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CALSPAN ADVANCED TECHNOLOGY CENTER

MASTE

MITIGATION OF BIOFOULING USING COATINGS

QUARTERLY PROGRESS REPORT #1

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Objectives

Objectives of this project are to evaluate benefits associated with control of the surface energetic properties of materials used in heat exchangers; and to identify preferred ranges of these surface conditions that minimize deposits of biological fouling known to deteriorate heat exchange efficiencies in seawater, brackish water and freshwater systems. The technical approach employed uses special diagnostic plates in novel flow cells where fluid flow conditions can be well-controlled, modifying the surface chemistry and surface energy of the plates with very thin coatings and examining the earliest events of biofouling caused by macromolecules and microbial organisms.

Project Activity - September 15 to December 5, 1980

A project outline was developed that summarized the objectives, statement of work, and timetable for Year 1 of the program. The following items describe the experiments that will be conducted during the first project year. The numbers assigned to the items coincide with the time line given in Figure 1. Project activity is on schedule at this time.

1. Choose surfaces (detergent washed Ge, glow discharge treated Ge, and 3 or 4 silane coatings).
2. Purchase chemicals, materials for flow cell construction, tubing, etc.
3. Assess seawater tank viability; place additional fouled panels.
4. Prepare preliminary cells.
5. Develop coating protocols.
6. Assemble preliminary cells and run 2-day exposure experiment. Six surfaces will be utilized. No heat exchange measurements will be made on this set. The integrity of the coatings and the preliminary fouling film build-up will be assessed.
7. Incorporate heat exchange measurement capability.
8. Carry out aquarium tests with 2 surfaces (detergent washed Ge, methylated coating) to develop time frame required for measurable heat exchange deterioration. Analyze surfaces completely.
9. Carry out entire series of experiments (all surfaces, exposure intervals, duplicates); analyze surfaces completely.
10. Arrange for Chesapeake Bay and TVA exposure experiments.

Figure 1 PROGRAM SCHEDULE – YEAR 1 (DOE-MITIGATION OF BIOFOULING)

11. Reduce analytical data.
12. Prepare annual report.

A preliminary list of test surfaces is given in Table 1. Two of the surfaces require a simple modification, detergent washing or glow discharge treatment, to the metal germanium. Five of the surfaces necessitate coating the germanium plate with chemicals. The prepared samples will offer a wide range of surface energy characteristics for the biofouling studies. The integrity of the coatings on the substrates will be determined in the first set of seawater exposure tests in the coming months. The samples will be analyzed for coating thickness, chemical composition, texture, and surface tension prior to and after exposure. The chemicals listed in Table 1 were purchased and received; development of a coating protocol is now underway.

A variety of other materials were purchased also: tubing, small submersible pumps, and items for flow cell construction. The flow cells to be used in the fouling experiments are made of Dow Corning Sylgard 184 encapsulating resin. Each cell is a cylinder approximately 1-3/16 inches in diameter and 3-3/16 inches long. The cells are molded in 2 halves with a central relief area for 2 germanium internal reflection plates. Flow is directed between the plates through an inlet and outlet tube made of Teflon. A uniform spacing is maintained between the germanium plates by using 2 Sylgard 184 shims. The molded cell halves are held together by a 3-inch piece of polycarbonate tubing, split lengthwise and encircled with a stainless steel clamp. The cell is positioned vertically with flow from the bottom to the top for elimination of air. Approximately 50 complete cells have been fabricated for these experiments.

Initial progress has been made for measuring heat exchange coefficients using germanium internal reflection plates. The basic temperature/resistance relationships are being correlated as well as other physical characteristics. Several electronic circuit concepts are under consideration for the germanium plate application.

In addition to the activities discussed above, a coastal marine aquarium system was established to simulate real-world biofouling conditions. Two 50-gallon aquaria, connected in series, will serve as a source of seawater

TABLE 1
PROPOSED TEST SURFACES

Surface Treatment or Coating	Molecular Structure
Detergent-Washed Germanium Glow Discharge Treated Germanium	
N-2-Aminoethyl-3-aminopropyl-trimethoxysilane	
Chloropropyltrichlorosilane	$\text{ClCH}_2\text{CH}_2\text{CH}_2\text{SiCl}_3$
Dimethyldichlorosilane	
β (3-4-Epoxy cyclohexyl) ethyl-trimethoxysilane	
(Heptafluoroisopropoxy)propyl-methyldichlorosilane	

to be fed to test cells. A schematic of the aquarium system, showing the proposed configuration for the biofouling experiments is provided in Figure 2.

A lighting regime designed to support algal growth and to simulate daily and seasonal variation of photoperiod was incorporated into the system. Although the tanks are aerated 24 hours per day, an algal filter tank was installed to ameliorate the effects of reduced photosynthesis which occurs at "night". The algal filter tank is fully illuminated, 24 hours per day, to permit algal utilization of night-time waste products from the aquaria.

Planned Project Activity - December 1980 to March 1981

- o Finalize coating protocols.
- o Determine coating integrity with 2-day exposure experiments and choose 3 or 4 suitable coatings.
- o Incorporate heat exchange measurement capability.
- o Determine time frame required for measurable heat exchange deterioration and choose exposure intervals for subsequent experiments.
- o Begin entire set of exposure experiments.

Figure 2 SCHEMATIC OF AQUARIUM SYSTEM
FOR BIOFOULING EXPERIMENTS