Biochemical Interaction of Few Layer Black Phosphorus with Microbial Cells Using Synchrotron macro-ATR-FTIR

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In the fight against drug-resistant pathogenic microbial cells, low dimensional materials are emerging as a promising alternative treatment. Specifically, few-layer black phosphorus (BP) has demonstrated its effectiveness against a wide range of pathogenic microbial cells with studies suggesting low cytotoxicity towards healthy mammalian cells. However, the antimicrobial mechanism of action of BP is not well understood and further in-depth investigations are required. In this work, the complex biochemical interaction between BP and a series of microbial cells is investigated using advanced, high-resolution microscopy techniques to provide a greater understanding of the antimicrobial mechanism. Synchrotron macro-attenuated total reflection–Fourier transform infrared (ATR-FTIR) micro-spectroscopy is used to elucidate the chemical changes occurring outside and within the cell of interest after exposure to BP nanoflakes. The ATR-FTIR data, coupled with microscopy, reveals chemical changes to the cellular phospholipids, proteins, structural polysaccharides and nucleic acids when compared to untreated cells. These changes can be attributed to the physical interaction combined with the oxidative stress induced by the degradation of the BP nanoflakes. This study provides an insight into the biochemical interaction of BP nanoflakes with microbial cells, allowing for a better understanding of the antimicrobial mechanism of action.