XPS as an advanced method for analysis of organic materials

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X-ray photoelectron spectroscopy (XPS) is known as a surface-sensitive method that allows us to obtain quantitative information about the chemical composition of different organic materials: for simple biomolecules (amino acids (AAs)) to complex organic material (bacteria, cells). However, it is still a challenge to make in situ XPS measurements of organic materials in their solid or liquid form and to provide a correct interpretation of measured data. For non-destructive measurements, the cryogenic XPS approach is often used and capable to reveal novel insights on the chemical structure and composition of organic materials.

Here we present technological challenges in XPS analysis of two different organic materials - AAs and cells (geobacter, Algae), respectively. The first part focuses on an understanding of the actual mechanisms of AAs interaction with carbon-based surfaces, namely with H-/O-terminated nanocrystalline diamond (NCD) and diamond-like carbon (DLC) films using XPS. The depth distribution (<10 nm) of bonding states was calculated from the angular-resolved XPS spectra using the maximum entropy method (MEM), i.e. the in-depth reconstructions of the bonding states at the interface of carbon-based materials. The detailed processing of XPS data revealed the dependence of AAs adhesion on the surface termination of carbon-based materials. The XPS data are corroborated with AFM, SEM and WCA measurements.

The second part focuses on the investigation of intact interfaces (based on freeze-drying or direct freeze-drying on sample holder) of centrifuged wet pastes of geobacter and Algae followed by standard XPS measurements at liquid nitrogen temperatures. The geobacter with/without yeast in the medium were investigated. The detailed XPS analysis of C 1s, O 1s and N 1s peaks was provided to obtain the information about the chemical composition of geobacter. The XPS study revealed that medium with yeast caused a dramatic increase of peptides and lipids contribution in the C 1s peaks. Moreover, the cryogenic XPS analysis was used to investigate the surface chemical composition of hydrophilic and hydrophobic types of Algae (both grown for 5 and 10 days) to understand as a key factor for the understanding of their hydrophilic/hydrophobic properties. The differences in processed C 1s and S 2p peaks for both types of Algae in dependence on the growth period will be discussed.

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