Phenotypical responses of Sulfate reducing biofilms grown on metal surfaces modified with 2D coatings

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Abstract: Microbiologically influenced corrosion accounts for 20-40 % of the total corrosion costs in the United States. Sulfate reducing bacteria significantly contribute to microbial corrosion of a range of metals including copper and steel. They obtain energy via sulfate respiration where they reduce sulfate to corrosive biogenic sulfide species and subsequently attack the metal surfaces. Microbial corrosion is one of the primary reasons for steel degradation in oil and gas industry, marine infrastructure and transportation. SRBs cells form biofilms by producing extracellular polymeric substances on to the metal surface which function as three-dimensional architecture to promote different activities including cell adhesion, cell aggregation, gene transfer, cell to cell communication and forming protective barrier against antimicrobial agents. Microbial corrosion is more aggressive in presence of biofilms compared to planktonic forms of sulfate reducing bacteria. Hence it is important to understand how gene expression, gene responses and subsequent biofilm phenotypical responses including microbial corrosion is impacted by both physiological parameters and surface properties of underlying materials. The surface properties are often influenced by the nature of coating used to protect material surface. Here we focus on development of next generation nano-scale coatings based on 2D materials. The long-term goal of this study is to get an in-depth understanding of phenotypical responses of sulfate reducing biofilms in response to variations in nano-scale heterogeneity of underling 2D coatings. I will share preliminary research findings from the past four years of my dissertation research. We will share results related to physiological response of SRB biofilm grown on copper surfaces modified with a single layer of hexagonal nitride (SL-hBN-Cu). The SL-hBN-Cu corrodes 2.5 times slower and reduces the double layer capacitance and pore capacitance of the underlying Cu surface by 4.5-fold and 10-fold, respectively when compared to copper modified with a single-layered graphene coating. We also report the over expression of the adhesion genes and proliferated growth of SRB with an increase in the number of hBN layers. I will also share interesting preliminary results on nano-filaments (nano wire like structures) that were consistently observed on the modified copper surfaces. These filaments were absent when sulfate reducing bacteria was grown on mild steel surface.

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Dr. Govind Chilkoor specializes in development and application of two-dimensional materials as anti- corrosion coating against microbial corrosion. Currently he is working on surface engineering approaches for retarding growth of the harmful biofilms as well as to encourage desirable biofilms. He has played a critical role in establishing microbial corrosion lab in CEE department at SDSM&T. Dr. Chilkoor obtained his PhD in the Civil and Environmental engineering at the South Dakota School of Mines and Technology. He received MS degree in the Chemical Engineering and Environmental engineering from New Mexico State University and South Dakota School of Mines and Technology respectively. He has 15 years of extensive experience in industrial and research aspects of chemical and environmental engineering. Govind has worked in three different multinational companies including Archer Daniels Midland, USA, DuPont Singapore Pte Ltd, Singapore, and ITC Ltd., India. Examples of his project work are related to biofuel (ethanol), soya bean and cotton seed oil solvent extraction, Lecithin and Acid oil plant production, Starch and Fibersol production, solar desalination of brackish water and R&D aspects of polyester fiber bi-component yarn.

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