Investigation of Streptococcus mutans biofilm growth on modified Au(111)-surfaces using AFM and electrochemistry

Biofilms of the bacterium Streptococcus mutans constitute perhaps the most important direct cause of human dental caries formation. We have studied S. mutans biofilm formation and properties on Au(111)-surfaces modified by self-assembled molecular monolayers (SAMs) of different thiol-based molecules based on a combination of atomic force microscopy (AFM) and electrochemistry using single-crystal Au(111)-surfaces. The thiols include both small, strongly hydrophilic molecules (cysteamine and the amino acid L-Cystein) and long straight-chain alkanethiol-based molecules with either hydrophobic (hexadecanethiol, MHD) or hydrophilic (mercapto-hexadecanoic acid, MHDA) end groups. The voltammetric reductive desorption (RD) peaks of the thiol-based SAMs in the absence and presence of biofilms and growth medium was in focus as a sensitive probe of the SAM local environment. AFM showed that S. mutans had grown to dense monolayers on all the four modified Au(111)-surfaces after 24 hour. The growth rates were slightly different and fastest for MHD-modified surfaces but the biofilms after 24 hour were indistinguishable. Reductive desorption signals of all the four compounds in phosphate buffer, pH 7.4 were very similar in the absence and presence of the biofilms and growth medium. RD in strongly alkaline solution where RD peak resolution is higher was also addressed. Most notably, the strong RD peaks of the long pure and functionalized MHD and MHDA in 0.1M NaOH remained in the presence either of biofilm together with growth medium or of the growth medium alone. The RD peak potential of the hydrophilic MHDA surface remained, further largely unaffected but the RD peak of the hydrophobic MHD SAM is distinctly shifted compared to the MHD SAM alone. The shifts were further in different directions for the S. mutans biofilm plus growth medium (negative shift) and for the growth medium alone (positive shift). Both the AFM images and the electrochemical data suggest that the biofilms form more efficiently and interact more strongly with the hydrophobic surface than with the hydrophilic surfaces.

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