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# Surface Analysis Strategies for Conducting Polymers

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Recently, the utilisation of conducting polymers (CPs) has become ubiquitous in biomedical research due to their special properties. The processing simplicity of this type of polymers class was reported to be one of the main reasons behind its widespread scrutiny and application. In addition, their conductive properties may stimulate electrical signals for certain tissues such as the brain, nerve, and heart. Polyaniline (PANI), Poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate) PEDOT-PSS), and Polypyrrole (PPY) are among the top choices for many scientists to explore the potentials of CPs as biomaterials. However, the bio-stability of these polymers has not been subjected to comprehensive study even though the biocompatibility properties have been reported extensively. The bio-stability can be interpreted as the ability of the polymer to retain its chemical states and conductivity. This is highly critical to ensure extended operational time of CPs when implanted.

Assessing the bio-stability of CPs, which is the key to study its chemical states,can be achieved by using X-ray photoelectron spectroscopy (XPS) technique-a surface sensitive tool. This technique would provide elemental analysis as well as the quantification of the chemical environments in one particular element (core level). Information at a few atomic layers could be detected, approximately at top 10 nm from surface to sub-surface of materials. In physiological environments, the dopant that resides in CPs backbone will normally leached out due to the differences in the acidity of the polymer and it's surrounding [1]. This unique problem challenges the integrity of CPs, as retaining its chemical stability as well as its conductivity properties are of utmost importance. The conductivityis driven by the presence of proton at the CPs backbone to promote the hopping motion of electron along the backbone. As most CPs are doped by acid dopants, the changes in the stability are reflected by these observations.

Another surface sensitive technique that normally goes hand-in-hand with XPS is Time of Flight Secondary Ionic Mass Spectroscopy (ToF-SIMS) [2]. This technique provides mass spectra and detection of fragments on the surface of materials. Loss of dopant fragment could be observed during the surface investigation and mapping. ToF-SIMS can also be used to obtain the depth profile along the cross section of materials. Any differences from the top to the interface and bottom of materials could be revealed through appropriate selection of sputtering ions. ToF-SIMS is a complementary technique for XPS, although by principle, TOF-SIMS and XPS data are extracted by molecular and electronic- based principles, respectively.

For the purpose of surface investigation on CPs, one can utilise and complement both method accordingly. However, it should be noted that one should understand the objectives clearly to analyse the samples using these techniques. Since reproducibility is a challenge, one should understand the parameter, thecondition of pressure and spectrophotometer used during the experiments. These variations could contribute to the irreproducibility of the results. In addition, results from XPS analysis should be treated subjectively as every analysis follows case by case basis. This includes the selection of background type, minimum and maximum binding energy, and shape of spectra. Another function of XPS that is not widely reported is its ability to provide work function calculation and valence region. These 2 interesting informations offer the opportunity to add more value to the current research of CPs.

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