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The interaction of activated sludge microorganisms with polymer biocarriers

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Entrapment of bacteria cells in polymeric matrices such as biocarriers is widely used for cell immobilization because synthetic polymers have strong mechanical strength and durability in contrast to natural polymers. Previous studies have shown that immobilized cell systems have the potential to degrade toxic chemicals faster than conventional wastewater treatment systems because high densities of specialized microorganisms are used in immobilized cell systems. The present study elucidates the mechanisms of interaction between microorganisms and the surface of polymer biocarriers. This information can be used for the optimization of the formation of biofilms on biocarriers for wastewater treatment as well as for the study of the transport of microorganisms in different environments. The two types of biocarriers that were used in this study are polyvinyl alcohol (PVA)-gel beads and Moving Bed Biofilm Reactor (MBBR) carriers. PVA gel is a promising type of synthetic polymer, which is cheap and non-toxic to microorganisms. It consists of 4 mm spherical beads with a solids content of about 10 % and specific gravity 1.025. One PVA-gel bead can hold up to 1 billion of microorganisms (depending on the operating conditions). MBBR biomass carriers are made from polyethylene and they have nominal diameter 20.5 mm and density slightly lower than water. Specific surface area and pore volume measured by BET method are parameters that allow making comparisons between the two different types of biocarriers regarding their effectiveness on wastewater treatment. Moreover, the biocarriers were also studied and characterized by Fourier Transform Infrared (FTIR) spectroscopy, molecular fluorescence, and Diffuse Reflectance UV-Vis spectra. The sludge samples that were investigated were taken from the aeration tank of the wastewater treatment plant of University of Patras (Greece). Measurements of the surface charge of the sludge, the biocarriers and the sorbed sludge on them, were accomplished using potentiometric mass titrations with different kinds of electrolytes (e.g. NaCl, $NaNO_3$) and at pH ranging from 4 to 11. In each case, the point of zero charge (pzc) was determined from these titration curves. The pzc of PVA gel beads was determined equal to 9.4. No pzc value was obtained for MBBR as expected based on its hydrophobic nature. For activated sludge microorganisms, two pzc values were obtained; pzc equal to 7.8 for a wet culture and 7.3 for the dry biomass. These observations suggest that for neutral pH commonly used for the treatment of wastewater the PVA gel surface will be positively charged whereas MBBR and activated sludge microorganisms will be neutral. Moreover, information about the electrical properties of bacteria cell walls will be obtained by IEP-microelectrophoresis and the determination of ζ-potential will be used for a more complete characterization of the electrical double layer of bacterial cell surfaces. The determination of pzc, iep, and surface charge of activated sludge and biocarriers is significant in understanding their interaction mechanisms and thus, the transport of microorganisms and the formation of biofilms on biocarriers.