Project 1: "Application of Nanocomposites on Controlling Biofilms in Drinking Water Distribution System"

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Project Summary

Bacterial growth is associated with the formation of a protective layer that is composed of extracellular polymeric substance (EPS) and water channels that serve as a permeable barrier. Biofilms are hence surface–associated and highly-stratified microbial communities consisting of dense, highly hydrated clusters of bacterial cells embedded in a hydrogel matrix of the EPS. Over 99% of microorganisms on earth live in these biopolymers, colonizing and covering large areas of wetted surface. Biofilm usually grow on the solid-liquid interface. The closest case in our daily life is the biofilm that grows on our teeth if we do not brush our teeth constantly and eventually will cause plaque. Another example is the huge cyanobacterial mat that could be commonly found in a natural lake, which is a visual case of biofilm.

Biofilms are the oldest and most successful form of life on earth and act as carriers of the environmental "self-purification" process. In environmental engineering, biofilms could be found in sand filtration, membrane, activated carbon column, where they degrade the organic compounds and hence play an important role in the water treatment plant. Biofiltration, biomembrane, or bioreactors are built up based on the biofilms community to utilize them as main carriers to treat the water. However, biofilms are not always welcomed in our life. Biofilms that grow on surgical sites will probably cause clinical infection. And those biofilms easily cover the filter in our air conditioner will decrease the efficiency of heat exchange. As for environmental engineering, we are concerned about the biofilm growing in the drinking water distribution system, which will carry pathogens and cause potential health risk to humans. On the other hand, biofilms in the environment can influence the mobility of colloids and colloid-bound

contaminants such as nanoparticles (NPs) in the environment either by sorption of NPs within biofilm matrix, or by remobilization of NPs due to the decomposition of biofilm and detaching biofilm compartments. This potential bioaccumulation of colloid contaminants, heavy metals or NPs is also concerned as a huge risk to human health safety

Biofilms found on the inner surface of water distribution pipelines will affect water quality aesthetically and public health. Various problems have been reported to be caused by biofilms in the drinking water distribution system, including color, odor and taste problem, corrosion of pipe material, leading to both heterotrophic and coliform regrowth, as well as providing protective reservoir for waterborne pathogens. Sloughing of the biofilm in drinking water distribution system will even cause an outbreak of pathogens in drinking water. Generally, conventional chemical disinfectants are dosed to control such a problem; however, those chemicals may react with various compounds in the water to form carcinogenic disinfection by-product (DBPs).

Nanotechnology has recently provided an alternative way for drinking water disinfection due to nanoparticles(NPs)'s high surface area, crystallographic structure and adaptability to various substrates and hence increasing contact efficiency with microbial cells and pathogens and eventually inactivating them. Carbon nanotubes (CNTs) have been proven to have a strong antimicrobial effect on bacteria when in suspension in water. However, antimicrobial effect of the CNTs is highly dependent on its dispersivity and stability, which are impacted by the presence of natural organic matter (NOM) in water. Thus, there is raising attention on the CNTs blended polymer nanocomposites, which can maintain the antimicrobial property of CNTs as well as provide another important property, which is the hydrophobicity of the polymeric material.

In the Environmental Chemistry Laboratory, participating teachers will assemble the biofilm reactors and cultivate two species of biofilm, *Pseudomonas fluorescens* (gram negative) and *Bacterium smegmatis* (gram positive) on various commonly used pipeline materials and tested polymer nanocomposites. The growth of biofilms will be evaluated by using the Confocal Laser Scanning Microscopy (CLSM). The main objective of this study is to understand the impact of different materials including nanocomposites on the biofilm growth in a water environment. Returning teachers will have the chance in training the new teachers. The objective of this project is to explore the application of polymer nanocomposites in the drinking water distribution system in order to prevent biofilm growth. Teachers will be provided with the necessary documentation for experimental procedures and interpretation of the results and will be trained prior to conducting any experiments.

Possible Ideas for Classroom Implementation

This project is expected to open the realm of the multidisciplinary field of environmental engineering to the teachers. It will empower them to show in a meaningful manner how such integrated knowledge is used to solve a pressing community problem. It will be attractive to women and minorities, who tend to choose a career pathway that could potentially improve the quality of people's life. The teachers will be assisted in enhancing lab infrastructure at their schools by simplifying the approaches they used in this research to suit the resources available to them. This activity, when integrated into math, science and social studies classes, exposes students to problems faced by environmental engineers as they develop new materials or technology to improve water quality and protect the public health.

Fig. 1. Biofilm Reactors Setup

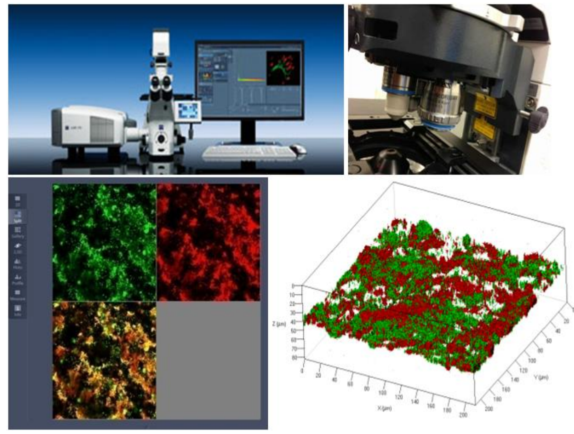

Fig. 2. Laser Scanning Microscopy

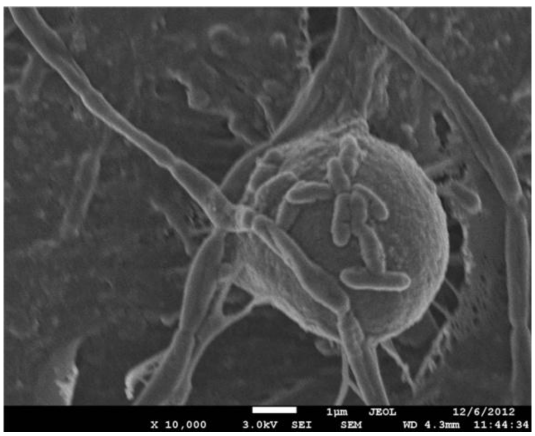

Fig. 3. Typical SEM Graph of Biofilm

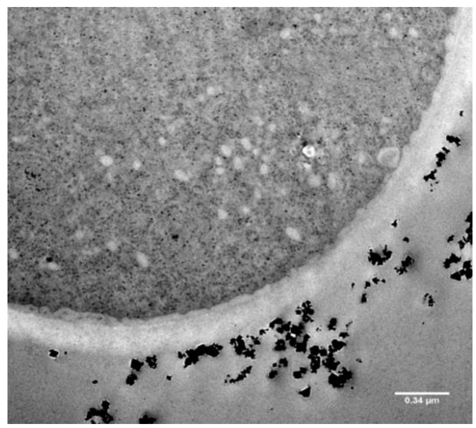

Fig.4. Typical TEM Graph of Cells Cross-Section