

## 5 CONCLUSION

The surface conductivities of the PPy/PVS films were in the range from 0.018 to 0.062 S/cm. The variation was due to the variation in concentration of pyrrole used (in the range 0.1 to 0.5 mole kg<sup>-1</sup>). From the results obtained, it can be concluded that the electrical conductivity of the polymer film was largely dependent on the conjugated polypyrrole chains.

However, there is no significant difference in surface conductivities between the electrolyte sides and the electrode sides. Details of the methodology and calculations in the determination of surface conductivities of polymers were generally not reported in most publications. Originally, the 'four point probe' method was used for measuring surface conductivities of semiconductor materials. The reliability of the 'four point probe' method and mechanism of electrical conductivity in conducting polymers need to be further investigated.

It was found that the sulphonated groups in the PPy/PSS and PPy/PVS films, were useful for removal of heavy metal ions at very low concentrations e.g. copper, nickel and cobalt ions (< 15 mg/L). Careful use of these films was found to be able to reduce the heavy metal ions concentrations down to approximately 1 mg/L.

The TOF-SIMS and ESCA results show the differences in surface behaviour between the electrolyte side surface and the electrode side surface of the three types of composite films studied. The deprotonation of pyrrolylium nitrogen (NH<sup>+</sup> to NH) had occurred at the electrolyte side after reduction. As a result, fewer PTS<sup>-</sup> anions were found on the electrolyte side surface. It was found that a PPy/PTS film was less useful for removal of cobalt ions compared to PPy/PSS and PPy/PVS films. Nickel

ions were less able to deposit on the PPy/PTS film compared to the PPy/PSS and PPy/PVS films.

It was found that there were more PVS<sup>-</sup> anions on the electrolyte side of the reduced PPy/PVS film. In addition, the insertion of monovalent cations (Na<sup>+</sup> or K<sup>+</sup>) into the PPy/PVS film were more effective compared to the divalent cations (Ni<sup>2+</sup>).

It was found that the PPy/PVS and PPy/PTS oxidised films were overoxidised at the large positive potentials applied and these films could not be completely reduced at the reduction potentials applied over the duration of electrolytes in the experiments.