Nanodiamond-polyaniline nanocomposites yield smart textiles

In a recent issue of *ACS Applied Polymer Materials* (<https://doi.org/10.1021/acsapm.0c00789>), researchers at RMIT University reported the integration of nanodiamond-polyaniline (ND-PANI) nanocomposites with wool fabrics using *in situ* polymerization. The goal of this work was to create smart multifunctional fabrics that are more comfortable to wear than currently available smart textiles due to improved mechanical properties.

“We add the PANI because we wanted to have a conductive textile and ND because of its multifunctionality. You can change textiles easily by using ND and it gives you a lot of different [functionalities] like UV resistance, resistivity, good mechanical properties, hydrophilicity, antimicrobial properties, improved wearability of the fabric, and it can be used to regulate the temperature of the body because of its good thermal conductivity,” Shadi Houshyar, the principal investigator of this study, told *MRS Bulletin*.

In this work, wool fabrics were treated with polyaniline (PANI), polyaniline-ND (PANI-ND), and polyaniline-boron-doped ND (PANI-BDND) to

study their effects on the resulting textile. Surface analysis suggests the possibility of hydrogen bonding and ionic/electrostatic interactions of PANI and ND with the surface of the wool fabric. Furthermore, it suggests that ND facilitated the attachment of PANI onto the surface of the wool fibers. “This means that it can act as a bridge between the PANI and the wool fabric,” Houshyar says.

The fabrics modified with ND showed a smaller increase in resistivity than the PANI modified fabric, suggesting a decreased removal of PANI in the former after several industrial washing procedures. “When we add ND, the coating became more permanent because of the ND’s ability to interact and create covalent bonds. Even when we washed it several times, it remained ... and continued to exhibit good properties. Although we lost some of the PANI during the washing cycles, it is much more stable when we add ND than if we use PANI by itself,” Houshyar says.

The treated wool fabrics would be ideal candidates for wearable sensors, as demonstrated by their large workable strain range, sensitivity, and full recovery of the electrochemical properties under cyclic strains. Moreover, sensors built using the three smart fabrics can detect human motion as evidenced by their ability to monitor the bending of a finger at different angles, as shown in the figure.

“Applications in the health industry are the main things we are looking for, combining different types of sensors to monitor patients in an easier, more comfortable way,” Houshyar told *MRS Bulletin*. “We thought of these for applications in defense and army, to reduce the weight of the protective clothing they wear. Likewise, it can have applications in sports under different environments due to the cooling and heating capacity the textile would provide,” she says.

When assessing the comfort and durability of the textiles, the research team found that ND can significantly improve the moisture absorption properties of wool, which remained unaffected after washing procedures. All treated fabrics displayed excellent breathability “because the nanocomposites work on the surface of the fibers and not on the pores,” Houshyar says.

The ND-PANI fabric showed a significant enhancement in abrasion resistance, likely due to ND’s capability of absorbing applied energy during abrasion. “These fabrics will last longer because of the abrasion resistance. The process has a low cost, and that is important because we do not want to produce fabrics that are expensive because then it is not for everyone,” Houshyar says.

“We are still working to improve the permanence and stability of the ND-PANI on wool. We are expanding this work toward other popular fabrics and looking for ways to change the color of the textiles to make them more appealing,” Houshyar told *MRS Bulletin*.

Reflecting on the future of these smart textiles, she says, “I see a huge opportunity for applications in the future, for the health industry, defense and sports, as well as everyday use. The possibility is to combine all electrical devices in one multifunctional user-friendly piece that has the ability to sense, store, and share data. It is not just textiles anymore, it’s multidisciplinary materials, fabrication, manufacturing... all coming together to achieve this goal.”

Xaimara Santiago Maldonado

(a) Schematic diagram of the modification of wool fabrics with polyaniline (PANI) and nanodiamond (ND) along with confocal fluorescence and scanning electron microscope images of the modified fabrics; (b) changes in resistance under variable angles of a finger wrapped by the coated fabrics. BDND is boron-doped nanodiamond. Credit: *ACS Applied Polymer Materials*.