ABSTRACT

Electrically conductive textiles are currently used in the fabrication of pressure sensors, electromagnetic interference (EMI) shielding devices, flexible heaters, static control clothing, and so on. In addition, conductive textiles have been deemed as being crucial for applications in next-generation wearable consumer electronics and smart clothing, which integrate the intelligent functionality of electronic devices with the flexibility and comfort of fashion clothing and are being designed to meet various innovative applications in military, public safety, healthcare, space exploration, sports, and consumer fitness fields. Generally, conductive textiles can be made by weaving metal strands into the construction of the textiles, or by coating (depositing) or embedding electrically conductive components, often carbon, nickel, copper, gold, silver, or titanium on the surface of textiles. Although these composite textiles have excellent conductivities, the stiff-feeling and easy-decay, which may be due to the breakage of the metal strands, sloughing of depositions, or chemical corrosion during use, are drawbacks that limit their applications.

Conductive polymers have gained much attention since their discovery, as they possess excellent electrical, electronic, magnetic, and optical properties commonly associated with metals, in addition to retaining the light-weight, flexibility, and processability of conventional polymers. Among the various conductive polymers, polyaniline (PANI) has been of great interest to many researchers owing to its lightness, good environmental and thermal stability, high electrical conductivity, good optical properties, easy preparation, and economic affordability. Furthermore, its conductivity can be modulated by carefully controlling its oxidation state and protonation

level, which makes PANI a prime choice in the fabrication of multifunctional conductive materials. In view of their soft nature, coating conductive polymers such as PANI onto fabric substrates is a feasible and effective strategy to overcome the problem of stiff-feel and chemical corrosion associated with conventional metal/fabric blends. This thesis describes the preparation and characterization of polyaniline coated textile substrates for strain sensor, pressure sensor, Electrode for EEG measurement and EMI shielding applications.

A conductive polyaniline coated nylon-lycra fabric has been developed and characterized for strain sensor application. The conductive fabric was fabricated by in-situ polymerization of polyaniline on the nylon lycra fabric at low temperature. The morphology of coating has been observed by means of scanning electron microscopy (SEM). The PANI coated fabric has been characterized chemically by means of energy dispersive X-Ray (EDX) and spectrometric analysis. The thermal characterization has been carried out by means of differential scanning calorimetery (DSC). The stability of the developed sensor is characterized with respect to temperature and humidity using Programmable Environmental Test Chamber. The sensitivity of the developed fabric sensor was characterized using Zwick tensile tester. The measurement of the conductivity change with strain shows that the prepared fabric exhibits high strain sensitivity while it’s good stability is indicated by a small loss of conductivity after the thermal and humidity aging tests. The developed strain sensor measures flexion angle of elbow up to 120^{o} angle.

For textile based pressure sensor development, the conductive polyurethane foam was developed by in-situ polymerization of aniline on polyurethane (PU) foam. The SEM studies revealed the deposition of PANI onto the PU surface and the presence of sulfur content in PANI coated foam was found through EDX analysis. The treated foam showed increase in light absorption in spectrometric analysis. From DSC studies, it was found that there is reduction in the melting temperature (T_m) of PU foam after polyaniline coating. The developed PANI coated foam was subjected to compression tests in Zwick /Roell tensile tester and electrical resistance was recorded during the tests to study the pressure sensing mechanism. The conductive foam exhibited varying electrical properties with respect to compression. It was found that a linear relationship existed between change in electrical resistance and applied pressure up to 100 N/m^2 and the changes are less beyond this, making it suitable for pressure sensor applications for 0-100 N/m^2 pressure range .

The textile electrode was designed and developed using the developed conductive polyurethane foam for Electroencephalography (EEG) biopotential measurements. The conductive PU foam was characterized for electrical resistance and impedance values through two probe resistivity measurement method. The conductive PU foam showed a surface resistance and impedance values of 7 KΩ/square and 1.45 MΩ respectively. Clinical trials were carried out using the developed textile electrode for EEG measurement. EEG measurements using hospital equipment revealed that the conductive PU foam electrode yielded results similar to commercial Ag/AgCl electrodes. Hence, this study reveals that the conductive PU foam electrode would be a feasible candidate for EEG measurements, particularly for continuous monitoring purposes.

In the final part, electrically conductive cotton, polyester and nylon fabrics have been prepared by using conductive polyaniline polymer for EMI shielding application. The structural studies showed that the crystalline region of fabric structure is not affected by the polyaniline. The SEM studies revealed a very uniform deposition of polyaniline on the fabrics. Thermal studies showed that the polyaniline treated fabrics have better thermal stability. Conductivity studies showed that the treated fabrics have good electrical conductivity and the surface resistivity values of cotton, polyester and nylon fabrics coated with polyaniline were 7, 5 and 5 KΩ/square respectively. The electromagnetic shielding tests showed that the cotton, polyester and nylon fabrics have the electromagnetic interference values of 25.85, 21.14 and 26.38 dB respectively in the frequency range of 8-12 GHz.