering not only in Japan but also in China, Korea and Italy.

Takako Fujimoto

Dr. Takako Fujimoto belonged to 1)Niigata University (1977-1981) and then has belonged to 2) Hokkaido University of Education (1992- at present), and has been professor since 1992. She has been Head, Japan Section of The Textile Institute of UK (2005-) and was a visiting professor, University of New South Wales, Australia (1996.9-1997.3). Her major research areas are theory of heat transfer of fibrous materials, mechanical properties and handle estimation of clothing fabrics, objective evaluation of clothing materials and durability of clothing materials. The number of her published original books is 5 and papers and articles is around 130. She received three prizes and awards related to the above scientific achievements.

Choji Murata

Choji Murata has been an engineer of Kato Tech. Co. Ltd. Since 19 and supports this research works technically.