Testing Metal-complex Conductive Ink and Dye Solutions on Fabric: Masking Metallic Fibers

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OVERVIEW

Metal-complex Conductive Inks: Metal-complex conductive inks are an advantageous alternative compared to their nanoparticle-based ink counterparts [1]. Electroninks is a leading company which has developed a metal-complex silver ink, EI-1201, with potential applications in the electronic textiles industry [2].

Motivation: EI-1201 ink displays a silver residue when deposited on various fabric types [3]. This is a major drawback to commercializing this product from an aesthetic perspective due to the intended application of being applied to the interiors of automotive vehicles. This project investigated the possibility of masking the color of silver coated fibers and tested the ink adhesiveness to the fabric surface when exposed to commercial washing conditions.

Methods: Red, green, and blue dyes at 1 wt.% and 5 wt.% concentrations were used to conceal the silver residue on 100% nylon and synthetic leather (SL). Optical microscopy was performed to observe the metallization of the ink solution onto the fiber structure. SEM and EDS analysis were additionally conducted to observe the silver distribution on the fabric surfaces. The electrical performance of the fabric was determined by measuring the 2-point resistance through a multimeter. Coated samples were washed in both tap water and distilled water-detergent solution through a procedure similar to AATCC 61 1B* [4] using a magnetic mixer.
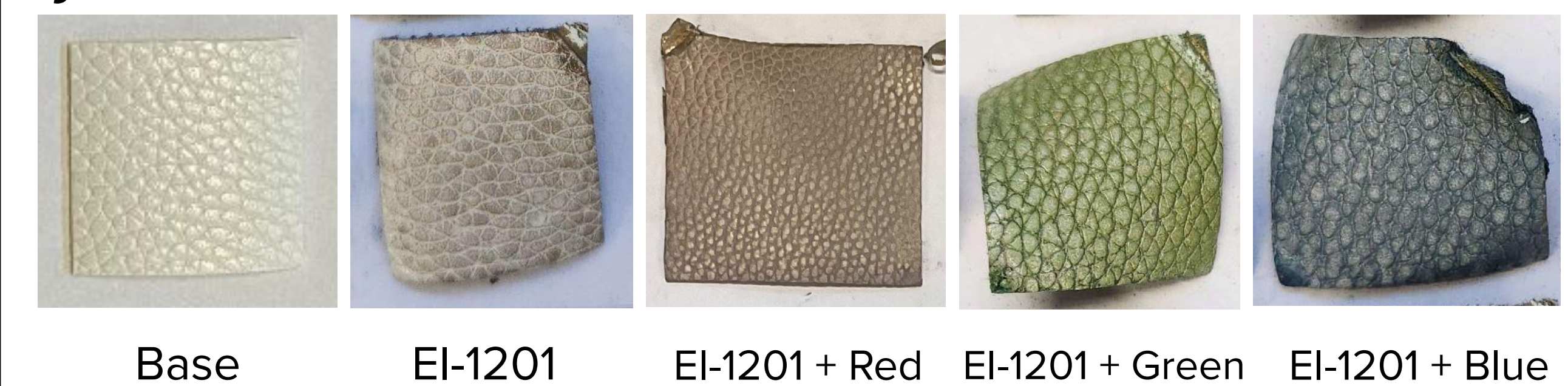
EXPERIMENT STEPS

Sample Prep → Plasma Clean (SL Only) → Coat → Cure → Data Analysis → Washability
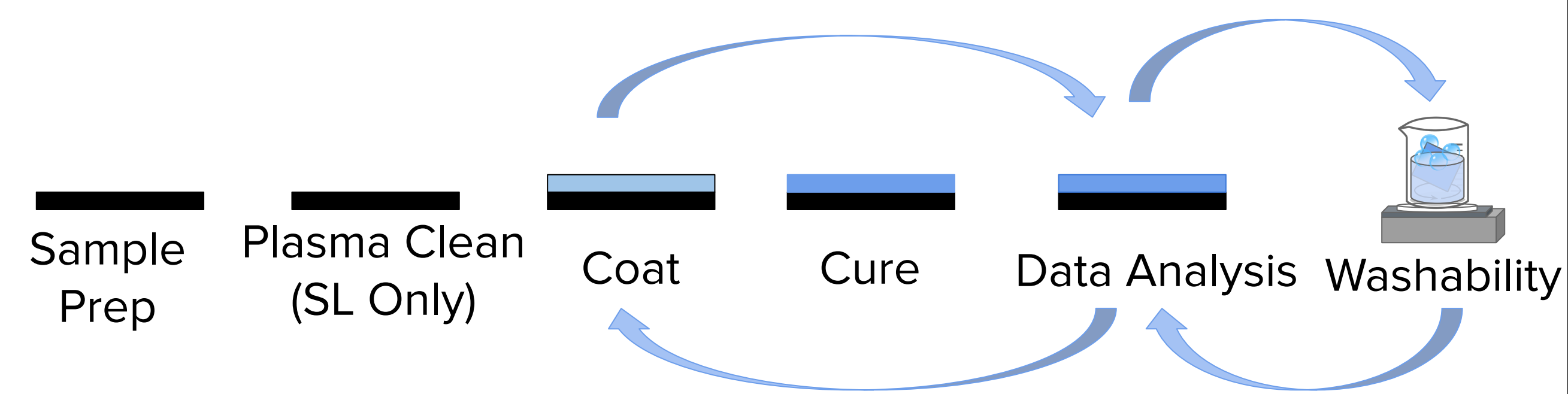
MATERIALS

Fabric	Type	Cure Condition
100% Nylon (N)	Ripstop	120℃ for 1 hour
Synthetic Leather (SL)	PU and Cotton	120℃ for 2 hours

FABRIC IMAGES

100% Nylon:
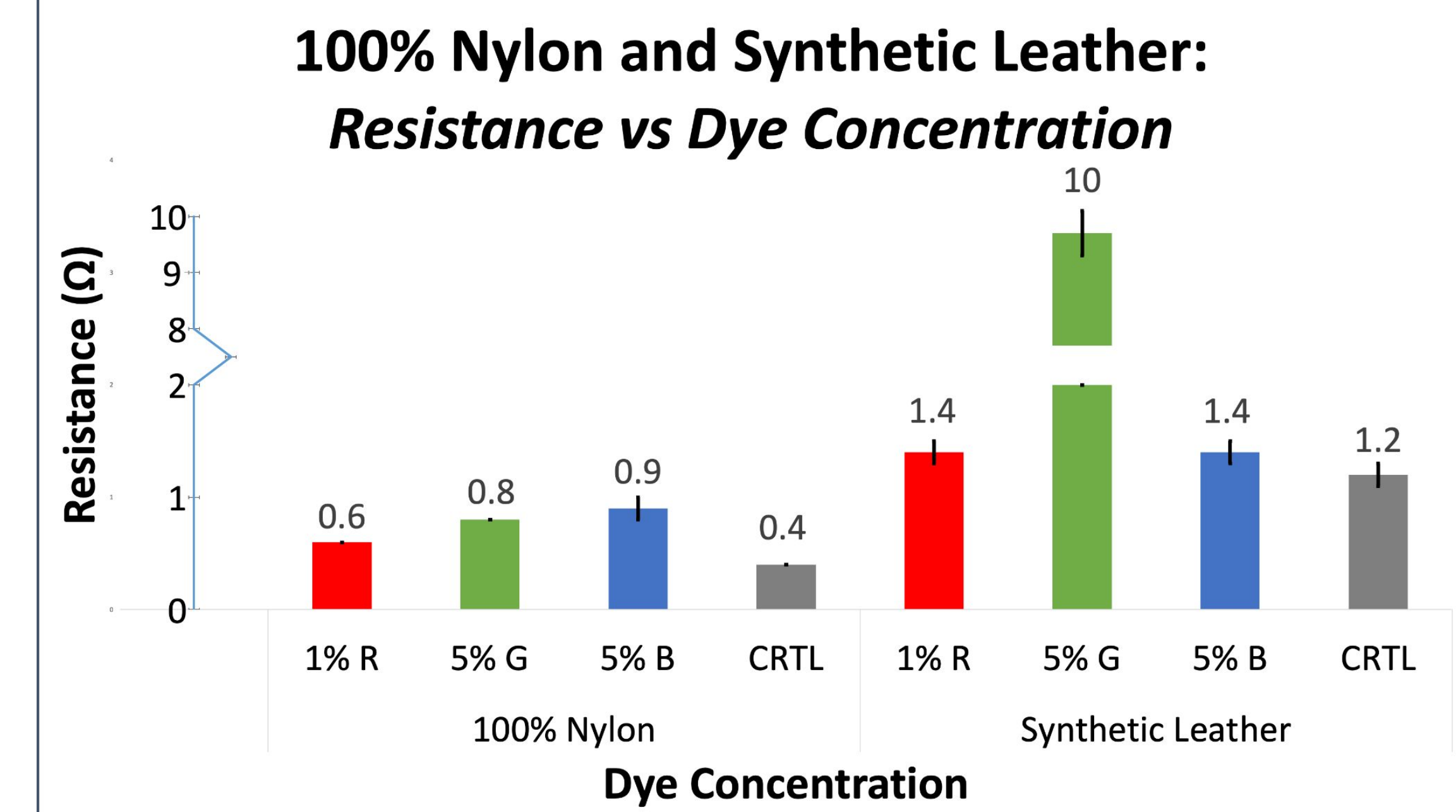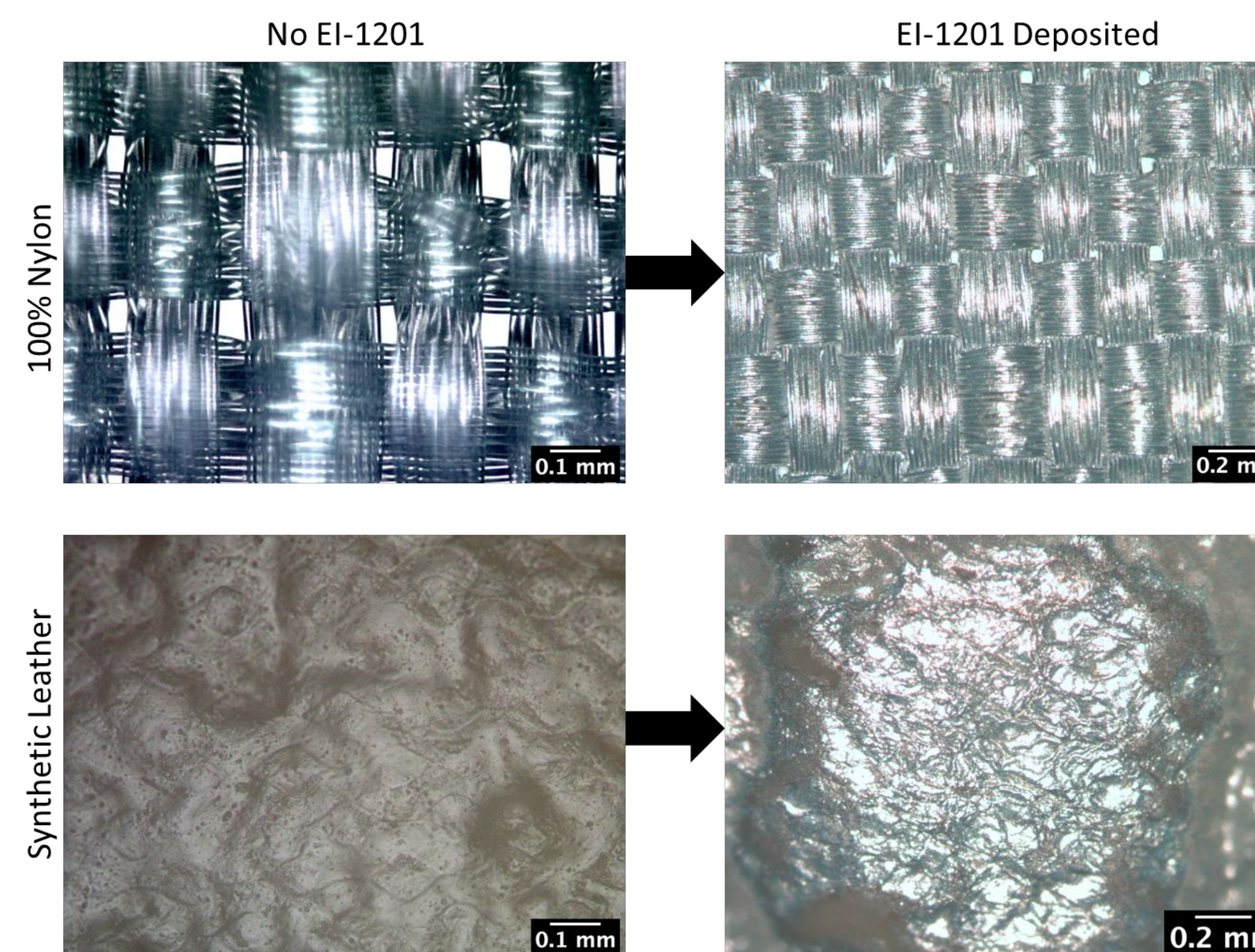

Base | EI-1201 | EI-1201 + Red | EI-1201 + Green | EI-1201 + Blue

Synthetic Leather:

Base | EI-1201 | EI-1201 + Red | EI-1201 + Green | EI-1201 + Blue

RESISTANCE MEASUREMENTS

100% Nylon and Synthetic Leather: *Resistance vs Dye Concentration*

R: Red || G: Green || B: Blue || CRTL: EI-1201

OPTICAL MICROSCOPY

No EI-1201 | EI-1201 Deposited

100% Nylon — 0.1 mm / 0.2 mm

Synthetic Leather — 0.1 mm / 0.2 mm

ENERGY-DISPERSIVE X-RAY SPECTROSCOPY ANALYSIS

100% Nylon 5 wt% Green Dye

WASHABILITY TESTING

Distilled Water: 150 mL — 31 ℃ — Liquid Detergent: ~ 1 mL — Coated Fabric

Heat | Mix 1 min | Mix 20 min | Dry at 120℃, 20 min
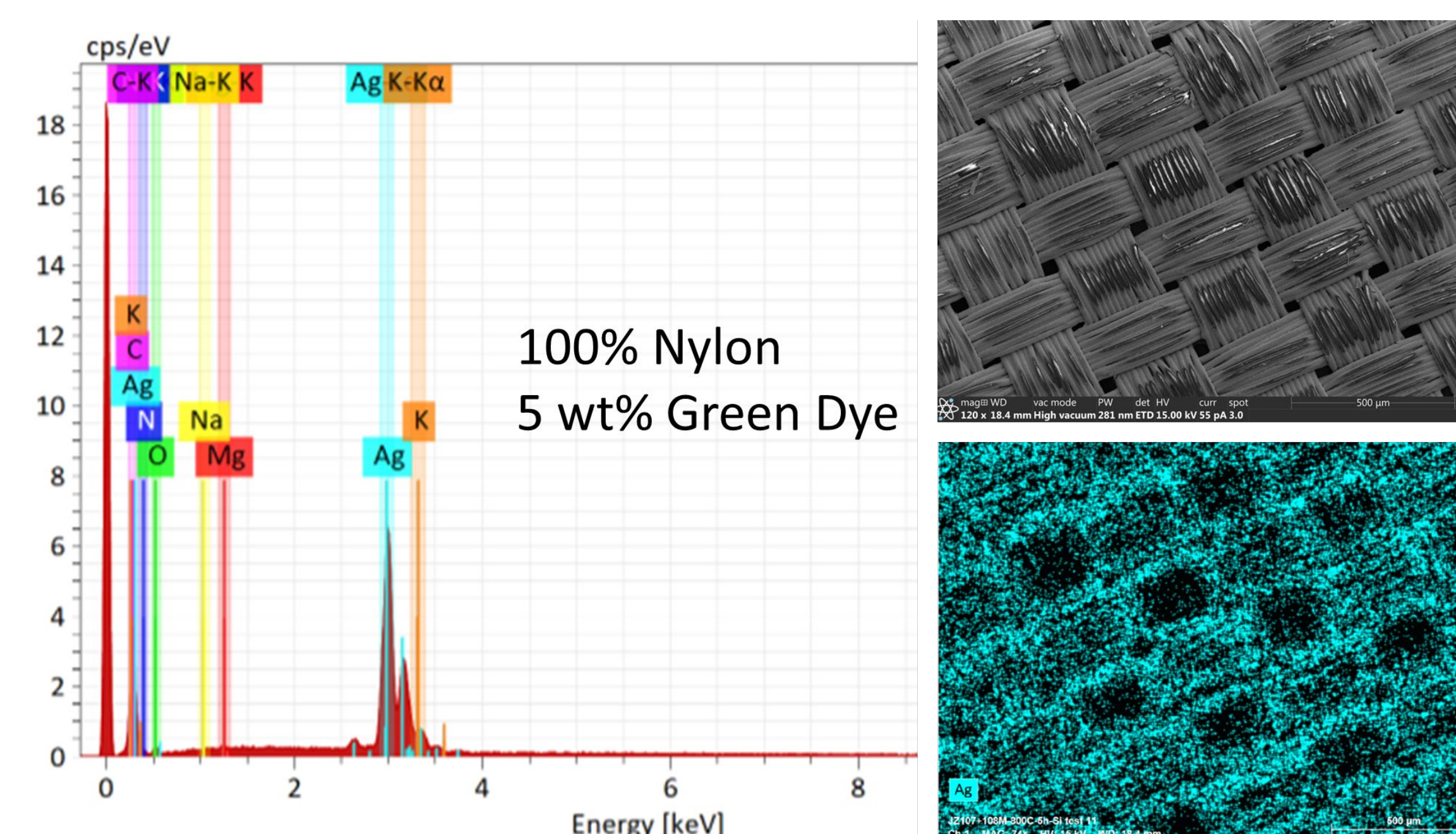
EI-1201 + 1% Red:

$$\frac{\Delta R}{R_0} * 100 = 66.7\%$$

$$\frac{\Delta R}{R_0} * 100 = 66.7\%$$

0.9 Ω — SL | 0.3 Ω — N

CONCLUSION

- Synthetic leather and Nylon fabrics were successfully metallized using EI-1201
- The color of silver coated textiles was masked using red, green, and blue dyes with best masking effect observed for green and blue colors
  - Addition of color to the fabric does not affect the electric properties severely; an increase in electrical resistance was observed when compared to uncolored silver fabrics
- Washability study indicates the coated dyes are not well adhered to the fabric and leaches during the washing process
- Addition of dyes does not prevent an formation of electrical network on fabric surfaces

Future work
- Add a fixing agent to improve dye adherence to the fabric
- Experiment with use of hydrophobic spray to protect dye coating from leaching during washing process while retaining the underlying electrical properties

ACKNOWLEDGEMENTS

REFERENCES

[1] Shahariar, Hasan, et al. "Inkjet Printing of Reactive Silver Ink on Textiles." ACS Applied Materials & Interfaces, vol. 11, no. 6, 2019, pp. 6208–6216, https://doi.org/10.1021/acsami.8b18231.

[2] "The Leader in Particle-Free Conductive Ink Products, Chemistry, and Knowledge." Electroninks, 2 June 2021, electroninks.com/.

[3] Silver Complex Ink: EI-1201, EI-1207, EI-1208; MSDS No. 58; Electroninks Incorporated: Austin, TX, June 25, 2020

[4] "American Association of Textile Chemists and Colorists." AATCC, 18 May 2023, www.aatcc.org/.