Plasma-Activated Water for Grease Removal: A Sustainable Alternative for Industrial Cleaning

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Abstract: Plasma-activated water (PAW) has shown promise as an environmentally friendly degreasing solution. This study investigates the efficacy of PAW and plasma-activated mist (PAM) in removing grease from aluminum, magnesium, and maraging steel surfaces. PAW's oxidation potential and surfactant-like properties enable grease breakdown without damaging metal substrates.

1. Introduction

Grease removal from metal surfaces is critical for aerospace, defense, and manufacturing industries. Traditional degreasing methods rely on hazardous solvents like trichloroethylene (TCE), posing environmental and health risks. Plasma-activated water (PAW) and plasma-activated mist (PAM) offer a chemical-free alternative by leveraging reactive oxygen and nitrogen species (RONS) to break down grease.

In this project, we investigated the use of gliding arc discharge (GAD) plasma, a non-thermal plasma technology capable of producing high-power power (>100 W/cm^3) plasma. GAD is a transitional, or "warm" discharge, that can provide unique combination of high temperature (2000 – 3000°C) plasma with non-equilibrium (i.e., cold or non-thermal plasma) properties [1]. The reverse-vortex type GAD, also known as "plasmatron", can be submerged into contaminated liquid solution or bulk solutions of water that can be activated with reactive species and then delivered to solid materials for treatment. This GAD plasma system is easily scalable and can achieve high productivity in the targeted transformations with lower energy consumption than traditional thermal arcs, pulsed arcs, or corona discharges. Nyheim Plasma Institute of Drexel University has pioneered the use of GAD for dissociation of CO_2 [2] and H_2S [3], for production of syngas [4], and for disinfecting water [5, 6], for cleaning fracking water [7], as well as for agriculture purposes [8].

2. Methods

We used Plasma-activated Water (PAW) to remove grease from different substrates such as aluminum, magnesium, and steel surfaces. To evaluate the effectiveness of PAW for grease removal, we followed the ADS-61A-PRF (Aeronautical Design Standard, Performance. Specification, Cleaners, Aqueous and Solvent, for Army Aircraft). In brief, a standard contaminant will be applied to aluminum, magnesium and steel coupons, followed by a 2-hour baking at 55 °C. Subsequently, all coupons will be photographed and weighed before and after contamination, with comparisons to after treating with PAW and PAM. Degreasing solvent trichloroethylene (TCE) will be used as baseline.

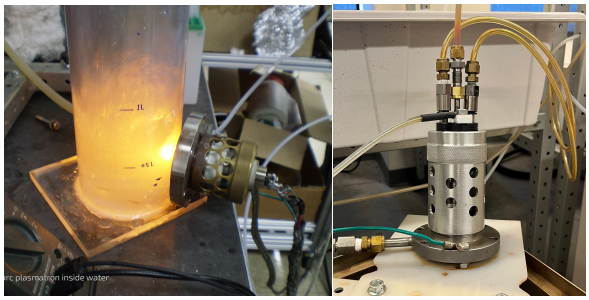

Fig. 1. Gliding arc plasmatron

3. Results and Discussion

Preliminary findings indicate that PAW significantly reduce grease residues across all tested metals. Compared to conventional solvents, PAW achieves similar degreasing performance while maintaining metal integrity and eliminating hazardous waste generation. The study demonstrates PAW's potential as an effective, sustainable degreasing solution for industrial applications.

Acknowledgement

This material is based upon work supported by the U.S. Department of Defense, Strategic Environmental Research and Development Program (SERDP) under Award Number WP25-S1-0236.

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