ASSESSING TOXICITY OF OBSCURANT GRADE PAN-BASED CARBON FIBER: AQUATIC SPECIES CHRONIC TESTS

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ABSTRACT

The Army Objective Force is characterized as organized, manned, equipped, and trained for land combat. In support of full-spectrum operations, Objective Force Concepts at the tactical level, and Objective Force Design emphasizing survivability and on-board multi-spectral capabilities, the newly developed Millimeter Wave Module has been added to the M56 smoke generation system by the Joint Program Manager for Nuclear Biological and Chemical Contamination Avoidance (JPM NBCCA). Use of polyacrylonitrile (PAN)-based carbon fiber in the module will provide user-capability for delivering large area obscurant screens in the millimeter wave-range of the electromagnetic spectrum while maintaining those capabilities already existing in the IR (graphite flakes) and visual (fog oil) ranges. We further support full spectrum training by providing species-specific portions of the ecotoxicological data necessitated by the National Environmental Policy Act (NEPA) and Fish and Wildlife Service (FWS) in order to gain training approval at national installations with minimal restrictions. To this end we are investigating the toxicity of PAN-based carbon fibers to the aquatic species *Ceriodaphnia dubia* (water flea), *Pimephales promelas* (fathead minnow), and *Selenastrum capricornutum* (green single celled algae). We adapt standard USEPA chronic aquatic toxicity methods to provide ecotoxicological results for both lethal and sub-lethal parameters, including LC_{50} (24-, 48- and 96-h), IC_{50}, EC_{20}, and EC_{50} values, and bounded NOEC and LOEC values.

1. INTRODUCTION

Since the 1940s, the Army has developed smoke generation systems (SGS) for use on the battlefield for protection and masking of both troop and mechanized equipment movements. As the modern battlefield has become more complex with the added abilities of detection and targeting in a wide range of electromagnetic methods, the Army has responded by augmenting SGS with new technology capable of providing multi-spectral smokes and obscurants. The M56 was developed to meet the Army's requirement for a highly mobile, multi-spectral, large area obscuration capability effective on the battlefield, protective of human health and environment, and usable in training. The M56 system is mounted on a M1097 High Mobility Multipurpose Wheeled Vehicle (HMMWV), powered by a turbine engine, and provides dissemination of both fog oil (visual obscurant) and graphite flakes (infrared obscuration) either separately or in combination. Following years of diligent work and optimization of the design, performance, and cost effectiveness of a millimeter wave module and its obscuration material, the Millimeter Wave Pre-Planned Product Improvement (MMW P^3I) program has

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successfully designed and fabricated a third module for use with PAN-based carbon fiber, adapting the M56.

Newly renamed the M56E1, the improved SGS must undergo an assessment of its impacts to the environment in response the National Environmental Policy Act (NEPA). Prior to being fielded to training units at national receiving installations, NEPA requires PMs to evaluate environmental impacts of an acquisition program before making major decisions that could effect the environment. The JPM NBCCA, the material developer, is responsible for the documentation of the general environmental effects of the M56E1 system, and has begun drafting a Programmatic Environmental Assessment (PEA). The Edgewood Chemical and Biological Center (ECBC) is leading the task of filling existing data gaps on the toxicity and fate of carbon fibers to terrestrial, aquatic, and representative wildlife species, and will forward resulting data for use in the PEA. Current ECBC toxicity tests focus on chronic effects of fibers on representative aquatic species.

2. TECHNICAL APPROACH

The PAN-based carbon fiber selected for use in the module is free of metal or chemical coatings, and has nominal dimensions of 5.5*u*m x 10mm. Its carbon content is a minimum of 92%, with total C/H/N/O at greater than 99% and total impurities at <1%. The material is chemically inert with greater strength and balanced mechanical properties compared to other carbon fibers. Due to the chemically inert nature of the material, potential for mechanical impact will be investigated by comparing results of two exposure methods. Chronic toxicity to aquatic species is determined from exposure to both carbon fibers in aquatic media, and to supernatants produced from fibers soaked in media. Aquatic test species are *Ceriodaphnia dubia* (daphnid), *Selenastrum capricornutum* (green algae), and *Pimephales promelas* (fathead minnow). Species selection is based on representative phylogeny, ecological relevance, and adaptation of standardized methods for all three species, determining potential acute and chronic toxicities. Tests are designed to provide dose-response information for mortality, growth, and reproduction. These methods are recommended by USEPA for testing of effluents, and may be used to test compounds and materials (USEPA, 1993; 1994). Organisms are cultured at ECBC using USEPA guidelines (1994).

3. DISCUSSION

Ecotoxicological data sets, including aquatic toxicity, build the MMW PEA that is delivered to M56E1-receiving installations in advance of fielding. Acquisition compliance under NEPA requires that federal agencies avoid delayed or poorly conceived environmental analyses, that in turn can seriously impact military operations and missions including restrictions on full-spectrum training for Objective Force Warriors. The JPM NBCCA and ECBC strongly support creation of thorough and data-rich environmental assessments, helping achieve Army objectives to: 1) match military mission activities with ecological compatibility of the land and natural resources, 2) integrate environmental considerations into decision-making processes, 3) identify and plan for environmental requirements that will apply to mission activities in order to avoid mission delays.

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