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**SUBJECT:** White Phosphorus Quenching by Water-Jel Technical Report on IITRI Project No. C08066

IIT Research Institute has completed a brief exploratory investigation of the ability of Water-Jel dressings to quench burning phosphorus and to delay re-ignition. Tests were performed on an inert substrate as well as on the skin of anaesthetised experimental animals, with results as described below.

## SUMMARY OF RESULTS

In the laboratory, on the 1-2 gram scale, it was necessary to heat white phosphorus to ignite it, probably due to the sample size, but also to the air velocity across the work surface of the fume hood used to contain the experiments.

In the tests on a metal substrate, WP samples quenched with water soaked dressings re-ignited in 1-5 minutes, while those quenched with Water-Jel failed to ignite in periods up to 30 minutes, although ignition could sometimes be effected by touching the sample with a spatula. There appeared to be a thin coating covering the samples which prevented ignition, even after the sample appeared to have melted.

The results of the animal experiments were not quite as uniform. Some of the Water-Jel quenched samples re-ignited within 30 minutes, while some of the water-quenched samples also reignited in this time. However, it seems clear that the Water-Jel tends to keep the sample moist, especially if there is a wound where the gel is retained by the cavity. If the water-soaked dressing has an open mesh, or is too thin, air can reach the phosphorus through the dressing to continue burning.

## EXPERIMENTAL

Preparation of white phosphorus samples.

All experimental work with white phosphorus was performed in a chemical fume hood. All handling of the phosphorus, was performed under water, and all phosphorus not in use was stored under water in sealed jars.

White phosphorus (WP), purchased from Aldrich Chemical Co., is supplied in cylindrical sticks, about 0.5 inch in diameter. After weighing a stick, it was cut with a knife into approximately sufficient 1-gram pieces for all planned tests. The samples were stored in a separate jar of water, and the stock container sealed and removed. In preparation for a test, the sample jar was brought to the hood and opened, a sample was transferred to a small beaker of water, and the jar sealed and removed.

Water-Jel dressings were supplied by Trilling Medical Technologies, Inc. Material used for the water - soaked dressings consisted of the gauze pads from Water-Jel dressings, from which all of the gelling agent has been removed by washing. In this way the size of the dressings for the two types of tests were kept the same.

## IITRI C08066 QUENCHING ON A METAL SUBSTRATE.

Several tests were performed in which WP was ignited on a flat metal test plate, quenched, and observed for possible re-ignition. It proved more difficult to obtain ignition of the phosphorus than anticipated possibly related to the airflow across the sample in the fume hood. In several experiments the phosphorus, was initially ignited by a match flame. Similarly, re-ignition did not occur unless the sample was heated. Tests were performed with 0.5 gram and 2 gram samples. Since the 2 gram samples burned with a considerable amount of smoke and began to sputter vigorously, we determined that larger- samples than this would be difficult to control in the animal tests. The amount of WP remaining after the quenching stop appeared quite adequate to test re-ignition, since about two - thirds of the sample remained.

### 0.5 Gram Tests, M-1 to M-4

A 150 watt reflector flood lamp was used to warm the samples for the re-ignition tests. In tests with 0.5 gram of WP the samples quenched with water-soaked dressings re-ignited in 1 and 3 minutes after uncovering under the lamp. Two samples quenched with Water-Jel dressings did not re-ignite in 12 minutes under the light, but the second one ignited immediately when it was probed with a spatula.

### 2 Gram Tests, M-5 to M-9

On the supposition that ignition of a larger sample may be easier, a 2 gram sample was allowed to dry for 15 minutes at ambient temperature (27 deg C) on a test plate without igniting. Upon ignition by match, quenching with Water-Jel and uncovering, it did not re-ignite in 20 minutes, nor did it ignite when probed with a spatula.

A "sand bath" (a pan of sand heated on a hot plate) was used to control the temperature of the test plates in the next experiments.

At 42 deg. C, WP samples did not ignite in 5 minutes, until they were touched with a spatula. After quenching with a water-soaked dressing, the first sample did not ignite for 22 minutes without the light, but ignited 3 minutes after the light was turned on. A sample quenched with a Water-Jel dressing did not ignite in 27 minutes with the light on, and appeared to be liquid with a thin "skin". When this covering was broken by touching it with a spatula, the sample ignited immediately.

At 55 deg C. 2 gram samples of WP ignited spontaneously in 1 and 3 minutes after placement. The sample quenched with a water-soaked dressing ignited in 1 minute when the dressing was removed under the light, but the Water-Jel quenched sample did not ignite in 30 minutes after uncovering under the light.

## ANIMAL TESTS

In order to simulate burns inflicted on personnel under "field" conditions, anaesthetised white rats were used in this series of experiments. At first, a small incision was made in the skin to expose about 1 square inch of flesh to serve as a test area. When it became apparent that liquid would accumulate in the incision and cover the phosphorus, the remainder of the tests were performed without incision. Instead, the haircoat was shaved to provide an exposed area for testing. The preparation of the animals is described in another section.

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Tests were performed in shallow metal pans, which would contain the rat and any phosphorus which might melt and run off the animal. Upon completion of the test, the rat was asphyxiated using carbon dioxide.

## TESTS ON INCISION, R-1 to R-5

Test R-1 - 2 grams WP, quenched with water.

A 2 gram piece of WP was placed in the incision, ignited by match, and quickly covered with a 4"x4" water-saturated dressing. Smoking continued and in 3 minutes, a tiny glowing spot appeared, where phosphorus vapour evidently was escaping through the mesh. It was extinguished with 1 ml of water, but appeared again after a few minutes. A second application of water extinguished it again, and it did not reappear, although moderate smoking continued. After one hour, the dressing was removed, and no ignition occurred in 30 minutes.

Test R-2 - 1 gram WP, quenched with water.

A test was performed in the same manner with 1 gram of WP, with identical results, except that the first glow appeared in 4 minutes.

Test R-3 - 2 grams WP, quenched with water.

After match ignition of a 2 gram piece of WP placed in the incision it was quickly covered with a 4"x16" water-saturated dressing, doubled over. Moderate smoking continued, but no "breakthrough" was observed. Water was added at about 15 minute intervals to keep the dressing from drying out. After 1 hour, the dressing was removed, and much of the WP was found stuck to the gauze. No ignition occurred for 30 minutes. Upon lighting the lamp, smoking became stronger, and the sample ignited in 1 minute.

Test R-4 - 2 grams WP, quenched with Water Jel.

When a 2 gram sample was ignited and quenched with a 4"x4" Water Jel dressing, smoking stopped completely, and did not resume until the dressing was removed after 1 hour. The phosphorus remained in the incision, covered with a layer of liquid, which did not dry completely in 30 minutes, nor in an additional 11 minutes under the lamp. When the WP was exposed under the light by probing with a spatula it ignited.

Test R-5 - 2 grams WP, quenched with Water Jel.,

Quenching was immediate as in Test 5, and the phosphorus was also covered with liquid which had not dried completely when the lamp was turned on after 35 minutes. The WP did not ignite in 15 minutes under the lamp, or when it was exposed by probing with a spatula.

## TESTS ON SHAVED HAIRCOAT R-6 to R11

Test R-6 - 1 gram WP, quenched with Water Jel.

Quenching was complete, with no smoke. Slight smoking began upon uncovering after 1 hour, and continued until the WP ignited after 28 minutes, without the lamp.

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Test R-7 - 1 gram WP, quenched with Water Jel.

Quenching was complete, with no smoke. Slight smoking began upon uncovering after 1 hour. No ignition occurred in 41 minutes without the lamp.

Test R-8 1gram WP, quenched with Water Jel.

Quenching was complete, with no smoke. Slight smoking began upon uncovering after 1 hour. No ignition occurred in 12 minutes without the lamp, nor in another 34 minutes after the lamp was turned on. Probing the WP with a spatula also did not cause re-ignition. The temperature next to the sample with the light on was 40 deg C.

Test R-9 - 1 gram WP, quenched with water saturated dressing.

After igniting the sample and covering it with two 4"x4" gauze dressings soaked in water, no smoking occurred. When the dressings were removed under the light after 1 hour, smoking began, and the sample reignited in 30 minutes.

Test R-10 - 1 gram WP, quenched with Water Jel.

After igniting the sample and covering it with a Water Jel dressing no smoking occurred. When the dressing was removed under the light after 1 hour, smoking began, and the sample did not re-ignite in 28 minutes. It ignited immediately when touched with a spatula.

Test R-11 - 1 gram WP, quenched with Water Jel.

After igniting the sample and covering it with a Water Jel dressing no smoking occurred. When the dressing was removed under the light after 1 hour, smoking began, and the sample re-ignited spontaneously in 31 minutes.

The experimental work reported herein was performed in the Chicago Laboratories by Dr. James N. Keith and Dr. Brooks J. Harder.

Respectfully submitted, IIT Research Institute, James N Keith, Ph.D Senior Scientist.

Reviewed by: A. Shefner Associate Director of Research ,Life Sciences Research.

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