

Low-Profile Non-Skid Coatings for Aircraft

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PROBLEM STATEMENT

When carrying out maintenance on high-wing aircraft such as the V-22 Osprey (see picture above), or boarding a jet fighter by walking along the wing, one of the foremost safety concerns involves falls. Falls are the result of slips that are caused by the lack of friction between the feet and the walking surface. Each year in North America, there are over 540,000 slip/fall injuries requiring hospital care and over 20,000 fatalities. Especially dangerous situations include wet surfaces, presence of spills and contaminants (water, sea spray, oil, grease and soil), weather conditions, and individual carelessness.

Falling from high wing surfaces (8-10 feet above the ground) can result in sprains, broken bones, concussions and death. Adding to the safety concerns in Naval operations are the adverse conditions at sea (condensation on cold wing surfaces, wind, rain and rough seas on aircraft carrier decks), for which the potential for injury skyrockets. Traditionally both the military and many commercial airlines have used non-skid treatments on upper areas of aircraft to provide a safer walking surface for maintenance personnel who must access these areas for routine service and repair operations.

These current “baseline non-skid” treatments are generally organic coatings mixed with large additives (e.g. sand and plastic media) that make the surface rougher. The current approach has many drawbacks, including increased weight and aerodynamic drag; and the extremely rough surfaces contribute to the severity of injuries through lacerations. In addition, rough surfaces are difficult to clean. Thus there is a need for an effective lower profile non-skid surface treatment that does not degrade aircraft aerodynamic performance and has a low maintenance cost.

TDA has developed new high-performance non-skid coatings that have a low profile (e.g. low surface roughness) through the use of proprietary TDA nanoparticle additives. Our coatings

have excellent dry and wet traction and better aesthetic appeal than current non-skid treatments. The lower profile reduces aerodynamic drag and laceration injuries, and retains fewer contaminants, thereby making them easier to clean and maintain.

WHO CAN BENEFIT

This SBIR project is a joint effort between NAVAIR, Bell Helicopter/Textron, Inc. and TDA Research. The overall goal is to develop an advanced non-skid coating for the V-22 Osprey wings that will provide a safe walking surface with a minimum of added weight and no increase in aerodynamic drag. The new non-skid coating will reduce maintenance costs and increase safety for both pilots and maintenance personnel.

TDA's non-skid topcoat has potential applications for all DoD aircraft wing surfaces and also aircraft interiors where non-skid coatings are needed for safety. In addition, commands such as NAVSEA could use TDA's new non-skid coatings on aircraft carrier decks, auxiliary ship deck surfaces, bridges and walkways. The non-skid coatings would also increase safety on other vehicles such as trucks, tanks and amphibious vehicles such as the AAV.

Although the primary product of this project is a low profile, non-skid topcoat for the V-22 Osprey, with virtually no modification the non-skid additives can be used to develop other non-skid (e.g. polyurethane, epoxy, acrylate) coatings.

BASELINE TECHNOLOGY

Current baseline non-skid coatings consist of a grit element embedded in a highly cross-linked and tough epoxy or polyurethane matrix. The grit element is usually broadcast over a thick wet coating and back-rolled into the paint. The grit is either aluminum oxide, a plastic media, or crushed walnut shells that usually measure 40-60 mesh (0.25-0.4 mm) or larger. Most non-skid treatments have a significant macroscopic surface roughness to impart traction (> 500 μinches). Unfortunately, this roughness can cause significant aerodynamic drag when applied to wing surfaces. Moreover, most non-skid surface treatments must be applied as a thick heavy coating (e.g. 20 to 25 mils compared to normal topcoat, 3-5 mils) to encase the large grit. Thus, because of aerodynamic and weight limitations, the non-skid treatment is applied only sparsely, providing minimal safe walking corridors (especially in bad weather). In addition, the baseline non-skid treatments often wear out quickly and must be removed and replaced frequently.

Table 1 shows a comparison of TDA’s non-skid topcoat with an unmodified topcoat and the Navy’s current non-skid coating for the V-22.

Table 1. Performance Characteristics and Comparisons of Non-Skid Properties

	Dry Conditions		Wet Conditions	Oily Conditions		
	Static COF	Kinetic COF	Slip Index (Resistance)	Static COF	Kinetic COF	Slip Index (Resistance)
Unmodified topcoat (Blank)	0.8	0.6	0.1	0.05	0.07	0.03
Current Navy non-skid treatment	1.5	1.2	0.7	0.7	0.7	0.2
TDA’s non-skid coating (draw-down)	1.5	1.1	>1	1	1	0.3
TDA’s non-skid coating (sprayed)	1.4	1.1	>1	1	1	0.3

The static coefficient of friction (COF) is the ratio of the force necessary to initiate the motion of an object on a horizontal surface to its weight, while the kinetic or dynamic coefficient of friction is the ratio between the force necessary to maintain the object in motion at a certain constant speed to its weight. The coefficients of frictions for dry coatings can be measured with good accuracy using a test fixture such as a Thwing-Albert Pullmeter, according to ASTM D 1894. Our measures have a typical precision of ± 0.1. Unfortunately this method is not accurate for measuring the coefficient of friction of wet surfaces. A more accurate measure of the wet traction is the slip index. This can be obtained using the English XL test fixture, according to ASTM F 1679. This test fixture gives accurate slip resistance indexes of wet surfaces between 0.1 and 1. Unfortunately, this instrument does not read slip indexes higher than one, but any coating with a slip index higher than one can be considered very safe.

The data in Table 1 show that TDA’s new non-skid formulation considerably improves the coefficient of friction over the blank polyurethane coating and matches the performance of the current V-22 non-skid coating for wing surfaces under dry conditions. More importantly, TDA’s non-skid formulation provides a significant improvement over the current V-22 non-skid coating treatment under wet and oily conditions. Furthermore, it provides the demonstrated level of improvement at a much lower profile (200-400 μinches) and weight than the baseline technology. To put the coefficient of friction values in Table 1 in perspective, the building and construction industry classifies surfaces as safe if their dry coefficients of friction are greater than 0.5.

TECHNOLOGY DESCRIPTION

TDA has developed a polyurethane-based coating with exceptional non-skid properties. The non-skid coating is based on commercial two-component polyurethane topcoats compliant with

MIL-RF-85285C that have been modified with proprietary TDA friction additives to create a composite non-skid material. The proprietary friction additives are based on low-cost inorganic oxides that have been surface-modified using new in-house technologies developed during the SBIR program. These surface treatments allow us to formulate lightweight, low-drag coatings with non-skid properties matching that of 80-grit sandpaper. These features are necessary for high performance aircraft. In addition our technology allows us to incorporate the friction additives directly into the coating formulation. In most traditional non-skid treatments the grit is broadcast onto the still wet paint and rolled into the paint, because it would settle out if mixed within the paint. TDA's additives can be pre-mixed in the paint because they do not settle out. The mixture of paint and friction additives can be easily applied by spraying or brushing and no additional work is needed after paint application.

TDA's enhanced non-skid coatings have a thin profile, are low-drag, and are light in weight. The non-skid coatings have a dry coefficient of friction (COF) of 1.5 ± 0.1 and a wet COF of 1.1 ± 0.1 (matching the COF of the 80 grit sand paper under both dry and wet conditions (1.5 ± 0.1 and 1.2 ± 0.2 , respectively)). TDA's non-skid coatings are smooth, matte and uniform, and have a thickness comparable to the unmodified topcoat (3-5 mil, compared to the 20-25 mil topcoats needed by the baseline technology). The surface roughness of TDA's coating is minimal (200-400 μ inches), and preliminary drag calculations show that our roughness would not cause any adverse effects on the aerodynamic performance of the V-22 Osprey under typical flight conditions. In addition, TDA's multi-phase composite coatings maintain the desirable properties of the original topcoat, including abrasion resistance, adhesion to the primer, chemical resistance, corrosion resistance, and flexibility. Therefore, TDA's non-skid topcoat can be used to coat military airplanes on those areas that need higher traction without increasing the airplane weight or damaging the performance of the topcoat.

The features, benefits and advantages of TDA's non-skid coating are listed in Table 2. Our non-skid performance exceeds that of the current V-22 non-skid coating. Moreover, the coatings provide non-skid performance comparable to that of 80-grit sandpaper under dry and wet conditions without the drawbacks described of the current baseline technology.

Table 2 Features, advantages and benefits of TDA's Non-Skid Coating

Features	Advantages	Benefits
Low profile	lower aerodynamic drag	better aircraft performance
Low weight	lower overall aircraft weight	wider use on wing surface
Single package	non-skid addtives are in the paint	ease of application
High wet COF	excellent wet traction	personnel safety
Longer life cycle	fewer replacement cycles	less aircraft downtime

CURRENT STATE OF DEVELOPMENT

Non-skid surfaces are surfaces that have a high coefficient of friction. The coefficient of friction of a material is a complex function of numerous factors (e.g. molecular adhesion, mechanical damping, surface shearing, ploughing, etc.). Consideration of these factors both individually and in combination has allowed us to produce additives that have significantly improved the coefficient of friction for polyurethane topcoats without promoting significant roughness. Under dry conditions most coatings afford enough friction to be safe. However, under wet (and oily) conditions where most accidents occur, most coatings are not safe. Therefore, any new additive must provide a non-skid coating that is safe under wet and oily conditions.

Unfortunately most current non-skid coatings have a significant surface roughness. During the Phase I and Phase II efforts TDA has developed coatings containing proprietary friction additives that offer excellent friction properties under both dry and wet conditions with a low surface profile (200-400 μ inches). We have calculated that the maximum allowable surface roughness that would not alter the aerodynamic performance of the aircraft under the typical flight conditions of a V22 (e.g. altitude of 5000 ft and an air speed of 300 knots) is 500 μ inches. Thus, our low-profile coating is well below the roughness that would cause aerodynamic drag.

To date, TDA has completed the optimization of the non-skid formulation starting from several commercial two-component polyurethane topcoats, tested the coating properties, proved its benefits over the current baseline technology, and demonstrated that this product can be used with both brush on and spray applications. Future milestones include demonstrating our technology to the Navy and to our Primes/Partners, carrying our product through the Navy qualification process, and scaling-up the production of our friction additives and coating formulation with the help of our commercial Partners. The final milestone is painting actual Ospray V-22 wing surfaces with TDA's non-skid coating.

REFERENCES

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Reports:

TDA can provide to qualified parties either hard copy or electronic versions of its Phase I and Phase II reports. TDA can also provide non-proprietary reports to the general public and more detailed reports to those parties willing to sign a non-disclosure agreement.

TECHNOLOGY AVAILABILITY

TDA can provide either pint or quart samples of our non-skid topcoat to Navy Commands, other Service Agencies, and other interested parties. TDA can also supply coated panels for evaluation. On a more restricted basis TDA can work with interested parties to adapt the non-skid additives to their proprietary coatings. Navy qualification of the coating is expected in 2004. TDA plans to scale up the production of the non-skid additives so that larger quantities will be available. Commercialization of the coatings will take place in 2005 with our current commercial partner.

ABOUT THE COMPANY

Since TDA began operation sixteen years ago, we have grown from two people to a staff of 65 with revenues of \$9.3 million in 2002. Our core areas include synthesis of advanced materials and chemical process development. TDA itself is a research company, and the technologies are commercialized through the creation of license deals with much larger partners or internally as spin-off companies. In 2002 our partners invested \$10.9 million to commercialize technologies we developed on research contracts, and sold \$1.6 million worth of our licensed products. TDA is privately owned by the active managers of the company, has been profitable every year and has funded its growth entirely from retained earnings.

One of TDA's largest research areas is the development of polymer additives and we have demonstrated a number of high performance materials. These materials include additives for improved Chemical Agent Resistant Coatings (CARC), high performance nanoparticle-based chromate-free corrosion inhibitors, improved lubricity nanocomposite coatings and nanoparticle additives to improve the solvent-resistance of coatings and elastomers.