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Applications of Hemp Fibers for Textiles

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TI Research

A chief service of the DODIAC is free technical inquiry (TI) research limited to four research hours per inquiry. This TI response report summarizes the research findings of one such inquiry. Given the limited duration of the research effort, this report is not intended to be a deep, comprehensive analysis but rather a curated compilation of relevant information to give the reader/inquirer a "head start" or direction for continued research.

Abstract

The Defense Systems Information Analysis Center was asked to identify the current research being done on hemp fiber textiles for application in the Department of Defense (DoD). Limited information regarding the specific request for hemp-fiber use within the DoD is identified. A general overview of hemp fibers and traditional materials used in DoD textile applications is given using relevant references. Research being conducted on the topic will be evaluated and studied for possible DoD applications.

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1.0 TI Request

1.1 Inquiry

Who current research is being done on hemp fiber textiles for application in the Department of Defense (DoD)?

1.2 Description

Hemp fiber in textiles specifically used in the DoD has long been seen as a promising area of research. This research effort provides a compilation of reports identifying DoD key players investigating hemp fiber and its use in textiles. Documents were found introducing hemp fiber and corresponding commercial research efforts. Traditional materials used in textiles for DoD applications are compared with hemp fiber. Based on subject matter expert (SME) insight and supporting documents, different ways hemp fiber could be used within the DoD are discussed.

2.0 TI Response

Defense Systems Information Analysis Center staff searched open-source documents and the Defense Technical Information Center's Research and Engineering Gateway and discussed the topic with relevant SMEs. Research revealed that the topic appears to be up and coming and, therefore, does not have many prominent key players. As a result, this report focuses on background and potential future steps for using hemp fibers in DoD textiles.

2.1 Overview of Hemp Fibers

"Hemp fibers have been used for thousands of years in textile products such as sacks, ropes, and fishnets" [1]. Currently, hemp fibers are being incorporated into clothing, cordage, curtains, rope, carpets, burlap, sacking, and shoes. Hemp fibers are a type of natural fiber being explored for various applications, such as in the building and construction industries [2]. They exhibit strong ultraviolet- and mold-resistant properties and ensure durability and efficiency in clothing, particularly in outdoor conditions. Due to its rough texture, hemp is often combined with softer fibers like cotton. In comparison to cotton, hemp is considered more ecofriendly and costs less to produce. It needs no pesticides or fertilizers, needs less water, and enriches the soil during each growth cycle. Additionally, it grows longer roots, which suppress erosion and help preserve topsoil. "As a result of these favorable properties, university research within the United States into hemp plant production, fibers, and fabric is rising" [1].

After every wash, hemp fiber becomes softer and the integrity of its fibers remains stable, even after multiple washings. Using hemp alone can create a somewhat rough end product, so it is advantageous to blend hemp with other fabrics in clothing and mask applications to soften the textile without sacrificing its durability. Hemp is compatible for blends with cotton and silk. After hemp is incorporated into fabric, its feel is somewhere between cotton and canvas. Hemp-based fabric does not shrink and is rarely affected by pilling. The long and sturdy fibers from the hemp plant result in a very soft and durable fabric [3].

Being lightweight, hemp fabric is extremely breathable, making it ideal for use in warm climates. When constructed in multiple layers, the fabric efficiently facilitates the path moisture takes from the skin into the atmosphere. The layered process discussed next was used in the fabrication of a hemp-based face mask but could be used in similar textile applications [3].

Woven into a coarser hemp fabric with various pinwheel or square patterns, the first hemp-fiber layer filters out the densest particles in the air. The increased thickness of the second layer's hemp fabric allows for effective water absorption. The third layer is made from wet-spun yarn (long-fiber hemp with a double strand) that is woven in multiple directions, making it the densest layer. The fourth and innermost layer, in contact with the wearer's skin, is typically composed of a silk-hemp blend, all silk, or 100% hemp. The number of fabrics for any garment varies, depending on the environment in which it will be used. This type of fabric is easy to dye and very effective in combating the growth of mold, mildew, and possibly harmful microbes [3].

2.2 History of Hemp Production in the United States

For a time, some fibers typically used in textiles were unavailable in the United States. "During World War II, when imports of abaca and jute were unavailable, the government instituted an emergency program to produce hemp as a domestic substitute" [4]. An alternative was needed, so the United States turned to hemp production. Production was at an all-time high in 1943 and 1944, with over 50,000 acres of hemp being harvested in 1943. Hemp was mainly used during the war for light fire hoses, rope, and parachute webbing [4].

A mill in DeForest, WI, had a particularly successful agricultural business because trade routes carrying alternative fibers were cut off from the United States. In 1943, the 50-acre plant processed about 20,000 lb of hemp. This level of production can be attributed to the 400 local farmers interested in the \$100/acre profit. The mill was eventually bought out in 1947 by the Oconomowoc Canning Company [5].

Due to concerns over the use of hemp for drug purposes, the commercial growth and production of the crop was prohibited by the U.S. federal government a decade later. In 1970, the Controlled Substances Act [6] further enforced this policy by outright banning all hemp production. Years later, the 2014 Farm Bill (also known as the Agricultural Act of 2014) [7] eventually reintroduced the crop, providing states with the ability to start a hemp research program. The bill allowed manufactures to process hemp and farmers to cultivate cannabis containing no more than 0.3% of tetrahydrocannabinol (THC). As of 2019, about 46 states abide by this bill, while other states still have the right to continue to ban hemp production [8–10].

2.3 Hemp-Fiber Use in the U.S. Military

In 2020, there were discussions between the U.S. military and the University of Wisconsin-Stevens Point (UWSP) regarding hemp being a viable solution to replace imported polyester and polymers in U.S. Army vehicles. Accordingly, researchers at UWSP are pursuing the production of a hemp textile that the military can assess for use.

In February 2020, a group of state legislators, including Wisconsin state legislator Paul Fowler, shared with representatives from the DoD that [11]:

The military wants to use [hemp] for seat belts, seat covers, or uniforms because officials believe hemp-fiber material can be safer and more durable—and it can be made in the United States as opposed to imported from other countries during geopolitical tensions.

State Representative Tony Kurtz, at that time, was the legislation sponsor of the research grant. According to Kurtz, the military is interested in hemp fiber due to the major disadvantages of current polyester blends used in its vehicles, aircraft, and uniforms. Kurtz explained the disadvantages of the current material used in textiles throughout the military [11]:

- Polyester blends have a shiny tint that the enemy can see from far distances.
- When polyester burns, it shrinks into bare skin, causing the material to melt into the wearer.
- Hemp will not shrink like polyester blends and is stronger than cotton textiles.

2.4 Current Hemp-Fiber Use in the Marine Corps

There are multiple performance benefits of hemp-based fabric compared to traditional military uniform textiles that include lower cost, lighter weight, more durability, more comfort, and

ecofriendly fabric. The goal would be to replace Marine Corps combat utility uniform (MCCUU) fabric with a uniform hemp-fiber fabric [1].

“The fabric would need to be produced with standard textile manufacturing processes and be Berry Amendment compliant” [1]. The Berry Amendment [12] is a statute that essentially requires the DoD to use its given funds to purchase certain products 100% domestically. The products included under this law have varied since its inception as part of the Appropriations Act in 1941 [13] but mainly apply to DoD purchases of stainless-steel flatware, dinnerware, footwear, clothing, textiles, hand or measuring tools, and food. To be considered a viable replacement, the hemp-fabric blend would at least need to compete with the traditional uniform fabric (i.e., MCCUU fabric). By satisfying and surpassing most of the regulations given in the MCCUU requirement form, the MCCUU purchase description meets these requirements [1].

A hemp-based uniform with increased durability, but decreased weight for marines is highly desirable to prevent tearing and reduce overall load. Other coveted properties include vector (insect) protection, better flame resistance (can self-extinguish), and camouflage defense, besides the standard visual and near-infrared requirement [1].

To meet requirements “all hemp products must comply with 21 USC 802(16) [14]. Only hemp products containing less than 0.3% THC on a dry weight basis are allowable” [1].

The following evaluates Marine-specific steps needed to pursue the implementation of hemp-fiber blends [1]:

- Phase I: Conduct research on and determine the performance levels of hemp fabric, as compared to existing MCCUU fabric.

Validation/tests should demonstrate where the fabric meets and exceeds the MCCUU fabric requirements, as defined in the MCCUU purchase description [15]. Develop a Phase II plan for prototype production.

Provide at least one MCCUU set (blouse and trouser) or an equivalent amount of fabric to the Marine Corps for Marine Corps testing and evaluation.

- Phase II: Optimize the material properties based on Marine Corps evaluation results and feedback in Phase I and scale up the production process to reduce manufacturing costs. Provide at least

an additional 10 MCCUU sets to the Marine Corps for evaluation based on the performance criteria in the MCCUU purchase description.

- Phase III, Dual-Use Applications: Demonstrate the suitability of the material in a clothing design and field evaluation. Integrate the material into relevant items for system-level testing, evaluation, and demonstration. Provide at least 100 MCCUU sets to the Marine Corps for evaluation.

It is logical to assume that a similar testing and evaluation process would take place if other military branches were to pursue the use of hemp fabric in their uniforms.

2.5 Current Research on Hemp Fiber

The versatility and strength of hemp in fabric blends could have significant applications in the DoD and for government employees. Using hemp fabric for textiles has been researched, but there is limited, available information on its possible use in DoD textiles. The following hemp-fiber applications are not considered to be a part of the DoD. However, these applications introduce interesting properties and variations of hemp fiber that could apply to many facets of the DoD. Hemp fabric could have a considerable advantage over pre-existing military textiles.

2.5.1 Hemp-Fiber Face Masks

Researchers in Eugene, OR, have developed a multilayered hemp-fiber face mask for humans and animals. Face masks are used throughout the world, notably in healthcare, labs, and construction sites. When producing face masks, hemp has become an increasingly desirable material to use. The multilayered hemp face mask invention by Keith Ray Elam has the following desired aspects [3]:

- It is a biodegradable, reuseable, and washable mask that is comfortable and fits flush with the wearer's face.
- The middle layer of the multilayered mask is made of dense hemp-fiber fabric to absorb sweat or water for effective filtration.
- The third layer is composed of a hemp fabric that is very dense and durable due to double-stranded, long-fiber hemp, which is wet-spun yarn woven in various directions.
- The inner-most fourth layer contacting the skin is made from hemp, silk, or a combination of the two.

The mask has a minimum of three layers, but more layers may be added, depending on the environment of its use.

2.5.2 Foundation Garments for Use by Uniformed Personnel

According to a poll of various active-duty police officers, there are some that fail to wear their protective Kevlar vests. This form of protection is mainly used to reduce the effectiveness and possibly stop penetration to the body from bullets, shrapnel from explosions, and other projectiles. Presumably, the vests are uncomfortable and disregarded due to overheating, chafing, and buildup of perspiration and body odor [16].

In Wake Forest, NC, Thin Gold Line, Inc., invented an undergarment to counteract these issues. The proposed undergarment includes padded regions comprising a specific material, including hemp, that absorbs perspiration, eliminates bacteria, and wicks perspiration away from the torso. This counteracts the increase in body temperature caused by wearing the vest and the odor generated by sweat. The garment also holds a minimum of one spacer to generate airflow within the primary material, further reducing temperature. The specific material used to wick away sweat and moisture from the body is primarily made from a synthetic hemp blend, synthetic cotton-hemp blend, or any combination thereof. “The primary material comprises one of a composite blend of several textile components including nylon, polypropylene, micromodal and/or ROICA, and hemp” [16].

This invention is intended to be used primarily by police officers, firefighters, military personnel, and other public safety personnel who require vests and/or equipment daily to successfully perform occupational duties. Due to the majority of military personnel using bulletproof vests and carrying heavy loads, a hemp-based fiber undergarment with cooling properties could be extremely beneficial, ecofriendly, and cost effective [16].

2.6 The Future of Hemp

Hemp fibers have multiple advantages for use in textiles, with the potential to be used throughout the DoD. While this is a relatively new research area, the current research is promising and requires further investigation, consideration, and funding. Increasing awareness through legislation and pairing with industry and academia can help pave the way for new textiles for military and government users.

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