SON Number: WPSON-13-02 **October 27, 2011**

Strategic Environmental Research and Development Program (SERDP)

FY 2013 STATEMENT OF NEED

Weapons Systems and Platforms (WP) Program Area

IONIC LIQUIDS TECHNOLOGY

1. Objective of Proposed Work

The objective of this Statement of Need (SON) is to develop an understanding of the fundamental properties and the key mechanisms applicable to surface engineering characteristics of ionic liquids technology. In this context, an "ionic liquid" is defined as a pure, non-aqueous salt that melts to the liquid state below 100°C. Proposals are sought that either: (1) investigate the fundamental mechanisms where ionic liquids perform a selected surface finishing application as described below, or (2) identify and characterize the process variables associated with fundamental properties in non-aqueous reactions for one or more selected application(s). Proposed research should address new chemistries and processes for the deposition and dissolution of metals, or new chemistries and processes for cleaning that can be used to replace high-VOC solvents. Any ionic liquid process investigated should not require operation in a sealed, controlled-atmosphere system.

The overall purpose of the research is to advance the state of knowledge associated with ionic liquids such that the insertion of new technologies can be accelerated to address Department of Defense (DoD) life-cycle cost and environmental issues related to weapons systems.

The following applications are of particular interest:

Alternative Plating Processes for Depositing Inorganic Coatings

Significant progress is being made in the application of ionic liquid systems for electroplating coatings approved for DoD applications. These coatings offer the potential to replace other coatings with environmental disadvantages, while ionic liquid systems may offer processing advantages. For example, high-purity aluminum (per MIL-DTL-83488) has been approved in some applications as a replacement for cadmium, with ionic liquid deposition of high-purity aluminum potentially bypassing line-of-sight limitations of ion vapor deposition (IVD) of aluminum and avoiding the pyrophoricity of toluene-based plating baths that are currently being considered. Research challenges for such ionic liquid deposition systems include:

- Surface activation properties for an adherent coating produced from ionic liquid plating solution;
- Boundary layer effects of ionic liquids and additives on the anode and cathode surface;
- Plating bath process variable (current density, circulation rate, temperature, etc.) effects, to improve plating efficiency (time and energy) and coating properties;

- Air- and water-stable ionic liquid processing mechanism for applications such as brush plating;
- Ionic liquid regeneration or recycling;
- Toxicity and disposal of ionic liquid wastes; and
- Avoiding moisture sensitivity of ionic liquid deposition baths.

Replacement Cleaning Processes

This addresses a broad range of potential applications for ionic liquids: degreasing, oxide removal before conventional plating, and other cleaning applications. Research challenges for ionic liquid cleaning systems include:

- Optimization of ionic liquid chemistry and process variables;
- Evaluation of ionic liquid consumption;
- Ionic liquid recycling or regeneration; and
- Toxicity and disposal of ionic liquid wastes.

2. Expected Benefits of Proposed Work

The proposed research will result in a benefit to DoD by providing a scientific understanding of the key ionic liquid mechanisms and process variables for specific applications. This improved understanding will support the transition of promising ionic liquid processes into use with the DoD's maintenance and manufacturing systems.

A fundamental understanding of ionic liquid behavior is expected to result in improved methods for verifying and quantifying the ionic liquid processes that can be used by both the coating manufacturer and the electronics assembler taking into account environmental and manufacturing variables. Gaining a scientific understanding of basic ionic liquid mechanisms and process variables will allow elimination or reduction in the use of hazardous materials in manufacturing and maintenance of DoD systems.

3. Background

Historically, the DoD has used a variety of effective, but hazardous, metals and chemicals in aircraft construction and maintenance. Electroplating in particular fabricates metal coatings with the properties that aerospace industry desires on a variety of aircraft parts; however, it is a large source of hazardous waste and toxic air emission. Also, inefficiency of aqueous electroplating makes it a major energy consumer (for example, for electrolytic hard chrome plating, only 10-20% of the power supplied is used for actual deposition; remaining power is consumed through hydrogen generation and other losses). Understanding and subsequent development of more conductive organic ionic salts could result in more efficient and less costly processes.

Non-aqueous ionic liquids are molten salts that are liquid at room temperature with little vapor pressure, wide electrochemical windows, and versatile chemical properties that have been demonstrated at laboratory and prototype scales to address the problems in the surface finishing industry. Over the last ten years, many new ionic liquids have been studied as replacements for common organic solvents used in the chemical industry. However, the use of ionic liquids has not been applied extensively to weapon system hazardous material replacements. The various semi-commercialized and laboratory ionic liquid chemistries require further development before

they are ready to transition into service. Evaluations of ionic liquid processes have revealed that a further understanding of basic mechanisms, fundamental properties, refinement of chemistries (of both ionic liquids and additives), and process optimization are required.

4. Cost and Duration of Proposed Work

The cost and time to meet the requirements of this SON are at the discretion of the proposer. Two options are available:

Standard Proposals: These proposals describe a complete research effort. The proposer should incorporate the appropriate time, schedule and cost requirements to accomplish the scope of work proposed. SERDP projects normally run from two to five years in length and vary considerably in cost consistent with the scope of the effort. It is expected that most proposals will fall into this category.

Limited Scope Proposals: Proposers with innovative approaches to the SON that entail high technical risk or have minimal supporting data may submit a Limited Scope Proposal for funding up to $150,000 and approximately one year in duration. Such proposals may be eligible for follow-on funding if they result in a successful initial project. The objective of these proposals should be to acquire the data necessary to demonstrate proof-of-concept or reduction of risk that will lead to development of a future Standard Proposal. Proposers should submit Limited Scope Proposals in accordance with the SERDP Core Solicitation instructions and deadlines.

5. Point of Contact

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For Core Proposal submission due dates, instructions, and addition solicitation information, visit the SERDP web site at www.serdp-estcp.org/Funding-Opportunities/SERDP-Solicitations.