

PN-ACD-234

REPORT

to Cooperation in Applied Science and Technology (CAST) Program
on the project

STUDY OF THE MECHANISMS OF FORMATION OF BIOFILMS AND DEVELOPMENT OF PROTECTIVE COATINGS FOR OPTIC SURFACES

Researchers Dr Tanya Kuritz, Oak Ridge National Laboratory, MS-6480, Oak Ridge,
TN 37830, (423)241-6013, kuritzt@ornl.gov

Dr L N Kouznetsova, Vavilov State Optical Institute, Tuchkov per 1, St
Petersburg, Russia 199164

Dates of visit November 5, 1995 - November 4, 1996

Research goals

- Develop chemical coatings that protect surfaces from formation of biofilms (consortia),
and
- Study molecular mechanisms of biofilm formation

Planned Research Objectives of the Visit

- Develop, synthesize, and test formulations that protect optical surfaces from microbial
growth and biofilm formation,
- Prepare recommendations on the applicability of different formulations for a variety of
applications

Research performed

A number of polymer coatings were synthesized on glass surfaces. Approach to the low-temperature direct polymerization of thin films on glass substrata developed in Russia served the basis for different formulations. Formulations were used that contained a variety of surface radicals in different combinations, such as dimethyldiethylsilane and vinyltriethoxysilane. Ability of these formulations to prevent microbial attachment to solid surfaces was tested with *Pseudomonas aeruginosa* strain PAO1 (common wound pathogen) and a number of blue-green algae (cyanobacteria) that are a cause of biofouling in marine and freshwater environments. In some experiments, tin complexes, copper salts and quaternary salt were added to the coatings to increase their biocidal effect.

Coatings were characterized by (1) measurement of the surface energy, and (2) topography as visualized by atomic force microscopy. Bacteria attachment was characterized by (1) staining of microorganisms attached to coated samples and direct microscopic count of these microorganisms, and (2) kinetics of surface coverage by bacterial films in optimized flow cells. Attachment of cyanobacteria was assessed after a prolonged growth of cultures in glass Erlenmeyer flasks covered or not, with polymer coating.

NATIONAL RESEARCH COUNCIL

OFFICE OF INTERNATIONAL AFFAIRS

2101 Constitution Avenue Washington D C 20418

OFFICE FOR CENTRAL
EUROPE AND EURASIA
Telephone (202) 334-2644
FAX (202) 334-2614

OFFICE LOCATION
The Foundry Building 2nd Floor
1055 Thomas Jefferson Street N W
CABLE ADDRESS NARECO

Date November 19, 1996
To USAID Center for Development, Information, Evaluation
From Sharon Vandivere
Subject CAST final reports

At the suggestion of John Daly of USAID's Bureau for Global Programs, I am sending the enclosed final reports of projects conducted under the Cooperation in Applied Science and Technology (CAST) program. The CAST program is funded by USAID and administered by the National Academy of Sciences. As I receive additional final reports, I will be sure to forward to you.

If you have any questions regarding the reports or the program, please contact me at 202-334-2644 or <ocee@nas.edu>

la

Specialized techniques used for characterization of solid surfaces and elucidation of their microtopography, Russian scientist was trained in an applied atomic force microscopy -- a novel state-of-the art method that allows extremely high resolution of material topography. Russian scientist received coaching in using PC and conventional office software.

Results of research

- (1) Polymer coatings in a variety of formulations failed to prevent bacterial attachment to solid surfaces, however, they could slow down the process of biofouling. Addition of tin inhibited bacterial attachment for 10-14 days. After that period, leaching of tin from the films led to the biofouling of coated surfaces. Copper stimulated attachment of *P. aeruginosa* to the surfaces, quaternary ammonium salts had no effect,
- (2) Thickness of coatings affected the rate of bacterial adhesion, while surface energy did not,
- (3) Surface microtopology of substrata did not affect bacterial attachment

Benefits of the Visit

Benefits to my research in microbial biotechnology were predominantly due to my exposure to another discipline due to working closely with a polymer chemist. It was important to critically assess applicability of protective coatings claimed by my Russian colleague to be extremely effective in the field against fungal fouling. Series of laboratory tests failed to prove this efficiency with other microorganisms, incl bacteria and blue-green algae (cyanobacteria). However, we were able to visualize, by atomic force microscopy, a process of tin leaching from polymer coatings, which, on its own, can make a case for the environmental protection. Collaborative research in the applied area helped me identify a gap in the fundamental knowledge: the effect of substratum field(s) on microorganism seems to be an important factor overlooked in the past research. I plan to continue fundamental research in this area.

During her stay at Oak Ridge National Laboratory, Dr. Kouznetsova was trained in atomic force microscopy - a method critical for current research in material science and polymer chemistry. She was also exposed to daily applications of computers and a variety of office and laboratory management techniques that are not available at her institution. As she has mentioned, her work at Oak Ridge National Laboratory will make her eligible for the second-step degree (Doctor of Sciences) at her institution. This degree would allow Dr. Kouznetsova to progress in her scientific and, possibly, administrative career.

This research resulted in two papers for the American Society for Microbiology Meeting on Biofilms (September 1996, Utah) and a paper for a peer-reviewed journal is in progress.

Future Collaboration

After completing research at Oak Ridge National Laboratory, Dr. L. N. Kouznetsova returned to Russia where she plans to continue her work on protective coatings at Vavilov.

Optical Institute We plan to exchange some additional data that will be presented in a research paper

Future collaboration with this group at Vavilov Optical Institute is unlikely since the coatings that are the area of expertise of this group at Vavilov Optical Institute did not show any superior quality in comparison with domestic products Lack of reasonable means of communication with this research group (no fax access, no e-mail) does not benefit the case

Benefits of the CAST Program

The benefits of the visit included the opportunity for the U S scientists to meet their Russian peers and to work together and to try to match different approaches to research and to life in general Russian colleagues should benefit from the exposure to new technologies, not available in Russia, and from the exposure to research routines that are standard in the U S but are not yet standard in Russia, such as data validation and use of electronic means for data processing and storage

Conversion in Russia is a painful process since the Russian system provides no support and does not guarantee any benefits to the institutions or individuals involved in this process Russian scientists are not used to the idea of initiative in research, competitive grant funding or technology transfer and are not friendly towards small businesses CAST-sponsored exchange is extremely valuable because it shows Russian defense scientists that their American peers have the system in place which makes them show entrepreneurial attitude to applied and defense research in order to stay in science Introducing the idea of free enterprise in applied sciences seems to me one of the most beneficial missions of CAST Program that contributes to the conversion aspect

A set of data resulting from our collaboration is very important to our fundamental understanding of the effect different characteristics of substrata to bacterial attachment The paper on these findings in preparation Another set of results obtained in this research points out to the impact of the substrata field on the attachment However, these findings merit further fundamental research which may not have any immediate commercial applications Since the coatings proposed by the Russian side did not show a desired efficiency of biofouling inhibition, I am not convinced in the possibility commercial application of these coatings in the near future

Financial Notes

CAST Support

Travel expenses for Dr Kouznetsova and family	\$3,000
Research supplies, English class	\$5,000
Stipend	\$6,000
Total CAST	\$14,000

University of Tennessee/ORNL Support

Direct support (stipend)	\$15,150
Overhead @ 23%	\$3,484 50
Total UT/ORNL	\$18,634 50

Grand total \$32,634 50

As a researcher under an exchange program, Dr Kouznetsova received a tax waiver from the University of Tennessee Therefore, direct tax-free payments to her were \$21,150 In rural East Tennessee, we enjoy low cost of living Apartment rent for Dr Kouznetsova and family was in mid \$200/month

Comments

- Conflict of cultures is the biggest problem that both the host and the visitor will experience The host should expect a “topsy-turvy” perception in the majority of areas Some concerns are echoed in the attached copy of the letter published two years ago in Science
- Verification and validation of conclusions published in Russian sources are crucial because the peer review process in Russia is a political endeavor rather than a fair assessment
- Availability of reasonably modern means of communication at your visitor’s institution is extremely important I would suggest that every host verifies that a fax machine or an e-mail terminal is available to the prospective guest It is also useful to verify that a potential visitor has some familiarity with PC

References

- 1 J Marcus *Science* 180 911 (1973)
- 2 _____ *Emblem and State in the Classic Maya Lowlands: An Epigraphic Approach to Territorial Organization* (Dumbarton Oaks Washington DC 1976)
- 3 W J Folan and J May Hau *Información* 8 1 (1984)
W J Folan *ibid* 9 161 (1985)

International Programs and Scientists in the Former Soviet Union

Scientists in the former Soviet Union (FSU) appreciate help from Western colleagues and international organizations. However, cultural differences and mutual misunderstanding bring some problems that undermine the effectiveness of current programs. I think it useful to list some general points in a random sequence.

- Besides the International Science Foundation (ISF), there still are no institutions in the FSU that provide grants based on open competition and reliable expertise. Funding in the Soviet Union used to be a kind of trade, often the same people distributed and benefited from a grant. The term

"conflict of interest" is unknown there. Thus, in trying to change the mentality of people in the East, it is important to do everything in an open-handed way.

- Long-term experience taught researchers in the East to think that the main aim of collecting open proposals was to collect new ideas and information that could be used by those having access to the files. Not once in the Soviet era were slightly modified, previously rejected proposals successfully submitted on behalf of another research group.

- Many scientists in the FSU think that the main aim of the ISF small-grant program is to collect a personal data bank. Therefore, they consider themselves not awarded but just paid for the information provided.

- The illusion is widespread in the East that Western scientists are much less creative than their Eastern colleagues. This assumption is based on a common practice of using Eastern results without proper referencing of work from the West. Therefore, the ISF larger grants program is considered by many to be an easy way of collecting new ideas and results. If each proposal is not given a short analysis that proves serious consideration and honest

competition, the program will produce undesirable side effects.

- The advertising campaigns usually do not correspond to the real value of awards, and this brings some disappointment even to those awarded.

- There is still no routine way for FSU scientists to get financial support for their participation in international conferences. They often travel at their own expense. Conference organizers ought to consider reducing registration fees for scientists from countries where such a fee may equal one-month's salary.

- Nonmilitary and basic sciences, which lack lobbying groups and means of direct pressure on the local and national authorities, suffer the most.

- Time is critical, and it is often lost when support comes, the recipient may already have lost his position.

- People in the FSU used to live in a kind of corporate state, therefore, they usually cannot distinguish between the supportive scientific community and the discriminative visa policy of a foreign country.

- Close contacts with FSU governmental bodies can discredit international scientific organizations in the eyes of the public because the majority of these governments do

not yet enjoy people's support and are considered to be corrupt and irresponsible. Superficially, it looks like giving the money to the same people who are responsible for the decline of science.

- Because of an undeveloped infrastructure, the contacts of international organizations with FSU scientists go through Moscow. A not unexpected side effect is that most of the laboratories awarded funds by the ISF for example are located there. Top-level officials from the government and the Academy of Science are skilled in dividing a pie to their own benefit. Evidently, international contacts are much easier for Muscovites to make than it is for scientists from other regions but that does not mean that Moscow is the only home of Russian science. On the other hand, the demands from new republics to contact them directly, although justified, can hardly bring much new. Unfortunately, besides the Baltic states, all of them have suffered heavy losses in research because of aggressive nationalism, lack of a system of national priorities, and economic decline. Having lost financial support for the projects in Russia that received recent ISF awards (and were thus considered successful and promising in the

West), I gratefully accepted an award from the US National Research Council that permitted me, in this situation, to continue my research in the United States. But does Russia benefit from this? And whom to blame? Revenging Russian bureaucracy or the ill-minded "West," which, according to the newest discovery of Russian nationalists, tries to destroy Russia by offering research opportunities to scientists who otherwise were supposed to change their occupation.

International cooperation is critical for the survival of science in FSU countries. Politically, it is important to preserve an intellectual elite who may be the only basis for future development and even renaissance. International recognition gives some moral support and raises the self-esteem of the best researchers in the currently suppressive, anti-intellectual political climate in most FSU countries. Scarce, but still existing, chances to escape as a "scientific refugee" or, at least, to get a temporary relief as a grantee or graduate student in a foreign laboratory is now almost the only motivation for the younger generation to join the scientific community. However, it is most important to keep pressure on the local governments,

which are responsible for the survival of national science. They are almost insensitive to domestic demands, but still mainly influenced from outside. Tax exemption for foreign grants and information about domestic funding of the awarded (and, presumably, the best) laboratories must be demanded. Among international programs, long-term cooperation between laboratories is much more productive than any short-term grants.

Sergey M. Shevchen
National Research Council
Senior Research Associate
960 College Station Rd.
Athens, GA 30605-2720, U.S.A.

Principal Research Scientist, Academy of Forest Sciences
Petersburg, Russia

Black Hole Theories

Faye Flam's Research News article "Theorists make a bid to eliminate black holes" (23 Dec, p 1945) describes some theories by John Moffat, and by Huseyin Yilmaz and Carroll Alley. The article quotes physicists Charles Misner and W.

