

# CHEMICAL AND BIOLOGICAL DEFENSE PROGRAM

## *General Information*

In response to Congressional interest in the readiness and effectiveness of U.S. Nuclear, Biological and Chemical (NBC) warfare defenses, Title XVII of the National Defense Authorization Act for Fiscal Year 1994 (Public Law 103-160) required the Department of Defense (DoD) to consolidate management and oversight of the Chemical and Biological Defense (CBD) program into a single office within the Office of the Secretary of Defense. The public law also directed the Secretary of Defense designate the Army as the Executive Agent for coordination and integration of the CBD program. The executive agent for the Small Business Innovation Research (SBIR) portion of the program is the Army Research Office-Washington (ARO-W).

The objective of the DoD CBD program is to enable U.S. forces to survive, fight and win in chemical and biological warfare environments. Numerous rapidly changing factors continually influence the program and its management. These forces include declining DoD resources, planning for warfighting support to numerous regional threat contingencies, the evolving geopolitical environment resulting from the breakup of the Soviet Union, U.S. participation in the Chemical Weapons Convention, and the continuing global proliferation of chemical and biological weapons. Improved defensive capabilities are essential in order to minimize the impact of such weapons. U.S. forces require aggressive, realistic training and the finest equipment available that allows them to avoid contamination, if possible, and to protect, decontaminate and sustain operations throughout the non-linear battlespace. Further information about the DoD CBD Program (and related programs) is available at the DoD Counterproliferation and Chemical Biological Defense Homepage at Internet address <http://www.acq.osd.mil/cp/>.

The overall objective of the CBD SBIR program is to improve the transition or transfer of innovative CBD technologies between DoD components and the private sector for mutual benefit. The CBD program includes those technology efforts that maximize a strong defensive posture in a biological or chemical environment using passive and active means as deterrents. These technologies include chemical and biological detection; information assessment, which includes identification, modeling and intelligence; contamination avoidance; and protection of both individual warfighters and equipment.

## *Tri-Service Program*

The U.S. Army, Air Force, and SOCOM have developed separate SBIR topics for research and development in various CBD areas of interest. No Navy topics will appear in this cycle. As lead agency, the Army will coordinate efforts related to the receipt, evaluation, selection, and award of Phase I proposals and similarly for potential follow-on Phase II efforts under this program.

### Submitting Your Phase I CBD SBIR Proposal

The CBD SBIR Program now requires that a proposing firm have Internet access via the World Wide Web, in order to submit its Phase I SBIR proposal – in its entirety – online. You must also submit an original and two copies via mail or other delivery means (See 4. Postal Submission below). Please review and follow these procedures when submitting each Phase I proposal:

1. Online Submission: The entire proposal including all forms must be submitted via the Internet. Go to the DoD SBIR proposal submission system (address: <http://www.dodsbir.net/submission>) which will lead you through the preparation of the following proposal sections:

- a. Proposal Cover Sheet Pages (Firm information and project abstract)
- b. Cost Proposal
- c. Technical Proposal
- d. Company Commercialization Report (does not count against 25 page limit)

2. Acceptable Formats for Online Submission: All technical proposal files will be converted to Portable Document Format (PDF) for evaluation purposes; therefore, the Technical Proposals should be submitted in PDF format. Other acceptable formats (PC/Windows) are: Text, Rich Text Format (RTF), MS Word, WordPerfect, and Adobe Acrobat. The Technical Proposal should include all graphics and attachments, should conform to the limitations on margins and number of pages, and should exactly reflect the hardcopy version. Offerors are responsible for performing a virus check on each submitted Technical Proposal. Each submitted electronic technical proposal will be scanned for viruses. The detection of a virus on any submitted electronic Technical Proposal may cause rejection of the proposal.

3. **Note:** Firms without Internet access must request an exemption by calling 703-617-7425 no later than January 7, 2001. Additional instructions will be provided.

4. Postal Submission: Postal submission includes an original signed proposal with all forms and required attachments, plus two copies. All proposals written in response to topics in this solicitation must be received by the date and time indicated in Section 6.2 of the introduction to this solicitation. Offerors are advised to submit proposal(s) well before the deadline. **Late proposals will not be accepted.**

**All Phase I proposals - one original (clearly marked, with original signatures) and two copies - must be submitted to the CBD SBIR Program Management Office at the address below. Each copy must include the signed Proposal Cover Pages, signed Cost Proposal and the signed Company Commercialization Report. All hand deliveries must be made to the Army Materiel Command (AMC) building mail room, located at the rear of the AMC building. Proposers should be aware that the AMC mail room hours are 0730-1530 hrs (local) and are subject to change without prior notice. \*Offerors using non-government courier services assume the risk for late delivery of proposals.**

Mail proposals to:

Dr. Kenneth A. Bannister

U.S. Army Research Office-Washington

**Room 8N31, Army Materiel Command Building**

5001 Eisenhower Avenue

Alexandria, VA 22333-0001

(703) 617-7425

Potential offerors must follow the proposal content rules for the agency which has proponenty for topics. Topics are numbered in series, with Army topics starting at 100, Air Force topics starting at 300, and SOCOM topics starting at 400. Detailed instructions for proposals to be submitted against Army topics are given below. **Refer to the appropriate Air Force and SOCOM sections in this Solicitation for information on how to prepare proposals for submission against Air Force and SOCOM CBD topics.**

### ***Army Proposal Guidelines***

The Army has enhanced its Phase I-Phase II transition process by implementing the use of a Phase I Option that the Army may exercise to fund interim Phase II activities while a Phase II contract is being negotiated. The maximum dollar amount for a Phase I feasibility study is \$70,000. The Phase I Option, which must be proposed as part of the Phase I proposal, covers activities over a period of up to four months and at a cost not to exceed \$50,000. All proposed Phase I Options must be fully costed and should describe appropriate initial Phase II activities which would lead, in the event of a Phase II award, to the successful demonstration of a product or technology. **The Army will not accept Phase I proposals which exceed \$70,000 for the Phase I effort and \$50,000 for the Phase I Option effort.** Only those Phase I efforts selected for Phase II awards through the Army's competitive process will be eligible to exercise the Phase I Option. To maintain the total cost for SBIR Phase I and Phase II activities at a limit of \$850,000, the total funding amount available for Phase II activities under a Phase II contract following an Option effort will be \$730,000.

Companies submitting a Phase I proposal to the Army under this Solicitation must complete the Cost Proposal within a total cost of \$70,000 (plus up to \$50,000 for the Phase I Option). Phase I and Phase I Option costs must be shown separately; however, they may be presented side-by-side on a single Cost Proposal. The Phase I Option proposal must be included within the 25-page limit for the Phase I proposal. In addition, all offerors will prepare a Company Commercialization Report, for each proposal submitted, which does not count toward the 25-page limitation.

Selection of Phase I proposals will be based upon scientific and technical merit, according to the evaluation procedures and criteria discussed in this solicitation document. Due to limited funding, the Army reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded.

Proposals not conforming to the terms of this solicitation, and unsolicited proposals, will not be considered. Awards are subject to the availability of funding and successful completion of contract negotiations.

#### Army Phase II Proposal Guidelines

CBD Phase II proposals are invited by the individual Service or SOCOM from CBD Phase I projects that have demonstrated the potential for commercialization of useful products and services. The invitation will be issued by the Service organization or SOCOM personnel responsible for the Phase I effort. Invited proposers are required to develop and submit a commercialization plan describing feasible approaches for marketing the developed technology. Fast Track participants may submit a proposal without being invited. Cost-sharing arrangements in support of Phase II projects and any future commercialization efforts are strongly encouraged, as are matching funds from independent third-party investors, per the SBIR Fast Track program (see section 4.5). Commercialization plans, cost-sharing provisions, and matching funds from investors will be considered in the evaluation and selection process, and Fast Track proposals will be evaluated under the Fast Track standard discussed in section 4.3. Phase II proposers are required to submit a budget for a base year (first 12 months) and an option year. These costs must be submitted using Cost Proposal, and may be presented side-by-side on a single Cost Proposal Sheet. The total proposed amount should be indicated on the Proposal Cover Page, Proposed Cost. Phase II projects will be evaluated after the base year prior to extending funding for the option year.

The Army is committed to minimizing the funding gap between Phase I and Phase II activities. With the implementation of Phase I Options, all Army Phase II proposals will receive expedited reviews and be eligible for interim funding. Accordingly, all Army Phase II proposals, including Fast Track submissions, will be evaluated within a single evaluation schedule.

#### ***Key Dates***

01.1 Solicitation Open	1 December 2000 – 10 January 2001
<b>Phase I Evaluations</b>	<b>January - April 2001</b>
Phase I Selections	April 2001
Phase I Awards	May 2001
Fast Track Applications Due	September 2001
Phase II Invitations	September 2001
Phase II Proposals Due	October 2001

## PROPOSAL CHECKLIST

This is a Checklist of Requirements for your proposal. Please review the checklist carefully to assure that your proposal meets the Army SBIR requirements. **Failure to meet these requirements will result in your proposal not being considered for review or award.** Do not include this checklist with your proposal.

- \_\_\_\_\_ 1. The proposal cost adheres to the individual Service (Army, Air Force) or SOCOM criteria specified.
- \_\_\_\_\_ 2. The proposal is limited to only **ONE** solicitation topic. All required documentation within the proposal references the same topic number.
- \_\_\_\_\_ 3. The proposal, including the Phase I Option Cost Proposal, is 25 pages or less in length. (Excluding the Company Commercialization Report.) Proposals in excess of this length will not be considered for review or award.
- \_\_\_\_\_ 4. The entire proposal including all forms must be submitted via the Internet using the DoD's Online SBIR Proposal System which can be accessed at address: <http://www.dodsbir.net/submission>
- \_\_\_\_\_ 5. The Proposal Cover Sheet and the Project Summary Sheet, are the first two pages of your proposal. The Proposal Cover Pages clearly show the proposal number assigned by the system to your proposal and is signed. The Project Abstract contains no proprietary information, does not exceed 200 words, and is limited to the space provided. The Cost Proposal is complete, signed, and is included as the last section of the proposal. (For Army topics the **Phase I and Phase I Option** costs must be shown separately on the Cost Proposal).
- \_\_\_\_\_ 6. The Company Commercialization Report, is submitted in accordance with Section 3.4.n. This report is required even if the company has not received any SBIR funding. (This report does not count towards the 25-page limit)
- \_\_\_\_\_ 7. The proposal contains only pages of 8.5" X 11" size. No other attachments such as disks, and video tapes are included. The proposal contains no type smaller than 11-point font size (except as legend on reduced drawings, but not tables). The proposal is stapled in the upper-left-hand corner, and no special binding or covers are used.
- \_\_\_\_\_ 8. An original with original signatures as required (**clearly marked**) and two copies of the proposal are submitted. The proposal must be sent registered or certified mail, postmarked by January 3, 2001, or delivered to the Army SBIR Office no later than **January 10, 2001, 3:00 p.m. local time** as required (see Section 6.2). Offerors who elect to use commercial courier services do so at their own risk. The Army **cannot** accept responsibility for proposals delivered late by commercial couriers.
- \_\_\_\_\_ 9. Include a self-addressed, stamped envelope and a copy of the Notification Form (Reference A) located in the back of the solicitation book, if notification of proposal receipt is desired. **No responses will be provided if these are not included with your proposal.**

## *INDEX OF CHEMICAL BIOLOGICAL DEFENSE FY01 TOPICS*

### **Army CBD Topics**

### **Air Force CBD Topics**

### **Special Operations Command (SOCOM) Topics**

## **CHEMICAL BIOLOGICAL DEFENSE FY01 TOPICS**

### **Army CBD Topics**

CBD01-100      TITLE: Lightweight Microarray Field Unit for Rapid Physiological Analysis of Army Personnel

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: To develop a rapid, lightweight system for assessing the physiology of individual Army personnel, and for rapidly identifying exposure of Army personnel to biological warfare agents, chemical agents, physical agents, infectious agents, and other agents that will have an impact on the physical performance of Army personnel.

DESCRIPTION: Microarrays are a recent technology, which allow rapid measurement of expression levels of very large numbers of genes. Previous methods of measuring gene expression levels could analyze one or at most a few genes at a time, required highly skilled laboratory personnel, and large, expensive laboratory equipment. Microarrays enable the analysis of all 60,000-80,000 human genes on a few slides, each approximately 2 square inches. Currently the use of microarrays is limited because the expense is high, the equipment is large, and isolating mRNA is still technically demanding and requires highly trained laboratory personnel. New research is required to develop small portable microarray units that could be used on the battlefield. Small microarray units could be developed that would contain pre-made microarray chips containing cDNA from all human genes. Army personnel would inject a small volume of blood (or other body fluid), and the self-contained unit would extract the mRNA, hybridize the samples to the microchips, and then analyze the data. The unit would be capable of emitting a detailed analysis that would allow medical personnel to assess the individual's health and identify biological, chemical, or physical exposures (i.e. these genes show altered expression levels), or a summary analysis that would enable the individual to make an informed decision about what to do (i.e. Data Outputs: exposure to anthrax, food poisoning, entering diabetic shock, hypothermia, stroke, etc.). Use of a portable, independent, battery-operated microarray unit would allow skilled or unskilled personnel to rapidly identify when an individual needs medical attention, when an individual has an infectious disease, and when the enemy is using chemical or biological warfare agents. Immediate identification of exposure to infectious agents will allow the reduction of spread of infectious agents and more rapid treatment, resulting in less time that the individual would be unable to perform his or her duties. Rapid identification of biological warfare agents would allow the army to minimize exposure and to initiate prophylactic treatment more quickly. Rapid identification of medical conditions would allow more rapid response, resulting in reduced sick time and death. The microarray unit would also have unlimited private sector possibilities including home units to alert persons that they need medical care, monitoring of high risk sectors such as individuals with diabetes or heart disease, and applications in remote populations without rapid access to medical care.

PHASE I: Research efforts should focus on automated mRNA extraction procedures, and building small self-contained microarray units. A successful Phase I will demonstrate the feasibility of a working prototype microarray unit that is portable and can extract mRNA from blood, hybridize the mRNA to pre-made microarray chips, and measure the output. Size, cost, and effectiveness are all factors in the successful product. Developing microarrays that can act as genotoxicological biosensors requires identifying a suite of genes whose changes in expression are well-correlated with toxicological insult. Therefore, Phase I will focus on the identifying of such genes and validating their predictive power by correlating their expression with symptoms and sequelae of exposure to

toxicants. After such DNA genotoxicological markers are identified and validated, the investigator will obtain cDNA clones of the genes of interest and construct a prototype microarray, which will also include a suite of genes known to be little affected by toxic exposure to serve as internal controls. Data will be obtained validating the entire microarray's ability to detect toxic exposure in a mammalian system.

PHASE II: Continue research to make microarray units smaller, cheaper, and better. Generate the data necessary for automated analysis of microarray results. For example, microarray analysis of blood from individuals exposed to specific biological warfare agents and infectious diseases, from individuals with food poisoning, from individuals with strokes, diabetes, and other disorders, and other conditions that may affect army personnel and result in a reduction of performance.

PHASE III DUAL USE APPLICATIONS: There are enormous commercial potentials for this system. Currently, the use of microarray technology is rather limited, due primarily to the high cost and the technically demanding nature of using current microarray systems.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Operating and Support Costs (O&S) will be favorably impacted by this technology. These microarray units will allow more rapid and accurate identification of physiological changes in army personnel. More rapid diagnosis will lead to more rapid treatment, which will in turn cause a reduction in medical costs because of reduced sick time and death of army personnel.

REFERENCE: Afshari, C.A., Nuwaysir, E.F., and Barrett, J.C. 1999. Application of complementary DNA microarray technology to carcinogen identification, toxicology, and drug safety evaluation. *Cancer Research* 59(19): 4759-60.

KEYWORDS: Microarrays, whole genome analysis, gene transcription, genomics, proteomics, bioinformatics, biotechnology

CBD01-101                      TITLE: Mass Customization Biomanufacturing Process

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: To develop a technique for mass customization of biological materials using self-regulating biomanufacturing processes.

DESCRIPTION: Bioprocess engineering, often referred to as biomanufacturing, is the applied continuum of biotechnology responsible for converting molecular genetic constructs to real products. The first industrial scale process for military application was in 1917 when a fermentation process was used to produce acetone for explosives, and the industry matured after 1945 with the production of antibiotics. More recently, the tools of molecular biology have enabled the exploration of the biosphere for new products. Genes which code for useful biological materials are identified and cloned into expression systems for production. Such systems include bacterial, fungal, insect cell, and mammalian cell culture, and all must be scaled up in order to produce an economically competitive product. Optimizing a scale-up bioprocess requires continual monitoring of feedstocks, nutrients, gases, temperature and product, a multivariate problem which varies, hence must be repeated, from product to product. Even within the same product, different production runs must be carefully monitored and controlled. What is needed is an expression system which is self-regulating and amenable to mass customization, i.e., one process with negligible real-time analysis suitable for producing any gene product.

PHASE I: Develop an expression system and fermentation process which couples protein expression (i.e., product) with expression of a reporter (e.g., fluorescent protein) which can monitor the production process. The reporter must be quantitatively linked to product expression and place an economically acceptable metabolic burden on the fermentation process. Product recovery and cost must be favorably comparable to standard fermentation processes.

PHASE II: Demonstrate the general applicability of the process to different classes of proteins (e.g., bacterial and mammalian) and to non-proteinaceous biomaterials (e.g., bacterial pigments). Address issues of cGMP validation

including reduction of components of the validation process. Final deliverable is a comprehensive bioprocess flowsheet.

**PHASE III DUAL USE APPLICATIONS:** This product would be applicable to the biomanufacture of any recombinant product, examples being vaccines, pharmaceuticals, structural biomaterials, nutraceuticals and catalytic materials. Military applications: The military is currently using recombinant antibodies for CB detection and medical diagnostics, and is developing catalytic enzymes for decontamination, demilitarization, and medical prophylaxis. A new program on biomaterials for low observables and obscuration is also planned. This biomanufacturing process would apply to all.

**KEYWORDS:** Biomanufacturing, mass customization, fermentation, cell culture, bioprocessing

**CBD01-102 TITLE:** Optimized Optical Parametric Oscillator (OPO) Converter for Solid State Standoff CB Sensors

**TECHNOLOGY AREAS:** Chemical/Biological Defense

**DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM:** PM, Nuclear Biological, and Chemical Defense Systems

**OBJECTIVE:** Establish technical feasibility of selecting, then optimizing, wavelength conversion schemes that will be promising candidates for 1 micron to 8-12 micron conversion. The selection will be based on schemes that avoid the use of AgGaSe<sub>2</sub> in order to increase system robustness. New non-linear materials may be considered due to the potential for high conversion efficiencies.

**DESCRIPTION:** Innovative and creative approaches to this research and development effort are requested to establish the technical feasibility of selecting, then optimizing, wavelength conversion schemes that will be promising candidates for 1 micron to 8-12 micron conversion. Development of such schemes directly supports both short-range (Joint Service Warning and Identification LIDAR Detector, also a Defense Technology Objective - DTO) and long-range (Artemis, WIDESPEC, and NBC Standoff Detector) goals for Contamination Avoidance. These are identified in the Joint Service Nuclear, Biological, and Chemical (NBC) Defense Research, Development, and Acquisition (RDA) Plan, and outlined in its CB Detection Roadmaps. These standoff detectors also support Army as well as Joint Service goals in Wide Area Decontamination by identifying and mapping areas requiring decontamination.

Significant flexibility is allowed in formulating proposed approaches to meet these goals. Efficient generation of tunable 8-12 micron output starting with a 1 micron pump source is difficult due to the large energy difference between the pump and 8-12 micron wavelengths. The conversion pathways that have been demonstrated previously use the delicate and costly non-linear crystal AgGaSe<sub>2</sub>, due to its high non-linear coefficient and bulk material transparency. Other conversion schemes to reach the 8-12 micron band have been demonstrated, but use 2.1 micron or 2.8 micron starting pump sources which are themselves inherently inefficient. In addition, overall electrical-to-optical conversion efficiencies have been poor in all schemes demonstrated to date, so that field operation of these systems would require unrealistically large battery sources.

What is needed is a robust, optimized OPO conversion scheme utilizing a 1 micron pump source that demonstrates good overall electrical-to-optical conversion efficiency without the use of low damage threshold crystals. Because the goal is to produce an efficient overall 1 micron to 8-12 micron conversion system, the OPO(s) need to be optimized in crystal length, crystal fabrication and coating, OPO pumping approach, OPO optical coating design, and coupling optics design for optimum conversion efficiency. Optimization of the conversion paths will include laser-OPO intracavity pumping configurations, OPO-OPO intracavity pumping configurations, crystal length optimization, and ion beam deposited very high damage threshold coatings. Multiple wavelength coatings, especially for the 8-12 micron OPO, will be a major development effort due to the current lack of process maturity in this wavelength region.

Most 8-12 micron conversion paths that have been demonstrated to date<sup>1</sup> have not been optimized due to lack of funding. Hence, optimized efficiencies are rarely reported and comparisons among different conversion strategies are not possible. With careful choice of non-linear material and wavelength conversion strategies, an OPO system that is optimized in the above mentioned parameters can provide a valuable performance benchmark that can be used to assess the viability and fieldability of these systems on virtually any platform. Furthermore, studies that quantify the performance of new “engineered” non-linear materials such as PPRTA and/or PPKTA may provide breakthrough conversion efficiencies that can make new platforms and applications possible due to the increased energy efficiency, lowered weight, and compactness.

The results of this effort will be applied in the near-term to the Artemis acquisition program to enhance its CB detection capabilities on the multiple platforms for which it is being developed. The Program Manager for NBC Defense Systems would be interested in providing non-SBIR funding during or after Phase II to integrate this capability (see attachment) into Artemis.

PHASE I: All efforts are to be directed toward establishing the feasibility of modeling studies and laboratory experiments designed to indicate approaches that will yield the desired optimization of the wavelength conversion scheme while using nonlinear crystals other than AgGaSe<sub>2</sub>. The selected crystals shall, of course, be commercially available in sizes commensurate with developing a transmitter with the desired output.

PHASE II: The goal of Phase II will be to employ the above strategies to build a prototype compact (less than 1 cubic foot) laser transmitter capable of emitting pulses of at least 500 microjoules energy with repetition rates of more than 500 Hertz. It will be fully tunable across the 8 to 12 micrometer band and any wavelength shall be accessible at the repetition rate of the laser for use in multiple systems/platforms.

PHASE III DUAL-USE APPLICATIONS: Phase III military applications include optimized full-sized and miniature standoff CB detectors for contamination avoidance and decontamination. In addition, dual-use intelligence and domestic preparedness applications could directly benefit from having a standoff detection device with optimized performance. Phase III commercial applications include spin-off detectors for standoff environmental pollution monitoring and for drug interdiction.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The optimized converter will allow standoff CB detectors to be more reliable and to have a faster response time. A more reliable, rugged converter will reduce the repair facility space, manpower, and quantity of spare/repair parts, and training requirements. The faster response time of the detector will give instantaneous results regarding the presence of CB agents which will reduce O&S and manpower costs associated with waiting for minutes or hours for delayed results. The availability of instantaneous results will also reduce the manpower and time required to perform inspections of potentially contaminated areas or materiel. For example, the optimized detector could allow inspections of 50 or more items of potentially contaminated materiel in the time it takes the current system to inspect one item.

REFERENCES: 1 “Efficient 1 micron to 8-12 micron OPO Converter,” Fukumoto, Fox, and Swim, Proceedings of the SPIE 14th Annual International Symposium on Aerospace/Defense Sensing, Simulation, and Controls, April 2000.

KEYWORDS: Chemical, biological, detection, LIDAR, standoff, sensitivity, nonlinear conversion

CBD01-103

TITLE: Adhesively Bonded Electrospun Membranes for Protective Clothing

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: PM, Soldier

OBJECTIVE: To develop adhesive bonding technology for laminating electrospun membrane-like materials to fabrics for protective clothing.

DESCRIPTION: Electrospun membranes have recently been prepared and evaluated for use as clothing membranes for protection against liquid and vapor chemical agents, biological warfare agents, and bacterial/fungal growth. The microporous membranes produced by electrospinning have shown promise as new lightweight clothing layers for protection from these and other threats to the wearer (Ref 1). Currently, electrospinning is limited to the manufacturing processes for filter media, not for clothing. A large technical barrier to the use of electrospun membranes in clothing is the bonding of these membranes to fabric substrates. Although traditional fabric lamination methods could be applied, the electrospinning technology itself has the potential to produce a new fabric lamination technique.

A new fabric bonding technology is sought for protective clothing, to minimize the effect of adhesive layers on fabric breathability, to lower laminating temperatures to preserve activity of reactive compounds that might be present in military fabrics, and to improve the drape of laminated fabrics.

PHASE I: Develop new adhesive spraying technology. One approach sought is by "fiberizing" adhesives through the use of known and novel fiberization techniques. Conduct coprocessing studies blending adhesives in new and creative ways to bond textiles to electrospun liners during manufacturing of the electrospun membrane. Identify and demonstrate fabric laminating methods for the resulting bondable electrospun membranes. A successful Phase I will be the delivery of an optimized lamination method and demonstration of the feasibility of the new technology for bonded fabric systems.

PHASE II: Successful methods from Phase I will be prototyped and then scaled up to demonstrate the capability of processing on a manufacturing level. A successful Phase II will deliver a prototype fabric bonded to an electrospun membrane to the Army for laboratory test and evaluation of durability, launderability, and breathability.

PHASE III DUAL USE APPLICATIONS: New electrospun membrane-like materials have promise in commercial outdoor clothing once laminating technology has been optimized for these new materials. Military application includes chemical protective clothing and extreme cold weather clothing.

#### REFERENCES:

1. Gibson, et. al, J. Coated Fabrics, vol. 28, pp. 63, July (1998).
2. Doshi, et. al., J. Electrostatics, 35, 151 (1996).
3. Reneker et. al., Nanotechnology, 7, 215 (1996).

KEY WORDS: Electrospinning, laminating, adhesive, membrane, fabric

CBD01-104

TITLE: Colorimetric End-of-Service Life Indicator for Mask Filters

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: PM, Nuclear Biological, and Chemical Defense Systems

OBJECTIVE: To develop an End-of-Service Life Indicator (ESLI) for use in current and future military protective mask filters that will respond to a broad range of chemical warfare agents and toxic industrial chemical vapors.

DESCRIPTION: Presently there is no means for the soldier to determine the residual service life of his or her NBC mask filter. Filters that may have been exposed to chemical warfare agents are disposed after 30 days following the chemical attack regardless of the level of exposure experienced by the individual. Filters that have not been worn in a chemical battlefield environment are disposed after a year of use in the field. These conservative change-out criteria impose a substantial cost and logistic burden to the services since adequate quantities of replacement mask filters need to be kept on hand.

Current military mask filters use ASZM-TEDA impregnated activated carbon to effectively remove chemical warfare agents. Low vapor pressure organic vapors such as the nerve agents are removed by physical adsorption in the microporous structure of the carbon, whereas relatively high vapor pressure acid gases such as certain blood agents are removed through chemical reaction (decomposition) with the impregnates. Although state-of-the-art colorimetric technologies exist for detecting specific contaminants, most rely on contaminant specific reaction chemistry and thus are not suitable as universal (i.e., "multi-contaminant") indicators. The optimal ESLI technology would use a generic indicator chemistry that responds to a wide range of toxic organic vapors and acid gases to alert the user to replace the mask filter. Realistically, no single indicator is expected to achieve such non-specificity. It is envisioned that a combination of different indicator chemistry will be required to detect the major classes of chemical agents, including toxic industrial chemicals. Nonspecific colorimetric ESLI concepts that target the major classes of organic vapors and acid gases (representative of chemical warfare agents) are those initially being sought. Small low-cost concepts that provide a reliable indication of remaining gas-life are needed that can be readily integrated into the filter without adversely effecting filter performance.

PHASE I: Investigate novel candidate colorimetric ESLI concepts that provide a visual means for indicating when the vapor/gas adsorptive capacity of respirator filters has reached its useful service life. The research shall focus on developing non-specific colorimetric concepts designed to target major classes of organic vapors and/or acid gases. Suitable ESLI chemistry and substrates will be identified and the feasibility of the concept(s) demonstrated through ex-situ testing using carbon-loaded test cells and vapor/gas challenges representative of the target chemical warfare agents (i.e., agent simulants).

PHASE II: Further develop the best candidate ESLI concept. Optimize the formulation of the ESLI and conduct ex-situ testing to characterize the overall performance of the ESLI concept. Appropriate performance parameters such as reaction time, reaction specificity (range of detection), color change intensity, and effects of temperature and humidity shall be assessed using different agent simulants, challenge concentrations, and airflow rates. Based on the results of the ex-situ testing, the optimum design/formulation and location of the ESLI in the filter carbon bed shall be determined. Conduct in-situ evaluations using modified mask filters and agent simulants to demonstrate the efficacy of the ESLI concept.

PHASE III DUAL-USE COMMERCIALIZATION: Phase III includes further development of the ESLI for both military and commercial respirator filter applications. Fabricate a minimum of 150 ESLI-equipped mask filter prototypes for follow-on in-situ evaluations. Conduct testing to validate the performance of the ESLI-filter prototypes. Deliver a minimum of 75 ESLI-filter prototypes for follow-on Government test and evaluation. The universal ESLI will directly benefit the current joint service mask filter (i.e., C2A1) and will also have significant applications in the current and future developmental mask programs such as the Joint Service General Purpose Mask and Joint Service Aircrew Mask. Likewise, the ESLI will have direct application to commercial respirator filters used in the workplace for protection against hazardous industrial vapors/gases. The ESLI will also have valuable dual-use application as a residual life indicator for military and industrial chemical protective clothing.

#### REFERENCES:

1. Thomas W. Mix et. al., "Colorimetric Concepts for Residual Filter Life Indicator", Chemical Research, Development, and Engineering Center technical report, CRDEC-CR-86028, August 1986.

KEY WORDS: Colorimetric indicators, End-of-Service-Life Indicator, chemical warfare agents, mask filters

CBD01-105 TITLE: Super-Efficient, Low Toxicity, Dendrimer-Quaternary Ammonium Compound Biocides

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: This topic seeks to exploit a recent research discovery that demonstrates super-effective biocides derived from commercially available dendrimers. The goal is to understand the basis for the exceptional activity and optimize the biocides for DoD and commercial use. These new materials are directly relevant to biological warfare defense, water decontamination, protective coatings, and pollution prevention.

**DESCRIPTION:** Dendrimers are highly branched molecules with regular and controlled architecture and a potentially high density of surface groups that can be used as a nanoscale scaffold for anchoring active chemical species (1, 2). It has been shown that by localizing n-alkyl terminated quaternary ammonium compounds (QAC) on a dendrimer surface, the biocidal effectiveness of the dendrimer-QAC toward E. coli bacteria is increased by more than 1000 times (3). Some of the unique benefits of these molecules are that they are not expected to be toxic to humans, are environmentally friendly, and are not known to form unwanted by-products during their activity. The unprecedented 1000 times improvement in dendrimer-QAC complex effectiveness may make them effective enough to be considered as a replacement for heavy-metal biocides in anti-fouling coatings, as antibiotics, and as a biocidal additive for water treatment in the field. In addition, the promising results on E. coli suggest that this complex may also be super-effective in destroying other bacterial species, including biological warfare agents. This timeliness and critical nature of this research topic is demonstrated by the fact that it addresses Chemical/Biological Warfare Defense and Protection, which is listed by the Joint Chiefs of Staff as one of the 10 Future Warfighting Capabilities most needed by the US Combatant Commands (4).

**PHASE I:** This topic proposes to investigate dendrimer-QAC complexes in order to commercialize this unique new technology. Modified commercially available dendrimers should be used rather than developing synthetic techniques for the dendritic portion of the biocide. Critical areas of research should include: (1) Exploration of the influence of dendrimer chemistry, size, and structure on the effectiveness of the biocide, (3) Characterization of the effect of chemistry of the quaternary ammonium groups on the effectiveness of the biocide, and (4) evaluation of the effectiveness of the biocide towards bacterial agents, including spore forming species, to identify the most promising applications for commercial exploitation.

**PHASE II:** Explore integration of the dendrimer biocides into platforms that may be used for military applications. Examples of suitable platforms include topical skin creams, glove materials, respirator materials or clothing that could be doped or treated with the dendrimer biocide to provide bacterial agent protection for soldiers, or coatings for structures, vehicles, membranes, clothing or medical devices that are resistant to biofouling. The effects of integration of the dendrimer biocides into the chosen platform on their effectiveness should be assessed, and the dendrimer biocide chemistry should be optimized for performance in the chosen application. Biocidal activity must be evaluated by testing with live bacterial species. Appropriate performance parameters such as speed of the protective response, durability, chemical stability, and human biocompatibility should be evaluated. Methods for processing and scale up of the technology should be developed. A completed, demonstrated prototype system must be delivered to the US Army Research Laboratory at the completion of this phase.

**PHASE III DUAL USE APPLICATIONS:** The results of this topic are expected to lead to the design of super-biocides for biological warfare agent defense, portable field water decontamination, reactive, protective coatings, and possibly new antibiotics. These materials may also be used in soldier or civilian protective clothing, and in a topical decontaminating cream, for water filtration, for tactical water distribution systems, and to produce heavy-metal free anti-fouling coatings, along with a host of commercial and DoD disinfectant applications.

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** Operating and Support Costs (O&S) will be very favorably impacted by this technology. The new biocides are 1000 times more efficient than current materials meaning considerably less material will be needed to achieve the same result. These new molecules are also less toxic to the environment than current materials (such as heavy-metal biocides in anti-fouling coatings), and are not known to form hazardous by-products as they are used, thus very costly remediation is not an issue. These biocides will be easily adaptable to a variety of key uses, such as decontaminating creams, portable water purification, and anti-fouling coatings. Their use in portable water purification can significantly reduce operation and logistics cost by eliminating costly removal/addition of chlorine during the purification process.

**REFERENCES:** (1) Tomalia, Scientific American, May, 1995, p. 62. (2) Tomalia, Naylor. and Goddard, Agnew. Chem. Int. Ed., 1990, 29, p. 138. (3) Chen, Beck Tan, and Cooper., Chemical Communications, 1999, p. 1585. (4) U. S. Army Science & Technology Master Plan, Vol. I, FY97

**KEYWORDS:** Dendrimer, biocide, quaternary ammonium compounds, biological warfare, decontamination

## Air Force CBD Topics

CBD01-300 TITLE: Detection of Toxic Industrial Materials (TIM) using Surface Acoustic Wave (SAW) Technology

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Human Systems Program Office

OBJECTIVE: Develop and demonstrate a novel sensor or Surface Acoustic Wave (SAW) coating to discriminate Toxic Industrial Material (TIM) in hazardous concentrations from naturally occurring backgrounds.

DESCRIPTION: This topic solicits innovative and creative solutions to a research and development (R&D) problem in the detection of TIMs. Included within the TIM designation, are the chemical warfare agent decomposition products. Many of these decomposition products are potentially toxic. The new solutions would most likely be novel, polymers for coating the SAW crystals. This does not exclude new or novel sensors that can be incorporated into the air handling system of the JCAD. All innovative approaches are encouraged and will be considered, provided they meet Phase I and II technical goals.

SAW detection technology is based upon the change in resonance frequencies of small, piezoelectric crystals. The SAW crystals are coated with polymers specifically tailored to attract the chemical of interest. As air is passed over the SAW crystals, TIMs are selectively adsorbed. The adsorption of chemical mass causes the shift in the resonant frequency of the SAW crystal. The JCAD uses an array of eight SAW crystals as the sensor component of the detector. The frequency responses from the SAW array are processed by a neural network algorithm to identify and quantify the TIM being "seen" by the JCAD. The JCAD requires the development of new sensor or SAW coating to expand or enhance the current sensor array for the detection and quantification of TIMs.

PHASE I: Laboratory measurements will be made to indicate the feasibility of the method proposed to discriminate TIMs from interferents. Specifically, the new approach shall focus on detecting the materials listed in the Toxic Industrial Material Hazards "HIGH" paragraph below. If possible, the materials listed in the MEDIUM and LOW paragraphs will be considered. Initial TIM detection levels will be workplace exposure limits established by Occupational Safety and Health Administration (OSHA) for each of the chemicals listed below.

Toxic Industrial Material Hazards:

HIGH: ammonia; arsine; boron trichloride; boron trifluoride; carbon disulfide; chlorine; 2-chlorovinylarsonous acid; diborane; diethyl methylphosphonate; diisopropylaminoethyl mercaptan; diisopropylaminoethyl methylphosphonothioic acid; ethyl methylphosphonic acid; ethylene oxide; fluorine; formaldehyde; hydrogen bromide; hydrogen chloride; hydrogen cyanide; hydrogen fluoride; hydrogen sulfide; lewisite oxide; Methylphosphinic acid; nitric acid, fuming; Phosgene; phosphorus trichloride; pinacolyl methylphosphonate; sulfur dioxide; sulfuric acid; thiodyglycol; tungsten hexafluoride;

MEDIUM: Acrolein; Acrylonitrile; Allyl alcohol; Allyl amine; Allyl chlorocarbonate; Boron tribromide; carbon monoxide; carbonyl sulfide; chloroacetone; chloroacetonitrile; chlorosulfonic acid; diketene; 1,2-dimethyl hydrazine; ethylene dibromide; hydrogen selenide; methanesulfonyl chloride; methyl bromide, methyl chlorofonate; methyl chlorosilane, methyl hydrazine; methyl mercaptan; nitrogen dioxide; phosphine; phosphorus oxychloride; phosphorus pentafluoride; selenium hexafluoride; silicon tetrafluoride; stibine; sulfur trioxide; sulfur chloride; sulfur fluoride; tellurium hexafluoride; tert-octyl mercaptan, titanium tetrachloride; trichloroacetyl chloride; trifluoroacetyl chloride

LOW: allyl isothiocyanate; arsenic trichloride; Bromine; bromine chloride; bromine pentafluoride; bromine trifluoride; carbonyl fluoride; chlorine pentafluoride; chlorine trifluoride, Chloroacetaldehyde; chloroacetyl chloride; Crotonaldehyde; Cyanogen; dimethyl sulfate; Diphenylmethane-4'-diocyanate; ethyl chloroformate; ethyl chlorothiofamate; ethyl phosphonothioicdi chloride; ethyl phosphonous dichloride; ethylene imine; hexachlorocyclopentadiene; hydrogen iodide; iron pentacarbonyl; isobutyl chloroformate; isopropyl chloroformate; isopropyl isocyanate, n-butyl chloroformate; n-butyl isocyanate; nitric oxide; n-propyl chloroformate; parathion;

perchloromethyl mercaptan; sec-butyl chloroformate; tert-butyl isocyanate, tetraethyl lead; tetraethyl pyroposphate, tetramethyl lead; toluene 2,4-diisocyanate; toluene 2,6-diisocyanate

PHASE II: Construct, assemble, and demonstrate a TIM sensor. The TIM sensor will be field tested to demonstrate that the proposed technique is not susceptible to the interferents present.

PHASE III DUAL-USE APPLICATIONS: Construct, assemble, and integrate a prototype TIM sensor in the JCAD. Conduct laboratory testing required to update the JCAD detection algorithm to include the TIM sensor. The prototype "JCAD plus" will be used in field tests to demonstrate that the proposed technique can be used by the warfighter's without an increase in false alarm rate. Phase III military applications include fixed-wing aircraft, rotary-wing aircraft, tracked vehicles, wheeled vehicles, personnel, shipboard, and fixed site applications. Phase III commercial applications include hazardous material emergency response units, environmental pollution monitoring, hazardous gas detection in commercial and residential applications, and industrial monitoring of chemical plant operations.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The (Joint Chemical Agent Detector) JCAD is designed to require a minimum amount of operation and support activities. Any new sensors included in the JCAD shall not increase the detector's operating and support costs.

KEYWORDS: Toxic Industrial Material, Toxic Industrial Chemical, chemical, chemical warfare agent, detector, Joint Chemical Agent Detector, chemical agent detector

CBD01-301                      TITLE: Improving Chemical Protective Capabilities of Silicon and Ethylene Propylene Diene Rubber (EPDM) Class Rubber Materials

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Human Systems Program Office

OBJECTIVE: Develop and demonstrate a novel coating or treatment process which blocks or effectively eliminates the transmission of chemical warfare agents and toxic industrial materials (TIMs) into and through silicon and EPDM class rubber materials used in NBC warfare protective masks. If possible, the proposed solution would significantly improve the protective capability of all types of rubber and plastic materials.

DESCRIPTION: This topic solicits innovative and creative solutions to increase the protective capability of common rubber materials used in chemical protective masks. The MCU-2/P mask is the current groundcrew NBC protective mask used by the USAF, USN, and in part by the USMC. The MCU-2/P is largely constructed from a silicon-based rubber. The current USAF aircrew NBC protective mask (MBU-19/P) components are constructed with EPDM rubber. Silicon and EPDM class rubber materials are desirable for masks because of their flexibility, superior performance in high temperature environments, comfort, resistance to degradation, etc. However, these rubber materials have lower chemical resistance capabilities compared to equivalent thickness of butyl rubber for example. The new solution would most likely be a novel application by brushing or spraying a coating. The proposed solution must be compatible with existing conventional application or treatment methods. The proposed solution must not cause degradation to other surrounding mask components, nor present a health or safety to personnel who may come in contact. All innovative approaches are encouraged and will be considered, provided they meet Phase I and II technical goals.

PHASE I: Laboratory demonstrations will be conducted to indicate the feasibility of the method proposed to improve rubber material protective capability. Specifically, the new approach shall focus on improving the chemical protective capability of the silicon and EPDM based rubber materials to allow no (or maximum acceptable traces of) chemical penetration at a desired time of 24 hours [36 hours Objective requirement].

PHASE II: Provide a prototype method or process which may be applied to the silicon based rubber components used with the MCU-2/P mask and the EPDM class rubber which is used with the MBU-19/P mask.. Subsequent

challenge testing with worse case, representative warfare and TIM chemicals to the treated masks shall show no (or maximum acceptable traces of) chemical penetration ever a desired time of 24 hours [36 hours Objective requirement].

**PHASE III DUAL-USE APPLICATIONS:** Phase III military applications include expansion of application to rubber and plastic components associated with aircrew and groundcrew masks, gloves, boots, clothing, capes, tarps, headgear, life support equipment, and protective shelters. Phase III commercial applications include improving protection of rubber and plastic components used in the protective gear associated with personnel involved with hazardous material emergency response units, environmental pollution monitoring, hazardous gas detection in commercial and residential applications, and industrial monitoring of chemical plant operations.

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** Nuclear, biological, and chemical (NBC) protective masks are designed to require a minimum amount of operation and support activities. Any new rubber coating or treatment shall not exceed costs associated with the current conventional use of adding butyl rubber material.

**KEYWORDS:** Coating, treatment, rubber, silicon, EPDM, mask, MCU-2/P, MBU-19/P, Toxic Industrial Material, Toxic Industrial Chemical, chemical, chemical warfare agent

CBD01-302                      TITLE: Flexible Filter for Military and Domestic Chemical/Biological Protection

**TECHNOLOGY AREAS:** Chemical/Biological Defense

**OBJECTIVE:** Develop a flexible filter for military and domestic chemical/biological protection.

**DESCRIPTION:** Current chemical/biological filter systems are bulky and cannot easily be integrated into the chemical/biological mask or hood design. The filtration system significantly limits the extent of size bulk reduction of the overall mask or hood assembly. Also, because these media are not very flexible (ie. they cannot be bent or folded), they limit design versatility and significantly limit size and bulk reduction of the final mask or hood assembly.

Currently available flexible filter media such as fibers, fabrics, felts, carbon entrapments systems, and impregnated webs have demonstrated limited chemical/biological vapor protection performance. Manufacturing processes for many of these media are often limited as well since they do not readily allow for catalyst impregnation in the final media. This is primarily due to the use of wet processing techniques in the paper or fabric making process.

Flexible filter media may also require complicated edge sealing processes to bind the media in the final assembly. This edge sealing further stiffens the media and further limits size and bulk reduction of the final assembly.

Overall, limitations in the current media and manufacturing processes do not allow the media to meet all of the requirements or allow the material to be versatile to meet all of the applications. The current specification for the mask NBC canister is MIL-PRF-51560A Current state-of-the-art for flexible filter media is as follows:

**CK Gas Life:**

State-of-the-Art: 80,000 Ct @ 32 1pm.

Design Goals\*: >40,000 Ct @ 50 1pm.

**DMMP Gas Life:**

State-of-the-Art: 240,000 Ct @ 32 1pm.

Design Goals\*: >150,000 Ct @ 50 1pm.

**Particulate Filtration:**

State-of-the-Art: <0.01% penetration @ 32 1pm.

Design Goals\*: <0.01% penetration @ 50 1pm.\*\*

Airflow Resistance:

State-of-the-Art: 25 mm H<sub>2</sub>O @ 85 lpm.

Design Goals\*: 20 mm H<sub>2</sub>O @ 85 lpm.

Surface Area:

State-of-the-Art: 250 cm<sup>2</sup>

Design Goals\*: <200 cm<sup>2</sup>

Thickness:

State-of-the-Art: 0.2" maximum

Design Goals\*: 0.2" maximum

lpm. - liters per minute

\* Use test conditions per MIL-PRF-51560A unless otherwise specified.

\*\* Use NIOSH Aerosol Test (0.185 +/- 0.02 count median diameter aerosol to 200 milligrams per cubic meter loading.

These design goals nearly double the required gas life performance over the existing state-of-the-art in flexible filtration media. Other media goals include:

- Offers easy and reliable edgeseal process without reducing flexibility of the media.
- Excellent sorbent retention and lack of media degradation due to operational flexing.
- Stable after exposure to moisture, humidity, and environmental extremes.
- Capable of high temperature storage to 160F without degradation.
- Suitable for future upgrade for toxic industrial chemicals.

It is expected that combinations of technologies or new state-of-the-art technologies will be needed to achieve these design goals. Combinations of state-of-the-art technologies can include particle and fiber technologies. New emerging technologies such as nanotechnology are also being sought. Versatility (ie. ability to use this media in a variety of novel chemical/biological mask and hood designs by tailoring the performance and flexibility of the media) of the final product will be important evaluation criteria. This versatility will include ability to change and adjust features and functionality, layering potential for improved performance, and ability to tailor for other types of chemical filtration such as toxic industrial chemicals. The final filter shall be capable of being integrated into a product using a typical manufacturing processes such as heat sealing, ultrasonic welding, bonding, etc. that do not limit media flexibility within the end product.

PHASE I: Research any new developments in flexible filter media technologies. Research existing and new manufacturing techniques that can be applied for edgeseal development. The research shall be concentrated in developing both a near term and long term candidate solutions for flexible filtration systems using combinations of new and emerging media and manufacturing processes.

PHASE II: Conduct testing to validate the chemical, environmental, and physical performance of the media. Characterize the candidate media for gas life, airflow resistance, aerosol penetration, physical properties, surface area characteristics, and environmental stability. Develop a matrix that evaluates cost and performance of all the candidate media. Phase II will culminate in prototype demonstration. Construct a sufficient number of filters for statistical performance verification. Deliver a set of prototype filters for Government surety evaluation.

PHASE III: Further develop the best candidate media/manufacturing process and construct a minimum of 500 flexible filters for evaluation. Conduct chemical, environmental, and physical performance testing to verify filter performance. Deliver 250 flexible filters for Government verification and to include in prototypes targeting all possible near and far term system applications.

DUAL-USE APPLICATIONS: The candidate filter systems will have significant applications in the current developmental mask programs such as the Joint Service General Purpose Mask, Joint Service Aircrew Mask, the Joint Service Chemical Environment Survivability Mask, and future mask systems. The candidate filter systems

will have application for other programs such as chemical protective clothing and gear. Industry will also have a use for the developed filter systems for domestic preparedness and escape equipment and gear.

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** The candidate filter systems developed could be used to replace some of the components used on the masks. The lighter weight and more flexible filter systems could be integrated into the hood or clothing and replaced with these systems rather than as a separate item.

**KEYWORDS:** Flexible Filter, Flexible Filter System, Chemical Biological Protection, Chemical Biological Mask, Vapor Protection

CBD01-303      **TITLE:** Improved Methods for the Polymer Coating of Surface Acoustic Wave (SAW) Crystals

**TECHNOLOGY AREAS:** Chemical/Biological Defense

**DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM:** Human Systems Program Office

**OBJECTIVE:** Develop and demonstrate a novel, inexpensive, process for application of polymer coatings onto Surface Acoustic Wave (SAW) crystals.

**DESCRIPTION:** This topic solicits innovative and creative solutions to a research and development (R&D) problem in the application of polymer coatings onto SAW crystals. The JCAD uses SAW technology for the detection, identification, and quantification of chemical warfare (CW) agents. SAW detection technology is based upon the change in resonance frequencies of small, piezoelectric quartz crystals. The SAW crystals are coated with polymers specifically tailored to attract the chemical of interest. As air is passed over the SAW crystals, CW agents and toxic industrial materials (TIMs) are selectively adsorbed by the polymers. The adsorption of chemical mass causes the shift in the resonant frequency of the SAW crystal. The JCAD uses an array of eight, polymer coated, SAW crystals as the sensor component of the detector. The frequency responses from the SAW array are processed by a neural network algorithm to identify and quantify the chemical being "seen" by the JCAD. The JCAD is the next generation chemical agent detector currently under development by BAE Systems, Austin, TX.

The heart of the technology are the polymer coated SAW crystals. Currently, the polymers are manually applied to the SAW crystals using an air brush technique. This technique does not apply uniform coating over the entire crystal, is not reproducible between individuals, and does not allow mass production of the SAW sensors. New, automated solutions are required to enhance the application of the polymers onto the crystals and to allow rapid mass production of the final form factor JCAD. All innovative approaches are encouraged and will be considered, provided they meet Phase I and II technical goals.

**PHASE I:** Laboratory measurements will be made to indicate the feasibility of the method proposed to uniformly and rapidly coat SAW crystals. Specifically, the new approach shall focus on quick and uniform application of polymers onto SAW crystals. Capability to scale-up the system proposed for mass production and cost per SAW coated are also prime considerations.

**PHASE II:** Construct, assemble, and demonstrate a prototype coating machine that is capable of applying uniform and reproducible polymer coatings. Conduct laboratory testing required to verify the performance of the new coating process. Demonstrate the capability to apply Government furnished polymer coatings to SAW devices in a cost efficient manner.

**PHASE III DUAL-USE APPLICATIONS:** Phase III military applications include fixed-wing aircraft, rotary-wing aircraft, tracked vehicles, wheeled vehicles, personnel, shipboard, and fixed site applications. Phase III commercial applications include providing a novel process to the electronics industry for the application of polymers.

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** The Joint Chemical Agent Detector (JCAD) is designed to require a minimum amount of operation and support activities. Any new coating process included in the JCAD production shall not increase the detector's operating and support costs.

KEYWORDS: Polymer Coating, Surface Acoustic Wave, chemical warfare agent detector, Joint Chemical Agent Detector, chemical agent detector

CBD01-304 TITLE: Improved Methods for Freeze-drying Complete Polymerase Chain Reaction (PCR) Mixes

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Human Systems Program Office

OBJECTIVE: Develop and demonstrate a novel process for freeze-drying complete PCR reaction mixtures in single use format for use in the austere military operating environment.

DESCRIPTION: This topic solicits innovative solutions to the R&D problem of freeze-drying complete PCR reaction mixtures in single use format. The reaction mixtures will contain synthetic oligonucleotide primers, and fluorescently labeled probes along with proper concentrations of the 4 dNTP's, buffers and salts needed to run a PCR reaction. The Air Force presently uses a PCR-based instrument, Ruggedized Advanced Pathogen Identification Device (RAPID), to detect and specifically identify and quantify, DNA or RNA specific to a given biological organism for which the reagents have been developed. The RAPID is designed for field use and is a suitcase sized portable device. A drawback to the RAPID's operation in the field is the fact that the reagents are temperature sensitive and require refrigeration. This is unfeasible in long-term deployed situations. It limits the number and the variety of tests that can be readily shipped to and stored at deployed locations. Consequently, the need for freeze-dried reagents is paramount to the success of this instrument and other testing platforms such as the SmartCycler, that employ probe hybridization technology.

Reagents will be provided for testing in a multicenter trial format at select Air Force, Army and Navy laboratories. Parallel testing will be performed on several platforms, to include at a minimum the RAPID and SmartCycler. Furthermore, reagents will be evaluated during Joint Service field exercises sponsored by the U.S. Army Institute of Infectious Diseases (USAMRIID).

The most critically temperature-sensitive components in the reaction mixtures are the DNA polymerase enzyme and the light-sensitive fluorochromes used for specific detection. Stabilization of the enzymes and maintenance of the fluorochrome's light-emitting properties is paramount to the long-term storage and ultimate functioning of the RAPID in the field. However, using single tube, large volumes is dangerous due to increased possibility of external contamination of the reaction and elimination of specific signal. Single-use reagent aliquots are much more desirable for ease of use and cost efficiency. A false positive result increases costs through loss of DNA target specimen, re-performance of work, and loss of reagent. By creating single-use, temperature stable reagents, a greater variety of assay types could be sustained in the field and used and/or resupplied as needed.

PHASE I: Experiments will be performed on formulations, which will allow the complete PCR reaction mixes to be freeze-dried into a temperature-stable format. This requires 5 complete probe and primer sets with 5,000 tests in aliquots of three 25ul reactions per tube. Proof-of-principle demonstration will be key.

PHASE II: Provide a process that would allow the freeze-drying of specific PCR sets developed. Demonstrate and verify the stability of the packaged reagents under a variety of temperatures and environmental conditions.

PHASE III DUAL-USE APPLICATIONS: There are both military and commercial applications for the reagents as manufactured and tested. The RAPID technology has the support of the Human Systems Program Office, the Air Force Institute for Environment, Safety, and Occupational Health Risk Analysis, the Air Force's Force Protection Battlelab and the office of the Air Force Surgeon General. Freeze-dried reagents could be immediately incorporated into the ruggedized field units for use in military vehicles or building scenarios such as aircraft, land vehicles, and watercraft or in field laboratories and/or hospitals. Civilian applications include use by public health agencies and hospitals to identify and track the spread of infectious diseases.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Freeze-dried reagents will reduce the operation costs of real-time PCR instrumentation by dramatically extending shelf life of temperature sensitive PCR reagents at sub-optimal temperatures. Freeze-drying significantly reduces the cost of continually replenishing and sustaining broad selections of expensive PCR reagents.

KEYWORDS: Polymerase Chain Reaction (PCR), freeze-drying, enzymes, fluorochrome, RAPID, biological detector

CBD01-305 TITLE: Decontamination of Chemical Protective Ensembles Comprised of Textile and Carbon Adsorbing Materials

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Human Systems Program Office

OBJECTIVE: Develop and demonstrate a novel process which decontaminates carbon impregnated chemical protective suits.

DESCRIPTION: This topic solicits innovative and creative solutions to address a need to enhance the currently accepted soap and water process to decontaminate carbon bead impregnated chemical protective suits. Decontamination is defined as the ability to neutralize chemical and biological agents. All innovative approaches are encouraged and will be considered, provided they meet Phase I and II technical goals.

PHASE I: Laboratory demonstrations will be conducted to indicate the feasibility of the method proposed to decontaminate both textile and carbon materials in chemical protective suits. The carbon bead decontamination efficacy should be as close to 100% as possible.

PHASE II: Provide a prototype method or process which can decontaminate carbon bead impregnated chemical protective suits. A system level test should be accomplished to correlate the system decontamination efficacy with laboratory level efficacies.

PHASE III DUAL-USE APPLICATIONS: Phase III military applications include Joint Service Lightweight Integrated Suit Technology (JSLIST) suits, Aircrew Ensembles (ACE), Joint Protective Aircrew Ensembles (JPACE), AF CWU-66/P, AF CWU-77/P, Army ABDU-BDO, and Navy Mk-1 underoverall, AF AERP masks

OPERATING AND SUPPORT COST (OSCR)REDUCTION: Chem-Bio protective suits are currently comprised of carbon-beads layered into cotton textile materials. Test have shown that the contamination lodged in the textile materials and between the carbon beads or on the surface can be removed through standard laundry washing. The carbon does perform its job of adsorbing chemical vapors as it were designed. To date, no extraction processes have been assessed. A novel mechanical textile process or solution to keep more contamination away from the adsorbing carbon would probably seem more feasible. Such a process should mechanically keep more contamination away from the carbon adsorbers without defeating all other physiological features. This would tremendously reduce the logistical tail of replenishing chemical protective suits to the warfront while supporting conventional cleaning to decontaminate chemical protective suits.

RELATED TEST REPORTS:

1. TNO-report, PML 1993-C26, March 1992, "Decontamination of protective Clothing". Decontamination efficacies of studied methods show that effectiveness is greatest starting with dry cleaning then micro-emulsion. Other decontaminants studied and in order of effectiveness are wash at 60oC, wash at 40oC and hot air.
2. CBIAC Task 80, Contract SPO900-94-D002, "Chemical Defense Ground Crew Ensemble Decontamination program Phase IV Pilot Scale Testing", February 1997. The engineering, design and fabrication of a safe and reliable test system to prove out the decontamination of chemical protective suits.

3. CBIAC Task 445, Contract DLA900-86-C-2045, "Chemical Defense Ground Crew Ensemble Decontamination Feasibility Assessment and Process Evaluation", April 1994. The identification of technical issues, knowledge gaps, and data requirements for evaluation of chemical apparel decontamination effectiveness and residual hazard hazards of overgarment decontamination. Tasks also included the identification and/or development of appropriate test methods to generate required information, identify current USAF equipment that can be used for decontamination of chemical protective apparel, to identify processes (procedures and equipment) for decontamination of chemical protective apparel and to conduct a logistical, engineering, operational and cost trade-off analysis of potential chemical apparel decontamination processes.

4. CBIAC Task 20, Final Report, Contract SPO900-94-D002, "Ground Crew Ensemble Decontamination Feasibility Testing Method Improvement Volume I, Aug 1996. The protective performance of chemical suits were evaluated with a liquid contamination/vapor penetration swatch test method. The conclusions obtained are that decontamination of chemical protective suits is feasible. The decontamination does leave residual agent in suit fabric.

KEYWORDS: Chemical protective ensembles, chemical protective suits, masks, undercoveralls, aircrew ensembles

### **SOCOM CBD Topics**

CBD01-400                      TITLE: Hand-Portable Waterless Decontamination System

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: US Special Operations Command, Program Executive for Special Programs

OBJECTIVE: Design, build, and evaluate a lightweight hand-operable and portable waterless decontamination for personnel and small equipment items.

DESCRIPTION: Highly mobile forces require rapid CB decontamination capabilities to protect personnel and vital equipment capabilities, and allow operations to continue once removed from hazardous environments. These forces often don't have access to or the time to use standard decontamination systems. This topic seeks to develop a simply operated system to effect necessary levels of decontamination in field-expedient situations, at a minimum cost in weight and cube. A waterless system is desired as a means to minimize logistics burden associated with this system. Of particular interest are decontaminating foams that are safe for people and equipment and dissipate rapidly.

PHASE I: Complete a study to quantify the threat characteristics given different scenarios, and how they can be addressed by a system as described above. Survey existing systems and evaluate scale-down options. Identify and evaluate new technologies. Conceptualize, and, when feasible, prototype and test potential solutions and supporting technologies.

PHASE II: Develop and demonstrate prototype systems in a realistic environment. Conduct testing to prove design feasibility including preliminary chemical and biological decontamination ability and concept of operations and support.

PHASE III DUAL-USE APPLICATIONS: In this era of increased concern about terrorism there is widespread need for personal decontamination systems for military and law enforcement. Systems like these would be useful in embassies, and in hospitals.

KEYWORDS: NBC individual protection, waterless decontamination, hand-portable

CBD01-401                      TITLE: Advanced Lightweight NBC Protective Clothing

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: US Special Operations Command, Program Executive for Special Programs

OBJECTIVE: Design, fabricate, and evaluate a lightweight NBC protective suit containing some or all of the following characteristics:

- a) semi-permeable or selectively permeable membrane, allowing ventilation of the wearer without exposure to outside chemical or biological hazards (liquids, vapors, aerosols, particulates)
- b) capability to detect C/B agent exposure to the suit
- c) capability to self-decontaminate when exposed to chemical and biological (C/B) agents
- d) capability to provide time until agent break through after receiving an agent exposure (viability of suit protection)

DESCRIPTION: Recent advances in electrospun nanofiber technology allow for development of advanced ultra-lightweight NBC protective gear comprised of multifunctional membranes and/or multiple materials. Lighter weight and the ability for the wearer to ventilate and thereby regulate the body's cooling combine for increased effectiveness and reduced degradation. Also, allowing integration of additional materials into the fiber mix provides the potential for incorporating capabilities for agent detection, self-decontamination and protection remaining indication directly into the protective suit.

PHASE I: Develop an overall system concept that defines an ultra-lightweight NBC protective suit integrating some or all of the technologies outlined above, identifying and prototyping, where feasible, enabling technologies and design concepts.

PHASE II: Develop and demonstrate prototype systems in a realistic environment. Conduct testing to prove design feasibility including preliminary chemical and biological agent resistance/protection, heat stress to wearer, and durability over extended operating conditions.

PHASE III DUAL-USE APPLICATIONS: Semi-permeable membrane materials are already widely used in commercial applications. Electrospun fiber technology is not presently used in the commercial fabric industry, but offers large potential for integration of new materials into the fabric construction process, as well as potential medical and packaging applications.

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